Hillview Hard Rock Quarry

Surface Water Assessment

Coast Wide Materials Pty Ltd

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SLR Project No.: 630.V12117.00200

27 June 2024

Revision: v0.5

Making Sustainability Happen

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
v0.5	27 June 2024	Emily Curtis/ Walter Rowlands/ Jack Jenness	Paul Delaney	Paul Delaney

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Coast Wide Materials Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

Executive Summary

Coast Wide Materials Pty Ltd intends to seek development consent for a new hard rock quarry within a rural area known as Booral in the Great Lakes Region of New South Wales. The proposed Hillview Hard Rock Quarry proposes to extract up to 1.5 million tonnes per annum of rhyolite over a planned life of 30 years.

This Surface Water Assessment has been prepared to identify potential surface water related environmental impacts and risks relating to the proposed Project, to describe mitigation measures that can satisfactorily mitigate impacts/risks on the receiving environment, and to outline minimum requirements for environmental management including monitoring of environmental performance. The study also responds to relevant issues identified in the SEARs dated 3 June 2024.

Key findings from this assessment include:

- During operation of the quarry, the total catchment area draining to Double Creek may be reduced by up to 48 ha. This represents less than 25% of the total creek catchment area (200 ha) and will not have a significant impact on catchment yield and environmental flows.
- During construction activities, potential impacts to water quality in Double Creek can be adequately managed by sequencing construction, progressive revegetation of disturbed areas, and implementation of erosion and sediment control measures described in this report. The primary control measures will be:
  - Sediment dams to collect stormwater runoff. Sediment dams will contain runoff from a 5-day, 95th percentile design storm. This will include new sediment dams, and use of the existing farm dam downstream of the proposed extraction area.
  - Progressive revegetation of disturbed surfaces, including mulching of the external batters.
- During operation of the quarry, a series of water storage dams will be used to manage site discharges:
  - Where practical, clean upslope runoff will be diverted past the quarry.
  - Runoff from the processing pad will be captured and re-used on site and kept within that area.
  - Runoff from the quarry extraction area will be stored in a pit sump. The pit sump will have capacity to store runoff from extended heavy rainfalls. Following rainfall, water may be pumped out to a Main Sump.
  - Water in the Main Sump is either stored for re-use on site during dry weather, or during extended wet weather water can be transferred into the Farm Dam for treatment and released from site in batches of up to 8 ML every 3 days.
- The 1% AEP flood along Double Creek does not inundate the embankment of the Farm Dam.
- No new dams or water management works are proposed within the 80 m riparian zone of Double Creek.

A CEMP will be prepared to manage potential environmental impacts during the construction phase. The CEMP will include a detailed ESCP.

Identified potential environmental impacts or risks, along with the accompanying control and/or mitigation measures to be incorporated at the Project are outlined in the following table.

Potential Impact/Risk	Mitigation Strategy	Where detailed in Assessment
Water management during operations	A WMP will be developed to detail requirements and procedures for: • monitoring and reporting on water quality; • procedure for erosion and sediment controls for ground disturbance activities; and • requirements for storage and use of hydrocarbons and chemicals, and a Spill Management Plan.	**Section 6.0** **Section 11.0**
Construction phase runoff water quality	Potential impacts to surface water quality from runoff from the quarry can be adequately managed by sequencing construction, progressive revegetation of disturbed areas, and implementation of erosion and sediment control measures described in this report. Control measures will include sediment dams located downslope of the extraction area which collect runoff from the staged clearing of the extraction area, and the final landform surface of the quarry. Sediment dams will contain runoff from a 5-day, 95th percentile design storm. Controls during construction will be managed in accordance with a Construction Environmental Management Plan (CEMP).	**Section 12.1**
Hydrocarbon spills	Hydrocarbon spills during the construction and operational phases will be managed in accordance with controls including bunding of storage tanks, spill kits, and management protocols. Requirements will be fully described in the CEMP and the Water Management Plan (WMP).	**Section 12.3**
Storage of materials with potential to adversely impact water quality	All materials stored on site which have potential to adversely impact water quality in the downstream receiving environment will be stored: • Under roof, and if stored within a bund, the bund will have a capacity of at least 110% of the stored volume; and/or • If not under roof, within a bund that has a capacity of at least 110% of the stored volume plus rainfall from a 10-year 72-hour rainfall event, and suitable arrangements to treat captured water/liquid; and/or • In accordance with best practice and the Australian Standard for the storage and handling of toxic substances AS/NZS 4452:1997. Requirements will be fully described in the CEMP and WMP.	**Section 12.3**
Wastewater Management	Process water will be contained on site for re-use. This will include water which has been used for quarry product washing or been in contact with areas possibly polluted by quarry product or concrete making materials. The containment standard will be a 10-year 72-hour rainfall event. Overflow will be directed to the Main Dam or Pit Sump in the extraction area.	**Section 12.3**
Flooding of the Project site	An ephemeral creek, Double Creek, flows to the north of the proposed extraction area and down towards Maytoms Lane. A road crossing of Double Creek is required along the proposed Maytoms Lane access road. Flood modelling by SLR has identified that flood waters along Double Creek will not inundate the proposed footprint of the Farm Dam in a 1% AEP flood event.	**Section 12.4** **Appendix A**
Flooding of haul road from Maytoms Lane	Outcomes of flooding (inundation of road/culvert design criteria) Affect on integrity of embankments Flood planning requirements – safe egress (incl PMF) Flood modelling by SLR has identified that flood waters along Double Creek will not inundate the proposed footprint of the Maytoms Lane haul road in a 1% AEP flood event.	**Section 9** **Section 12.4** **Appendix A**

Potential Impact/Risk	Mitigation Strategy	Where detailed in Assessment
Safe egress during extreme rainfall	The haul road may be inundated during extreme flow events along Double Creek. However, the quarry extraction area is not within a flood prone area and will provide safe refuge during extreme flood events. A Flood Emergency Response Plan should be prepared as part of operational management documentation.	**Section 12.4** **Appendix A**
Change in peak flows in adjacent creeks	Flood modelling carried out for this study shows that the project has negligible effect to downstream flow and adjacent creek conditions with a slight reduction in flood depths downstream. The Groundwater Assessment predicts minor to moderate decrease in natural stage heights and flow conditions (up to an 8% flow reduction in Double Creek and 19% in Brewers Creek).	**Section 12.1** **Section 12.4** **Appendix A**
Catchment yield and environmental flows	Following construction of the quarry, rainfall runoff from the extraction and operational areas will be captured in a sediment basin, reducing the total catchment area draining to Double Creek by up to 48 ha. This represents less than 25% of the total creek catchment area (200 ha) and will have a minimal impact on catchment yield and environmental flows in the creek. Water will be transferred from the sediment basin to the Farm Dam, and then released to the environment via a Licensed Discharge Point (LDP) under a controlled release strategy.	**Section 12.5**

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1.0 Introduction

1.1 Project Overview

Coast Wide Materials Pty Ltd intends to seek development consent for a new hard rock quarry within a rural area known as Booral in the Great Lakes Region of New South Wales (NSW). The proposed Hillview Hard Rock Quarry (the Project) proposes to extract up to 1.5 million tonnes per annum (Mtpa) of rhyolite over a planned life of 30 years, operate site infrastructure including a processing plant and transport material off-site via public roads.

The Project is classified as a State Significant Development (SSD) under the provisions of Division 4.12 of Part 8 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) in accordance with the Environmental Planning and Assessment Regulation 2021. It will require development consent from the Minister (or delegate), along with some secondary approvals.

1.2 Project Description

The proponent of the Project is Coast Wide Materials Pty Ltd based on the Central Coast of NSW. The company directors have been involved in the operation of construction material developments/facilities for approximately 40 years.

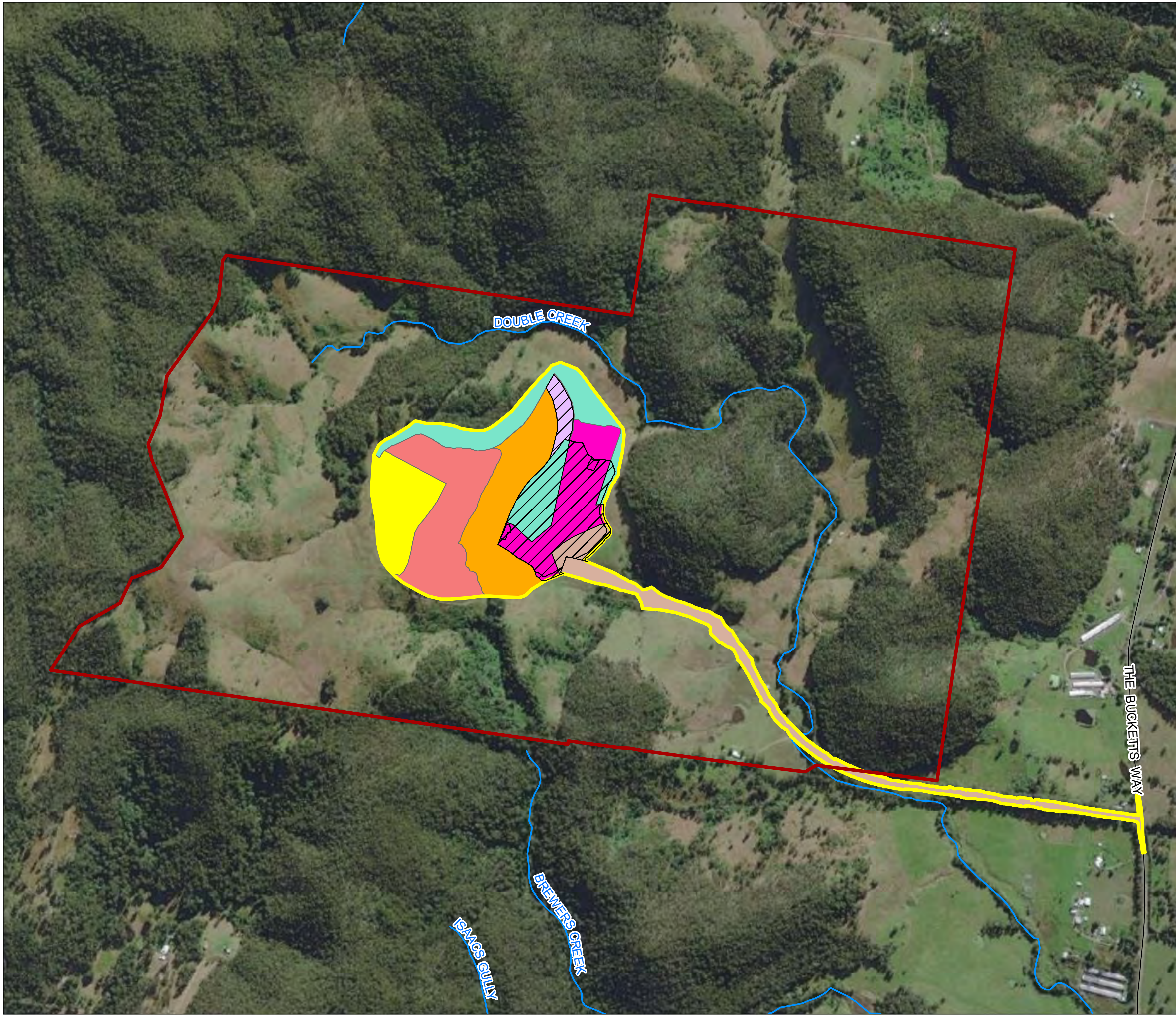
The proponent is seeking to establish the Project on a subject site of approximately 400.3 hectares (ha) comprising seven lots: Lot 60 DP 1094397, Lot 1 DP 159902, Lot 62 DP 95029, Lot 63 DP 95029, Lot 2 DP 1166923, Lot 3 DP 1166923, Lot 4 DP 1166923, and Lot 64 DP 95030. The total proposed quarry footprint is considerably smaller comprising 48 ha. The Project will require clearing of vegetation to gain access to the processing pad and extraction areas, site preparation works and installation of infrastructure and supporting services to facilitate operations at the site. Road upgrades to Maytoms Lane and the Bucketts Way will also be required to cater for vehicle movements.

The Project will be undertaken over seven (7) key stages during which approximately 45 million tonnes of resource material is proposed to be extracted at a rate of up to 1.5 Mtpa over 30 years. The proposed quarry layout indicating the 7 key stages is shown in **Figure 1.** During the initial years of operation, it is not expected that extraction amounts will reach 1.5 million, as there are site establishment works to be completed prior to the main extraction activities commencing. These establishment works will include the new intersection of The Bucketts Way and Maytoms Lane; construction of the main access to the processing pad; creation of the processing pad; and installation of other infrastructure including site offices and facilities, weigh bridges, and processing machinery. Some of these processes will result in the winning of material, however some of this material will also be used in site establishment activities.

A summary of key project details is presented in **Table 1**.

Table 1: Key Project Details

Project Element	Summary of Project	
Address	67 Maytoms Lane, Booral NSW 2425	
Proponent	Coast Wide Materials Pty Ltd	
Local Government Area	MidCoast Council	
Proposed development	Hard Rock Quarry	
Mining method	Traditional drill and blasting over extraction area of 45 ha	
Resource	Quarry extraction of Rhyolitic Tuff from Reduced Level (RL) 205 mAHD (highest point) down to final RL 95 mAHD	
Disturbance areas	**Total disturbance area:**	**48 ha**
	Stage 1 disturbance area:	9.5 ha
	Stage 2 disturbance area:	2.4 ha
	Stage 3 disturbance area:	10.6 ha
	Stage 4 disturbance area:	1.1 ha
	Stage 5 disturbance area:	5.4 ha
	Stage 6 disturbance area:	9.6 ha
	Stage 7 disturbance area:	9.4 ha
Annual production	Up to 1.5 million tonnes	
Mine life	30 years	
Total resource recovered	45 million tonnes	
General infrastructure	Access roads, including intersection works, electricity supply, on-site sewer management system	
Product transport	Transport by truck with average of 358 movements (178 in, 178 out) throughout the 11-hour day	
Operational workforce	15 full-time employees, anticipated to comprise quarry manager supervisors, drivers, weighbridge operator and administration clerk	
Hours of operation	Extraction and processing operations	Monday to Saturday: 6am to 10pm
	Internal product transfers to stockpiles	Monday to Saturday: 6am to 12am (midnight)
	Haulage from and to the development site	Monday to Saturday: 7am to 6pm
	Blasting activities	Monday to Friday: 9am to 4pm
	Maintenance activities	24 hours a day, 7 days a week
Capital Investment Value	$6.5 million	



HILLVIEW QUARRY EIS
SURFACE WATER ASSESSMENT

Proposed Quarry Layout
Indicating 7 Key Stages

FIGURE 1

- Project Site
- Disturbance Footprint
- Watercourses
- Roads
- Stage 1
- Stage 2
- Stage 3
- Stage 4
- Stage 5
- Stage 6
- Stage 7
- Processing Facility

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:16,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

SLR

1.3 Purpose of this Document

SLR Consulting Australia Pty Ltd (SLR) was engaged by Coast Wide Materials Pty Ltd to prepare a Surface Water Assessment (SWA) for the Project. SLR has prepared this SWA as a technical study to append to the Environmental Impact Statement (EIS) required to accompany the Development Application.

The purpose of this document is to identify potential surface water environmental impacts or risks associated with the Project, describe mitigation measures that can satisfactorily mitigate impacts/risks on the receiving environment, and outline environmental management requirements including monitoring of environmental performance.

The SWA:

- examines the existing environment;
- identifies potential soil and surface water environmental impacts or risks associated with the Project;
- describes measures and controls to be incorporated at the Project to mitigate impacts and risks in accordance with best practice, guidelines and legislation. In particular a system of staged sediment basins and water storage dams is detailed; and
- outlines minimum requirements for ongoing environmental management requirements including monitoring of environmental performance.

The assessment considers site hydrology, flooding and flood safety issues, water balance and water security, local site hydrology, as well as water quality issues during both the construction and operational phases of the Project.

1.4 Objectives

The key objectives for surface water management at the Project, as addressed in this assessment, are as follows:

- to prevent the discharge of dirty sediment laden water into watercourses impacting on receiving waters, including minor unnamed streams, Double Creek, Karuah River, and Port Stephens;
- to capture and treat site water so that it complies with water quality standards which reduce the risk of pollutants impacting on receiving waterbodies;
- to manage potential for the project to adversely affect peak flows and flood behaviour along Double Creek;
- to limit the impact of potential for changes to the existing low flow and environmental flow regime in Double Creek; and
- to ensure that there is adequate water on site for operations and environmental management during periods of extended dry weather.

1.5 Assessment Methodology

1.5.1 Site Visit

SLR conducted site visits during February 2020 and April 2020 to obtain information on site soils, catchment wide drainage patterns, and assess the existing condition of Double Creek.

1.5.2 Supplied Data

The proponent has provided the following information relating to the proposal:

- Disturbance area.
- Access road alignment.
- Outlines and staging of extraction and infrastructure areas.
- Details of staging for access, process pad and extraction.
- Water quality data.

1.5.3 Topographical Survey

Topographical survey of the Project site was provided by the proponent. Additional topographic data beyond the extents of the detailed survey was obtained from the Shuttle Radar Topography Mission (SRTM) data, for the purpose of identifying catchment watersheds beyond the extent of detailed survey.

1.5.4 Assessment of Existing Environment

Assessment of the existing environment has included site inspections and a desktop assessment of relevant publicly available information.

1.5.5 Review Site Hydrology

Data review was performed to conceptualise the hydrological setting at the Project. Understanding the site is critical to informing the requirements of the Surface Water Assessment.

1.5.6 Assess Site Water Management

An appropriate scheme to manage site waters is essential to minimising the impact of the proposed Project.

The construction and operation of the proposed quarry including road access, have potential to impact on downstream watercourses and waterbodies. This chapter provides a description of the overall proposed strategy for managing surface water at the Project.

1.5.7 Water Balance Model

A Water Balance Model (WBM) has been used to identify how often the proposed stormwater system discharges to the environment, and how much water needs to be sourced for water supply. The WBM uses historical daily rainfall and evaporation records to predict future performance of the proposed water management system. Sensitivity analyses include allowance for climate change scenarios.

1.5.8 Erosion and Sediment Control

Requirements for Project sediment controls have been based on the guidelines published in the ‘Blue Book’ (Managing Urban Stormwater: Soils and Construction Vol. 1, 4th edition and Vol. 2E Mines and Quarries (Landcom, 2004 and DECC, 2008), and recognising the sensitivity of the receiving watercourses to additional sediment loads.

1.5.9 Hydrology and Flooding

Analysis of hydrology and flood behaviour of the adjacent watercourses and flow of surface water across the Project have been carried out in accordance with Chapter 6, Book 1 of the online version of the Australian Rainfall and Runoff 2019 (ARR 2019) Guidelines (Geoscience Australia, 2019) and using the XP-SWMM 2D software.

1.5.10 Water Supply

The Project will require water during construction and operations for various applications. Water will be required for dust suppression, portable toilet systems and potable use during construction. In operation, demands will extend to include regular maintenance and cleaning of site plant and infrastructure and water required for site offices. This assessment includes estimates for water supply during the different phases and describes suitable methods for water supply.

1.5.11 Water Quality Assessment

Water quality objectives have been based on analysis of water quality data from samples collected on Double Creek at locations upstream and downstream of the site, as well as Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000, and Australian and New Zealand Governments (ANZG) 2018 water quality guidelines.

1.5.12 Environmental Impacts and Proposed Mitigation Measures

Potential impacts on the environment due to the Project during the construction and operational phases, and the development of appropriate mitigation measures have been assessed based on specifics of the Project proposal, available site knowledge and consideration of typical potential impacts from comparable projects.

2.0 Requirements

2.1 Secretary's Environmental Assessment Requirements

The proposal is classified as an SSD and the NSW Department of Planning and Environment (DPE) issued Secretary's Environmental Assessment Requirements (SEARs) for the Project on June 3 2024 (DPE, 2024a). The SEARs are pursuant to Application Number SSD-70557215.

SEARs relevant to surface water and where they are addressed in this study are listed in **Table 2**.

Table 2: SEARs Requirements and Where Addressed

Application Number	SSD-70557215
Relevant SEARs Requirement	**Report Section Where Addressed**
A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures	**Section 6.0 – Site Water Management** **Section 7.0 – Water Balance Modelling** **Section 10.0 – Water Supply**
Identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000	**Section 2.3 – Relevant Legislation, Regulations and Guidelines** **Section 5.6 – Water Sharing Plan**
Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP)	**Section 5.4 – Harvestable Rights** **Section 5.6 – Water Sharing Plan** **Section 10.0 – Water Supply**
A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP	**Section 8.0 – Erosion and Sediment Control** **Section 11.0 – Monitoring Licensing and Reporting** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
An assessment of any likely flooding impacts of the development	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
An assessment of the likely impacts on the quality and quantity of existing surface and ground water resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives	**Section 7.0 – Water Balance Modelling** **Section 11.0 – Monitoring, Licensing and Reporting**
An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users	**Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.	**Section 6.0 – Site Water Management** **Section 11.0 – Monitoring, Licensing and Reporting** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**

This report does not address issues related to groundwater where these aspects are listed in **Table 2.** The Groundwater Assessment for the Project is detailed in 'Hillview Quarry – Groundwater Assessment-R01-v0.92' (SLR, 2024a).

2.2 Other Authorities

Other authorities who have provided water planning requirements to be considered in the EIS include:

- NSW Department of Climate Change, Energy, the Environment and Water,
- NSW Environment Protection Authority (EPA),
- NSW Department of Planning, Housing and Environment; and
- MidCoast Council.

Requirements relevant to water planning and where they are addressed are shown in **Table 3.**

Table 3: Requirements of Other Authorities and Where Addressed

Relevant Requirement	Report Section Where Addressed
NSW Department of Climate Change, Energy, the Environment and Water	
5. The EIS must map the following features relevant to water and soils including: a. Acid sulfate soils (Class 1,2,3 or 4 on the Acid Sulfate Soil Planning Map). b. Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method). c. Wetlands as described in s4.2 of the Biodiversity Assessment Method. d. Groundwater. e. Groundwater dependent ecosystems. f. Proposed intake and discharge locations.	**Section 4.0 – Site Description** **Section 5.0 – Hydrological Setting** **Section 6.0 – Site Water Management**
6. The EIS must describe background conditions for any water resource likely to be affected by the development; a. Existing surface and groundwater. b. Hydrology, including volume, frequency and quality of discharges, including at proposed intake and discharge locations. c. Water Quality Objectives (as endorsed by the NSW Government) including groundwater as appropriate that reoresent the community's uses and values for the receiving waters. d. Indicators and trigger values/criteria for the environmental values identified at c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	**Section 4.0 – Site Description** **Section 5.0 – Hydrological Setting** **Section 11.0 – Monitoring, Licensing and Reporting**
7. The EIS must assess the impacts of the development on water quality, including: a. The nature and degree of impact of receiving waters for both surface and groundwater, demonstrating how the development protects the WQO where they are currently being achieved, and contributes towards achievement of the WQO over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction. b. Identification of proposed monitoring of water quality.	**Section 11.0 – Monitoring, Licensing and Reporting** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**

Relevant Requirement	Report Section Where Addressed
8. The EIS must assess the impact of the development on hydrology, including: a. Water balance including quantity, quality and source. b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodpalain areas. c. Effects to downstream water dependent fauna and flora including GDE's. d. Impacts to natural processes and functions within rivers wetlands, estuaries, and floodpalins that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (eg river benches). e. Changes to environmental water availability, both regulated/licensed and unregulated/rules based sources of such water. f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options. g. Identification of proposed monitoring of hydrological attributes.	**Section 6.0 – Site Water Management** **Section 7.0 – Water Balance Modelling** **Section 10.0 – Water Supply** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
9. The EIS must map the following featues relevant to flooding as described in the Flood Risk Management Manual (NSW Government 2023) including: a. Flood prone land. b. Flood planning area, the area below the flood planning level. c. Hydraulic categorisation (floodways and storage areas).	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
10. The EIS must describe flood assessment and modelling undertaken in determing the design flood levels for events, including a minimum of 1 in 10 year, 1 in 100 year, flood levels and PMF, or an equivalent extreme event.	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
11. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: a. Current flood behavious as identified in 11 above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intesnity of flood producing rainfall events due to climate change.	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
12. Modelling in the EIS must consider and document: a. The impact on existing flood behaviour for a full range of flood events including up to the PMF. b. Impacts of developmenet on flood behaviour resulting in detrimental changes in potential flood affectation of other development or land. This may redirection of flow, flow velocities, flood levels and hydraulic categories. c. Relevant provisions of the Flood Risk Management Manual 2023.	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**

Relevant Requirement	Report Section Where Addressed
13. The EIS must assess the impacts on the proposed development of flood behaviour, including: a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. b. Consistency with Council floodplain risk management plans. c. Compatibility with flood hazard of the land. d. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. e. Whether there will be adverse effect to beneficial inundation of the floodplain environment on adjacent to or downstream of the site. f. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. g. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters to be discussed with SES and Council. h. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council. i. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based on PMF or equivalent extreme flood event). These matters to be discussed with and have the support of Council and the SES. j. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
14. The [EIS] must describe the potential effects of coastal processes and hazards (within the meaning of the Coastal Management Act 2016), including sea level rise and climate change: a. On the proposed development b. Arising from the proposed development.	**Section 9.0 – Flood Assessment**
15. The [EIS] must consider have regard to any certified Coastal Management Program (or Coastal Zone Management Plan) and be consistent with the management objectives described in the Coastal Management Act 2016 and development controls for coastal management areas mapped under the State Environmental Planning Policy (Resilience and Hazards) 2021.	**Section 9.0 – Flood Assessment**
NSW Environment Protection Authority	
3. Water	
A detailed Water Quality Impact Assessment (WQIA) for construction and operation of the project must be prepared. The WQIA must:	
a. Demonstrate that all practical options to avoid discharge have been investigated and implemented.	**Section 6.0 – Site Water Management**
b. Demonstrate that measures have been taken to reduce the level of contaminants in the	**Section 6.0 – Site Water Management** **Section 7.0 – Water Balance Modelling**

Relevant Requirement		Report Section Where Addressed
	discharge, so that any impact is reduced where a discharge is necessary.	
c.	Identify the condition of the local catchment and those immediate areas on and around the proposed development e.g. soils, erosion potential, vegetation cover, etc.	**Section 4.0 – Site Description** **Section 5.0 – Hydrological Setting**
d.	Identify nearby water resources, the background water conditions (including river flow data, water flow/direction and quality data, the depth to groundwater, groundwater flow/gradient and quality data, reliance on water resources by surrounding users and by the environment) and relevant water quality objectives in line with relevant guidance/standards.	**Section 4.0 – Site Description** **Section 5.0 – Hydrological Setting**
e.	Identify existing impacts to water resources (including other industrial discharges).	**Section 4.0 – Site Description** **Section 5.0 – Hydrological Setting**
f. g.	Identify any water intakes, intake frequency and volumes related to the proposed development; and Identify any expected discharges (including stormwater), discharge quality, discharge frequency and volumes related to the proposed development.	**Section 4.0 – Site Description** **Section 5.0 – Hydrological Setting** **Section 6.0 – Site Water Management** **Section 7.0 – Water Balance Modelling**
h.	Describe the nature and degree of impact that any discharge/s will have on the receiving environment. This includes consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment. (This should also include intercepted saline groundwater or acidic runoff generated by acid sulphate soil where appropriate.)	**Section 5.0 – Hydrological Setting** **Section 11.0 – Monitoring, Licensing and Reporting** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
i.	Identify potential impacts to surface and groundwater during both construction and operational stages and identify best practice mitigation measures (pollution control) and strategies to protect surface and\groundwater resources, particularly erosion and sediment controls during the construction stage and the rehabilitation stage and the inclusion of permanent erosion and sediment controls where required and applicable.	**Section 8.0 – Erosion and Sediment Control** **Section 11.0 – Monitoring Licensing and Reporting** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
j.	Include a detailed water balance and discharge inventory.	**Section 7.0 – Water Balance Modelling**
k. l.	Include an assessment of any mixing zones; and Include any proposed discharge limits.	**Section 11.0 – Monitoring Licensing and Reporting**
4. Land		
Identify if the soils and groundwater in the area of the project are contaminated or are acid forming (i.e. acid sulphate soils) and if so, identify best practice mitigation measures (pollution control) and strategies or remedial and/or disposal actions that will be required/undertaken if applicable in accordance with relevant guidance/standards. Investigations should be undertaken in accordance with (but not limited to) guidelines identified in Attachment B.		**Section 4.0 – Site Description** **Section 8.0 – Erosion and Sediment Control**

Relevant Requirement	Report Section Where Addressed
Identify potential impacts to soils and groundwater /land resources as a result of the proposed development and identify best practice mitigation measures (pollution control) and strategies that will be required/undertaken if applicable in accordance with relevant guidance/standards.	**Section 8.0 – Erosion and Sediment Control** **Section 11.0 – Monitoring Licensing and Reporting** **Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
5. Waste	
Identify all waste types that will be generated as a result of the proposed development during both construction and operation, their classification and the ways in which they will be legally handled, stored, transported, reused, recycled or disposed of, including sampling/monitoring, record keeping, waste tracking, contingency measures and any other verification practices, in accordance with relevant guidance/standards.	**Section 8.0 – Erosion and Sediment Control** **Section 11.0 – Monitoring Licensing and Reporting**
Identify options and strategies for waste minimisation, reuse, and recycling across all activities and processes during both construction and operational stages.	**Section 11.0 – Monitoring Licensing and Reporting**
6. Storage and Use of Fuels / Chemicals etc	
• Identify all fuels/chemicals/products/dangerous goods to be stored/used onsite; and • Identify adequate handling, storage, control, and usage requirements for any dangerous fuels/chemicals/products to be stored/used onsite.	**Section 8.0 – Erosion and Sediment Control** **Section 11.0 – Monitoring Licensing and Reporting**
8. Cumulative Impacts	
Identify the extent that the receiving environment is already stressed by existing development and background levels of emissions to which this proposal will contribute; and identify the cumulative impacts of the proposed development in a local context.	**Section 4.0 – Site Description**
9. Monitoring Programs	
Include a detailed proposal of any noise, air, water, land, waste, meteorological etc monitoring during construction and operation to ensure and assumptions, predictions, goals, criteria etc are achieved. The proposal should include a detailed description of the monitoring locations, sample analysis methods and the level of reporting proposed.	**Section 8.0 – Erosion and Sediment Control** **Section 11.0 – Monitoring Licensing and Reporting**
NSW Department of Planning, Housing and Environment	
1. A detailed and consolidated site water balance.	**Section 7.0 – Water Balance Modelling**
2. Description of all works/activities that may intercept, extract, use, divert or receive surface water and/or groundwater. This includes the description of any development, activities or structures that will intercept, interfere with, or remove groundwater, both temporary and permanent.	**Section 5.0 – Hydrological Setting** **Section 10.0 – Water Supply**
3. Details of all water take for the life of the project and post closure where applicable. This is to include water taken directly and indirectly (including through inflow and seepage), and the relevant water source where water entitlements are required to account for the water take. If the water is to be taken from an alternative source confirmation should be provided by the supplier that the appropriate volumes can be obtained.	**Section 5.0 – Hydrological Setting** **Section 6.0 – Site Water Management** **Section 7.0 – Water Balance Modelling** **Section 10.0 – Water Supply**

Relevant Requirement	Report Section Where Addressed
4. Details of Water Access Licences (WALs) held to account for any take of water where required, or demonstration that WALs can be obtained prior to take of water occurring. This should include an assessment of the current market depth where water entitlement is required to be purchased. Any exemptions or exclusions to requiring approvals or licences under the Water Management Act 2000 should be detailed by the proponent.	**Section 7.0 – Water Balance Modelling** **Section 11.0 – Monitoring Licensing and Reporting**
5. A description of groundwater conditions that provides an understanding of groundwater level across the site under a range of wet and dry conditions.	**Hillview Quarry – Groundwater Assessment-R01-v0.92' (SLR, 2024a).**
6. The development of a thorough groundwater conceptual model with supporting cross section and extraction mining depth supported by field data.	**Hillview Quarry – Groundwater Assessment-R01-v0.92' (SLR, 2024a).**
7. Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, groundwater dependent ecosystems, and ground water levels; including measures proposed to reduce and mitigate these impacts.	**Section 5.0 – Hydrological Setting** **Section 7.0 – Water Balance Modelling** **Section 11.0 – Monitoring Licensing and Reporting**
8. Proposed surface and groundwater monitoring activities and methodologies and details of a proposed water management plan.	**Section 6.0 – Site Water Management** **Section 11.0 – Monitoring Licensing and Reporting**
9. Identification and impact assessment of all works/activities located on waterfront land including an assessment against Guidelines for Controlled Activities on Waterfront Land (NRAR 2018).	**Section 4.0 – Site Description** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
10. Assessment of project against relevant policies and guidelines.	**Section 2.0 - Requirements**
Mid Coast Council	
Identify any adverse effects that may occur to downstream properties. Included are the reduction of base flows that will result from the development.	**Section 12.0 – Environmental Impacts and Proposed Mitigation Measures**
Identify what critical infrastructure will need to be protected from the PMF.	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**
Design of suitable sized tailings dams and the ongoing maintenance (ie flocculation of the residual runoff) as part of the measures to ensure the environmental flows of stormwater are maintained: • Including the construction of Maytom Lane and the remainder of the access road during construction stage and when the quarry is operational: and • The dam will require a weir overflow designed at the 5% AEP with dam walls constructed t above the 1% AEP flood. The dam must be designed to withstand the PMF flood.	**Section 6.0 – Site Water Management** **Section 8.0 – Erosion and Sediment Control**
The haulage road crossing of creek/watercourses: • Road surface flood free for minimum 1 in 10 AEP; and • The design is to ensure safe passage for vehicles up to a 1% AEP flood especially crossing over Double Creek. The structures and embankments	**Section 9.0 – Flood Assessment** **Appendix A – Hillview Hard Rock Quarry – Flood Assessment Report**

Relevant Requirement	Report Section Where Addressed
(including erosion control of the embankments) to withstand a PMF.	
Dam Design: • Spillway crest with a minimum 5% AIE walls designed to the 1% AEP. • Critical dam wall and embankments (including erosion of embankments) designed/constructed to withstand a PMF; and • An Evacuation Plan will be required.	**Section 6.0 – Site Water Management**

This report does not address issues related to soil, land resources, or groundwater where this aspect is listed in Table 3. The Land Resource Assessment for the Project is described in 'Hillview Quarry Land Resources Assessment-R01-v3.0' (SLR, 2024a).

2.3 Relevant Legislation, Regulations and Guidelines

The following NSW legislation have been considered, as last accessed on 28 July 2023:

- Protection of Environment Operations Act 1997.
- Environmental Planning and Assessment Act 1979.
- Fisheries Management Act 1994.
- Water Management Act 2000.
- The Water Management (General) Regulation 2018.
- Dam Safety Act 2015 / Regulation 2019.

The management of surface water on site should be consistent with the following guidelines:

- ANZECC & ARMCANZ 2000 Guidelines for Fresh and Marine Water Quality (referred to as ANZECC 2000)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).
- Australian Rainfall and Runoff 2019 (ARR 2019) Guidelines.
- Climate Change Impacts and Risk Management: A Guide for Business and Government.
- Australian Green Infrastructure Council (AGIC) Guideline for Climate Change Adaptation.
- Flood Risk Management Manual: The policy and manual for the management of flood liable land (FRMM 2023).
- Guidelines for Controlled Activities on Waterfront Land (2018)
- Managing Urban Stormwater – Soils and Construction (4th Edition), (DECC 2008).
- Managing Urban Stormwater – Soils and Construction, Volume 2D, Unsealed Roads, (DECC 2008).
- Managing Urban Stormwater – Soils and Construction, Volume 2E, Mines and Quarries, (DECC 2008).
- NSW Water Quality Objectives.

2.3.1 Protection of Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the EPA. An Environment Protection Licence (EPL) will be required for the Project due to the proposed site activities and scale of proposed extraction.

The EPA's risk-based licensing approach includes assessment of site-specific risks posed by each licensed activity, in terms of the risks relating to the day-to-day operations as well as the pollution incident risk at the premises. Assessment includes environmental management systems and practices the licensee has in place to control and mitigate environmental risks associated with their licensed activities.

The POEO Act imposes a very strong duty of care on operators not to pollute via the following:

- **Section 120** – it is illegal to pollute or cause or permit pollution of waters. Water pollution includes introducing anything, including litter, sediment, fuel, oil, grease, wash water, debris, detergent, paint, etc. into waters or placing such material where it is likely to be washed or blown into waters or the stormwater system or percolate into groundwater;
- **Section 116** – makes it an offence to allow any substance to leak, spill or otherwise escape (whether or not from a container) in a manner that harms or is likely to harm the environment; and,
- **Section 167** – requires the occupier of any premises to maintain and operate any pollution control equipment installed at the premises in a proper and efficient condition or manner.

2.3.2 Water Management Act 2000

The Water Management Act 2000 (WM Act) enables allocation of water for the environmental health of NSW's rivers and groundwater systems, while also providing licence holders with secure access to water and the opportunity to trade water. The WM Act requires an assessment of impact on waterfront land resulting from a controlled activity within 40 metres of a river, lake, or estuary (as defined on the map provided in *Water Management (General) Regulations 2018*). Since the Project involves work on waterfront land, approval will be required from WaterNSW.

The WM Act also defines basic landholder rights which include stock rights and harvestable rights. Water may be extracted under these rights without the need for a Water Access Licence (WAL), although where groundwater is accessed, the bore must still be approved by DPI – Water.

2.3.3 Fisheries Management Act 1994

The Project will include a crossing of Double Creek which has potential to impact riparian vegetation and fish passage. The Project will incorporate design features to mitigate impact in accordance with the *Fisheries Management Act 1994* (FM Act) and NSW Fisheries guidelines.

3.0 Climate

3.1 Rainfall

Rainfall varies considerably across the Hunter region due to complex interactions between local weather patterns, the influence of larger scale climate patterns such as El Nino Southern Oscillation (ENSO), topographical effects such as the Barrington Tops, and the influence of sea surface temperature towards the coast.

Rainfall data for the Project site is based on Bureau of Meteorology (BoM) data from the Stroud Post Office (Station ID: 061071), which is approximately 10.5 km to the north-north-west of the site (BoM, 2023a).

This station has 133 years of daily rainfall data from 1889 to date and provides an excellent record of historical rainfall. **Table 4** provides a summary for the station.

Table 4: BoM Rainfall Station Summary – Stroud Post Office (Station ID: 061071)

Station	Station Number	Distance from site (km)	Data availability
Stroud Post Office	061071	10.5	1889 - Present

Average annual rainfall at Stroud Post Office is 1143.8 mm. Seasonal rainfall variance is apparent, with highest rainfall occurring across October-March as typical for Eastern Australian climates. Average monthly and annual average rainfall depths are shown in **Table 5**.

Table 5: Average Monthly Rainfall – Stroud Post Office (Station ID: 061071)

Month	Average Rainfall (mm)
January	115.1
February	124.9
March	149.7
April	100.1
May	88.7
June	100
July	75
August	63.6
September	63.4
October	78.1
November	85.3
December	101.6
Average Annual Rainfall (mm)	1143.8

The station indicates there can be considerable fluctuation in the depth of rainfall from year to year near the site. The lowest recorded annual rainfall was 541 mm in 1980, and the highest annual rainfall was 1,900.2 mm measured in 1980. In particular, there are stark differences in summer rainfall between dry and wet years.

For example, the 10th percentile rainfall in March is 38.4 mm, while the 90th percentile rainfall is 341.6 mm.

Rainfall statistics for the Stroud Post Office are summarised in **Table 6** The statistics include the mean monthly and annual rainfalls, as well as information for minimum, median, and maximum recorded rainfall months/years, and the 5th, 10th, 90th and 95th percentile months/years. Data accessed from the BoM website, 2 May 2023.

Table 6: Detailed Monthly and Annual Rainfall Depths (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	115.1	124.9	149.7	100.1	88.7	100	75	63.6	63.4	78.1	85.3	101.6	1,143.8
Lowest	1.8	0	4.4	5.2	1.3	0	1	0	0	1.1	4.6	6	541
5th %ile	18.8	14.5	25.3	15.1	13.9	10.8	5.8	6	4.9	9.5	10.2	22.6	685.8
10th %ile	27.4	22.3	38.4	23.3	20.4	18.6	13.6	9.9	9.7	17.7	18.1	27	753.4
Median	98.4	100.1	115.7	82.1	65	81.1	59.8	42.6	47.9	57.7	78.8	90.1	1,115.2
90th %ile	187.4	241.9	341.6	201.2	170.2	216.5	157.9	138.6	141.9	153.9	163.2	206.5	1,529.4
95th %ile	248.1	323.1	423.2	256.2	249.1	268.2	217.9	169	160.1	230.5	183.7	223.4	1,637
Highest	538.3	511.7	527	537.8	375	521	293.9	494.3	245	355.9	296.2	301.9	1,900.2

Intensity-Frequency-Duration (IFD) information for the site was sourced from the BoM website (2016 IFD data), accessed 2 May 2023 (BoM, 2023b). Rainfall depths for various Annual Exceedance Probability (AEP) and storm durations are shown in **Table 7**.

Table 7: BoM 2016 Rainfall Depth – Frequent to Rare Storms: Stroud Post Office (Station ID: 061071)

Duration	Annual Exceedance Probability / (Average Recurrence Interval)						
	63.2% / (1 in 1)	50% / (1 in 1.44)	20% / (1 in 4.48)	10% / (1 in 9.49)	5% / (1 in 20)	2% / (1 in 50)	1% / (1 in 100)
30 min	20	23	32.8	40	47.6	58.4	67.2
45 min	23.3	26.8	38.3	46.8	55.6	68.2	78.4
1-hour	25.8	29.6	42.4	51.8	61.6	75.4	86.7
1.5-hour	29.6	34	48.6	59.4	70.6	86.3	99.3
2-hours	32.6	37.4	53.5	65.3	77.6	94.9	109
3-hour	37.6	43.1	61.4	74.9	88.9	109	125
4.5-hour	43.8	50	71	86.4	102	125	144
6-hour	49.1	56	79.1	96.2	114	139	160
9-hour	58.1	66.1	92.9	113	133	163	188
12-hour	65.7	74.7	105	127	150	183	211
18-hour	78.4	89	124	150	177	217	250
24-hour	88.7	101	140	169	199	245	282
30-hour	97.3	110	154	185	218	268	309
36-hour	105	119	165	199	234	288	332

Duration	Annual Exceedance Probability / (Average Recurrence Interval)						
	63.2% / (1 in 1)	50% / (1 in 1.44)	20% / (1 in 4.48)	10% / (1 in 9.49)	5% / (1 in 20)	2% / (1 in 50)	1% / (1 in 100)
48-hour	116	132	184	222	261	320	369
72-hour	132	150	210	253	297	364	419
96-hour	141	161	226	273	320	391	449
120-hour	147	168	236	285	335	408	467
144-hour	150	172	241	292	344	418	477
168-hour	152	174	244	296	349	423	481

3.2 Evaporation

The closest BoM meteorological station recording daily evaporation is Paterson (Tocal AWS) (Station ID: 061250), which is approximately 39 km south-west of the site (BoM, 2023a). This station has 45 years of daily Class ‘A’ pan evaporation data from 1967 to date which is a sizable record of evaporation. The station is situated a similar distance inland as the Project site (30 to 40 km) and likely has comparable evaporation rates. **Table 8** provides a summary for the station.

Evaporation in site water bodies has been assumed to be 75% of the Class ‘A’ Pan evaporation depths due to corrections for temperature for deeper waterbodies (Pekel et al., 2016). The Average monthly Class ‘A’ pan evaporation at Paterson (Tocal AWS), estimated water body evaporation and monthly rainfall depths are compared in **Table 9**.

Table 8: BoM Evaporation Station Summary – Paterson (Tocal AWS) (Station ID: 061250)

Station	Station Number	Distance from site (km)	Data availability
Paterson (Tocal AWS)	061250	39	1967 - Present

Table 9: Mean Monthly “A” Pan and Water Body Evaporation at Paterson (Tocal AWS) (Station ID: 061250)

Month	Mean monthly evaporation - Class 'A' pan (mm)	Mean monthly evaporation - water body (mm)
January	189.1	141.8
February	149.7	112.3
March	130.2	97.7
April	96.0	72.0
May	74.4	55.8
June	63.0	47.3
July	74.4	55.8
August	102.3	76.7
September	132.0	99.0
October	161.2	120.9
November	174.0	130.5

Month	Mean monthly evaporation - Class 'A' pan (mm)	Mean monthly evaporation - water body (mm)
December	204.6	153.5
Average Annual Class 'A' pan evaporation	1550.9	1163.2

A comparison of mean monthly rainfall and water body evaporation has been made to characterise the likely relationship between incident rainfall and evaporation at the Project site. **Figure 2** depicts monthly averages of rainfall and evaporation alongside 5th and 95th percentile monthly rainfall. The plot indicates that rainfall exceeds evaporation from February through to July, while evaporation rates would likely surpass rainfall depths across the warmer months from August to January.

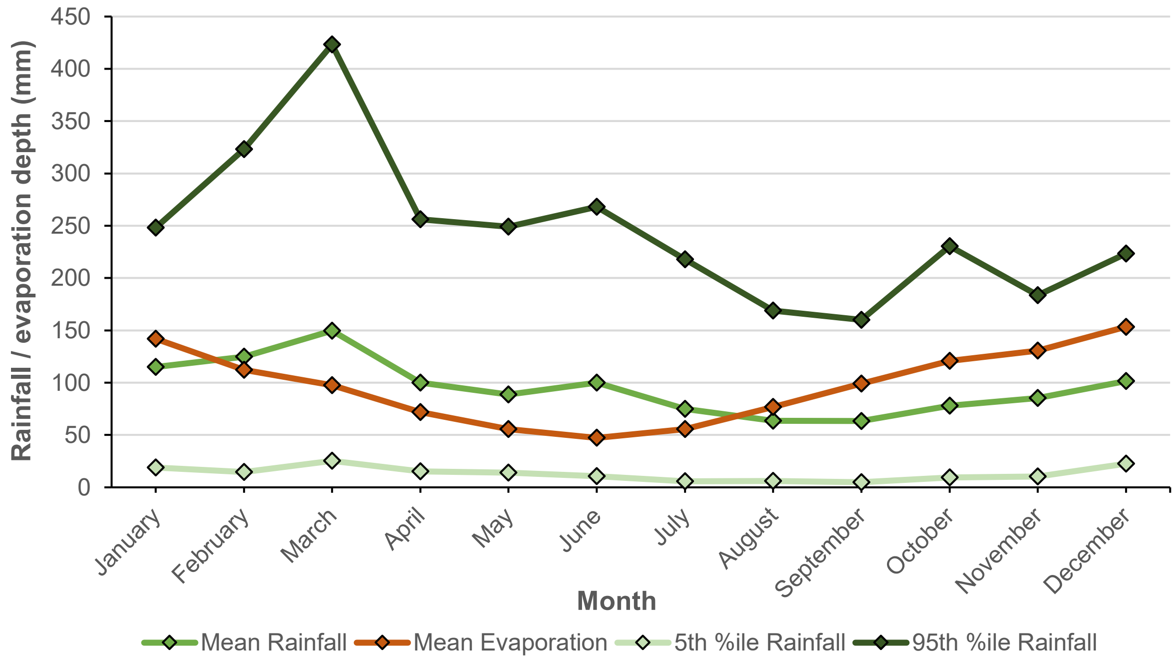


Figure 2: Comparison of Mean Monthly Rainfall and Evaporation (In Water Bodies) Depth

3.3 Climate Change and Effects on Rainfall

There is now widespread recognition that human activities are contributing to observed climate change. Climate change (warming) has the potential to increase the prevalence and severity of rainfall extremes and needs to be considered in flood planning for long term projects.

Current and projected climate change effects in Australia have been documented jointly by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the BoM in a series of Climate Change in Australia 'Cluster Reports'. The Cluster Reports, for eight regions of Australia, are to assist regional decision makers in understanding the important messages deduced from climate change projection modelling. The Cluster Reports present a range of emissions scenarios across multiple variables and years. They also include relevant sub-cluster level information in cases where distinct messages are evident in projections.

Based on the location of the Project, the appropriate climate change projections for planning consideration are documented in the East Coast Cluster Report (Dowdy et al., 2015). Last updated in 2021, the East Coast Cluster Report states:

- there is very high confidence in continued substantial increases in projected mean, maximum and minimum temperatures. For the near future (2030), the mean warming across all emission scenarios is projected to be around 0.4 to 1.3°C above the climate of 1986–2005. By 2050, for an intermediate scenario (Representative Concentration Pathway (RCP) RCP4.5) the projected warming is 1.1 to 2.2 °C;
- for mean annual rainfall depths most RCP4.5 models indicate little change in rainfall by 2050, but with a consensus of +5% to -15% by 2090;
- decreases in winter rainfall are projected with medium confidence. Other changes are possible but unclear;
- time spent in drought is projected, with medium confidence, to increase over the course of the century; and
- there is high confidence that there will be future increase in the intensity of extreme rainfall events.

For example, a 20-year return one day rainfall increasing by 12%.

In 2014, the OEH published the ‘North Coast – Climate Change Snapshot’ (OEH, 2014), which is based on the NSW and Australian Regional Climate Modelling (NARCliM) Project 1.0 (NSW Government, 2014), with an Intergovernmental Panel on Climate Change (IPCC) A2 emission scenario which indicated:

- a long-term increase in mean annual temperature of 1.5 to 2.4 degrees by 2060-2079;
- a near future (2020-2039) increase in annual rainfall of 0-5% annually, but with a decrease in summer rainfall of 0 to 5%; and
- a far future (2060-2079) increase in annual rainfall of 5-10% annually, but with a reduction in winter rainfall of -10 to -5%.

Methods adopted in this study to account for the effects of climate change on rainfall and flood estimation recognise the uncertainty associated with future climate change, and take into account climate change effects as described below:

Flooding – The 0.5% (1 in 200) AEP has been modelled in lieu of the 1% AEP event. This method is consistent with ARR 2019 Guidelines and the East Coast Cluster Report estimated temperature increase under RCP4.5 scenarios by 2090. For a 24-hour rainfall event this would represent an increase in rainfall of 14%.

Extended Dry and Extended Wet Weather – It is usual to test the performance of water storage systems by applying daily records of historical rainfall over long periods (many decades) that capture the natural variability of climate including wet years and periods of extended drought. To allow for changes in water balance modelling inputs, including the impacts of climate change, a sensitivity analysis is included which allows for:

- an increase in modelled daily rainfall depths of 10%; with no increase in evaporation; and
- a decrease in in modelled daily rainfall depths of 20%, with a 10% increase in evaporation.

4.0 Site Description

4.1 Existing Site and Surrounding Land Use

The Project Site is located approximately 8 km south of Stroud and 5 km northwest of Allworth on the western side of Bucketts Way in the Great Lakes district of NSW (**Figure 1** and **Figure 3**) and the Mid Coast Local Government Area (LGA). The site is accessed from 67 Maytoms Lane, Booral NSW. **Table 10** lists the various land titles within the Project Site, which cumulatively comprise approximately 400.3 ha.

Table 10: Schedule of Land Titles

Lot	Deposited Plan (DP)	Tenure
Lot 1	DP 159902	Freehold
Lots 2, 3 and 4	DP 1166923	
Lot 60	DP 1094397	
Lot 62 and 63	DP 95029	
Lot 64	DP 95030	

Maytoms Lane, which is an unsealed rural access road, connects the Project Site to Bucketts Way. Bucketts Way, which is a sealed two-lane regional road, connects to the A1 Pacific Highway approximately 20 km south of the Project site and Gloucester about 50 km to the north.

The visual amenity of the general area is that of a river valley surrounded by undulating topography, with areas of bushland (remnant and regrowth native vegetation) interspersed with land that has been cleared or partially cleared and used for stock grazing, small-scale poultry operations and small rural/lifestyle holdings (**Photo 1**). While the Project site has been partially modified and disturbed as a result of past clearing and agricultural activities, there remain some areas of undisturbed land and native vegetation.

The catchment of Double Creek upstream of the Project site is mostly cleared grazing land that incorporates some areas of native bushland, and a large area of undisturbed bushland to the north of Double Creek. The site has numerous existing farm dams which are used for stock watering.

4.2 Cumulative Impacts

Cumulative impacts consider the combination of effects from the subject proposal and other proposals.

The only relevant development is a Quarry located 6 km south in the Limeburners Creek catchment, which is a similar development producing 500,000 tpa of hard rock and was approved in January of 2024. The Deep Creek development has stated within the EIS that the proposed quarry will have limited-to-negligible impacts upon flows, water quality, and downstream users.

The potential impacts of the Hillview Quarry on the receiving environment are outlined in **Sections 4.2.1, 4.2.2, and 4.2.3**, and considered to be negligible.

Since the environmental assessments for both Deep Creek and Hillview Quarries identify negligible impacts to the receiving water environment, and the proposals constitute a small portion of the overall Karuah River catchment, SLR consider that the potential for cumulative impact is negligible.

4.2.1 Flows

During operation, the proposed quarry footprint will result in changes to the catchment area of Double Creek. These changes are attributed to the management of runoff from the disturbed quarry area, as outlined in **Section 6.0**.

The results of the flow analysis outlined **Section 5.5** indicate a slight decrease in the volume of flows in Double Creek for the operational period of the proposed quarry, with up to an 8% predicted decrease in baseflows. Due to the catchment area of the quarry draining to Double Creek constituting approximately 12% of the total creek catchment, this decrease will not have a significant impact on environmental flows.

The flood assessment outlined in **Section 9.0** and **Appendix A** indicate negligible changes to velocities in Double Creek upstream and downstream of all proposed development associated with the Quarry. The Hillview Quarry is considered likely to have negligible impact on watercourse flows and potential for scour.

4.2.2 Water Quality

Management of the potential water quality impacts throughout the life of the Hillview Quarry would be undertaken as outlined in **Section 11.0**. Management would work in conjunction with erosion and sediment control measures outlined in **Section 8.0** that will be utilised during construction, operation, and closure phases of the operations to manage water quality.

Water quality in downstream waterways is not anticipated to be adversely impacted as a result of the proposed quarry with the onsite water management over the life of the development, as outlined in **Section 6.0**.

As a result, the cumulative potential impacts on water quality in downstream watercourses is considered to be low.

4.2.3 Downstream Users

Due to the large scale of the downstream catchment of the Karuah River, Water quantity is not anticipated to be adversely affected by the proposed quarry in a local context.

4.3 Topography

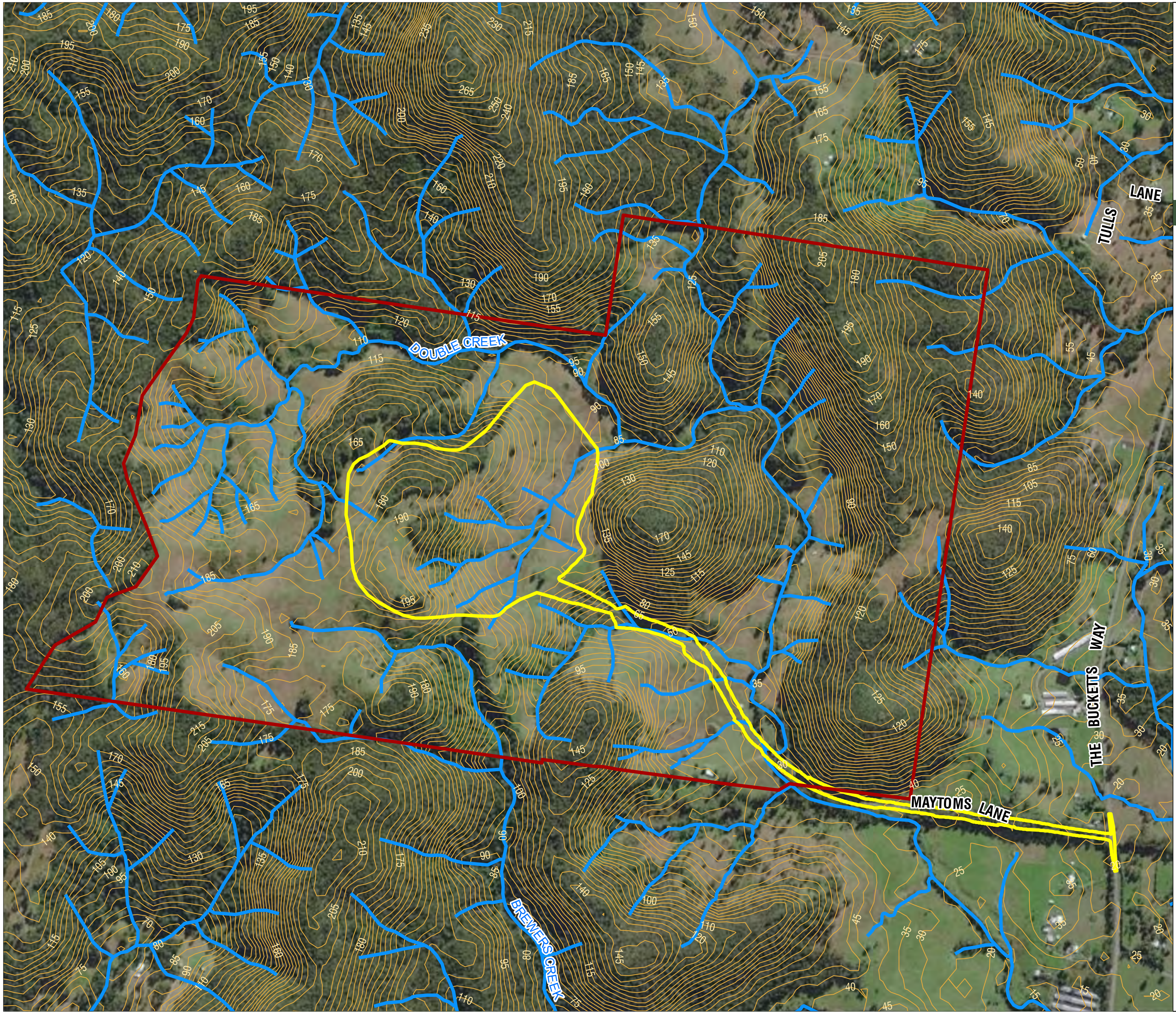
Local topography at the Project is irregular and undulating. The site is traversed by ridgeline systems which trend to the north-west from higher elevations along the southern boundary with elevations up to 220 mAHD. The ridgeline systems include a number of hills and saddles which are steep sided and characterised by slopes of 15% to 35%.

The majority of the proposed extraction area falls within a single valley which drains northwards towards Double Creek (**Photo 2)**. The extraction area has a total area of approximately 45 ha and falls from an elevation of 206 mAHD down to 95 mAHD. Rainfall runoff from this central valley reports to a series of existing farm dams. The largest existing farm dam is located approximately 200 m upstream of Double Creek.

The existing site topography and drainage pattern are shown in **Figure 3**.

Photo 1: View North Across the East of the Project Site

Photo 2: Central Valley with Double Creek in Background and Existing Farms Dams



HILLVIEW QUARRY EIS
SURFACE WATER ASSESSMENT

Topography and Drainage

FIGURE 3

- Project Site
- Disturbance Footprint
- Watercourses
- Contour (5m Interval)

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:16,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

SLR

H:\Projects-SLR\630-SrvNTL\630-NTL\630.12117 Hillview Quarry EIS\06 SLR Data\GIS\SURFACE WATER FIGURES\REVISED NOVEMBER 2023\SLR63012117_SW_F3_TOPO_DRAINAGE_01.mxd

4.4 Surface Hydrology

4.4.1 Description

The Project site is located within the Karuah catchment. Bordered by the Manning River catchment in the north, and the Hunter River catchment in the south and west, the Karuah catchment occupies an area of 4,480 km^2 (DPE – Water, 2021). Three major river systems drain the Karuah River basin. The Karuah and Myall rivers drain south to Port Stephens, while in the north, the Wallamba, Wallingat, Wang Wauk, and Coolongolook Rivers drain east in the northern part of Wallis Lake. Of these river systems, the closest to the site is the Karuah River situated roughly 2 km east of the site boundary and 4 km downstream. The primary watercourse at the site, Double Creek, drains to Cromarty Creek which then drains directly to the Karuah River (**Figure 3**).

The Karuah River flows for approximately 90 km from the foothills of the Barrington Tops National Park to the Port Stephens estuary. The Karuah River flows into Port Stephens downstream of the town of Karuah. The Karuah River is a broad tidal estuary along its lower reaches, and oysters are grown along the banks in some areas. The lower reaches of the Karuah River and estuary are subject to tidal influence. The tidal sections of the Karuah River are well downstream of the site, and flood behaviour at the Project is not influenced by backwater from tides.

Double Creek traverses the properties containing the site. It flows in a generally easterly direction to the north of the Project extraction area, before turning in a south to south-easterly direction through the south-eastern corner of the site.

The disturbance area associated with quarry extraction does not impinge on Double Creek. The quarry extraction area is located within the catchment of a tributary of Double Creek; a ‘central valley’ which contains the bulk of the quarry extraction and processing area flows northwards into Double Creek. There is a large existing farm dam downslope of the proposed quarry extraction area, and two smaller farm dams higher up in the catchment.

The access road proposed to provide quarry access from Bucketts Way will require a crossing of Double Creek within Lot 1 DP159902 (**Photo 3**).

Photo 3: Double Creek to East of Extraction Area and at Existing Road Crossing

4.4.2 Watercourse Characterisation

The NSW Planning Portal Spatial viewer identifies several 'blue line' watercourses which are tributaries of Double Creek that traverse the Project footprint (DPE, 2019).

Watercourses pertinent to the Project have been assessed with the Strahler Ordering System as described in NSW Government Gazette No. 37, 24 March 2006, and the classification of watercourse orders into schedules as described by the Water Management (General) Regulation 2018. A summary of the schedules is provided below and the methodology for determining stream order is outlined in **Figure 4**.

- Schedule 1 – usually intermittent streams and consisting of first or second order waterways.
- Schedule 2 – third and higher order waterways that drain into primary catchment rivers.
- Schedule 3 – these watercourses are major rivers, including their primary tributaries and associated alluvial groundwater zones.

The Strahler System

The method of determining the stream order of a watercourse shown on a topographic map is the Strahler System. The Strahler System is described as follows and demonstrated opposite.

a) Any watercourse that has no other watercourses flowing into it is classed as a first order stream.
b) If 2 streams join, the resulting stream is:
   i. The same order as the highest order of the 2 streams, or
   ii. If the 2 streams are of the same order, the order greater than that of the 2 streams.

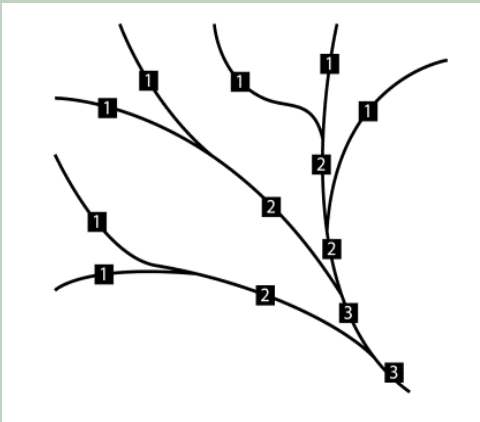


Figure 4: The Strahler System

Watercourses at/near the Project site have been characterised as follows:

- **Karuah River** – Schedule 3 major river. Karuah River drains directly into Port Stephens. The Project site is approximately 4 km upstream of the Karuah River.
- **Double Creek** – Schedule 2 creek (4th order). The watercourse's alignment is highly sinuous traversing between steep catchment slopes. Much of the creek bed is founded in bedrock with steep bedslopes. Along the lower reaches of Double Creek, the banks and riparian zones have been disturbed by grazing and other rural land uses, and there are minor indications of creek bank instability at some locations.
- **Brewers Creek** – Schedule 2 creek (3^{rd} order). Brewers Creek is of similar nature to Double Creek with steep slopes dominating majority of its catchment. This watercourse occurs south of the proposed quarry footprint and extends outside the Project boundary.
- **Upper tributaries at proposed quarrying site** – Schedule 1 waterways (1st and 2nd order). These are generally very steep and shallow watercourses with low sinuousity. The beds typically have good vegetative cover with some natural armouring by the natural rock.
- **Lower tributaries within 'central valley' of proposed quarrying site** – Schedule 2 creek (3rd order). This watercourse follows along the floor of the 'central valley'. It has a large existing farm dam approximately 150 m upstream of Double Creek.

- **Tributaries crossing proposed haul road** – Schedule 1 waterways (1st and 2nd order) and Schedule 2 creeks (2nd order). Several tributaries of Double Creek through open and vegetated areas cross the proposed road.

4.4.3 Riparian Corridors

4.4.3.1 Local Environmental Plan

The Local Environmental Plan (LEP) applicable to the LGA of the Project is the Great Lakes Local Environmental Plan 2014 (the LEP). Clause 7.7 of the LEP (Riparian land and watercourses) requires that, before determining a development application for development on land to which Clause 7.7 applies, the consent authority must consider:

a) whether or not the development is likely to have any adverse impact on the following:
    - the water quality and flows within the watercourse;
    - aquatic and riparian species, habitats and ecosystems of the watercourse;
    - the stability of the bed, shore and banks of the watercourse;
    - the free passage of fish and other aquatic organisms within or along the watercourse;
    - any future rehabilitation of the watercourse and riparian areas; and

b) whether or not the development is likely to increase water extraction from the watercourse; and

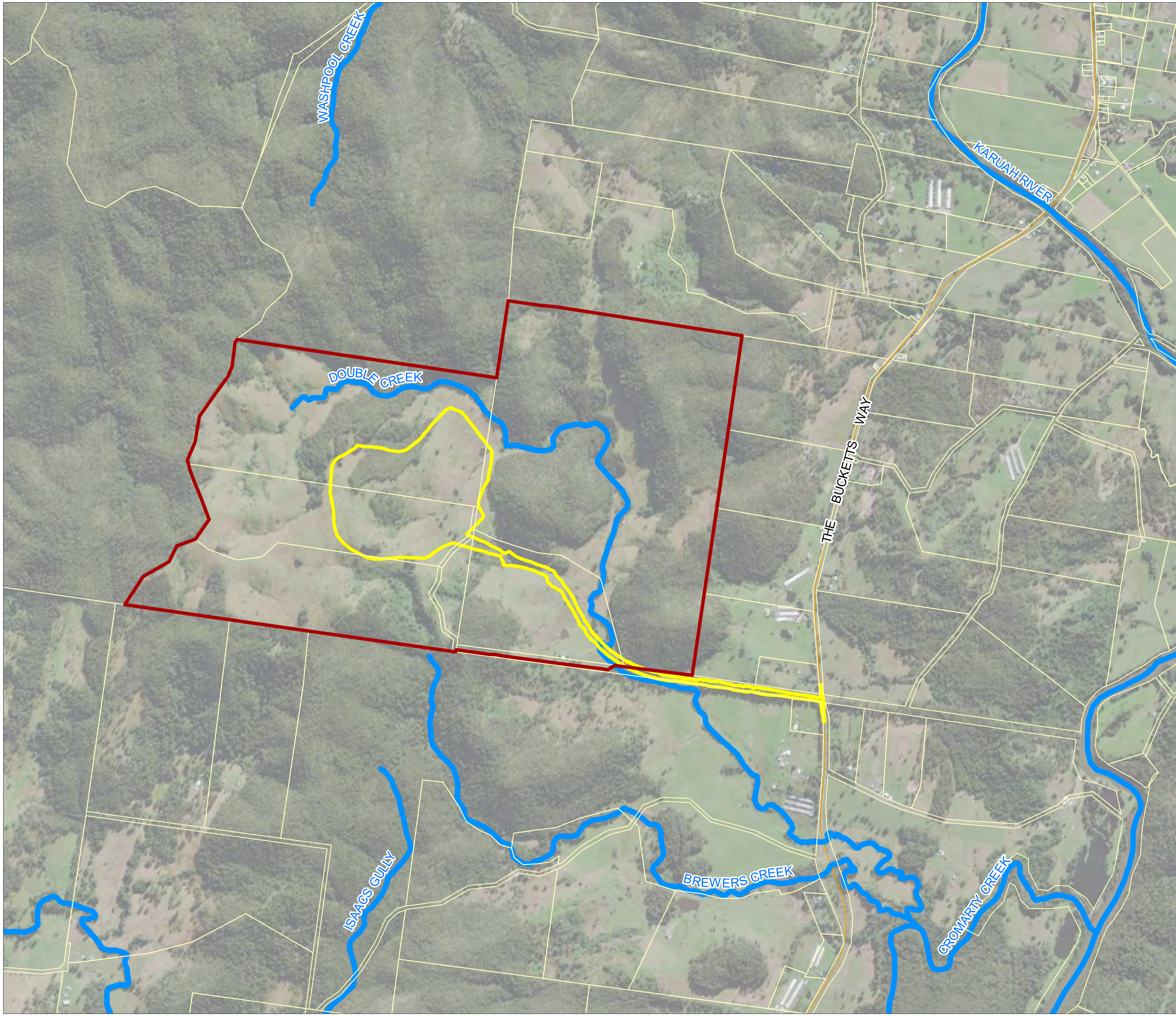
c) any appropriate measures proposed to avoid, minimise, or mitigate the impacts of the development.

This requirement applies to ‘all land that is within 40 metres of the top of the bank of each watercourse on land identified as “Watercourse” on that map.’ The map to which this refers is the LEP ‘Watercourse Map’ which is broken down into 13 separate sub-maps. The watercourse sub-map relevant to the Project is titled WCL_005.

Figure 5 presents an extract of the Watercourse Map comprising watercourses recognised at the Project. Double Creek is the only “Watercourse” at the Project identified in the Watercourse Map. The other minor watercourses surrounding the site and within the proposed quarry extraction footprint are not identified this way in the LEP.

The proposed haul road along Maytoms Lane will include a crossing of Double Creek which would involve modification of the riparian corridor. The road design for the crossing will need to comply with the LEP and the broader requirements of the WM Act pertaining to controlled activities on waterfront land. The design will need to ensure long-term stability of the creek bed, shores and banks is maintained (i.e., limited scouring) and a CEMP will be in place inclusive of an ESCP during construction to minimise harm to Double Creek.

The proposed extraction area of the quarry footprint does not coincide with Double Creek or within 40 metres either side of the creek.



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Watercourses as mapped in the Great Lakes Local Environmental Plan 2014 (Watercourse Map - Sheet WCL_005)

FIGURE 5

- Project Site
- Disturbance Footprint
- Watercourses
- Roads

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)
Watercourse Mapping:
Great Lakes Local Environmental Plan 2014
Watercourse Map - Sheet WCL_005

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:25,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

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4.4.3.2 Controlled Activity Approvals

A controlled activity is an action carried out in, on, or under waterfront land as regulated under the WM Act. Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary. This means that applicants must obtain a Controlled Activity Approval (CAA) from the DPE before commencing a controlled activity.

The riparian corridor (**Figure 6**) consists of the:

- Channel which comprises the bed and banks of the watercourse (to the highest bank).
- Vegetated Riparian Zone (VRZ) adjoining the channel.

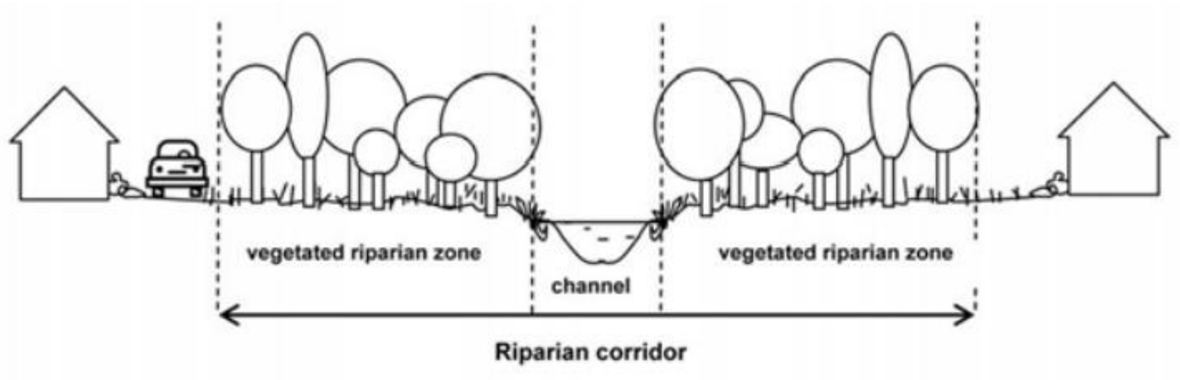

Figure 6: Riparian Corridor Schematic

The DPE recommends a VRZ width adjacent to 'blue line' streams to avoid impacts to riparian corridors as outlined in **Table 11** (DPE, 2022b). The VRZ correlates to the total riparian corridor width to be considered a buffer zone around a recognised watercourse. VRZ widths may be averaged provided the minimum width is not less than 50% of the nominal VRZ width.

Table 11: Recommended Riparian Corridor Widths

Watercourse Type	VRZ Width (Each Side of Watercourse)	Total Riparian Corridor Width
1st order	10 metres	20 m + channel width
2nd order	20 metres	40 m + channel width
3rd order	30 metres	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts or rivers influenced by tidal waters)	40 metres	80 m + channel width

Figure 7 shows the total riparian corridor width for applicable watercourses at the Project. As Double Creek is a 4th order stream, a total riparian corridor width of 80 m plus the channel width applies. A 60 m width plus the channel width applies at Brewers Creek.

The DPE has endorsed the 'Riparian corridor matrix' to enable applicants to identify certain works and activities that can occur on waterfront land and in riparian corridors. **Table 12** presents the Riparian corridor matrix.

It should be noted that the matrix relates to CAAs under the WM Act only, and that applicants must still comply with other relevant government legislation, such as threatened species, flood planning levels and fisheries guidelines.

Table 12: Riparian Corridor Matrix

Stream Order	VRZ	RC Offsetting for Non-RC Uses	Cycleways and Paths	Detention Basins		Stormwater Outlet Structures and Essential Services	Stream Realignment	Road Crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1st	10 m	•	•	•	•	•	•	•		
2nd	20 m	•	•	•	•	•		•		
3rd	30 m	•	•	•		•			•	•
4th	40 m	•	•	•		•			•	•

As the Project is classified as SSD, the Project is exempt from requiring CAA under the EP&A Act. It is still beneficial for the Project to consider guidance on CAAs when planning for works within riparian corridors.

The Flood Assessment carried out for this study shows that the crossing infrastructure provided by ADW Johnson has negligible effect to downstream flow.

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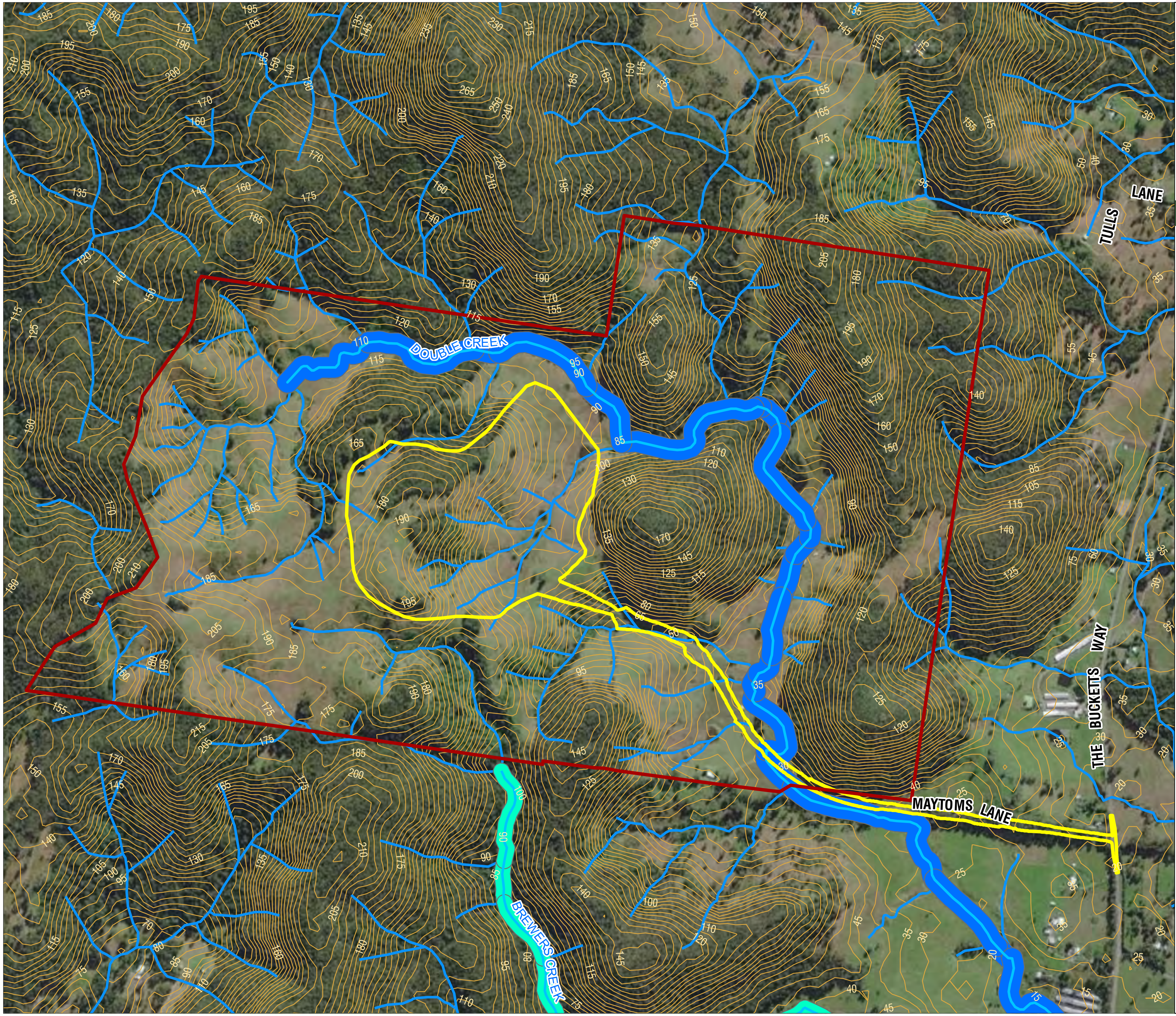
Riparian Corridor Zones at the Project

FIGURE 7



- Project Site
- Disturbance Footprint
- Watercourses
- Contour (5m Interval)
- Double Creek Riparian Zone (80m)
- Brewers Creek Riparian Zone (60m)

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:16,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

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4.5 Site Soils

General information on site soils was obtained from the eSPADE public database and the Sharing and Enabling Environmental Data in NSW (SEED) database (NSW Government, 2022). eSPADE provides access to soil profile and soil map information published by the DPE, and SEED contains various mapped environmental datasets for NSW administered by DPE including Australian Soil Classification (ASC) Soil Type mapping.

Soil landscape mapping within eSPADE indicates that the Project comprises two ASC types (**Figure 8**):

- Rudosols
- Kurosols (Natric)

A site-specific soil survey was conducted as part of the Land Resource Assessment. The investigation identified two soil map units within the Project Site according to dominant ASC soil types: Eutrophic Kandosol and Subnatric Brown Sodosols (**Figure 9**).

Detailed information on soils at the Project is provided within the Land Resource Assessment.

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Site Soils - Statewide Land and Soil Mapping: ASC Classification

FIGURE 8

Project Site
Disturbance Footprint
Watercourses
Roads

Dominant ASC - Order

Kurosols - natric (KUn)
Rudosols (RU)

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)
ASC Mapping:
Department of Planning, Industry and Environment, 2021, Australian Soil Classification (ASC) Soil Type map of NSW, Version 4.5

0 200 400 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:16,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	JG/LF

SLR

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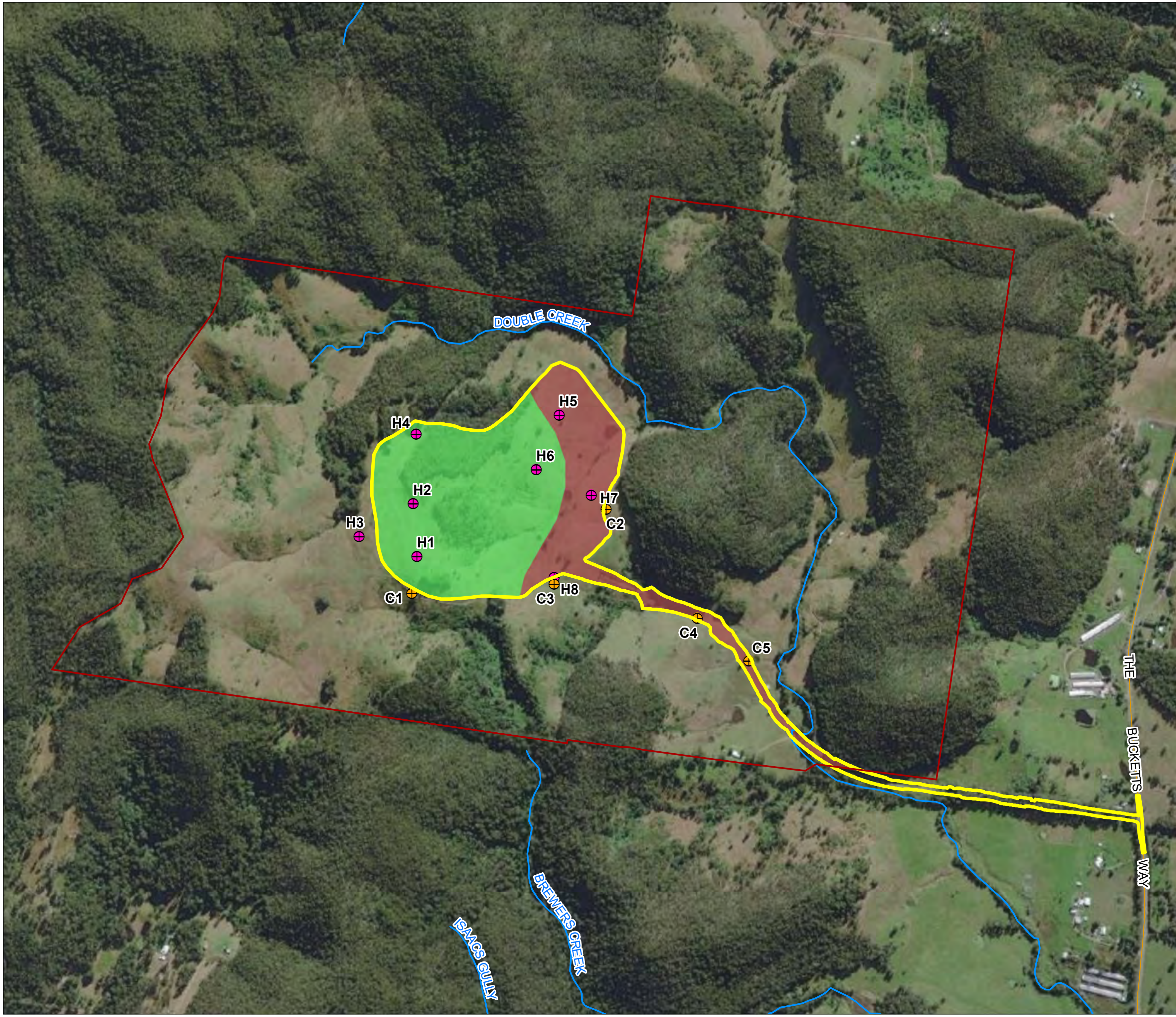

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Site Soils - Site-specific Soil Survey: ASC Classification

FIGURE 9

Project Site
Disturbance Footprint
Watercourses
Roads

Inspection Locations

Check Sites
Detail Sites

ASC Soil Type

Eutrophic Black/Brown Dermosol
Subnatic Brown Sodosol

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 200 400 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:16,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	JG/LF

SLR

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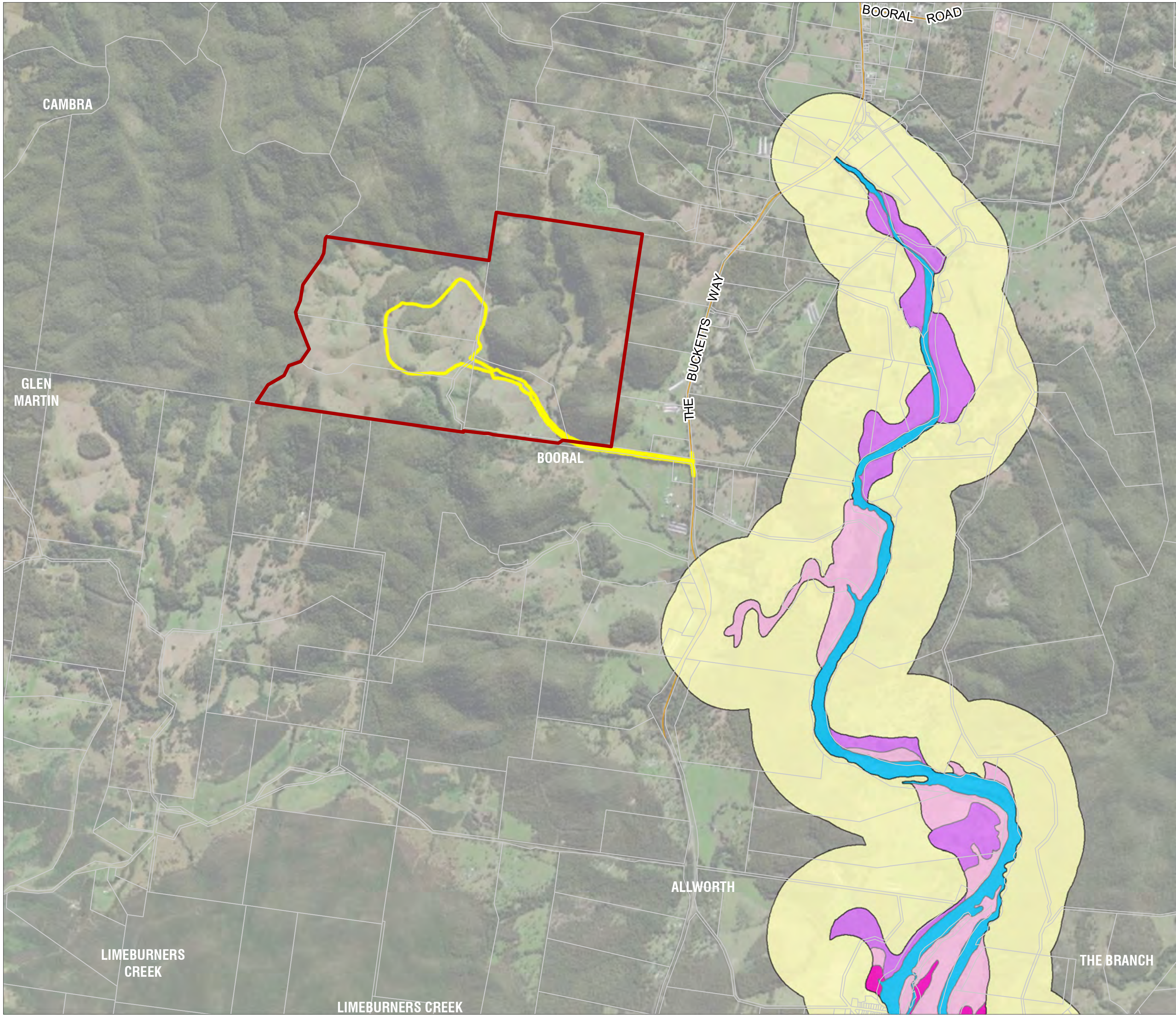
4.6 Salinity and Acid Sulfate Soils

General information on site salinity was reviewed through the SEED database. The salinity mapping from SEED suggests that salinity does not pose development implications towards the Project.

Laboratory tested Electrical Conductivity (EC) values were used to determine salt store, all of which were non-saline. Further information regarding soil salinity is provided in the Land Resource Assessment.

The LEP maps the presence of Acid Sulfate Soils (ASS) in the LGA of the Project through the 'Acid Sulfate Soils Map' which is broken down into 13 separate sub-maps. The ASS sub-map relevant to the Project is titled ASS_005.

Figure 10 presents an extract of the Acid Sulfate Soils Map nearby to the Project. ASS is mapped as occurring within the estuary of the Karuah River, but the mapped extent does not coincide with the Project site. Accordingly, the potential of encountering ASS is considered to be low since there are no known occurrences of ASS on lands proximal to the site.



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Acid Sulfate Soils as mapped in the Great Lakes Local Environmental Plan 2014 (Acid Sulfate Soils Map - Sheet ASS_005)

FIGURE 10

Project Site
Disturbance Footprint
Roads
Lot

Acid Sulfate Soils

Class 1
Class 2
Class 3
Class 4
Class 5

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)
Watercourse Mapping:
Great Lakes Local Environmental Plan 2014
Acid Sulfate Soils Map - Sheet ASS_005

0 200 400 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:40,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

SLR

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4.7 Groundwater

The Project lies within the Myall Block and is hydraulically separated from geological formations to the east within the Permo-Triassic Gloucester Basin that contains the Alum Mountain Volcanics, Dewrang Group, and Gloucester Coal Measures (McVicar et al., 2014), and therefore there is anticipated to be limited interaction between the Permo-Triassic bedrock in the Gloucester Basin and the Carboniferous bedrock at the Project location.

In addition, the Permo-Triassic basins in the Hunter subregion to the south of the Project are also not considered in connection with the Carboniferous bedrock at the site is not considered to have any groundwater connections with areas to the north-east due to the geological basin divides that define its boundary (Bioregional Assessments, 2022)

Detailed information on groundwater at the Project site is provided in the Groundwater Assessment.

4.8 Geology

The Booral region is underlain by a complex suite of lithologies, which range from Permian aged sandstones, mudstones, conglomerates and coal seams to Carboniferous aged basalt flows, ignimbrites, and rhyolites (Division of Resources and Geoscience, n.d.). The lithologies are intersected by the Targan Fault, a reverse fault that strikes in a north-south direction and dips at a moderate angle between 31 and 60 degrees.

On-site geological investigations have found that the Project Site is underlain by a Rhyolitic Tuff composed of finely microcrystalline, coarse phenoclasts of feldspar and quartz, as well as other trace minerals. The Rhyolitic Tuff is thought to have originated as an acid ash flow tuff comprised of quartz and feldspars dispersed though a welded matrix of vitric shards and some compressed pumice. The upper 28 metres (on average) of Rhyolitic Tuff is hematised, with the underlying material being free of haematite mineralisation. Geotechnical aspects of the stratum are suitable for use in concrete and road construction applications.

No soil hazard features were identified within the Project Site.

Detailed information on geology at the Project site is provided in the Groundwater Assessment.

5.0 Hydrological Setting

5.1 Site and Receiving Environment

A description of the existing site hydrology is provided in **Section 4.3**. In summary, the site is traversed by Double Creek which has a Strahler Order of Schedule 2 (4th order) that drains to the Karuah River. The disturbance area of the proposed quarry does not impinge on Double Creek. Multiple existing farm dams are present at the Project site that service stock watering. The Project is not within a drinking water catchment, and there are no ‘homestead water supplies’ downstream.

Downstream from the proposed quarry extraction area, and South of Maytoms Lane, the lands surrounding Double Creek are predominantly used for grazing. There are poultry sheds near Bucketts Way. It is also noted that lands south of Maytoms Lane and west of Bucketts Way have been approved for a rural residential subdivision.

Further downstream along the Karuah River and into Port Stephens there are significant wetlands. The estuary of the Karuah River has been identified as a priority oyster aquaculture area in the NSW Oyster Industry Sustainable Aquaculture Strategy 2021, (NSW Department of Primary Industries (DPI), 2021). The identified area extends from the town of Karuah and approximately 12 km upstream along the Karuah River. The identified oyster growing area is approximately 6 km downstream from the confluence of Double Creek and the Karuah River, which is approximately 10 km downstream from the Project site.

5.2 Water Quality

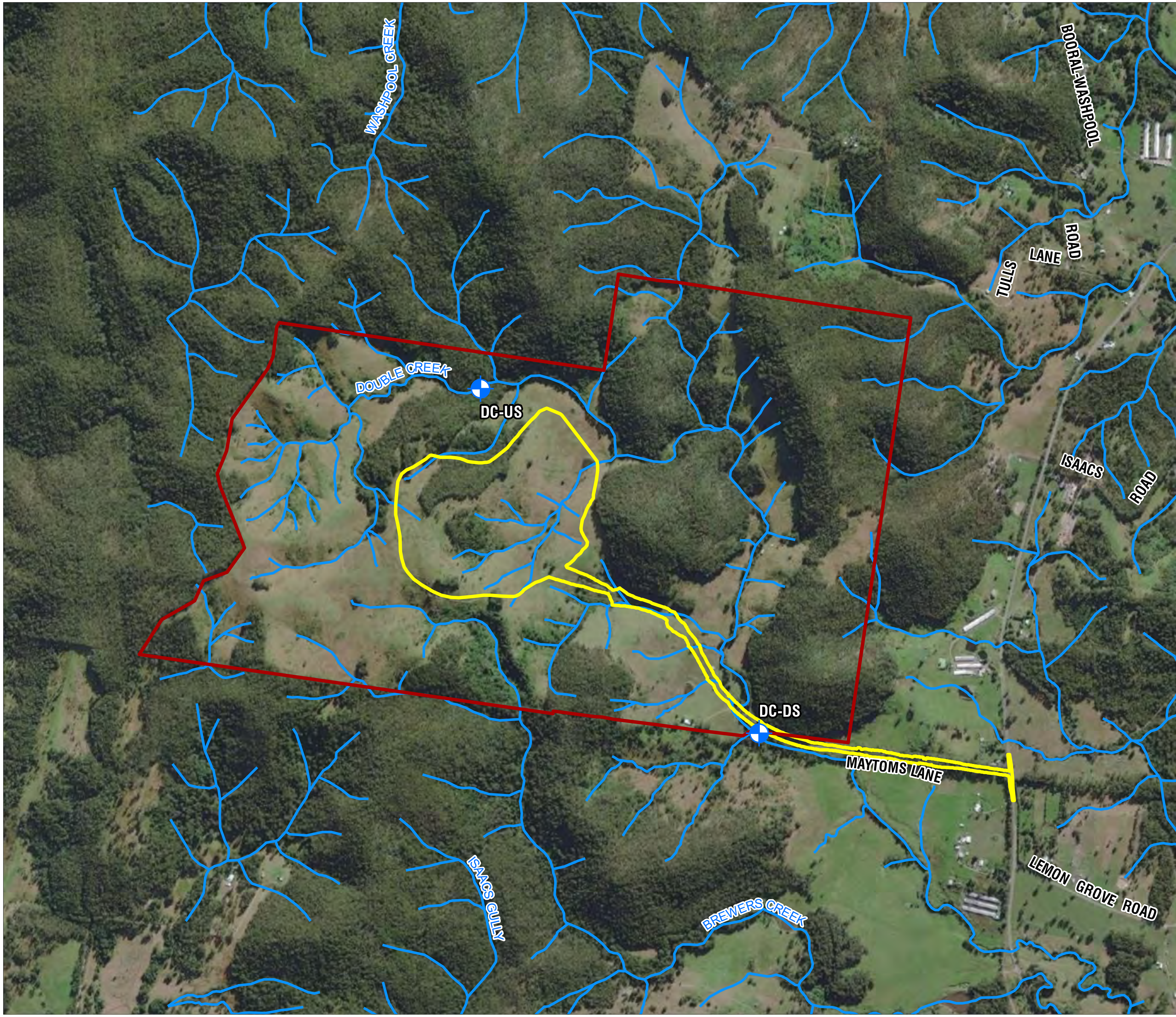
Surface water quality data was collected at the site from two designated monitoring points in Double Creek across 2019 and 2020. An upstream monitoring point (DC-US) is established north of the proposed quarry footprint intended as a reference site, and a downstream monitoring point (DC-DS) has been defined along the existing Maytoms Lane to monitor for change. The monitoring locations are shown in **Figure 11**.

A total of 20 and 23 sampling rounds have been conducted from DC-US and DC-DS, respectively. During late 2019 to early 2020, no samples could be taken at DC-US for three sampling events as no water was present. Samples collected from the monitoring sites were submitted for laboratory analysis to National Association of Testing Authorities (NATA) accredited facility VGT Laboratory. Analytes examined include pH, temperature, Electrical Conductivity (EC), Total Suspended Solids (TSS), turbidity, Dissolved Oxygen (DO), fluoride, total alkalinity, hardness, ammonia as N, nitrate as N, nitrite as N, total nitrogen, phosphate as P, total phosphorous, total cyanide, dissolved metals (sodium, potassium, calcium, magnesium) and total metals (aluminium, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, tin, vanadium, zinc).

Plots depicting laboratory results for select analytes are presented in **Figure 12** through **Figure 20.** These include key analytes (pH, temperature, EC, TSS, turbidity and dissolved oxygen) and analytes that exceed trigger values outlined in the ANZECC 2000 Guidelines *‘Slightly-moderately disturbed systems’* triggers Table 3.4.1, and ‘*South-east Australia’* triggers Table 3.3.2 and Table 3.3.3 including subscript information. All laboratory data is tabulated in **Appendix B.**

The plots indicate that key water quality metrics at Double Creek, including pH, EC, TSS and turbidity are within acceptable ranges when compared to ANZECC 2000 Guidelines criteria. Observations of pH are neutral (between pH 6.5 to 8) with slightly more acidic pH recorded at the upstream monitoring point (**Figure 12**). Temperature measurements at both monitoring points are consistent and reflect seasonal fluctuations in ambient temperature (**Figure 13**). Records of EC (**Figure 14**), a parameter indicative of salinity, show that freshwater conditions have prevailed at the upstream monitoring point while the downstream monitoring point has experienced salinity level spikes in the brackish range. For the most part, downstream salinity has mirrored upstream salinity trends (particularly from February 2020 onwards) and all observations have been within ANZECC 2000 trigger values. Readings for TSS and turbidity (**Figure 15** and **Figure 16**) are all below the ANZECC 2000 limit at both locations. Available data show that TSS and turbidity levels are stable at the downstream monitoring point, while some fluctuation has been observed at the upstream point. DO concentrations (**Figure 17**) have followed seasonal fluctuation at both sampling locations (higher concentrations in winter) and generally lower concentrations have been observed upstream as expected with the elevation difference (DC-US = 95 mAHD, DC-DS = 28 mAHD).

Laboratory data for select nutrients and metals was compared against ANZECC 2000 water quality criteria. Results for most analytes were at acceptable concentrations and only a handful of parameters exceeded defined trigger values. Ammonia as N and total nitrogen (**Figure 18**) were generally below established trigger levels, however elevated concentrations were recorded during initial monitoring and multiple total nitrogen exceedances at DC-DS occurred in later 2019 and 2020. Each monitoring site experienced one exceedance of total phosphorous (**Figure 19**), during different sampling events. Otherwise, total phosphorous levels were below the 0.05 mg/L Limit of Reporting (LOR) nearly every round. Exceedances of total metals were flagged for aluminium, copper and zinc at both monitoring locations (**Figure 20**). Aluminium levels were below the 0.01 mg/L LOR for majority of monitoring campaigns, with minor exceedances only observed twice at DC-US and once at DC-DS. Similarly, copper levels at both sites were generally below LOR for nearly all sampling rounds. One copper reading was recorded above the trigger level at each site on separate occasions. Zinc levels at both monitoring locations breached the ANZECC 2000 trigger concentration in the majority of sampling events. The results indicate elevated zinc concentrations may be characteristic of the Project site



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Baseline Surface Water Monitoring Locations at the Project

FIGURE 11

Project Site
Disturbance Footprint
Watercourses
Surface Water Quality Monitoring Location

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:20,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

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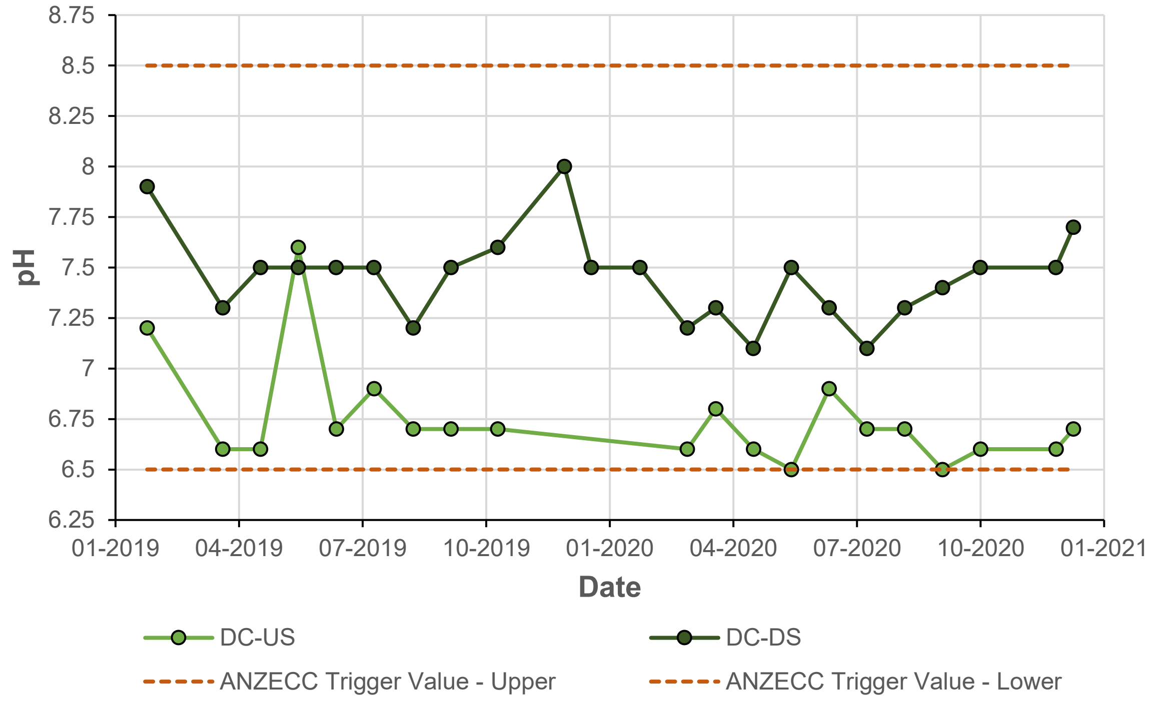


Figure 12: Double Creek – pH

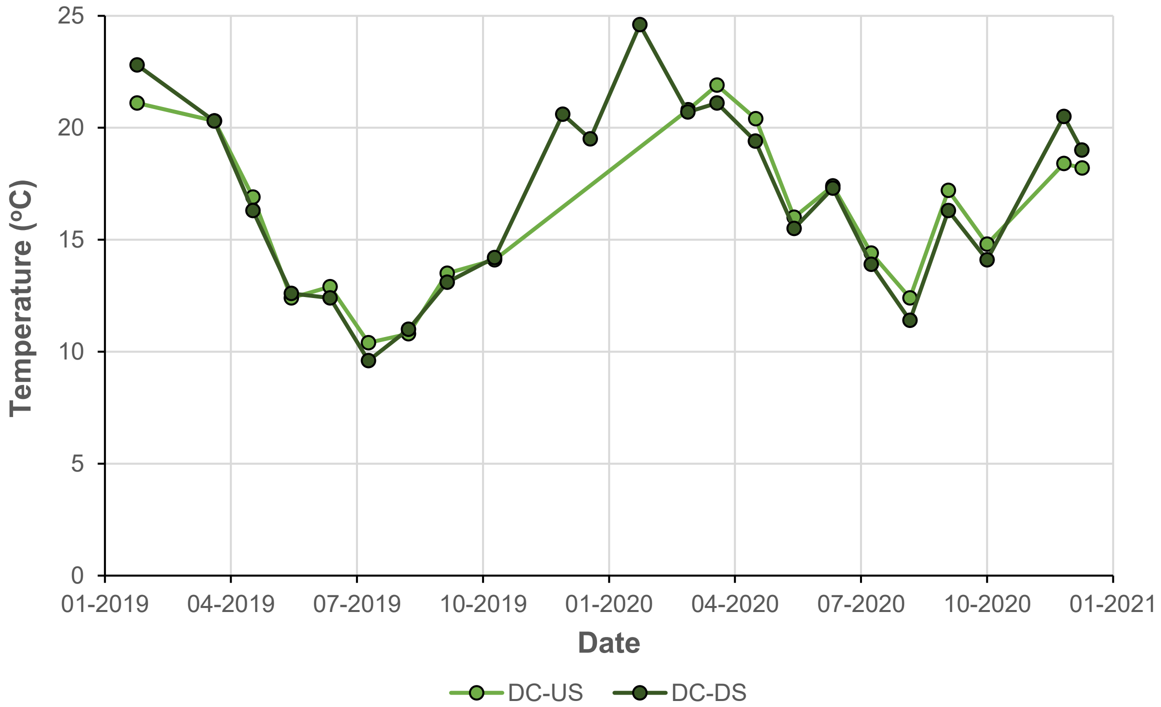


Figure 13: Double Creek – Temperature

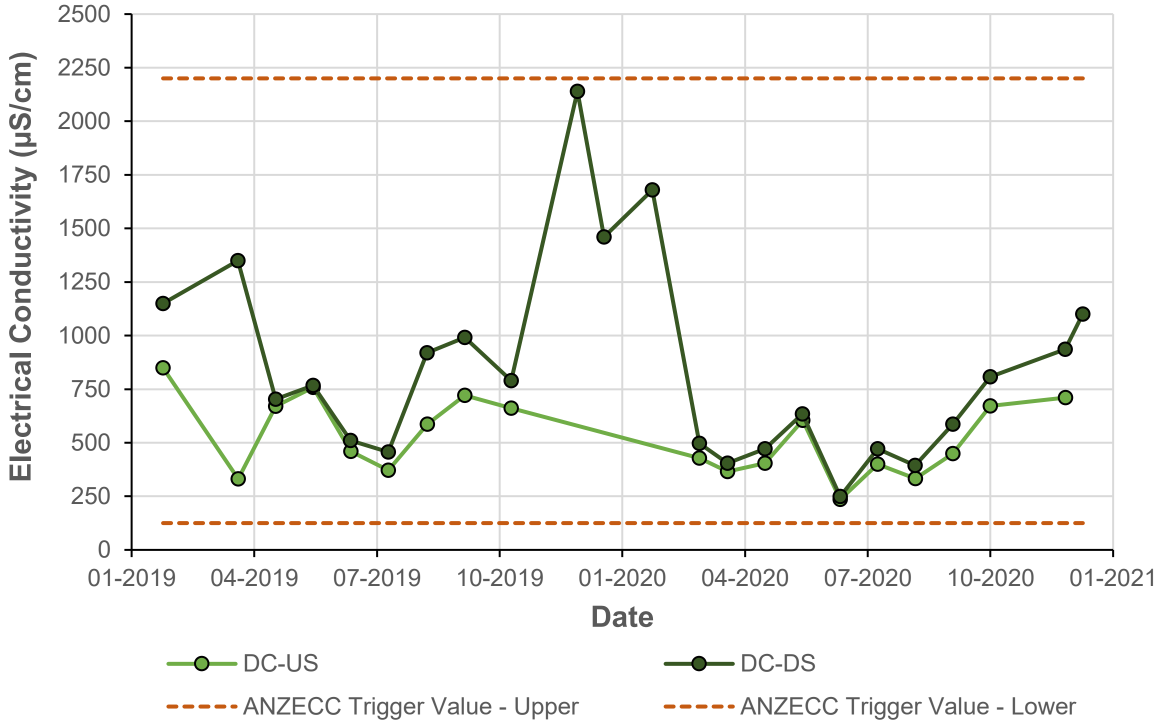


Figure 14: Double Creek – Electrical Conductivity

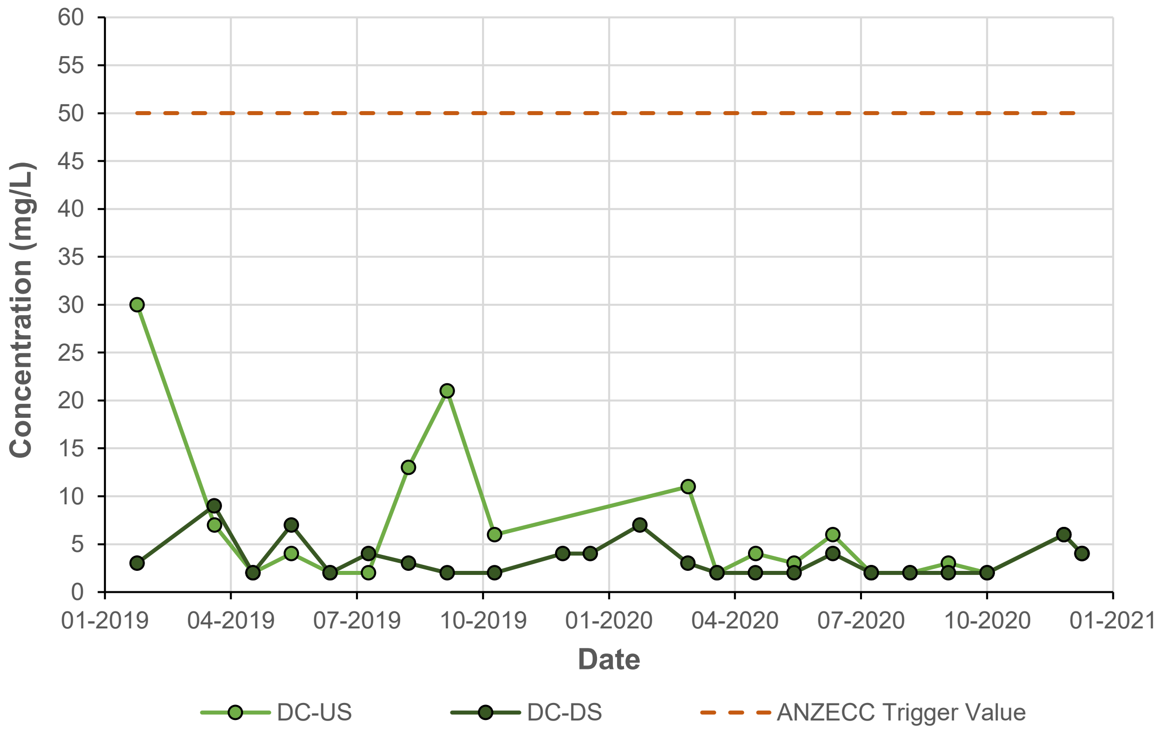


Figure 15: Double Creek – Total Suspended Solids

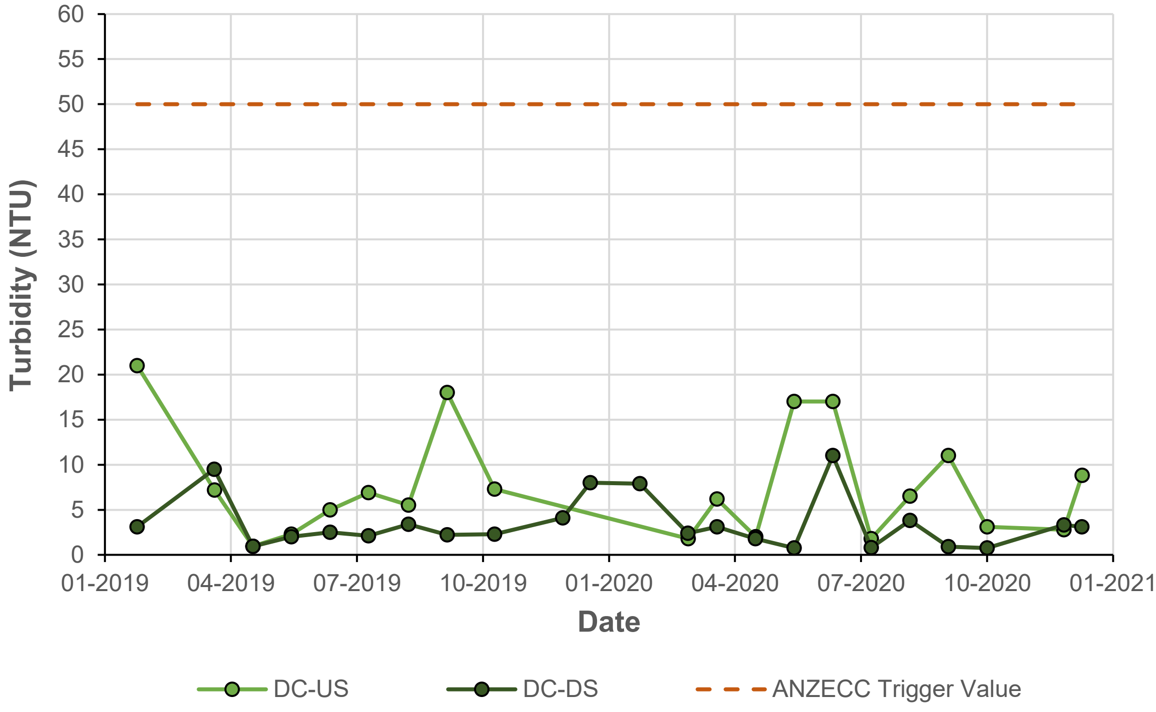


Figure 16: Double Creek – Turbidity

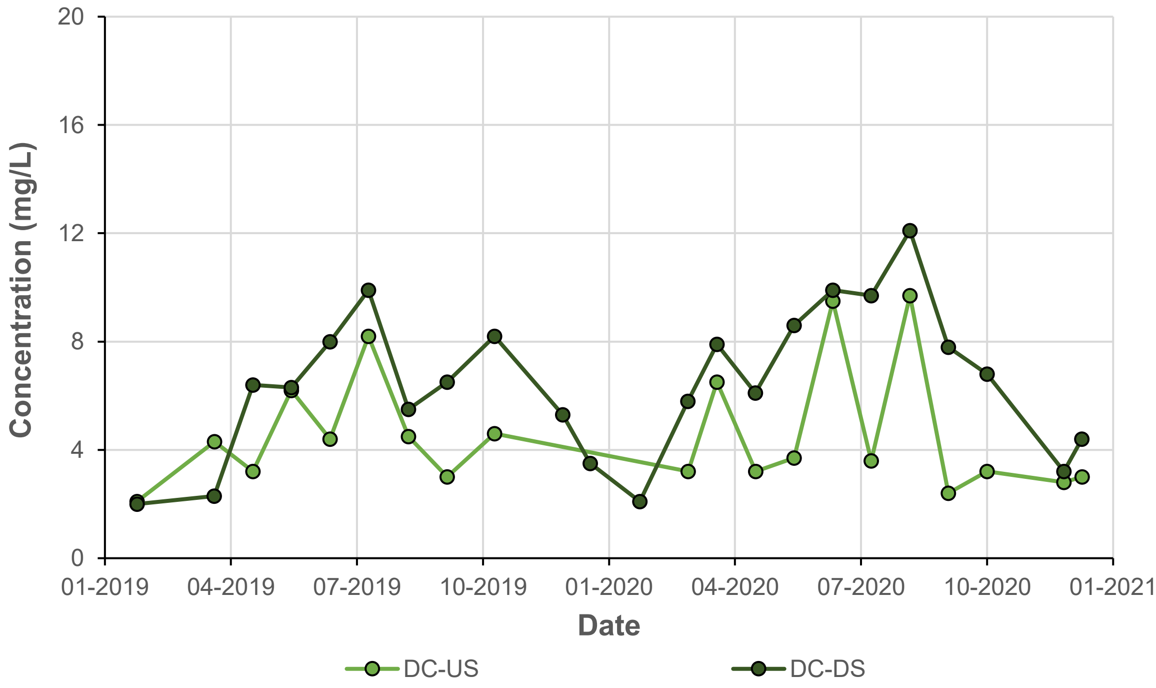


Figure 17: Double Creek – Dissolved Oxygen

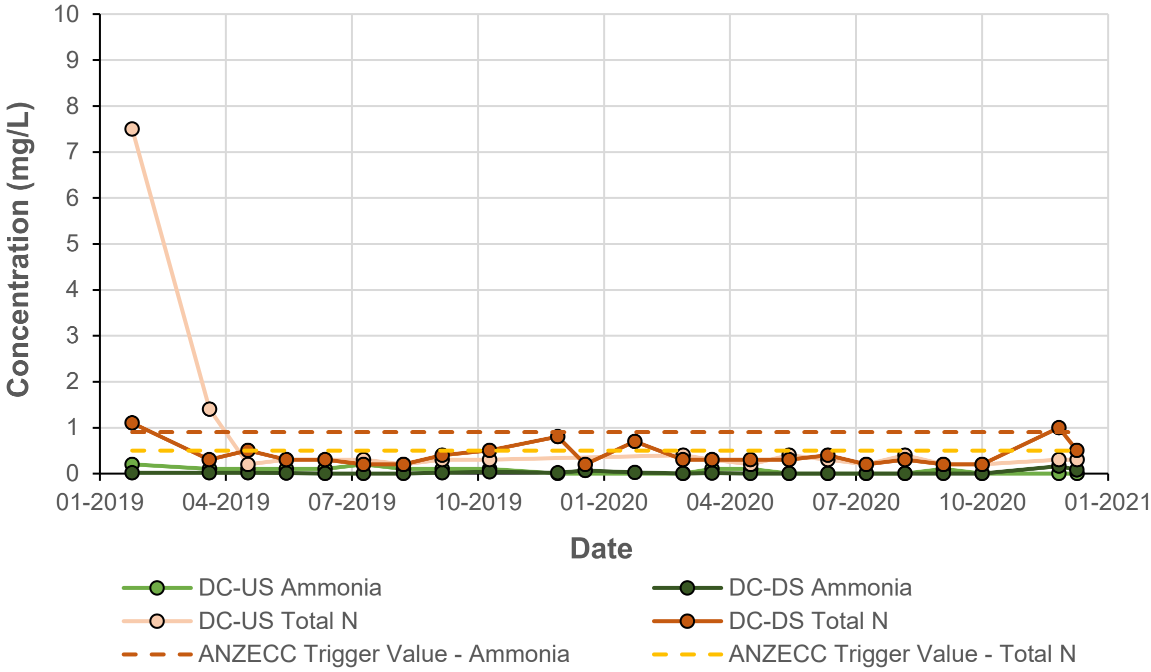


Figure 18: Double Creek – Total Nitrogen and Ammonia

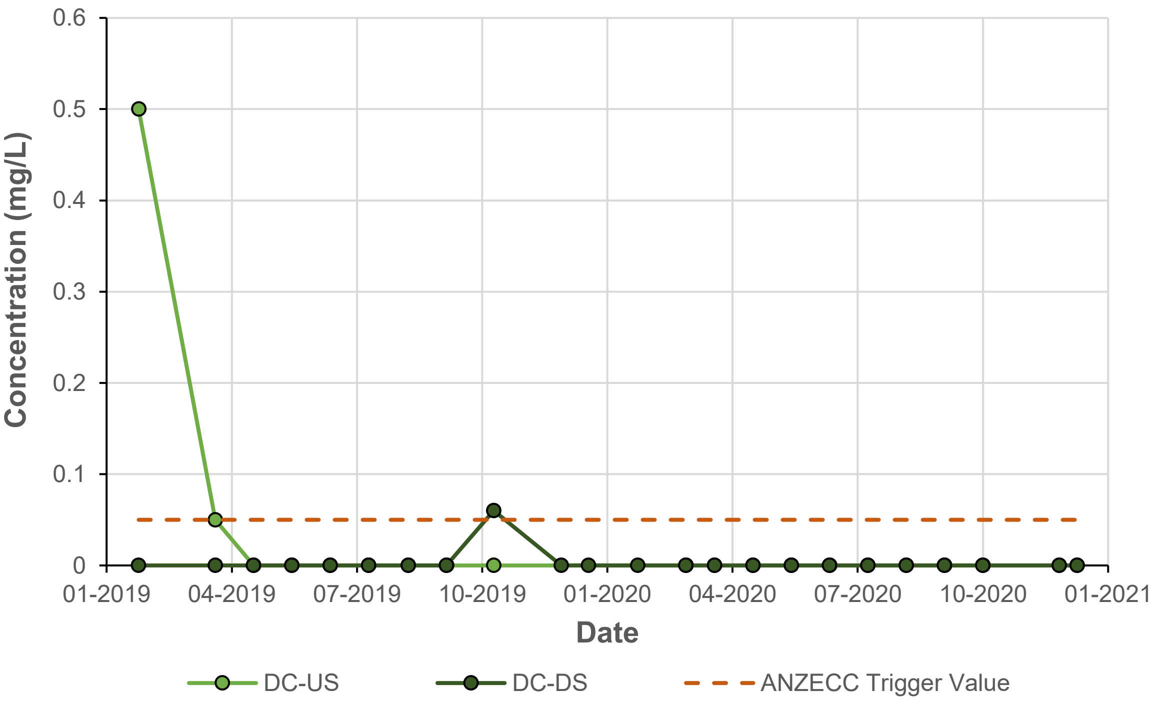


Figure 19: Double Creek – Total Phosphorous

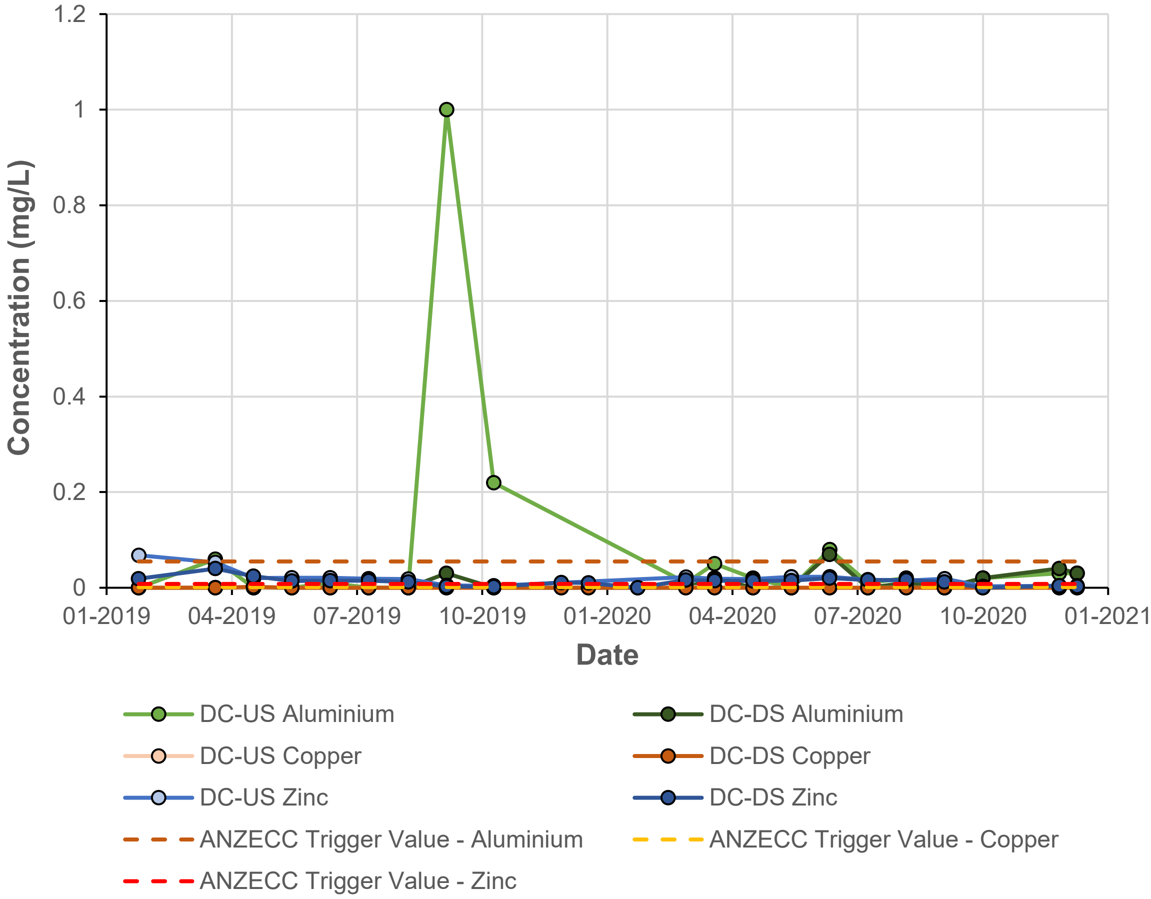


Figure 20: Double Creek – Total Aluminium, Copper and Zinc

5.3 Mean Annual Runoff

The areas of catchments contributing to flows in Double Creek and calculated Mean Annual Runoff (MAR) for the natural catchments are shown in **Table 13**

Table 13. The Double Creek catchment with delineated sub catchments is mapped in **Figure 21**. Note the southern catchment is clipped to the east in line with Bucketts Way, corresponding to the eastern Project boundary.

MAR has been calculated using a site average rainfall depth of 1,143.8 mm and a volumetric rainfall runoff coefficient of 10% (0.1) based on the WaterNSW Maximum Harvestable Rights Dam Capacity Calculator (WaterNSW, 2022).

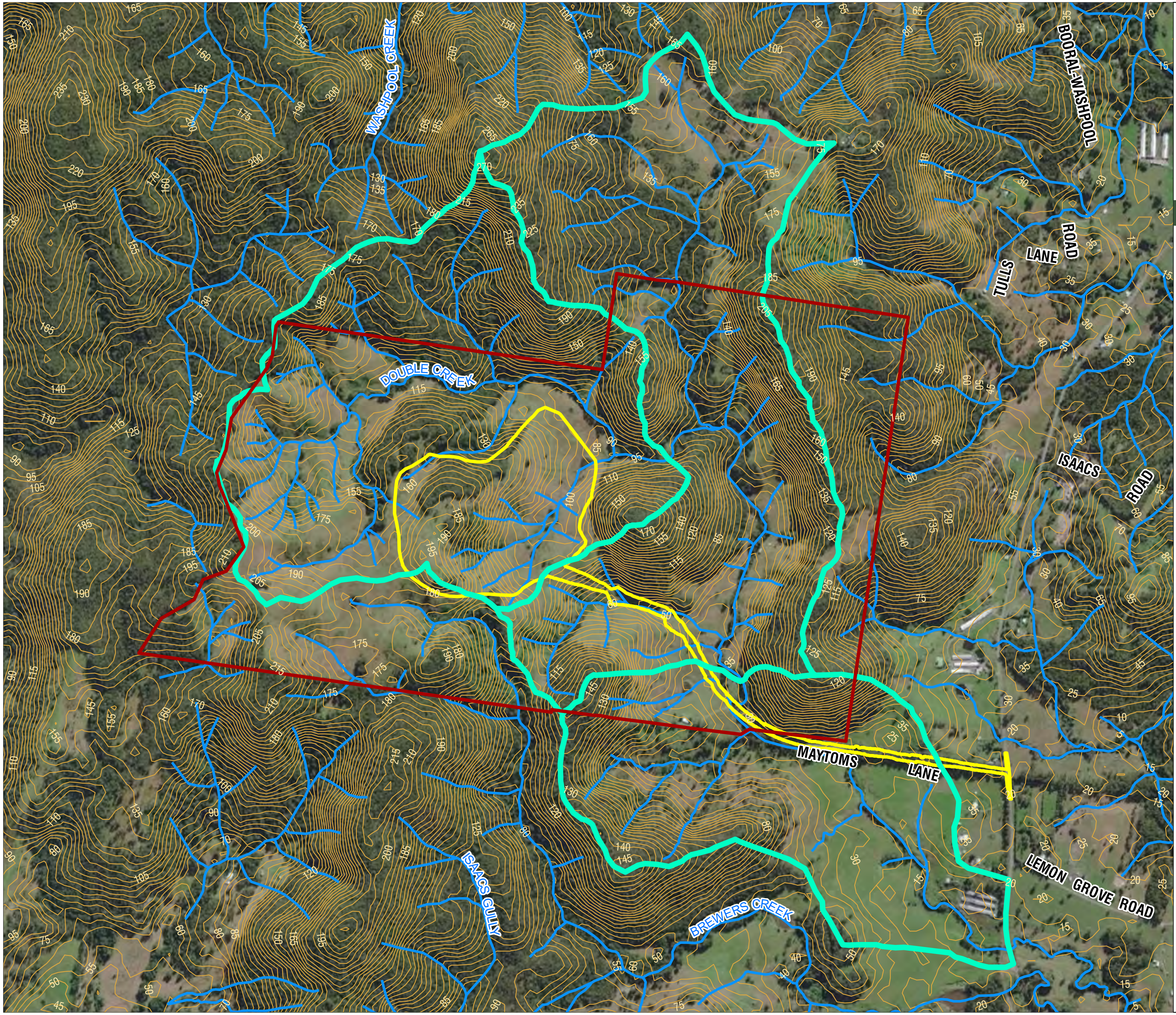
The MAR was derived by the following expression:

$$MAR\left(\frac{m^3}{yr}\right) = Annual\ Rainfall\left(\frac{m}{year}\right) \times Catchment\ Area\ (m^2) \times Runoff\ coefficient$$

Table 13: Mean Annual Runoff Estimate for Double Creek Catchments

Location	Catchment Area (ha)	MAR (m^3/year)	MAR (ML/year)
Double Creek – upstream of proposed quarry extraction area	205	234,480	234
Double Creek – at confluence with northern tributary	215	245,900	246
Double Creek – at Maytoms Lane	130	148,700	149

The existing grazing property has numerous farm dams. Assuming that these dams are within harvestable rights (discussed in **Section 5.4**), then the existing annual runoff that reaches Double creek could be less than the above MARs calculated for the natural catchments.



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Double Creek Catchment

FIGURE 21

- Project Site
- Disturbance Footprint
- Catchment Boundary
- Watercourses
- Contour (5m Interval)

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:20,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

5.4 Harvestable Rights

Under the WM Act, landholders in NSW have 'harvestable rights' to capture and store a proportion of the rainfall runoff from a landholding in one or more harvestable rights dams without requiring a WAL, water supply work approval or water use approval. Landholders in NSW can establish harvestable rights dams on non-permanent minor streams, hillsides, or gullies (but not on or within 40 metres of a third-order or higher stream) and capture a percentage of rainfall runoff from the landholding. The *Water Management (General) Regulation 2018* defines a minor stream as a first-order or second-order stream using the Strahler stream ordering method.

The proportion of rainfall runoff that may be captured under harvestable rights and how the water can be used depends upon where a landholding is located. As of May 2022, the capture limits and permitted applications are as follows:

- **Coastal-draining catchments** – up to 30% of the average annual regional rainfall runoff may be captured and used for consumption, stock watering and extensive agriculture.
- **Central inland-draining catchments** – up to 10% of the average annual regional rainfall runoff may be captured and used for any purpose.
- **Western Division** – all rainfall runoff may be captured and used for any purpose.

The boundaries of the harvestable rights areas are shown in **Figure 22**.

In accordance with **Figure 22**, the Project site is classified as a costal-draining catchment and would be entitled to capture up to 30% of rainfall for various applications. The maximum allowable capture volume is referred to as the Maximum Harvestable Right (MHR).

WaterNSW offers an open-source tool known as the MHR capacity calculator to allow for the computation of the MHR for a given landholding. Based on a total site area of 400.3 ha, the combined maximum dam capacity of all harvestable rights dams on the landholding with reference to the 30% of rainfall runoff is 132.1 ML. However, only up to 10% of this water could be used for purposes not pertaining to domestic consumption, stock watering or extensive agriculture. This means the Project could only utilise up to 10% (equal to 44.03 ML) of clean water captured for quarry-related purposes. Should the Project wish to extend the rights for increased harvestable rights from 10% to 30% (to cover other uses), a notification form must be submitted to DPE – Water.

The existing property has numerous existing farm dams, and it is uncertain if the MHR has already been reached. The *Water Management (General) Regulations 2018* allows for additional dam capacity to be constructed if that dam is for the purpose of pollution control, including sediment basins. As such, water captured in sediment dams at the Project would not contribute towards the MHR total.

The Project will involve a reduction in the capacity of dams harvesting water, as follows:

- Two small farm dams within the proposed extraction area will be decommissioned. The capacity of these dams is unknown but likely to be less than 1 ML each.
- The existing farm dam north of the extraction area will be retained at its present capacity of around 5 ML.
- Additional dams for pollution control comprising a central Main Dam (15 to 20 ML) and an Infrastructure Sump (41.5 ML).
- A large temporary storage within the extraction area, named the Pit Sump within this report, which will temporarily store up to 13 ML of potentially dirty water following extreme rainfall events, and release this water to the downstream storages, and later to the environment in 8 ML portions following water quality treatment.

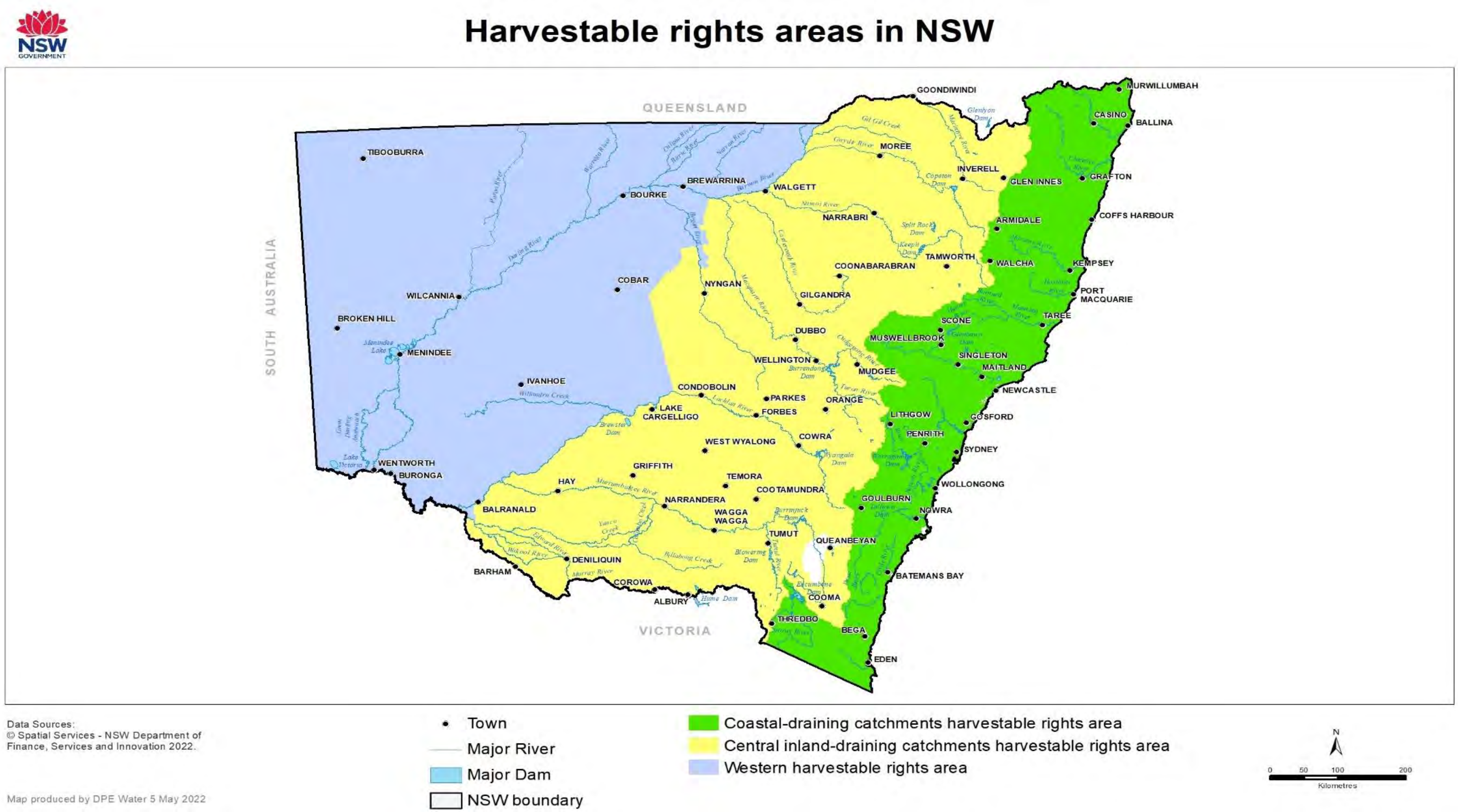

Figure 22: Harvestable Rights Areas in NSW

5.5 Catchment Yield and Environmental Flows

The existing farm dams associated with existing grazing activities will intercept and store runoff from light rainfall events, reducing the frequency and magnitude of low flow discharges to Double Creek. However, this effect would be offset by the extensive clearing on the existing property, which has the effect of increasing rainfall interception and resulting in reduced runoff.

When the quarry is fully operational, runoff from potentially polluted areas including sediment laden runoff, will be detained on site and subsequently either:

- stored to meet future operational water demands; or
- treated and released to Double Creek as a controlled discharge.

During operation of the quarry, the catchment area draining to Double Creek may be reduced by up to 48 ha. This constitutes approximately 12% of the total creek catchment area (400.3 ha) and will not have a significant impact on catchment yield and environmental flows.

5.6 Water Sharing Plan

Access to water and water sharing arrangements are set out in the WM Act. Water Sharing Plans (WSPs) have been developed for rivers and aquifers across NSW to balance the allocation of water to the environment with the needs of water users.

The Project site is within the catchment for the Water Sharing Plan for the Karuah River Water Source 2003. This WSP applies to the Karuah River and all its tributaries that enter the Karuah River downstream of the WaterNSW streamflow gauge at Booral (Station ID: 209003).

As discussed in **Section 5.4**, the Project can capture up to 44.03 ML of water under harvestable rights to be used for any purpose. All sediment dams established at site would serve as pollution control, and as such any water captured in these dams would not contribute towards the allowable 44.03 ML.

If the Project requires additional water, the proponent may apply for a WAL under the WSP for the Karuah River Water Source 2003. Clause 31.1 of the WSP for the Karuah River Water Source 2003 specifies that a total of 3,360 ML/yr is estimated to be required for water extraction under the WSP, indicating there may be capacity for water allocation to supplement the Project.

The proponent holds a WAL for groundwater access. WAL 44439 permits up to 100 ML/yr of groundwater extraction from the New England Fold Best Coast Groundwater Source, a hard rock groundwater source defined under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016. It is understood that the WAL is not currently associated with any bores, however the proponent may install water supply bore(s) in future to meet water demands at the Project.

Any flows out of dams used for operational purposes should be recorded, and an allocation purchased for flows exceeding the harvestable right total (44.03 ML).

6.0 Site Water Management

6.1 Overview

Without incorporation of suitable mitigation measures into the proposed Project, the construction and operation of the proposed quarry including road access, have potential to impact on downstream watercourses and waterbodies. This chapter provides a description of the overall proposed strategy for managing surface water at the Project.

Additional information on requirements for proposed mitigation measures are provided in **Section 12.0**.

6.2 Classes of Water

Five classes of water will be present on site, and these will be generally managed as follows:

- **Clean water** – water from undisturbed areas of the upslope catchment – diverted around the operational site and discharged to receiving environment;
- **Stormwater** – 'dirty' water which is not contaminated with pollutants other than sediments. Erosion and Sediment Control (ESC) measures will be installed to minimise the area of exposed soils and the potential for erosive/sedimentation effects. Stormwater will be conveyed by surface drains to site water storage(s);
- **Wastewater** – water which is used for washing quarry products or that comes into contact with site areas which are potentially polluted, is considered to be wastewater. Wastewater may be re-used, but all wastewater re-used or not must be contained on site;
- **Sewerage** – water from site amenities including washing water, flushing of toilets, etc.
- **Potable water supply** – water suitable for drinking, showering, and washing.

6.3 Basis of Design

The basis of design for the proposed conceptual water management scheme is documented in **Table 14.**

Table 14: Basis of Design

Aspect	Objective	Measures	Performance Standard
Clean Water	Minimise impact to natural flow regime in Double Creek	Install clean water diversion drains to divert upslope runoff to streams	Design diversion drains with capacity to convey runoff from a 2% AEP event (Blue Book Vol 2E)
Stormwater	Water quality during construction or operational phases	Sediment Dams (may be incorporated with water storage dams)	Managing Urban Stormwater (Blue Book) Contain runoff from a 5 day 95th percentile rainfall event (may also include additional capacity for storage of operational water) (Blue Book Vol 2E)

Aspect	Objective	Measures	Performance Standard
Wastewater - Pollution control in infrastructure area	Minimise potential for pollutants to enter streams	Surface water contained and re-used within infrastructure area. Runoff stored in Infrastructure Dam Grease and oil trap at workshop. Appropriate storage of hazardous chemicals	Overtopping less than 1 in 20 years (Overtops into Farm Dam not directly to Double Creek) as demonstrated by water balance modelling. (Blue Book Vol 2E) [Overall capacity also greater than 100-year 3-day runoff]
Water security (during extended dry weather)	Adequate supply of water reliably available for operations and dust suppression	Site dams include additional capacity for storage of operational water. Runoff captured during wet weather would be used to supplement water supply during dry weather On site water supplemented by external supply via a licensed groundwater bore when required.	WBM modelling demonstrates that there is always adequate water for operations and environmental controls (based on historical rainfall records). WBM sensitivity analysis including climate change scenarios demonstrates robustness of water supply
Planned discharges (during extended wet weather)	Allow excess stormwater to be treated and discharged in a controlled manner, reducing the frequency of unplanned discharge from dams (via spillways) during extreme rainfall or extended wet weather. Control water quality of site discharges Minimise water quality impact along Double Creek	Stormwater will be pumped from site storages to the Farm Dam, where it may be treated and released to Double Creek when water quality is verified as complying with discharge limits.	Planned discharges limited to 8 ML each and one discharge per 3 days Water quality of planned discharges within discharge limits Monitor water quality at different points along Double Creek and, if identified, exceedances of trigger values reported and investigated
Uncontrolled discharges (extreme rainfall)	Allow safe discharge of site water during extreme rainfall events Limit frequency of potentially dirty water leaving site	Spillways at the Main Dam and Infrastructure Dam will allow safe overtopping into the Farm Dam. Water will discharge to Double Creek via a spillway at the Farm Dam	Drains and spillways able to safely discharge 1% AEP event Unplanned discharges occur less than 1 in 5 years
Flooding along Double Creek	Dams and roads are safe during extreme rainfall events	Along the Maytoms Lane/haul road section predicted to flood in 1% AEP – flood warning signs, depth indicators, stable design of road embankments capable of withstanding flood.	Dams and roads have immunity for the 1% AEP event.

6.4 Proposed Water Management System

The Water Management System (WMS) will include water infrastructure to capture, store, treat and discharge surface water. This will include a number of dams with functions as described below.

Farm Dam (8 ML) –. In subsequent stages it would be used only to hold water for treatment (flocculation) prior to discharging water off-site during periods of extended rainfall.

Infrastructure Sump (41.5 ML) – for sediment control during the initial construction stage, as well as to capture, store and re-use runoff in the product processing/workshop/ stockpile area which has a higher potential for water to contain pollutants. It is sized so that it overflows very rarely (less than 1 in 100 years). If overflow does occur during rare events, flows are diverted into the Farm Dam to inhibit uncontrolled discharge off-site. If water demands from the Infrastructure Sump cannot be met, water is pumped to the Infrastructure Sump from the Main Dam. The processing/stockpiling hardstand should grade towards the Infrastructure Sump.

Pit Sump (13 ML) – to capture and store potentially sediment laden stormwater from the operational quarry, clean runoff area, and associated access roads. It is envisaged that this would include a smaller sump (maybe 20 m x 30 m) to collect ‘every day’ water, plus a much broader inundation area to contain runoff from much rarer events. Water from the Pit Sump will be pumped out to the Main Dam for operational use and to maintain low water levels within the Pit Sump to avoid nuisance flooding within the quarry works area. The Pit Sump would need to contain substantial volumes of water several times a year, but this water could be pumped out within a week or so to allow operations to recommence. The Pit Sump could be formed by situating the haul road to run around the top of a bund of natural material elevated 3 m above the Stage 5 base level.

Main Dam (up to 40 ML) – The required capacity would be proportionate to the disturbance area, so would initially start out being smaller, and eventually reach 40 ML when the quarry footprint is fully developed. To receive pump-out from the Pit Sump, overflow from the Upper Dam and be the main operational water storage. This dam would be quarried into the landform rather than constructing an embankment. If water levels in the Main Dam approach capacity, water from the Main Dam is pumped into the Farm Dam for treatment and controlled off-site discharge.

Upper Dam (up to 8 ML) – to allow some water to be stored near the top of the quarry for dust suppression. It would also reduce peak flows running down the edge of the haul road. This dam may be moved down the hill once or twice with subsequent quarry stages, then eventually merge with the Pit Sump. Overflows from the Upper Dam are directed into the Haul Road Table Drain and discharge into the Pit Sump.

Sand Dam – A Sand Processing Plant Dam, referred to as the Sand Dam in this assessment, will be established adjacent to the Sand Wash Plant in the south-west corner of the processing pad. The Sand Dam will act as a sediment dam for processing water at the Sand Wash Plant, and a drain will be established on the western perimeter of the processing pad to gravity feed water from the Sand Dam to the Infrastructure Sump. The Sand Dam is sized as a part of the Infrastructure Sump volume and should be sized according to the demands of sand processing.

Haul Road Table Drain – direct overflows from Stage 6 works into a table drain alongside the haul road, and discharge into the Main Dam.

Clean Water Diversions – various clean water diversions are arranged across the site to divert potential run-on to disturbed areas. During the early quarry stages, clean water will be drained away from the disturbance area to allow discharge into Double Creek.

6.5 Staging of Quarry Development

The quarry infrastructure and extraction area will be staged over multiple phases. It is important to understand and assess the potential environmental impacts and identify the mitigation measures across the stages, as the footprint of the extraction area increases more rainfall is captured and this additional rainfall needs to be appropriately managed. There is also a complementary increase in water demand for use in dust suppression and for processing of quarry products.

The quarry will progress through multiple stages of development, with varied levels of quarry production. The following stages have been examined for the WBM and requirements for site sediment control:

Stage One: Commencement of haul road construction from Maytoms Lane to the processing pad. No on-site water storages active.

Stage Two: Initial development of the processing pad, continued development of the slot cut and commencement of the intersection and Maytoms Lane upgrade. The Infrastructure Sump, Sand Dam, and Main Dam are established.

Stage Three: Finalisation of the processing pad and the haul road to Maytoms Lane, and commencement of the internal haul road.

Stage Four: Continued internal haul road construction works and excavating the Run of Mine (ROM) pad to 105 mAHD.

Stage Five: Extraction commences at the top of the hill. The Upper Dam and Pit Sump storages are established. The Main Dam increases to maximum capacity of 20 ML.

Stage Six: Extraction continues down the eastern face to 128 mAHD. The Upper Dam increases to maximum capacity of 8 ML.

Stage Seven: Extraction down to final landform elevation of 95 mAHD; self-draining void established at 100H:1V gradient towards the Main Dam. Main Dam and Infrastructure Sumps remain in place, with capacities increased to satisfy sediment deposition volumes according to the ‘Blue Book’. These water storages are expected to ‘silt up’ over the period of rehabilitation for the final landform.

The seven stages of quarry development along with the water storages that will be available for each stage are presented in **Figure 23** through **Figure 29.**

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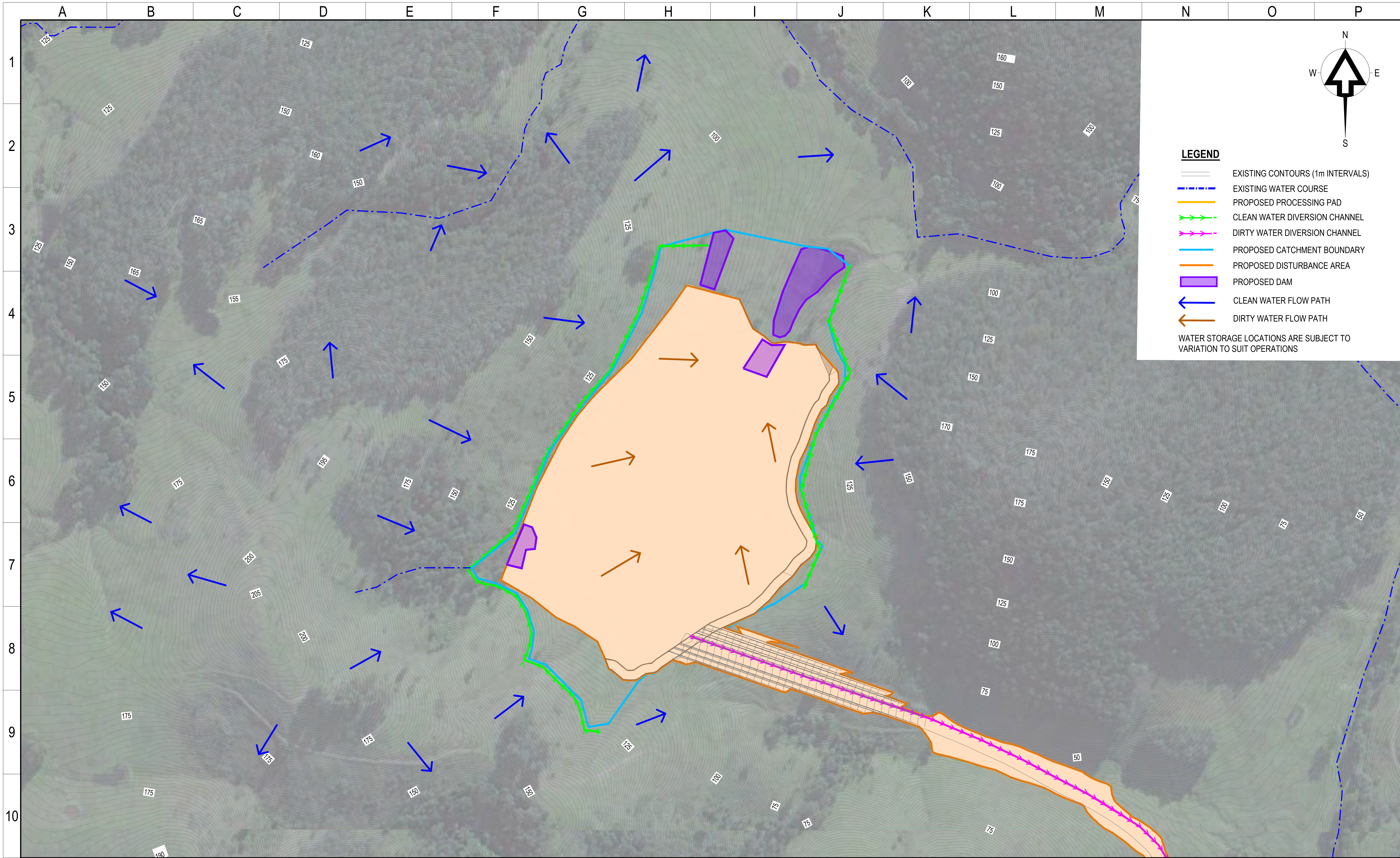

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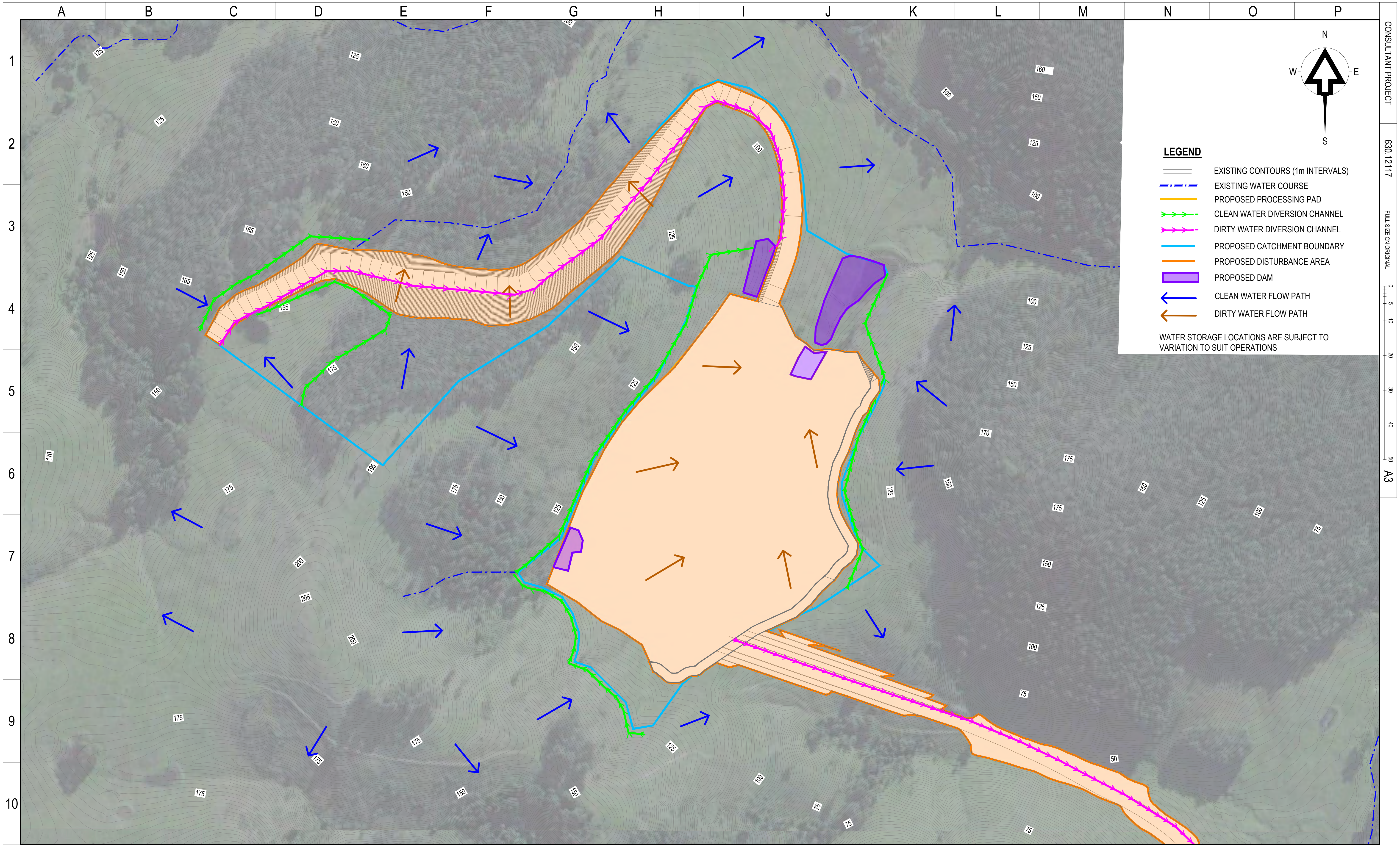

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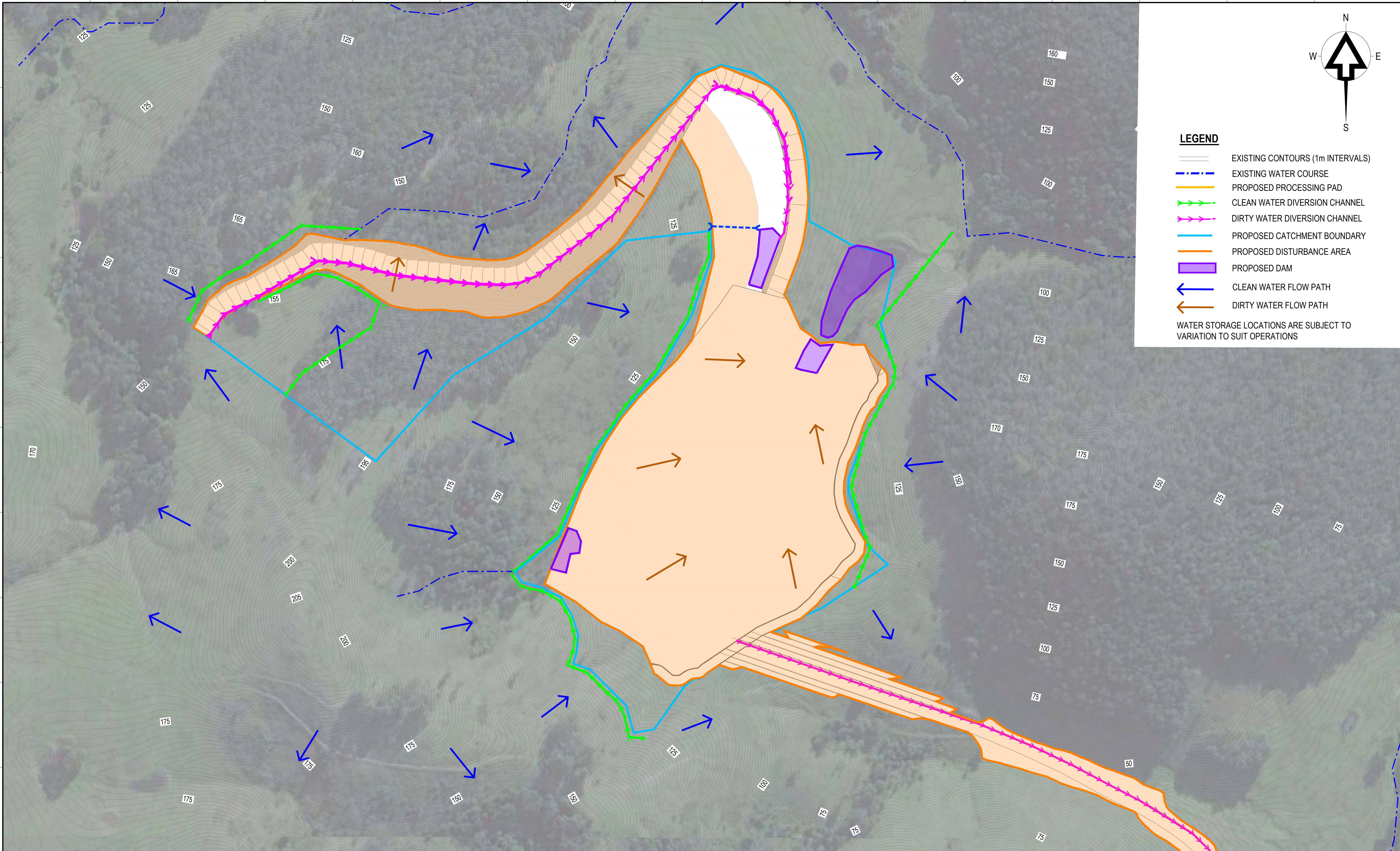

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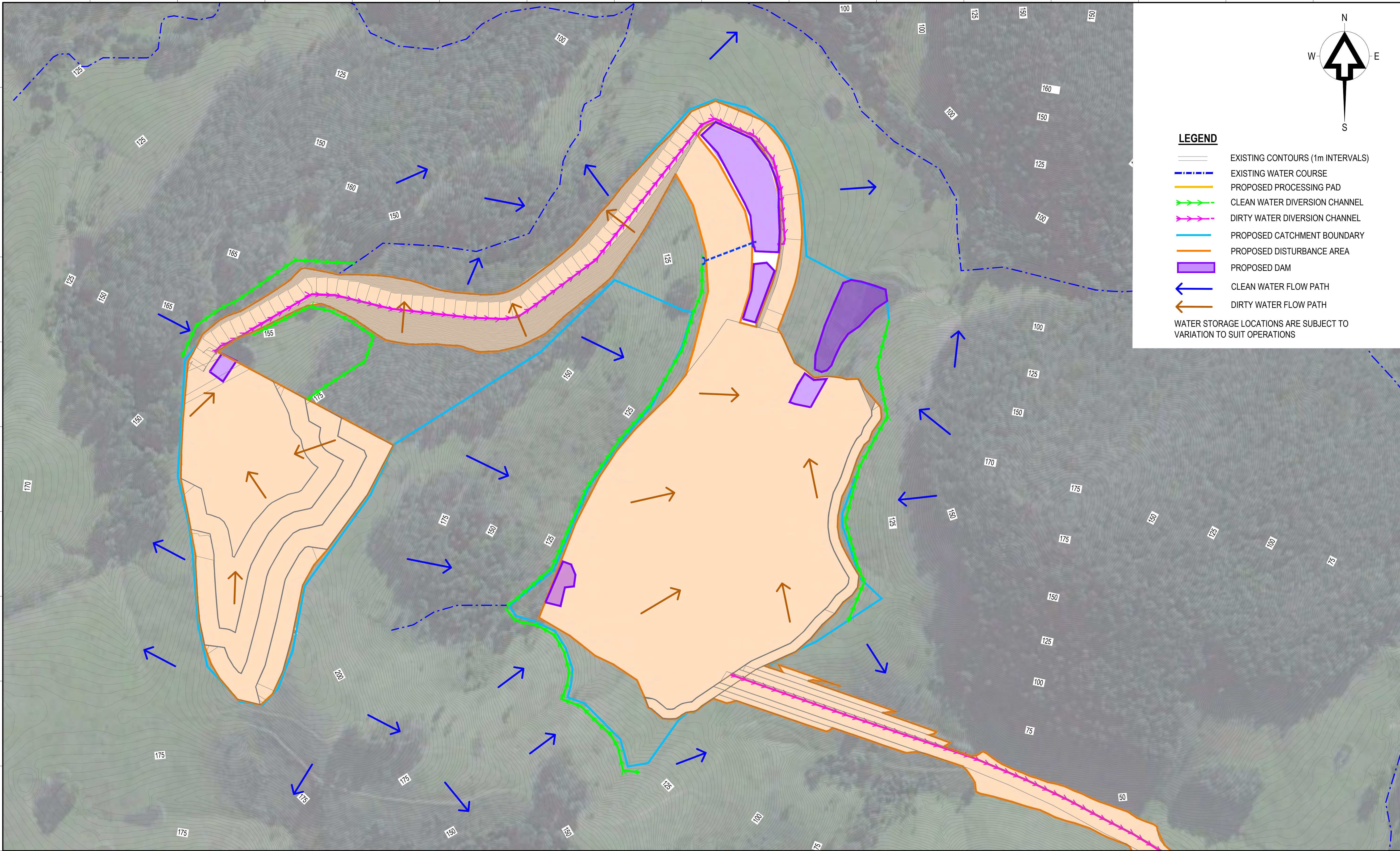

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- EXISTING WATER COURSE
- PROPOSED PROCESSING PAD
- CLEAN WATER DIVERSION CHANNEL
- DIRTY WATER DIVERSION CHANNEL
- PROPOSED CATCHMENT BOUNDARY
- PROPOSED DISTURBANCE AREA
- PROPOSED DAM
- CLEAN WATER FLOW PATH
- DIRTY WATER FLOW PATH

WATER STORAGE LOCATIONS ARE SUBJECT TO VARIATION TO SUIT OPERATIONS

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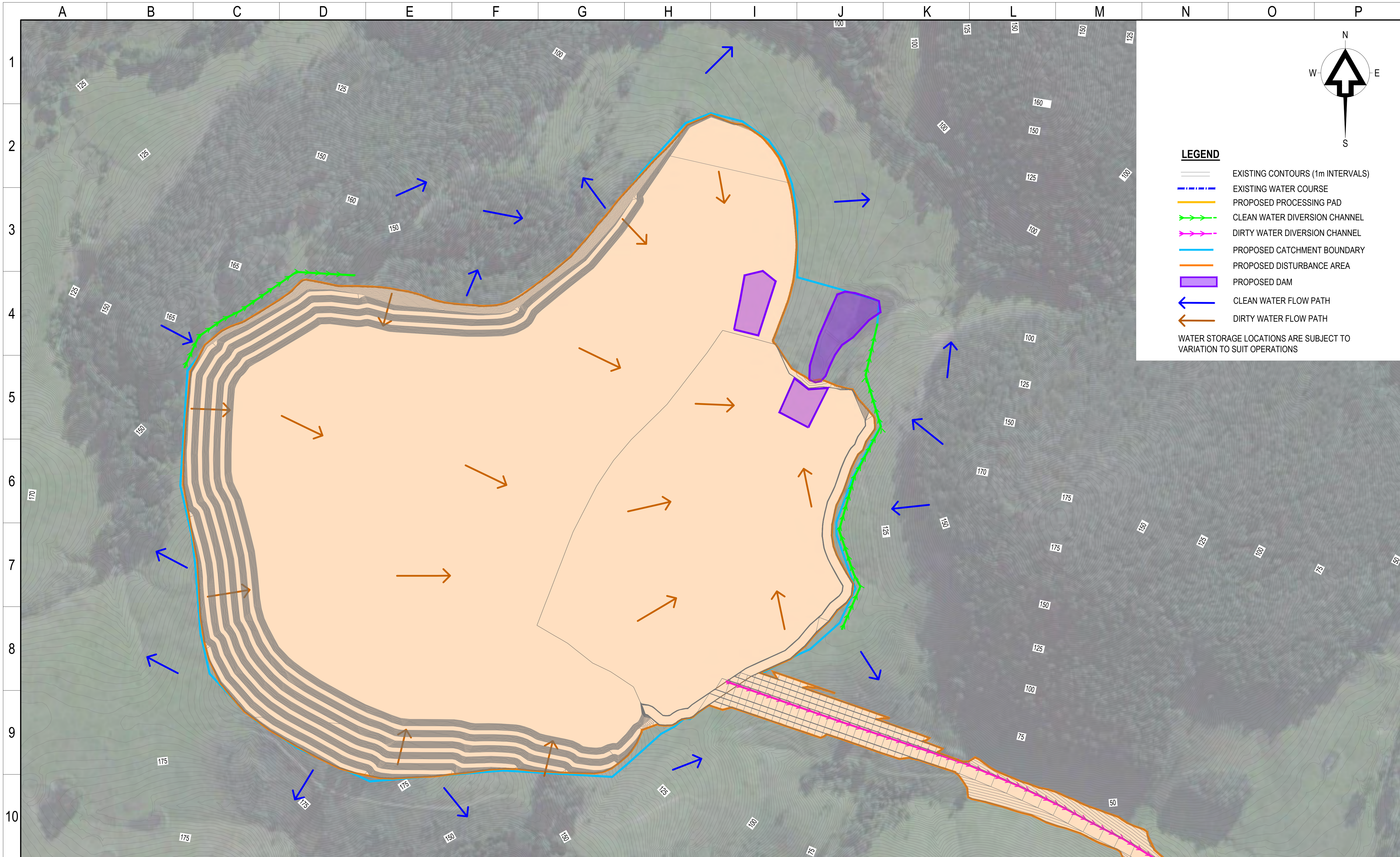

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7.0 Water Balance Modelling

7.1 Overview

The principal objectives of the Project WBM are associated with water supply and demand, and the frequency of discharge of water off-site. Specifically, the WBM aims to identify the following:

- the required capacities for site dams to meet on-site water demands during extended periods of dry weather;
- the volume of externally sourced water supply required to meet on-site water demands;
- the volume of treated water discharged from site dams to the environment as controlled discharges; and
- how often untreated water from site dams would overflow to the environment as uncontrolled discharges during extended periods of heavy rainfall.

Minimum dam sizes required for sediment control at various locations and stages of site progress have been developed for compliance with the ‘Blue Book’ (Managing Urban Stormwater: Soils and Construction Vol. 1, 4th edition and Vol. 2E Mines and Quarries (Landcom, 2004 and DECC, 2008).

The WBM assesses the likely future performance of the proposed WMS, based on the application of a long period of historical rainfall and evaporation data.

7.1.1 Model Configuration

The modelling software used to represent the Project water balance was GoldSim Version 14 (GoldSim Technology Group, 2021). Goldsim is a graphical, object-oriented system simulation software for visualising and modelling static and dynamical systems. This software is considered an industry standard in Australia for simulating the balance of water at mining/extractive operations and forecasting future water supply and demand.

The model simulates daily changes in the volumes of stored water in response to inflows (rainfall, groundwater, and externally sourced water) and outflows (evaporation, operational water demands, and controlled releases/overflows).

The following simplifications and assumptions were incorporated in the WBM:

- the WBM uses daily time steps over a simulation length of 123 years of historical daily rainfall depths as recorded at the Stroud Post Office BoM meteorological station (Station ID: 061071);
- the potential for rainfall and evaporation to change over time is recognised, and a sensitivity analysis considers the outcomes with annual rainfall shifting to be 10% wetter, and 20% drier with 10% extra evaporation. Refer **Section 7.4** for further details;
- an evaporation pan coefficient of 0.75 was applied to the evaporation data sourced from Paterson (Tocal AWS) BoM meteorological station (Station ID: 061250);
- it was assumed that water could be transferred between sumps within the working pit as required. The configuration of these sumps will change as the quarry operation progresses.
- dam capacities utilised in the GoldSim model exclude sediment storage volumes. Sediment storage volumes have been estimated using the Revised Universal Soil Loss Equation (RUSLE) calculations as per the ‘Blue Book’. Dam construction will need to include these additional volumes which are shown in **Table 20**;

- no allowance was made for leakage from the dams;
- sand processing dam is included in the storage of the processing pad and is not sized separately to the infrastructure sump dam;
- the existing ‘Farm Dam’ was assumed to have a capacity of 8 ML based on site contours;
- runoff from the quarry catchment was represented by the Australian Water Balance Model methodology, as described in **Section 7.1.2.2**;
- it was assumed that existing dams were at 25% of total capacity at the start of the GoldSim simulation. Newly constructed dams in each stage were assumed to be empty at the start of the Goldsim simulation;
- dust suppression for quarry extraction area is sourced from the ‘Main Dam’ or the ‘Upper Dam’;
- it was assumed that only 20% of the quarry extraction area will require dust suppression due to the nature of the quarry surface material. The daily application rate is 10 mm/day and is only applied when the rainfall depth is less than 4 mm;
- some progressive rehabilitation was assumed to have taken place by Stage 7; these areas would not require dust suppression; 25% of the final quarry extraction area is expected to be rehabilitated;
- dust suppression for the processing area is sourced from the ‘Infrastructure Sump’;
- it was assumed that 60% of the infrastructure and processing area will require dust suppression. The daily application rate is 10 mm/day and is applied when the rainfall depth is less than 4 mm. The application rate may be increased to 13 mm/day when the Infrastructure Sump is greater than 80% full, but only when daily rainfall is less than 3 mm;
- groundwater inflow to the extraction pit was assumed to be near zero initially and increasing to 0.4 ML/day once the extraction area footprint is fully developed; and
- a pumped groundwater supply is available when there is a shortfall in water available from site water storages with capacity to deliver 100 ML/yr commensurate with the WAL held by the proponent; and
- no potable water or wastewater was considered within the WBM.

7.1.2 Model Inflow Sources

7.1.2.1 Rainfall

Several BoM meteorological stations are located proximal to the Project site. The Stroud Post Office BoM meteorological station (Station ID: 061071) was selected for use within the WBM due to its proximity, data source size (119 years) and completeness of data. A total of 123 years of historical rainfall data (1900 to present) were used within the WBM. Average monthly rainfall statistics can be viewed in **Section 3.1.**

The modelled data represents an average over 123 years of data allowing observation of the long-term results within the WBM. From this rainfall dataset, two years were chosen to represent the 10th (1923 – dry year) and 90th percentiles (1956 – wet year) for rainfall. These values are shown in **Table 15**.

It can be seen from **Table 15** that the difference between statistical and actual precipitation for the selected dry and wet years are minimal (less than 1%) and as such these years are considered to be appropriate for use within the WBM.

Table 15: Comparison of Total Annual Precipitation

Year	Statistical Percentile Precipitation (mm)	Actual Precipitation (mm)	Difference (mm)
Dry Year (10^{th} percentile, 1923)	753.4	748.3	5.1
Wet Year (90^{th} percentile, 1956)	1,485.1	1,492.9	7.8

7.1.2.2 Runoff

The Australian Water Balance Model (AWBM) (Boughton, 2004) was used to simulate runoff from rainfall on the various catchments and landform types specific to Australia. The AWBM is a nationally recognised catchment water balance model that can relate runoff to rainfall with daily data and calculates losses from rainfall for flood hydrograph modelling. To inform runoff inputs for the Project WBM, modelling of the following three different sub-catchment types was undertaken using AWBM:

- Natural Surface/Undisturbed;
- Rehabilitated Areas;
- Hardstand; and
- Open Pit.

In the absence of recorded calibration data, AWBM parameters for natural, hardstand, open pit mining and rehabilitation areas are applied based on industry accepted values for these land types. These values are presented in **Table 16** and are deemed fit-for-purpose for the Project WBM.

Table 16: AWBM Parameters

Parameter	Natural (Undisturbed)	Hardstand	Open Pit	Rehabilitation
C1 (mm)	7	5	5	20
C2 (mm)	70	10	10	200
C3 (mm)	150	40	500	400
A1	0.134	0.134	0.134	0.134
A2	0.433	0.433	0.433	0.433
BFI	0.350	0.05	0.90	0.70
K-base	0.950	1.00	0.99	0.99
K-surf	0.350	0.10	0.10	0.68

7.1.2.3 Groundwater Inflows

The on-site WMS is predicted to interact with groundwater inflows. Groundwater inflows are defined as waters reporting to the WMS from aquifers internal to the quarry and external to the disturbance extent as induced by quarry operations. As the quarry extraction progresses, groundwater inflows are expected to gradually increase; likely peaking when the final landform is established.

Estimates of groundwater inflow to water storages at the quarry have been informed by the numerical groundwater model as described in the Groundwater Assessment. Predicted groundwater inflows used within the WBM for each quarry stage and water storage are provided in **Table 17**.

Table 17: WBM – Groundwater Inflow Rates

Quarry Stage	Groundwater Inflow rate (ML/day)				
	Main Dam (ML/day)	Upper Dam (ML/day)	Pit Sump (ML/day)	Infrastructure Sump (ML/day)	Farm Dam (ML/day)
Stage 1	Not Constructed			No groundwater inflows forecasted	
Stage 2	0.015	Not Constructed			
Stage 3	0.015	Not Constructed			
Stage 4	0.023	Not Constructed			
Stage 5	0.017	0.009	0.027		
Stage 6	0.059	0.032	0.091		
Stage 7	0.091	Decommissioned			

7.1.2.4 External Water Import

Coast Wide Materials Pty Ltd hold a WAL (WAL 44439) that permits up to 100 ML/yr of groundwater extraction from the New England Fold Best Coast Groundwater Source, a hard rock groundwater source defined under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwaters Sources 2016.

The WAL is not currently linked to any bores, however SLR understands that a water supply bore(s) may be installed in future to supplement water demand during the life of the Project.

7.1.3 Model Outflow Sources

7.1.3.1 Quarry Processing

The quarried product will require a constant water source for processing throughout the Project. Water used to meet processing needs would be recycled on-site to minimise demand for water inputs. The quarried product is assumed to have a water content of 0.03 kL/tonne. At a maximum production rate of 0.6 Mt/year, this equates to a water demand of 0.05 ML/day.

7.1.3.2 Dust Suppression

Spraying of water by tanker or other means is a major water demand at quarries and is necessary to reduce the generation of dust. The rate of water application for dust suppression is dependent on the prevailing climatic conditions and rainfall.

The following assumptions for dust suppression demand were made within the WBM:

- only 20% of the quarry extraction area will require dust suppression due to the nature of the quarry surface material. The daily application rate is 10 mm/day and is applied when the rainfall depth is less than 4 mm. Average total demand is 0.4 ML/day;
- 100% of the haul road area will require dust suppression. The daily application rate is 10 mm/day and is applied when the rainfall depth is less than 4 mm. Average total demand is 0.2 ML/day;
- 100% of the access road area will require dust suppression during construction phase in stage one, before the road is sealed. The daily application rate is 10 mm/day and is applied when the rainfall depth is less than 4 mm;
- some progressive rehabilitation was assumed to have taken place by Stage 7; these areas would not require dust suppression; 25% of the final quarry extraction area is expected to be rehabilitated;

- water from the Infrastructure Sump is utilised for dust suppression of the processing area only, so to separate the potentially contaminated water from the dirty water system; and
- it was assumed that 60% of the infrastructure and processing area will require dust suppression. The daily application rate is 10 mm/day and is only applied when the rainfall depth is less than 4 mm. The application rate may be increased to 14 mm/day when the Infrastructure Sump is greater than 80% full, but only when daily rainfall is less than 3 mm.
- No dust suppression required for final landform as no disturbance occurs on site.
- Storages including the Main Dam, Upper Dam, and Infrastructure Sump increase in demand if storages reach 80% capacity. Increase in dust suppression demands shown in **Table 19**.

Water required for dust suppression of the quarry haul road is preferentially sourced from the Upper Dam to avoid large amounts of water being frequently trucked up the hill. However, as required to meet the demands of the Upper Dam, water may be trucked from the Main Dam with an assumed truck capacity of 6 ML/truck/day.

Dust suppression demands employed in the WBM for each stage are shown in **Table 18**.

Table 18: Dust Suppression Demands

Quarry Stage	Dust Suppression rate (ML/day)				
	Main Dam (ML/day)	Upper Dam (ML/day)	Pit Sump (ML/day)	Infrastructure Sump (ML/day)	Farm Dam (ML/day)
Stage 1	Not Constructed				0.50
Stage 2	0.0	Not Constructed		0.60	0
Stage 3	0.21	Not Constructed	0	0.60	0
Stage 4	0.28	Not Constructed	0	0.60	0
Stage 5	0.07	0.32	0	0.60	0
Stage 6	0.07	0.47	0	0.60	0
Stage 7	0	Closed		0	0

Table 19: Increased Dust Suppression Demands

Quarry Stage	Dust Suppression (ML/day)				
	Main Dam (ML/day)	Upper Dam (ML/day)	Pit Sump (ML/day)	Infrastructure Sump (ML/day)	Farm Dam (ML/day)
Stage 1	Not Constructed				0.5
Stage 2	0.0	Not Constructed		1	0
Stage 3	0.21	Not Constructed	0	1	0
Stage 4	0.32	Not Constructed	0	1	0
Stage 5	0.11	0.48	0	1	0
Stage 6	0.11	0.96	0	1	0
Stage 7	0	Closed		0	0

7.1.3.3 Evaporation

A proportion of water at the site will be lost naturally through evaporation. This will impact water storages and water sprayed for dust suppression. Evaporation data from Paterson (Tocal AWS) BoM meteorological station (Station ID: 061250) has been analysed to provide monthly evaporation rates for input into the WBM.

The recorded average annual evaporation is approximately 1,550.9 mm. Average monthly evaporation statistics can be viewed in **Section 3.2.**

7.1.3.4 Site Discharges

A Licenced Discharge Point (LDP) will be established at the Farm Dam when an EPL is issued for the Project. The LDP has been included in the WBM and is modelled as following a controlled release scheme of 8 ML (the estimated existing Farm Dam capacity) every 3 days allowing for flocculation in the dam to occur to completion. This is modelled to occur when the Farm Dam reaches 80% capacity. The capacity of the Farm Dam is sufficient to meet the design criteria described in **Section 6.3** and therefore uncontrolled discharges are only expected during extreme storm events.

If uncontrolled overflow occurs at any other water storage within the WMS, the overflow is to remain on-site.

7.1.4 Sediment Basin Sizing

The minimum capacity required for sediment basins have been determined in accordance with the ‘Blue Book’. Proposed capacity of some dams may be larger to accommodate operational water storage.

The settling zone capacity design to capture runoff from a 5-day 95th percentile rainfall depth is calculated in accordance with the ‘Blue Book’, using the following parameters:

- Volumetric disturbed runoff coefficient (Cv) of 0.75, 0.86, 0.86, and 0.9 for the Infrastructure Sump, Main Dam, Pit Sump, and Upper Dam respectively;
- Volumetric clean runoff coefficient (CCv) of 0.3 as a best estimate of pervious areas; and
- 95th percentile rainfall (R) 91.5 mm corresponding to the closest given value (Nelson Bay).

Annual sediment loads were calculated using the RUSLE equation in accordance with the ‘Blue Book’, using the following parameters:

- Erosion control practice factor (P) of 1.3 corresponding to a compacted and smooth surface;
- Rainfall erosivity factor (R) of 2750 corresponding to the location of the site on the 'Blue Book' erosivity map;
- Soil erodibility factor (K) of 0.05 corresponding to the 'Blue Book' safe/conservative value; and
- Ground cover and management factor (C) of 1 corresponding to a mostly disturbed surface with very limited grass cover surface.

Required water storage volumes for sediment control are shown in **Table 20**. It should be noted that since the volumes required are multi-day events, these volumes are included in the WBM. However, additional storage is required for the storage of accumulated sediments in the base of dams.

Table 20: Water Storage Capacities and Sedimentation Deposition Rates

Water Storage	Settling Zone Volume (5-day 95%ile rainfall) (ML)	Annual Sediment Volume from RUSLE (ML)	Reduction Factor & Comments	Number of years sediment storage	Factored Sediment Volume (ML)	Dam/Sump Volume [Goldsim] (ML)	Required Minimum Volume (ML)
Main Dam	12.31	1.45	0.5[2]	3	2.2	40	42.2
Upper Dam	13.63	2.27	0.5[2]	3	3.4	8	11.4
Pit Sump	11.90	1.30	0.5[2]	2	1.3	13	14.3
Infrastructure Sump	8.35	1.58	0.5[2]	3	2.4	41.5	43.9
Farm Dam	8.0	0.2[1]	Nil	3	0.6	8	8.6

1. Assume clean water diversions are built prior to disturbance. Sediment volume based on professional judgement.

2. Assume coir sediment trap upstream of the water storage.

7.2 Dam Storage Management

On-site water storages will require ongoing management to ensure ample capacity is available to capture rainfall runoff for which they were designed. This will be achieved by following a set of Dam Operating Rules as outlined in **Table 21**. Management will be centred around pumped transfers between water storages when particular storage levels are reached with the goal of conforming to the defined operating volumes for each water storage. Dam capacities, operating volumes, dimensions, reporting catchments/dams and the operating rules are summarised in **Table 21**.

Table 21: Dam System Volumes and Surface Areas as Modified in GoldSim

Water Storage	Total Capacity (ML)	Operating Volume (ML)	Surface Area at top water level (ha)	WBM Initial Volume (ML)*	Overflow Receiver	Dam Operating Rules		
						To	Rate (ML/day)	When
Main Dam	20-40	0.074-0.287[1]	0.35	0-5[1]	Farm Dam	Farm Dam	5	90% full

Water Storage	Total Capacity (ML)	Operating Volume (ML)	Surface Area at top water level (ha)	WBM Initial Volume (ML)*	Overflow Receiver	Dam Operating Rules		
						To	Rate (ML/day)	When
						Upper Dam	6	Upper Dam is < operating volume
						Infrastructure Sump	0.72	Infrastructure Sump is < operating volume
Upper Dam	8	0.374-0.63[1]	0.05	1.75-2[1]	Pit Sump	-	-	-
Pit Sump	13	Emptied to avoid interruption to operations	1.5	0-3.25[1]	Main Dam	Main Dam	0.6	40% full
						Main Dam	0.3	Less than 40% full
Infra-structure Sump	41.5	0.698-0.998[1]	0.5	10.375	Farm Dam	Farm Dam	-	If overflow occurs
Farm Dam	8	Nil	0.36	2-4[1]	Offsite	Offsite	Allow 3 days for flocculation then empty (8 ML/day)	80% full

1. Volumes are subject to variation based on quarry staging and demand rules outlined in **Section 7.1.3.2**. Initial Volume for Stage 7: Volume is assumed 0 ML at the start of the stage in which the storage is constructed.

7.3 Water Balance Model Results

Average year results of the site water balance modelled over a 123-year period are summarised in **Table 22.**

7.3.1 Extreme Dry Conditions

To demonstrate performance of the water balance during extreme dry conditions, the driest year scenario was simulated, and the attributes of that year are summarised in **Table 23**.

The dry conditions were simulated using the 10th percentile annual rainfall record, which was 1923, with an annual rainfall of 753.4 mm. which is outlined in **Section 3.1.**

7.3.2 Extreme Wet Conditions

To demonstrate performance of the water balance during extreme wet conditions, the wettest year scenario was simulated, and the respective attribute of that year is summarised in **Table 24.**

The wet conditions were simulated using the 90th percentile annual rainfall record, which was 1956, with an annual rainfall of 1529.4 mm. which is outlined in **Section 3.1.**

Table 22: Water Balance Results – Average Climate Conditions

		Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
	Description	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**
Model Inflows	Catchment runoff	63.9	76.1	76.1	99.8	100.5
	Groundwater inflow	5.5	8.5	8.5	19.4	66.3
	External Water Requirements	100	100	100	100	100
	Total Input	169.4	184.6	184.6	219.3	266.8
Model Outflows	Evaporation (from water storages)	14.0	14.0	14.0	21.4	21.5
	Dust suppression	189.1	256.4	277.6	312.3	364.5
	Quarry products processing	5.5	7.3	9.1	11.0	18.3
	Total Output	208.6	277.7	300.7	344.7	404.3
Off-Site Discharge	Controlled release (treated)	11.3	11.3	11.3	11.9	17.0
	Off-site overflow (untreated)	0.0	0.0	0.0	0.0	0.1
	Total Off-Site Discharge	11.3	11.3	11.3	11.9	17.1

Table 22 indicates that in an average year, 12.6 ML of treated water would be released off-site. The GoldSim analysis also indicates that in an average year 100 L of water would need to be imported from groundwater bores to site in order to cover the dust suppression and processing demands when there is insufficient water available in site dams from rainfall runoff. Over a 123-year period, the site has an average overflow frequency of 0.12 occurrences per year (1 in 8.3 years), discharging an average of 0.03 ML/Year.

Table 23: Water Balance Results – Extreme Dry Climate Conditions

		Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
	Description	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**
Model Inflows	Catchment runoff	31.0	35.3	35.2	49.3	49.6
	Groundwater inflow	5.5	8.5	8.5	19.5	66.5
	External Water Requirements	100	100	100	100	100
	Total Input	136.5	143.8	143.7	168.8	216.1
Model Outflows	Evaporation (from water storages)	14.1	14.1	14.1	21.5	21.6
	Dust suppression	194.8	263.9	285.6	321.3	374.7
	Quarry products processing	5.5	7.3	9.1	11.0	18.3
	Total Output	214.4	285.3	308.8	353.8	414.6
Off-Site Discharge	Controlled release (treated)	0.0	0.0	0.0	0.0	0.0
	Off-site overflow (untreated)	0.0	0.0	0.0	0.0	0.0
	Total Off-Site Discharge	0.0	0.0	0.0	0.0	0.0

Table 23 indicates that 0 ML of treated water would be released off-site in the extreme dry year. The GoldSim analysis also indicates that 100 L of water would need to be imported from groundwater bores to site in order to cover the dust suppression and processing demands when there is insufficient water available in site dams from rainfall runoff. Over this year, the site does not overflow within any of the 5 stages.

Table 24: Water Balance Results – Extreme Wet Climate Conditions

		Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
	Description	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**	**Average (ML/year)**
Model Inflows	Catchment runoff	115.4	140.5	140.5	176.5	177.6
	Groundwater inflow	5.5	8.5	8.5	19.5	66.7
	External Water Requirements	0	0	0	0	0
	Total Input	120.9	149.0	149.0	196.0	244.3
Model Outflows	Evaporation (from water storages)	14.1	14.1	14.1	21.6	21.7
	Dust suppression	185.8	251.7	272.5	306.6	357.8
	Quarry products processing	5.5	7.3	9.1	11.0	18.3
	Total Output	205.4	273.1	295.7	339.2	397.8
Off-Site Discharge	Controlled release (treated)	32.0	32.0	32.0	51.8	147.4
	Off-site overflow (untreated)	1.5	1.5	1.5	0.0	0.1
	Total Off-Site Discharge	33.5	33.5	33.5	51.8	147.5

Table 24 indicates that in the extreme dry year, 12.6 ML of treated water would be released off-site. The GoldSim analysis also indicates that in an average year 0 L of water would need to be imported from groundwater bores to site in order to cover the dust suppression and processing demands when there is insufficient water available in site dams from rainfall runoff. Over this year, the site has an average overflow frequency of 2.32 occurrences per year (1 in 5.2 Months), discharging a maximum of 1.52 ML in any of the 5 stages.

7.3.3 Staged Overflow Frequency and Volume

The storage levels within each of the individual dam systems are also presented **Figure 30** to **Figure 48** below. These figures show the storage levels within each of the individual dam systems over the 123-year simulation period in relation to the total storage volumes.

Figure 30 to

Figure 34 represents the Infrastructure Sump storage level over the 123-year period and indicates an irregular pattern of this dam being then filled from the Main Dam if the demands of the sump cannot be met. Losses from the sump are attributed to overflow to the Farm Dam, and utilisation to meet demand requirements.

Figure 35 to **Figure 39** presents the Farm Dam storage level over the 123-year modelling period and indicates a regular pattern of this dam being filled directly from the Infrastructure Sump, before being flocculated and discharged off site to the proposed licenced discharge point. After treatment, this water can also be utilised to fulfill on site demands if required.

Figure 40 to **Figure 44** presents the Main Dam storage level over the 123-year modelling period and indicates a trend of this dam being filled by pumping from the Pit Sump, where the rate of discharge is dependent upon the remaining capacity of the Main Dam and Pit Sump. Losses from the Main Dam are attributed to utilisation to meet demands, and discharge to the Farm Dam when remaining dam capacity is equal to or less than 10%.

Figure 45 and **Figure 46** presents the Farm Dam storage level over the 123-year modelling period and indicates a regular pattern of this dam being emptied and filled continuously through the entire period, with rare occasions of overflow in Stage 6 of the quarry progression. Frequent emptying is caused by the upper dam being utilised to satisfy dust suppression requirements for the upper quarry section, while refilling occurs through water carting from the Main Dam of up to 6 ML.

Figure 47 and **Figure 48** presents the Pit Sump storage level over the 123-year modelling period and indicates an irregular influx of water which is attributed to captured runoff from rainfall events. The Pit Sump discharges water to the Main Dam, where the rate of discharge is dependent upon the remaining capacity of the Main Dam and Pit Sump.

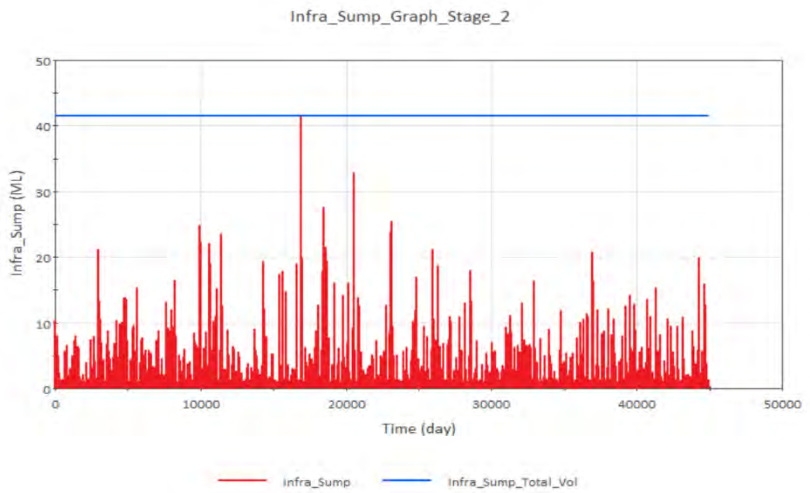


Figure 30: Infrastructure Sump Storage – Stage 2

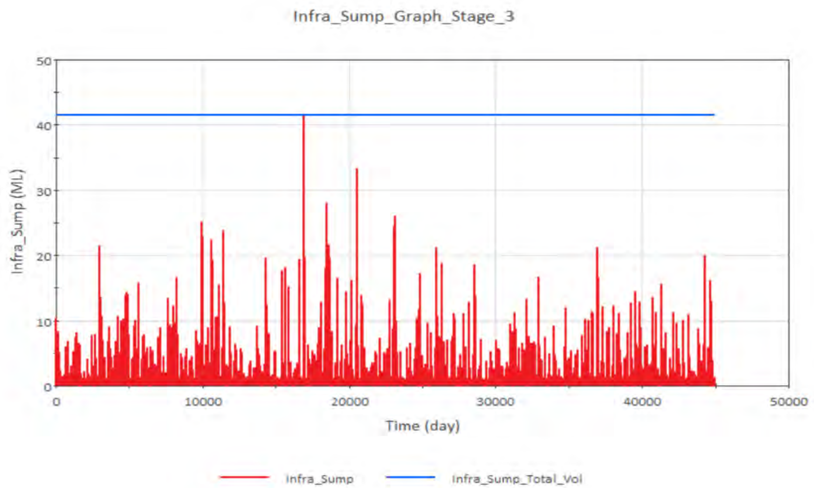


Figure 31: Infrastructure Sump Storage – Stage 3

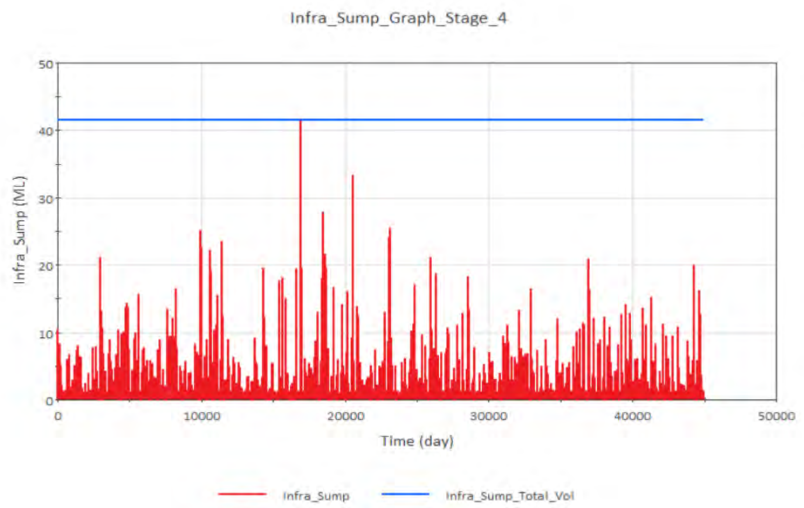


Figure 32: Infrastructure Sump Storage – Stage 4

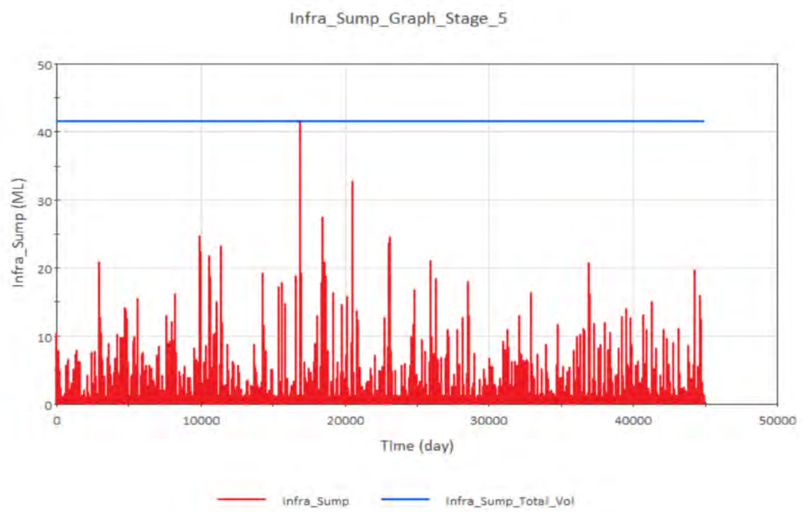


Figure 33: Infrastructure Sump Storage – Stage 5

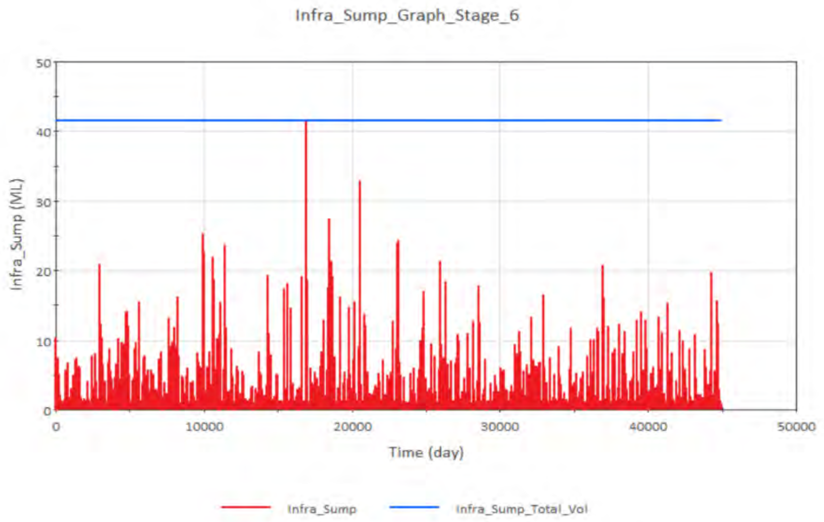


Figure 34: Infrastructure Sump Storage – Stage 6

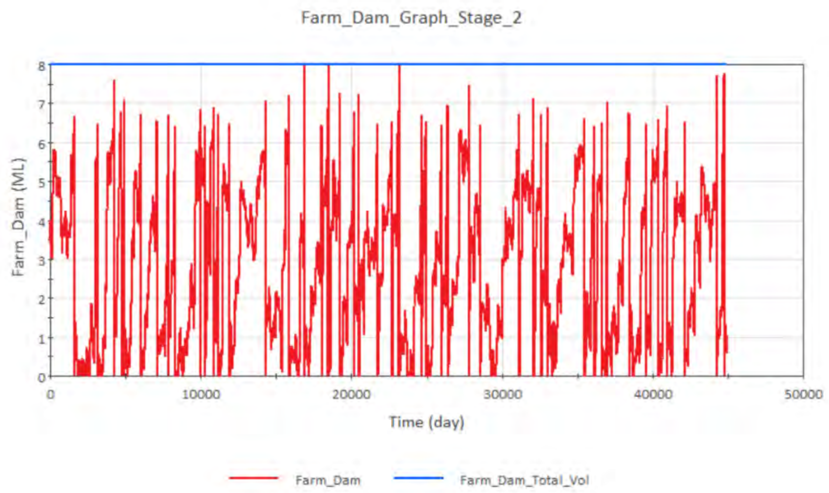


Figure 35: Farm Dam Storage – Stage 2

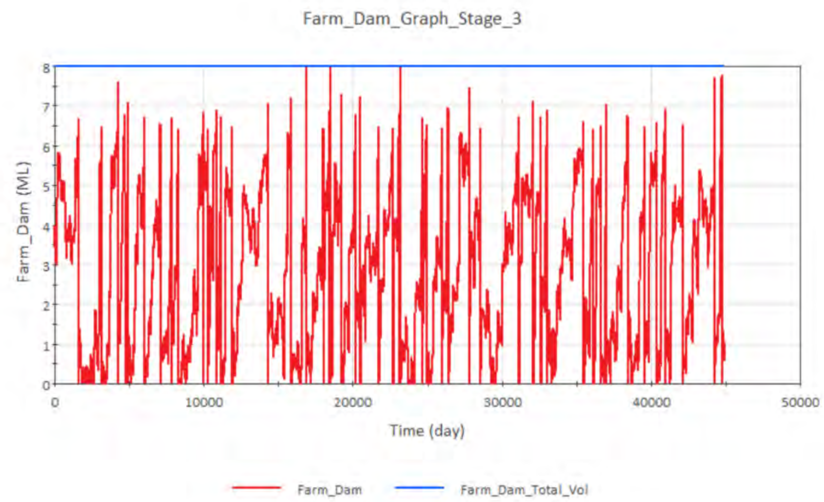


Figure 36: Farm Dam Storage – Stage 3

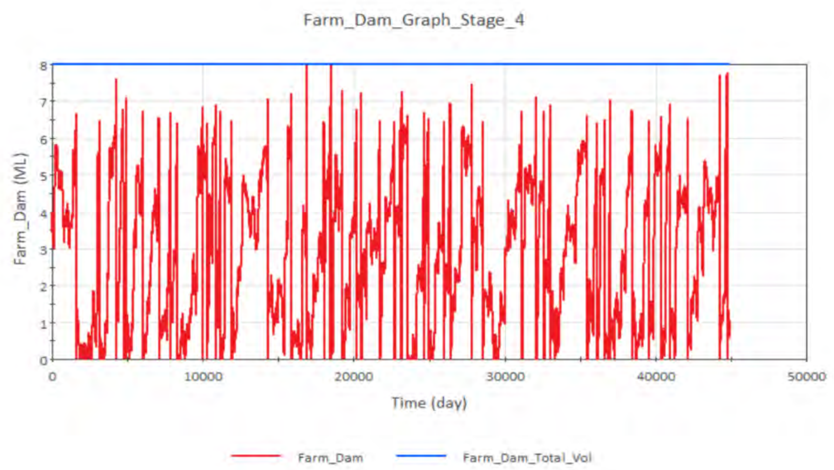


Figure 37: Farm Dam Storage – Stage 4

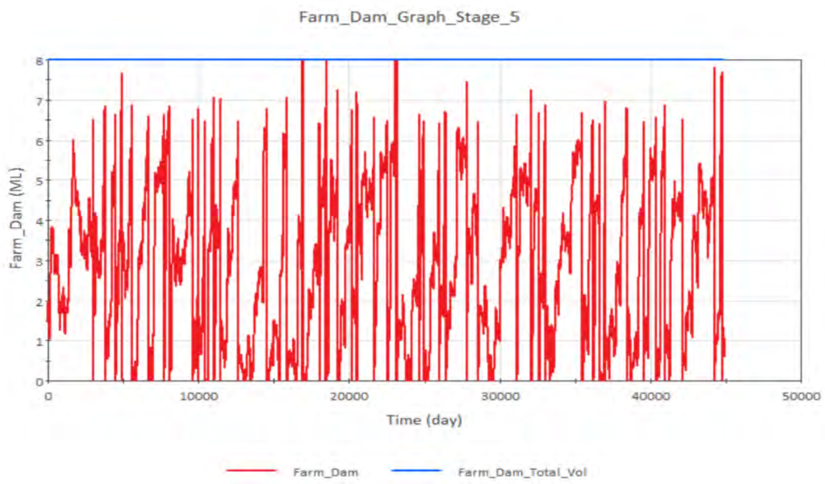


Figure 38: Farm Dam Storage – Stage 5

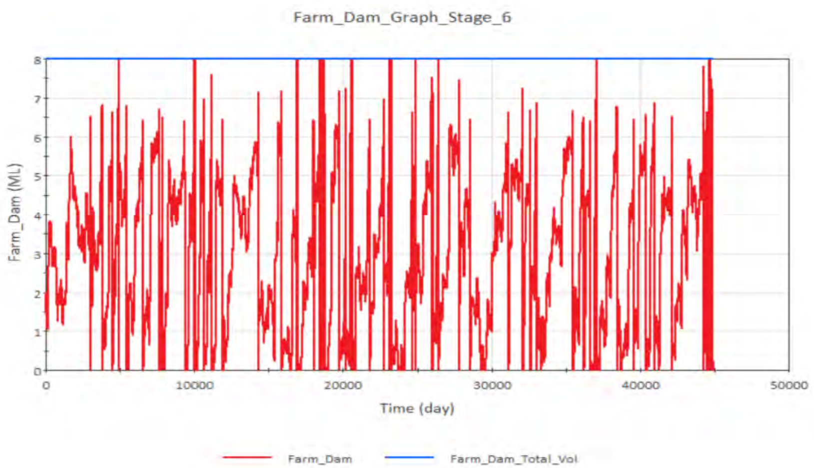


Figure 39: Farm Dam Storage – Stage 6

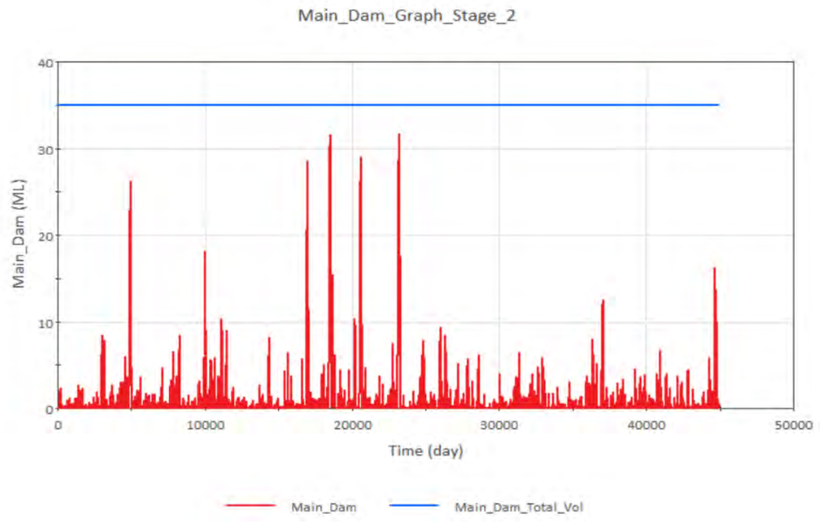


Figure 40: Main Dam Storage – Stage 2

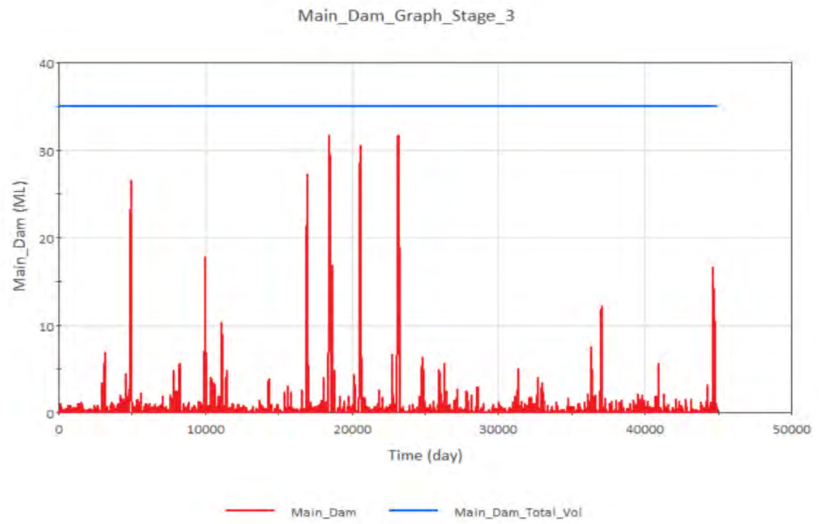


Figure 41: Main Dam Storage – Stage 3

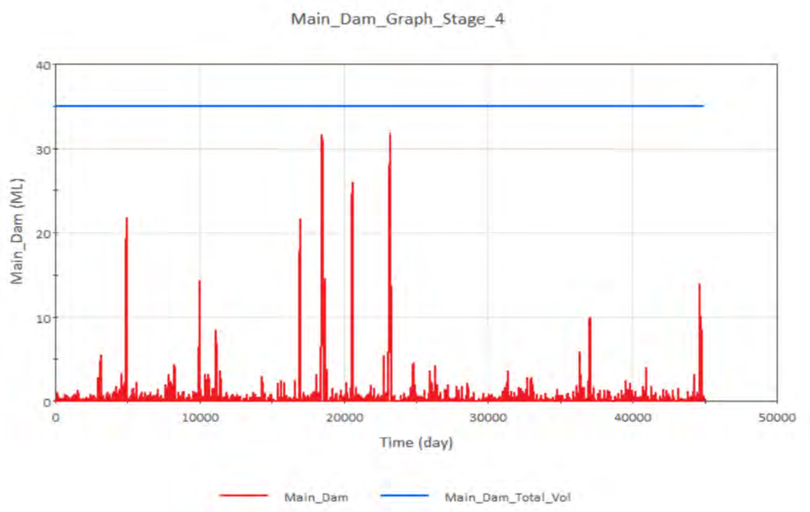


Figure 42: Main Dam Storage – Stage 4

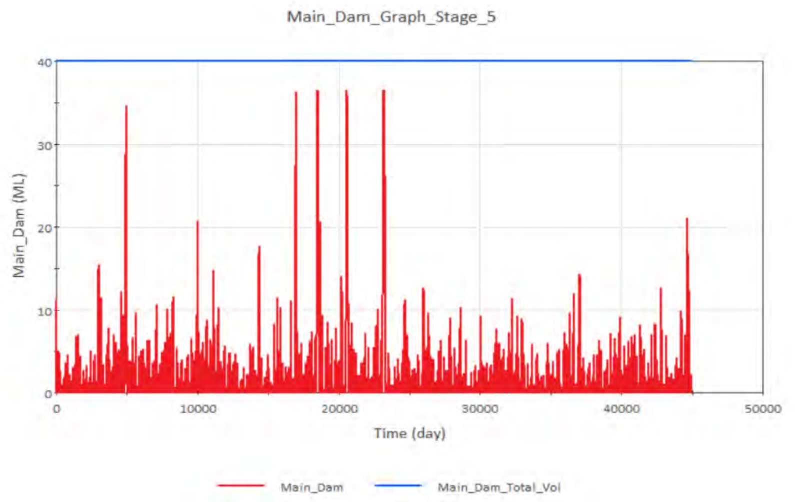


Figure 43: Main Dam Storage – Stage 5

Figure 44: Main Dam Storage – Stage 6

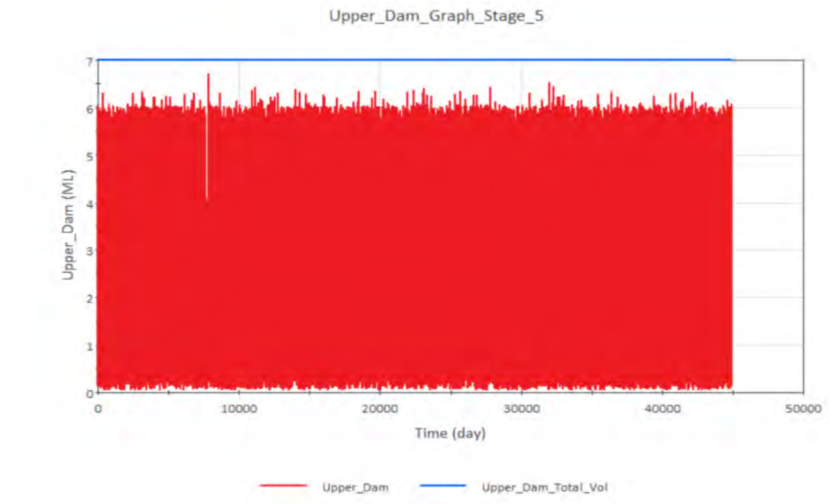


Figure 45: Upper Dam Storage – Stage 5

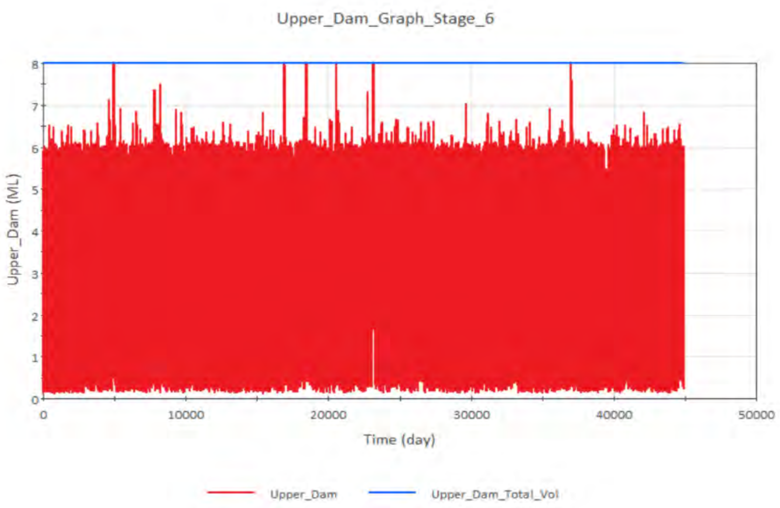


Figure 46: Upper Dam Storage – Stage 6

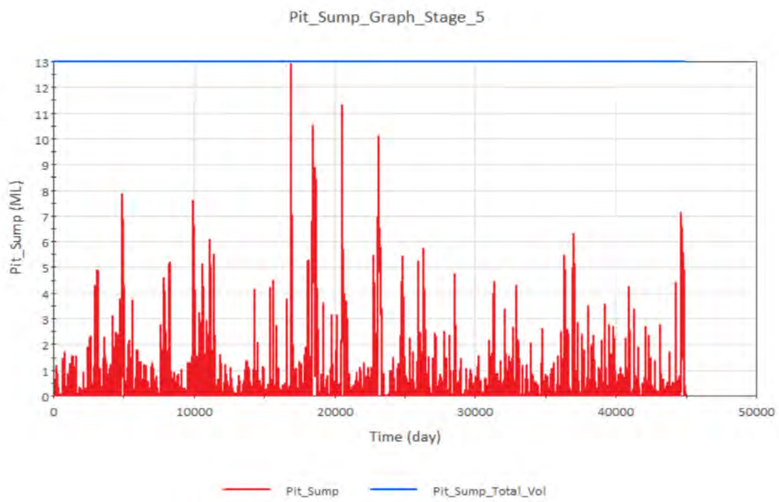


Figure 47: Pit Sump Storage – Stage 5

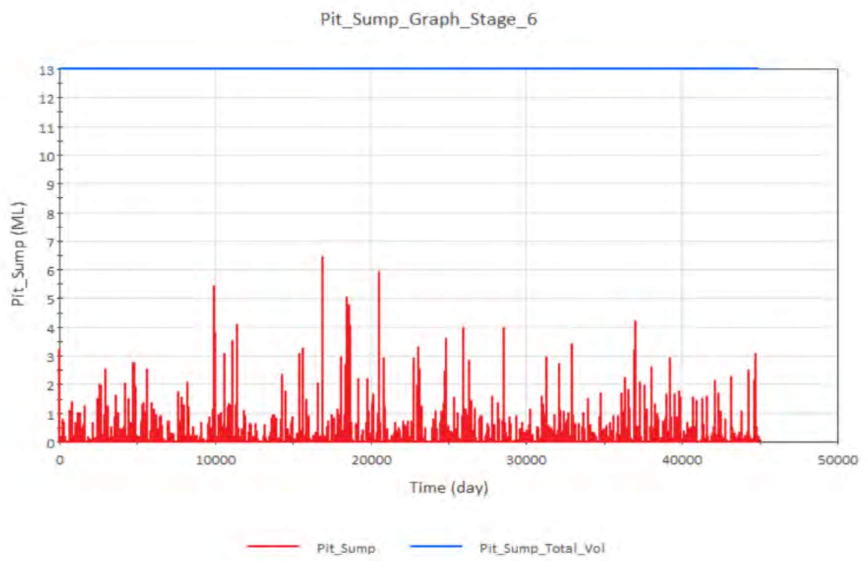


Figure 48: Pit Sump Storage – Stage 6

7.4 Sensitivity Analysis

All predictive water balance modelling has inherent uncertainty associated with it. Models are simplifications of reality and necessarily rely on assumptions and selection of uncalibrated model parameters to simulate the water balance of a system.

A sensitivity analysis has been carried out on the model to test the impact of potential variability in the modelling assumptions on the quantity of controlled discharge from site, and the required volume of external water supply required.

- rainfall increases by 10%, and rainfall reduces by 20% plus 10% increase in evaporation;
- water demands on site varied by plus and minus 10%; and
- changes in the volume of groundwater flowing into the pit, -30% to +30%.

Sensitivity analyses have been applied only to the longer-term scenario for quarry development (Stage 6). Results are presented in **Sections 7.4.1 and 7.4.2.**

7.4.1 Rainfall Sensitivity

Sensitivity of input rainfall was analysed using scenarios advised in **Section 3.3** which simulate extended dry and wet weather. Detailed results of the sensitivity analysis are presented in **Table 25.**

Table 25: Results of Sensitivity Analysis - Rainfall

	Rainfall (ML/year) (%change)		
	(-20% and Evaporation +10%)	(0%)	(+10%)
Total Runoff (ML/year)	66.6	83.3	91.6
Total Controlled Discharge off-site (ML/year)	5.4	12.6	17.0
Total External Water Supply Requirement (ML/year)	29.9	28.0	27.2

Results provided in **Table 25** correspond with modelled climactic shifts, evident in the linear relationship between rainfall and total runoff.

7.4.2 Groundwater Sensitivity

Sensitivity of groundwater inflows were analysed by assessing two scenarios outlined in **Section 7.4**. Detailed results of the sensitivity analysis are presented in **Table 26.**

Table 26: Results of Sensitivity Analysis - Groundwater

	Groundwater Inflow (ML/year) (%change)		
	(-30%)	(0%)	(+30%)
Total Runoff (ML/year)	83.3	83.3	83.3
Total Controlled Discharge off-site (ML/year)	12.2	12.6	13.3
Total External Water Supply Requirement (ML/year)	28.3	28.0	27.8

8.0 Erosion and Sediment Control

Disturbance activities associated with the Project will present the potential to generate sediment that can be transported by wind and rainfall runoff which may pose a risk to surface water quality. The level of erosion risk will vary with respect to the stage of the Project. As such, Erosion and Sediment Control (ESC) measures will need to be implemented at site as discussed in the following sections.

8.1 Construction Phase

The primary risk to surface water quality during construction is ground disturbance associated with site earthworks. Construction works will expose site soils and there is potential for erosion to mobilise sediments into receiving watercourses. Without appropriate controls there is potential for an increase in turbidity and nutrient loads in the receiving watercourses which may cause water quality and ecological impacts.

The potential for erosion will be mitigated by the following factors:

- Construction will be sequenced, such that the disturbance area at any one time will be minimised as far as practicable.
- Divert clean water around disturbed areas, keeping separate from potentially sediment laden water.
- Gentle grades, and a combination of vegetation and surface cover across the site reduce the potential for erosion or sediment transport.
- Provide a system of suitably spaced surface drains to reduce the potential for erosion by limiting the fetch of overland flows.
- Install sediment basins to capture and treat potentially sediment laden water prior to discharge.

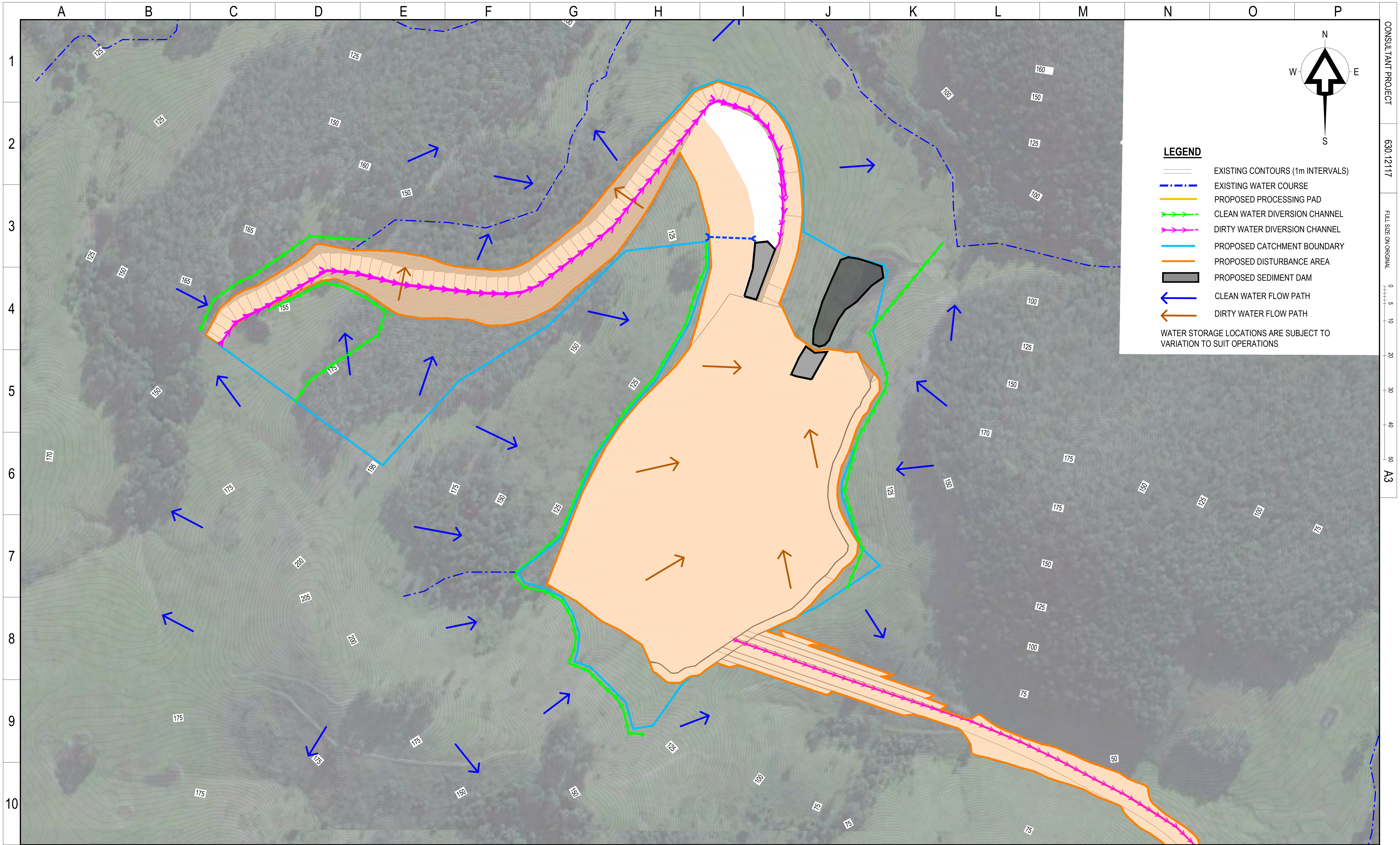
With the implementation of standard erosion and sediment control measures in accordance with Managing Urban Stormwater: Soils and Construction (Landcom 2004) the potential environmental impact is considered very low and manageable.

A site wide Erosion and Sediment Control Plan (ESCP) will be prepared as part of the Construction Environmental Management Plan (CEMP) for the Project. The ESCP will be prepared in accordance with Managing Urban Stormwater: Soils and Construction (Landcom 2004), Volume 1, 4th Edition (Landcom 2004), known as 'the Blue Book', and Volume 2E: Mines and Quarries (DECC 2008a). Mitigation measures and site management practices should include:

- Staging of construction works and progressive revegetation to limit the disturbed area.
- Establishment of 'No-go zones' to prevent unnecessary disturbance of site soils by construction vehicles in site areas outside of the construction footprint.
- Diversion of upslope runoff around the areas disturbed by earthworks.
- Installation of sediment fences around the perimeter of disturbance areas.
- Installation of sediment traps with level spreaders at locations where site overland flow paths discharge to the adjacent existing landform.
- Installation of a shaker pad at the site exit to reduce mud or clay on vehicle wheels being tracked onto external roads.
- Localised ESC measures to external batters not draining to a sediment basin, including mulching and seeding of slopes, sediment fencing, and vegetated buffer strip.

- Stabilisation of table drains alongside access tracks using vegetation and rock check dams, or rip-rap when required.
- Clean quarry end of access road with a sweeper at least fortnightly, or when there is a build-up of mud and/or silt.
- Construction, operation, and maintenance of sediment basins.
- Appropriate site storage of hydrocarbons within bunded areas, and Spill Management Plan.
- Inspection of ESC measures following heavy rainfall.
- Water quality monitoring and reporting requirements.
- Providing an appropriate level of resourcing for environmental management and monitoring.

Sediment Dams will be constructed as shown in **Figure 49.**



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PROJECT: HILLVIEW QUARRY SURFACE WATER DESIGN

DRAWING TITLE: FIGURE 49 CONSTRUCTION PHASE - SEDIMENT DAMS

DRAWING NUMBER: 630.12117 - SK08

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8.2 Operational Phase

During the quarrying of rock from the extraction area, there is a high potential for sediment laden water to be generated from access tracks, batters and stockpiles. This water will report to the base of the quarry extraction area where it can be stored. Although there is often very high capacity to store large volumes of water within the pit, it is often undesirable to store water for long periods of time since this can interfere with operations. Pit water is therefore pumped out to other site dams where it can be stored for on-site re-use, or during extended wet weather treated for planned discharge off-site.

The proposed management strategy at the Project is for pit water to be collected in a small sump at the nadir of the extraction area and pumped into the Main Dam. Storage in the Main Dam will be either:

- beneficially re-used within site for dust suppression, and product processing; or
- pumped in batches of 8 ML to the Farm Dam, where it will be flocculated to improve water quality. When water quality complies with the site water quality requirements, the water will be released to the environment as a controlled release. The discharge water quality requirements are detailed in **Section 11.5**.

Environmental management of the site WMS will be in accordance with a Water Management Plan.

ESC measures and site management practices during operation should include:

- The controlled release of water during extended wet weather to reduce the possibility of unplanned discharge of untreated water overtopping site storages.
- A wheel wash/vehicle wash for all exiting vehicles or access road to reduce tracking of dirt and mud onto the access road.
- Access road surface should be sealed.
- Progressive revegetation of disturbed surfaces.

8.3 Closure Phase

At the closure phase of the Project, surface infrastructure will be removed, and the site regraded to grades compatible with the target closure land-use. Topsoil will be replaced and the surface revegetated. Dams will remain for some time as revegetation progresses, then eventually will either be filled with locally sourced material or repurposed for alternative means.

During this phase it is likely that there will be broadscale disturbance of site soils, and there is a risk of soil erosion until an effective vegetative cover is established to stabilise the surface. Potential impacts of erosion include reduced water quality in receiving watercourses, ecological impacts associated with increased sediment load, and a potential loss of future land productivity if topsoil is eroded.

Typical NSW DPE conditions and rehabilitation objectives include:

- A safe, stable, and non-polluting site.
- Restoring land use capability to its pre-existing use.
- Ensure public safety in the community at all times.

An ESCP will be prepared for the closure activities, and will consider controls such as:

- Staging of works to limit disturbance area.
- Perimeter sediment controls.

- Temporary drainage works such as contour banks to limit the lengths of overland flow.
- The use of cover crops and/or mulches to provide temporary ground cover.

8.4 Sediment Dam Maintenance

During each Project phase, water collected in sediment dams may be beneficially used on site for dust suppression and/or irrigation purposes rather than discharged to the environment. The applicable NSW Water Quality Objectives (WQOs) as outlined in **Section 11.5** must be met prior to any discharge to the environment.

The storage capacity of the sediment dams, which is made up of the ‘settling zone’ and the ‘sediment storage zone’, will be actively managed in order to comply with the ‘Blue Book’ requirements. The following operations and maintenance actions will be carried out to ensure compliance:

- the dams must be dewatered within 5 days following rainfall, to ensure the available storage capacity is equal to the ‘settling zone’ volume; and
- the dams must be desilted when the volume of accumulated sediments exceeds the ‘sediment storage zone’ volume.

Additionally, it is recommended that the following actions be undertaken to assist in the operation and maintenance of site sediment dams:

- installation of depth markers (volume-stage) to indicate key dam levels/storages (so levels can be easily identified to prompt management actions at target depths); and
- inspections of the sediment dams will be carried out following heavy rainfalls.

9.0 Flood Assessment

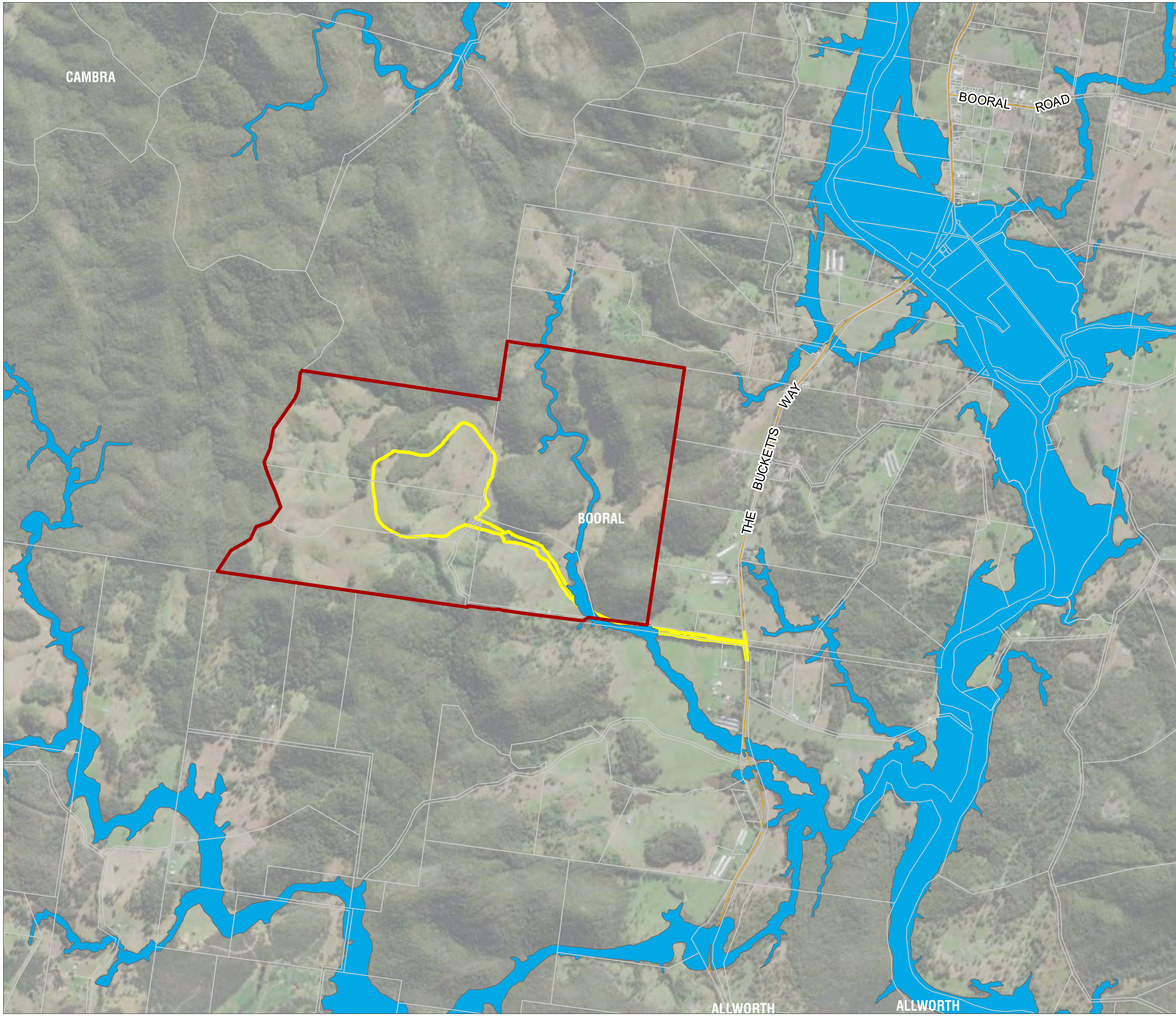
The NSW Government's Flood Prone Land Policy aims to provide solutions to existing flooding problems in developed areas and ensure that new developments are compatible with the flood hazard and do not result in additional flood problems or risks in other areas. Under the Flood Prone Land Policy, the management of flood prone land remains the responsibility of local government. To facilitate this, the NSW Government has published the *Flood Risk Management Manual: The Policy and Manual for the Management of Flood Liable Land (Department of Planning and Environment (DPE), 2023)* to guide local government authorities in the implementation of Flood Prone Land Policy and provide funding in support of floodplain management programs.

9.1 Flood Planning Mapping

The Great Lakes Local Environmental Plan 2014 contains a Flood Prone Land Map that identifies the Flood Planning Area (FPA) for the MidCoast Council LGA. The FPA pertains to a Flood Planning Level (FPL) corresponding to the 1 in 100 ARI/1% AEP rainfall event.

Figure 50 shows an extract of the FPA at the location of the Project, which indicates:

- a floodplain is identified along Double Creek within the subject site;
- the extent of recognised FPA is downstream of the proposed quarry;
- the floodplain mapping does not show any FPA immediately north of the proposed quarry extraction area; and
- the floodplain mapping does not show any FPA immediately north of the proposed quarry extraction area.



HILLVIEW QUARRY EIS SURFACE WATER ASSESSMENT

Flood Planning Area as mapped in the Great Lakes Local Environmental Plan 2014 (Flood Planning Area Map - Sheet FLD_005)

FIGURE 50

- Project Site
- Disturbnce Footprint
- Roads
- Lot
- Flood Planning Area

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)
Flood Mapping:
Great Lakes Local Environmental Plan 2014
Flood Planning Area Map - Sheet FLD_005

0 200 400 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:33,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

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9.2 Coastal Zone Management Planning

The Great Lakes Coastal Zone Management Plan (CZMP) 2016 contains areas of high importance to coastal management for the MidCoast Council LGA. The CZMP does not outline the upstream reaches of Karuah River or Double Creek as an area with requirement for coastal zone management.

The State Environmental Planning Policy (Resilience and Hazards) 2021 states:

"Development consent must not be granted to development on land identified as "proximity area for coastal wetlands" or "proximity area for littoral rainforest" on the Coastal Wetlands and Littoral Rainforests Area Map"

General information on coastal wetlands and littoral rainforest was reviewed through the SEED database. Mapping from SEED outlines that the proposed development is not on land identified as proximity area for coastal wetlands or littoral rainforest.

The proposed development and surrounding areas are not categorised as land subjected to coastal hazards or containing coastal features (coastal waters of the state, coastal lakes, coastal lagoons, land adjoining those features, including headlands and rock platforms) outlined in Part 2 – Section 7 and 8 of the Coastal Management Act 2016.

9.3 Site Specific Flood Behaviour Assessment

SLR has carried out a site-specific flood behaviour assessment in order to:

- assess any likely flooding impacts of the development; and
- assess likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users.

SLR's Flood Modelling Report is included as Appendix A of this report. The key findings are as follows:

- Detailed hydraulic modelling has confirmed the Site is unaffected by floodwaters up to and including the 1% AEP flood. This conclusion includes both backwater influences from the Double Creek catchment, and potential ponding upstream of the Maytoms Lane crossing.
- Hydraulic modelling of overland flow over the Site has confirmed erosion and mobilisation of fines is unlikely to occur after stripping vegetation cover.
- The Project does not affect flood behaviour along Double Creek. There is no increase in peak flows, velocities, or depths either upstream of downstream of the Project site.
- The development of the Maytoms Lane crossing does not increase afflux, overland and in-stream velocities, or flood hazard.

9.4 Changes in Peak Discharge

The proposed development will involve the construction of conveyance drains, containment bunds and sediment basins. These proposed changes to the topography will reduce the contributing catchment area and peak discharges downstream of the Site will reduce.

Figure 51 outlines the reduction in peak-flow due to the development.

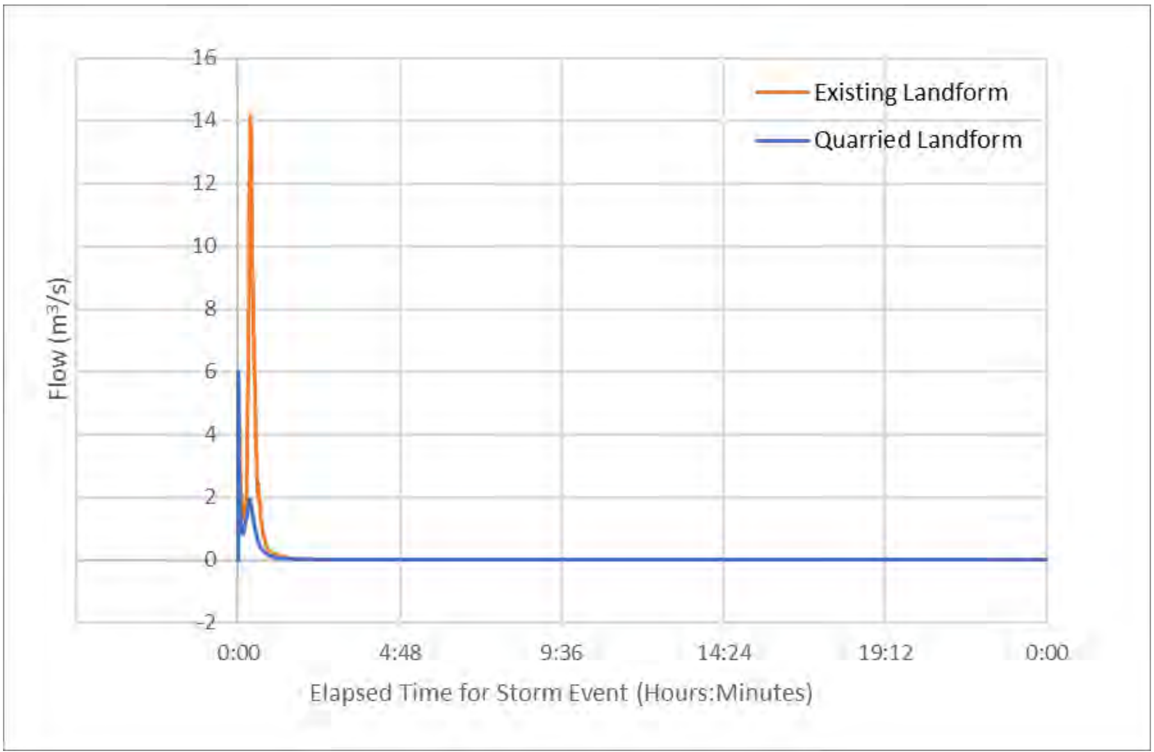


Figure 51: Peak-flow hydrographs pre- and post-development

Additionally, the development of the Maytoms Lane crossing does not impede on flow downstream.

9.5 Risk to Loss of Life

The Project will be designed to minimise risk to occupants from flooding events, in accordance with the Flood Risk Management Manual (DPE), and any relevant requirements within a Floodplain Management Plan (DPI – Water). This would include the risk of extreme events along Double Creek inundating the access road.

The direct run-on catchment area to and through the Site is only approximately 3 km^2, and therefore the run-on rate from direct rainfall is low.

The Site would be unaffected by a 1% AEP (1 in 100) in Double Creek. The conveyance of Double Creek is sufficient to convey the floodwaters downstream will very little surcharge of the overbanks, as shown in **Figure 52**.

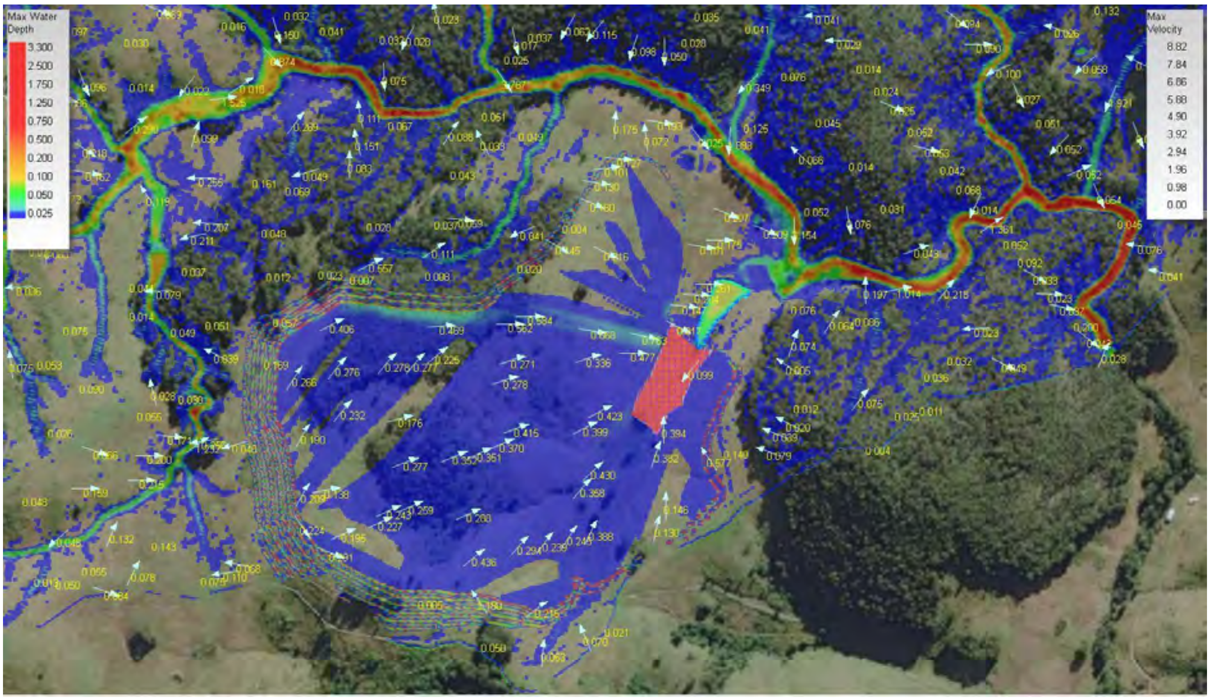


Figure 52: Inundation and velocities of the Site from a 1% AEP event in Double Creek

The Site has runoff depths of 0.05 m and velocities of up to 0.8 m/s, where these conditions are considered a very low hazard, generally safe for people, vehicles, and buildings.

During extreme rainfall events, there may be a potential risk to life associated with the Double Creek crossing egress to the site, this matter will be addressed within the detailed design stage. In the event that the creek overtops the road, then occupants should remain on Site until flood levels reduce.

10.0 Water Supply

10.1 Construction Phase

Water will be used during the construction phase earthworks for dust suppression. This water will be accessed from existing farm dams within the Project site as permitted under harvestable rights, brought to site in water tankers and sourced from site water storages as they are developed.

Construction water requirements for the Project are estimated between 0.4 ML/day to 1 ML/day.

Wastewater during construction will be captured using portable toilet systems and appropriately removed from site/disposed in accordance with Council/water authority requirements.

Potable water may be transported to site in bottles for use by the construction workforce.

As some construction activities will proceed after permanent site facilities are established (such as development of the internal haul road), requirements for water supply after this time will align with **Section 10.2.**

10.2 Operational Phase

During operation of the quarry, water will be utilised for the following purposes:

- Potable water for site offices.
- Maintenance and cleaning of site plant and infrastructure.
- Dust suppression on site access roads.

Demands for non-potable water supply will be met by drawing water from the various on-site water storages. The demands may be augmented by methods including:

- Water tanks collecting roof water at site facilities.
- Supplementary water as required via water trucked to site and stored in a water tank.

Operational water requirements for the Project have been estimated at 1 to 1.5 ML/day.

The details for provision of potable water, grey water and wastewater infrastructure would be confirmed during the detailed design phase of the Project. Water use approval is not required for State Significant Developments under section 4.41 (1)(g) of the EP&A Act.

10.2.1 Potable Water

Potable water demands will be very low, with water use limited to water used in the site office and workshop for drinking, washing, and showering. Water used for drinking will be imported to site in bottles or by tanker, and if trucked to site, stored in a water tank identified as solely for potable water supply.

Supply needs for other staff amenities will be met via rainwater collection from the rooves of the site office and workshop. Water will be treated using a proprietary water treatment system prior to use.

10.2.2 Firefighting Water

The quarry will implement static water tanks for firefighting purposes. Water for firefighting will be stored in an elevated tank situated near the site workshop and office.

This water will only be used for firefighting and not for potable water supply nor for general non-potable site water use. The firefighting water tank will be sized to comply with firefighting requirements.

The tank levels would be topped up as required from non-potable water supply sources as outlined in **Section 10.2.**

Fire water runoff from firefighting activities within the site processing area would report to and be contained in the Infrastructure Sump.

10.2.3 Sewerage

The volumes of sewage generated on site will be limited. A proprietary aerated wastewater treatment system will be installed and operated on site to treat and dispose of sewage generated by staff amenities.

A septic tank that will direct effluent to a transpiration bed is being considered within the processing area extent. As the system will be within the processing area, any overflow from the system during heavy rainfall will be directed to the Infrastructure Sump which is intended to serve as a dirty water dam.

Facilities will be established in accordance with the requirements of the MidCoast Council.

11.0 Monitoring, Licensing and Reporting

11.1 Environmental Protection Licence

Given the nature of the proposed site activities and scale of proposed extraction, the EPA will issue an EPL for the Project as required under the POEO Act. These licences focus on protecting the environment (including human health and hygiene) and address, air, noise, waste and land contamination issues as well as regulating discharges to water from premises.

To understand the range of potential pollutants contained in the discharge from a premises, a licence holder will generally need to characterise site waters that could be discharged. Through an EPL, the EPA will administer requirements to characterise site waters that could include:

- sampling and chemical analysis:
  - at each discharge point where the pollutants in the discharge may vary.
  - sampling at different times where the pollutant types and concentrations in the discharge may vary with different operational activities.
- an environmental audit of a premises to develop a profile of chemical pollutants or naturally occurring pollutants that may be in the discharge from the premises, including:
  - an inventory of the chemicals used at the premises.
  - an assessment of the risks of water pollution based on the adequacy of storage, handling, and management of the chemical pollutants at the premises.
  - an assessment of whether the activity is increasing the rate of generation of naturally occurring pollutants compared with background levels.
- comprehensive flow data on the discharge and receiving waters.
- an understanding of the environmental values of the water affected by the discharge and the practical measures available to restore or maintain those values.
- research to identify the range of pollutants commonly found in discharges from an industry type or similar premises.

An EPL requires that an 'Annual Return', comprising a Statement of Compliance and a summary of any monitoring required by the licence (including the recording of complaints), be submitted to the EPA. The proponent will need to comply with this requirement and submit the Annual Return document within 60 days after the end of each reporting period. The EPL would remain in place throughout the life of the Project.

11.2 Construction Phase

A Construction Environmental Management Plan (CEMP) will be prepared during the detailed design phase of the Project that will outline the environmental measures, monitoring and reporting required to ensure satisfactory environmental performance. Minimum requirements for inclusion within the CEMP include:

- Water quality monitoring during the construction phase will be carried out as described below for the Water Management Plan (WMP).
- An ESCP for construction activities that is consistent with the measures outlined in this EIS.

Minimum requirements for inclusion within the CEMP are documented in **Section 8.0** (ESCP) and **Section 11.7** (Hydrocarbons and chemicals) of this report.

The CEMP will apply to Stage 1 of quarry development, and at any time major construction at the site undertaken such as the establishment of the processing pad, the internal haul road, or any dam construction.

11.3 Water Management Plan

During the operational phase of the Project, which will be considered as Stage 2 of quarry development onwards, environmental matters relating to water will be managed in accordance with a Water Management Plan (WMP) (or similar document). The WMP will outline the environmental measures, monitoring and reporting required to ensure satisfactory environmental performance. It is typical for a WMP to describe the management of both surface water and groundwater at a development, or alternatively separate Surface and Groundwater Management Plans are prepared.

For surface water, minimum requirements for inclusion within the WMP include:

- Water quality monitoring from the three locations shown on **Figure 53**. Water quality monitoring is to include monitoring at the two background locations in addition to water quality monitoring at the LDP to be established at the Farm Dam. The Project water quality monitoring will initially be only from the existing Farm Dam, on the basis that this will be representative of all activities associated with the quarry;
- A Surface Water Monitoring Program (**Section 11.4**) to incorporate water quality testing for the suite of analytes identified in **Table 31**;
- Quarterly data review of monitoring results, and comparison to the trigger and background water quality;
- Annual reporting of monitoring results, and comparison to the trigger and background water quality;
- ESCP for ground disturbance activities as per **Section 8.0** of this report; and
- Requirements for storage and use of hydrocarbons and chemicals, and a Spill Management Plan, as per **Section 11.7** of this report.

11.4 Surface Water Monitoring Program

A Surface Water Monitoring Program (SWMP) will be incorporated in the WMP and followed at the site to observe any surface water quality related impacts associated with construction, operation, and closure of the Project. Key sources of potential impact include initial establishment and development works, quarrying, operation of the processing facility, stockpile areas and the supply of water to the site.

11.4.1 Baseline Data

Baseline water quality data for the Project is available from two monitoring sites established along Double Creek as discussed in **Section 5.2**. Surface water quality data was collected from the designated monitoring points between 2019 and 2020, totalling 20 and 23 sampling rounds between the two locations.

The water quality data collected from Double Creek has been used to inform water quality trigger values to be followed at the Project as discussed below.

11.4.2 Surface Water Quality Monitoring

Surface water quality monitoring will be undertaken periodically at the three monitoring locations identified in **Figure 53**.

The periodic monitoring regime will include:

- **Monthly monitoring** – Field measurement of pH, EC, temperature, TSS and Total Dissolved Solids (TDS) and laboratory measurement of pH, EC, temperature, TSS, TDS, turbidity, Total Nitrogen and Total Phosphorous; and
- **Quarterly monitoring** – Field measurement of pH, EC, temperature, TSS and TDS and laboratory measurement of pH, EC, temperature, TSS, TDS, turbidity, DO, fluoride, sulphate, total alkalinity, hardness, ammonia as N, nitrate as N, nitrite as N, total nitrogen, phosphate as P, total phosphorous, total cyanide, hydrocarbons, dissolved metals (sodium, potassium, calcium, magnesium) and total metals (aluminium, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, tin, vanadium, zinc).

Data collected through periodic surface water monitoring at the site will be reviewed quarterly and annually, and comparison will be made to the trigger values in **Section 11.5** and background water quality. Exceedance of trigger values will be reported and actions will be taken consistent with the protocol described in **Section 11.6.**

Reactive water quality sampling will be undertaken immediately in response to overflow from any sediment dams at the Project or if surface water is known/suspected to be impacted by a spill, discharge, or other incident. Photos will be taken if an incident occurs, a water sample collected, and a targeted selection of analytes will be assessed through laboratory dependent on the nature of the incident (an appropriately qualified specialist should be consulted to determine the analytical suite). The Impact Investigation Procedure outlined in **Section 11.6.1** will be activated if reactive sampling is required.

Surface water sampling procedures at the Project should adhere to the following standards and procedures:

- Standards Australia (1998). *“Water Quality – Sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples”. Australian/New Zealand Standard 5667.1:1998.*
- *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales* (DEC, 2004).

11.4.3 Visual Inspections

Visual inspections of the engineered surface water management and ESC structures should be undertaken on the following basis:

- monthly;
- prior to any predicted significant rainfall events; and
- following any significant rainfall events.

Inspections would focus on the capacity and condition of the surface water management and ESC structures, water retention within the sediment dams, pooled water or sediment in drainage structures, condition of any vegetation (grass) within drains and general water management practices across the site. Where water management or ESC structures are identified to have reduced capacity or are in poor condition, remediation works will be undertaken without delay. If the structures have excessive sediment build-up or scouring, they will be desilted, regraded and/or reshaped to ensure the structures maintain their design capacity and can handle subsequent rainfall events.

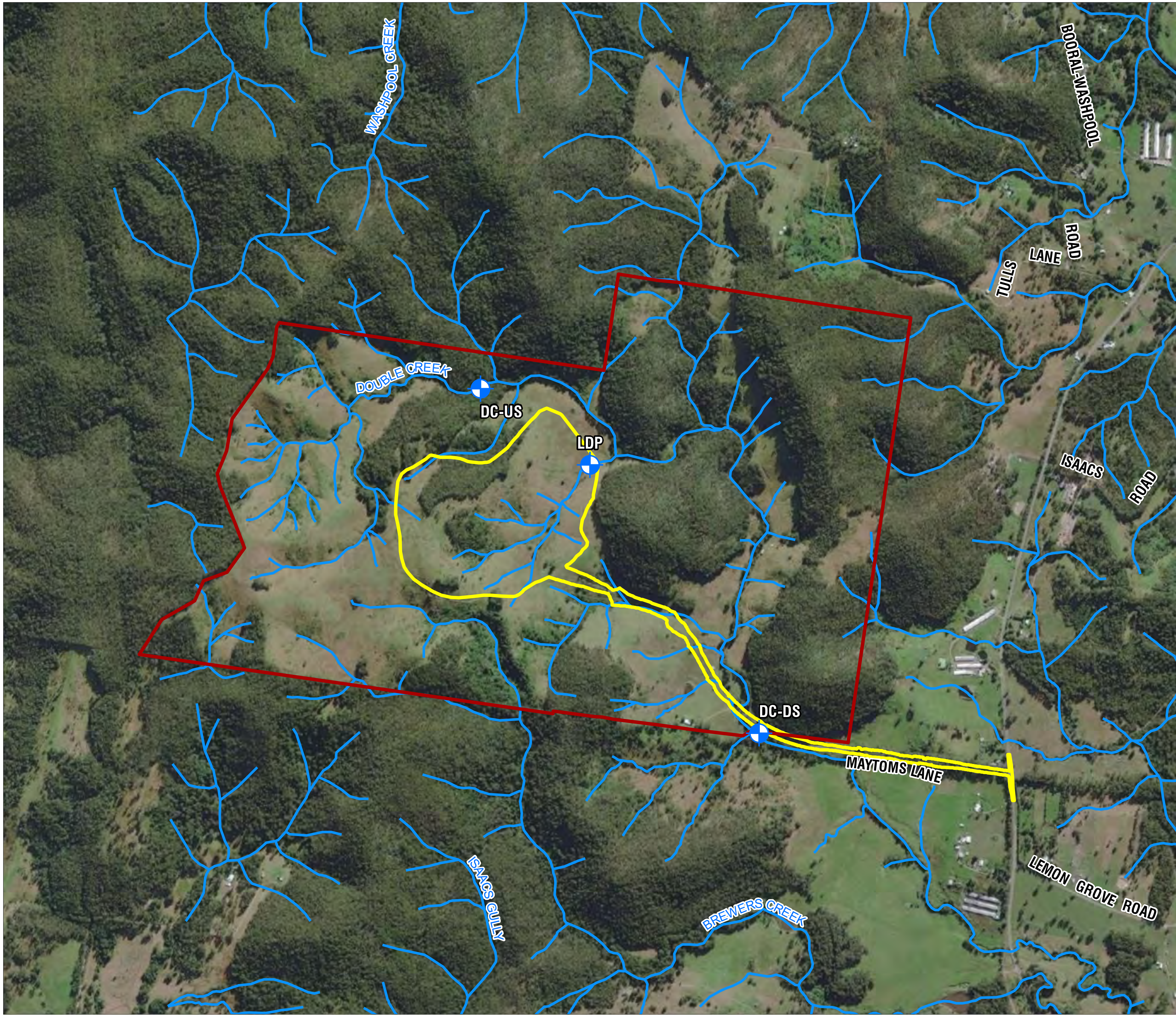
The results of any visual inspections and any remediation works required/undertaken shall be recorded in an inspection checklist and retained for future reference.

11.4.4 Channel Stability and Stream Health Monitoring

The Project will be established within the receiving catchment of Double Creek, thereby modifying the catchment, and the creek is being proposed to receive regular discharge from the Farm Dam. As such, the Project should monitor the integrity of Double Creek to assess for any impacts arising from changes to the runoff and flow regime.

Channel stability and stream health monitoring should be conducted annually at Double Creek for the first ten years of the development (from Stage 1 construction onwards) by an appropriately qualified specialist(s). The outcomes of annual monitoring would be reported, including any recommended actions or mitigation measures that will be employed to maintain or prevent degradation of the watercourse. The monitoring program will be consistent with the Rapid Appraisal of Riparian Condition (RARC) methodology (Jansen et al., 2005) and the CSIRO Ephemeral Stream Assessment Methodology (CSIRO, 2011).

The requirement for channel stability and stream health monitoring at the Project will be reviewed after the ten-year period to determine if continued monitoring is necessary.



HILLVIEW QUARRY EIS
SURFACE WATER ASSESSMENT

Proposed Surface Water Quality Monitoring Locations

FIGURE 53

Project Site
Disturbance Footprint
Surface Water Quality Monitoring Location
Watercourses

Data Sources:
NSW Spatial Information Exchange
ESRI Basemap world imagery (May 2023)

0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:20,000 at A4
Project Number:	630.12117
Date:	22-Nov-2023
Drawn by:	LF

SLR

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11.5 Surface Water Monitoring Trigger Values

11.5.1 Derivation of Guideline Values

Two different approaches have been considered to identify appropriate guideline values for water quality at the Project:

- Published 'default guideline values' as appropriate to achieve agreed water quality objectives for environmental values relevant to the receiving environment of the Project.
- The use of site-specific monitored water quality data from a reference site and/or baseline pre-development water quality data.

These two approaches are discussed in the following sections.

11.5.2 Water Quality

The NSW Water Quality and River Flow Objectives are the agreed environmental values and long-term goals for NSW's surface waters. Water Quality and River Flow Objectives for most catchments in NSW are published on the Department of Environment Climate Change and Water website (https://www.environment.nsw.gov.au/ieo/).

The Project site's contributing catchment is the Karuah catchment which drains the Karuah River to Port Stephens. During rainfall events, runoff from the site drains to Double Creek and its tributaries via overland flow, channels and swales.

The relevant agreed Water Quality Objectives and River Flow Objectives for Uncontrolled Streams within the Karuah River and Great Lakes catchment are detailed in **Table 27.**

Table 27: Environmental Values and River Flow Objectives for Uncontrolled Streams within the Karuah River and Great Lakes Catchment

Water Quality Objectives	River Flow Objectives
Aquatic Ecosystems	Protect pools in dry times
Visual Amenity	Protect natural low flows
Secondary contact recreation	Protect important rises in water levels
Primary contact recreation	Maintain wetland and floodplain inundation
Livestock water supply	Mimic natural drying in temporary waterways
Irrigation water supply	Maintain natural flow variability
Homestead water supply	Manage groundwater for ecosystems
Drinking water at point of supply-Disinfection only	Minimise effects of weirs and other structures
Drinking water at point of supply-Clarification and disinfection	
Drinking water at point of supply-Groundwater	
Aquatic foods (cooked)	

River Flow Objectives suggest that the natural regime of flows from the Project site should be retained as far as practically compatible with other requirements, mimicking natural flow patterns as closely as possible.

11.5.3 ANZG 2018 Default Water Quality Trigger Values

ANZG 2018 advocate a risk-based approach to water quality assessment and management. That is, the intensity of assessment of current water quality status or impacts on water quality should reflect the risk of impacts on the achievement/protection of the Water Quality Objective.

For Protection of Aquatic Ecosystems in NSW, and for irrigation water used in primary production, the ANZG 2018 Guidelines refer to the ANZECC & ARMCANZ 2000 default trigger values for major physicochemical stressors, which are used to assess whether the condition of an ambient water body supports the environmental values. These values, summarised in **Table 28**, provide typical values which if exceeded warrant investigation, and could adversely impact downstream environments and/or water uses.

The catchment receiving environment for The Project site is Double Creek which is considered to be a '*slightly to moderately disturbed ecosystem*' in accordance with ANZG 2018 and ANZECC 2000. Based on this classification, a protection level of 95 per cent for freshwater ecosystems, as recommended in the ANZECC 2000 Guidelines, is considered to be suitable for toxicants. Consideration is also given to the downstream.

With regard to the preservation of water quality for the purposes of livestock drinking water the revised guidelines have not been published yet, and will be available via the following weblink, (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance).

Table 28: Trigger Values – Environment and Irrigation Water

Parameter	Default Trigger Value for NSW lowland rivers for aquatic ecosystems in slightly disturbed ecosystems
Total Phosphorous (TP) (mg/L)	0.05
Total Nitrogen (TN) (mg/L)	0.5
Ammonium (NH_4^+) (mg/L)	0.02
Total Suspended Solids (TSS)	50 mg/L or 'Professional Judgement'
Turbidity (NTU)	6-50
Salinity (µS/cm)	125-2200
pH	6.0–8.0
Pesticides	Concentrations in discharge water should not exceed the crop injury threshold values in Table 4.2.12 of the ANZECC 2000 Guidelines
Heavy metals and metalloids	Concentrations in discharge water should not exceed the STV values in Table 4.2.10 of the ANZECC 2000 Guidelines
Thermotolerant coliforms (cfu/100mL)	<1000

The ANZECC 2000 Guidelines for recreational water quality and aesthetics, for secondary contact such as boating and fishing, and visual recreational use, provide water quality triggers as shown in **Table 29.**

Table 29: Trigger Values – Recreation

Parameter	Range of trigger values for NSW east flowing lowland rivers
Microbiological:	
• Faecal coliform	• 1000 organisms / 100 mL
• Enterococci	• 230 organisms / 100 mL

Parameter	Range of trigger values for NSW east flowing lowland rivers
Physical and chemical: • Visual clarity • Toxic chemicals • Surface films	• <20% reduction • Toxic substances should not exceed the values in ANZECC 2000 Table 5.2.3 for general chemical, and Table 5.2.4 for pesticides • Oils and petrochemicals should not be visible as a surface film, nor detectable by odour

The ANZECC 2000 Guidelines for aquatic foods (relating to oyster growing) provide water quality triggers as shown in **Table 30**.

Table 30: Trigger Values – Aquatic Foods

Parameter	Range of trigger values for NSW east flowing lowland rivers
Physico-chemical: • Suspended Solids	• Less than 40 mg/L (freshwater)
Toxicants – Metals: • Copper • Mercury • Zinc	• Less than 5 µgm/L • Less than 1 µgm/L • Less than 5 µgm/L
Toxicants – Organochlorines: • Chlordane • PCB's	• Less than 0.004 µgm/L • Less than 12 µgm/L

Trigger values are the numeric criteria that if exceeded, indicate potential for harmful environmental effects to occur. The default trigger values provided in ANZECC 2000 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed. If they are exceeded, further investigation is "triggered" for the pollutant concerned.

The trigger values provided in the ANZECC 2000 Guidelines are intended to be an indicator of potential environmental problems measured in the ambient waters. The ANZECC 2000 Guidelines are not originally intended for direct application to the water quality of stormwater from individual sites or systems, although in the absence of better information they are commonly used in such a manner.

11.5.4 Water Quality Assessment Criteria

Existing agricultural land-uses within the catchment, such as cattle grazing and poultry sheds, have potential to reduce the water quality in Double Creek when compared to a pristine catchment. The catchment has moderate extent of clearing but the riparian vegetation is largely intact. The catchment can be categorised as a '*slightly to moderately disturbed ecosystem*' in accordance with ANZG 2018 & ANZECC 2000.

ANZECC 2000 recommends that wherever possible, site-specific data should be used to define trigger values for physical and chemical factors which can adversely impact the environment. Trigger levels developed in accordance with the guidelines are statistically based, accommodate site-specific anomalies and use a statistical measure to represent the variability of natural conditions.

A minimum of two years of monthly data at the reference site is advised before a valid trigger value can be established. Despite the amount of available data for the Project site just falling below the recommended total, this assessment advocates that site-specific water quality trigger values be derived and followed for DC-US and DC-DS. This is based on the following rationale:

- the data represent water quality captured during a recognised drought period that prevailed over NSW between 2017 and the end of 2019 (BoM, 2022), and then a wetter than average period during 2020 (therefore providing seasonal and climatic variability in the data); and
- if the default ANZG 2018 & ANZECC 2000 trigger values are adopted at the Project, it is likely that within the first year of operation sufficient data would be available through monitoring to derive site-specific trigger values and the default values could be superseded.

The appropriate level of protection is for the median value at the test site to be less than the 80th percentile values from the reference site data. For some stressors such as oxygen and pH the 20th percentile values are also applicable. For aquatic ecosystems ANZG 2018 notes that Default Guideline Values (DGVs) should be based on either 80th or 20th percentiles of minimally impacted reference-site data.

ANZG 2018 also notes that for physical and chemical stressors (including toxicants) in water and sediment, the DGVs provide a suitable level of protection for *slightly to moderately disturbed ecosystems.*

11.5.5 Surface Water Quality Trigger Values

Site-specific trigger values were derived for water quality at Double Creek monitoring sites DC-US and DC-DS. The site-specific trigger values were deduced in accordance with ANZG 2018 & ANZECC 2000, with the 80th percentile for each analyte calculated from the baseline dataset for DC-US and DC-DS. A 20th percentile trigger value was determined pH and dissolved oxygen content. As discussed in **Section 11.5.4**, the amount of baseline data available falls slightly under two years of monthly monitoring; however, the data represents both drought and wet conditions, and 24 monthly data points would be available shortly after operations commence.

For the discharge monitoring point, the ANZG 2018 & ANZECC 2000 trigger values were adopted due to the absence of baseline data. More specific triggers were adopted for pH & TSS (based on **Table 28**) alongside copper & zinc (based on **Table 30**).

The water quality trigger values to be followed at the Project are presented in **Table 31**. Trigger values are specified only for parameters with a trigger in ANZG 2018 & ANZECC 2000. Where all baseline data for an analyte measured at DC-US or DC-DS is equal to the LOR, the ANZG 2018 & ANZECC 2000 trigger value was adopted. Triggers for hydrocarbon monitoring should be derived once the Project commences and the array of hydrocarbon sources present at site is confirmed.

Table 31: Surface Water Quality Trigger Values

Parameter	DC-US	DC-DS	Discharge Point	ANZG 2018 & ANZECC 2000 Trigger Value
pH (pH unit)	6.6 - 6.8	7.3 - 7.5	6.0 - 8.0	6.5 - 8.5
Electrical Conductivity (µS/cm)	712	1130	2200	2200
Dissolved Oxygen (%)	32 - 62	42 - 87	85 - 100	85 - 100
Turbidity (NTU)	12.2	4.0	50	50
Total Suspended Solids (mg/L)	12.2	6.4	40	50
Sulphate (mg/L)*	1000	1000	1000	1000

Parameter	DC-US	DC-DS	Discharge Point	ANZG 2018 & ANZECC 2000 Trigger Value
Sodium (mg/L)*	80	170	115	115
Ammonia as N (mg/L)	0.06	0.06	0.9	0.9
Nitrate as N (mg/L)	0.024	0.022	0.7	0.7
Total Nitrogen (mg/L)	0.4	0.5	0.5	0.5
Total Phosphorus (mg/L)	0.05	0.05	0.05	0.05
Total Cyanide (mg/L)	0.007	0.007	0.007	0.007
Total metals				
Aluminium (mg/L)	0.072	0.038	0.055	0.055
Arsenic (mg/L)	0.003	0.001	0.013	0.013
Boron (mg/L)	0.036	0.06	0.37	0.37
Cadmium (mg/L)	0.0002	0.0001	0.0002	0.0002
Chromium (mg/L)	0.001	0.001	0.001	0.001
Cobalt (mg/L)	0.002	0.1	0.1	0.1
Copper (mg/L)	0.002	0.002	0.001	0.0014
Iron (mg/L)	0.508	0.152	10	10
Lead (mg/L)	0.0034	0.0034	0.0034	0.0034
Manganese (mg/L)	0.214	0.114	1.9	1.9
Molybdenum (mg/L)	0.05	0.002	0.05	0.05
Nickel (mg/L)	0.011	0.011	0.011	0.011
Selenium (mg/L)	0.011	0.011	0.011	0.011
Silver (mg/L)	0.00005	0.00005	0.00005	0.00005
Vanadium (mg/L)	0.002	0.002	0.5	0.5
Zinc (mg/L)	0.022	0.016	0.005	0.008

Note: Trigger values derived from ANZG 2018 default guidelines value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems, except where * is denoted (value from ANZECC 2000 default guideline value for primary industries).

An exceedance investigation will be conducted in line with the Impact Investigation Procedure protocol in **Section 11.6.1** if three consecutive trigger value exceedances occur for the same analyte at a designated monitoring site.

11.5.6 Surface Water Discharge Quality Limits

The quality of water discharged from the site will be monitored through monthly sampling at the LDP to be established at the Farm Dam as indicated in **Figure 53**. The results will be assessed against the surface water quality trigger values provided in **Table 31,** and three consecutive exceedances for the same analyte will enact the Impact Investigation Procedure protocol described in **Section 11.6.1.**

11.6 Surface Water Response Plan

11.6.1 Impact Investigation Procedure

In the event a surface water quality trigger exceedance as outlined in **Section 11.5.5** is identified, or an unplanned water related incident occurs, the following impact investigation procedure will be activated:

- If an exceedance or trend is identified that has caused or threatens to cause material harm to the environment, the relevant regulatory agencies (including DPE, EPA and DPI Water) will be immediately notified and any instructions administered will be followed.
- If a complaint is received, the complaint will be documented and the procedure in the site Complaint Management System (or equivalent) will be followed.
- Where a sediment dam overflows or an off-site surface water discharge is identified, sampling will be initiated to characterise the quality and quantity of waters discharged.
- If an exceedance or trend is identified in a data set:
  a) The first step will be to verify if the data appears anomalous. The relevant data set will be reviewed by an appropriately qualified person who will determine if further investigation is necessary and/or additional sampling is necessary.
  b) Where monitoring results indicate that a trigger value has been breached, the regulatory agency will be notified within 14 days of completion of monitoring.
  c) If a surface water quality/flow trigger exceedance is identified, then an investigation into the potential for environmental harm will be completed and sent to the regulatory authority within 3 months of receiving the analysis results.
  d) Once the validity of the breach is established or a landholder complaint has been verified, a preliminary investigation will be undertaken by an appropriately qualified specialist involving the evaluation of the monitoring results/complaint in conjunction with Development activities being undertaken at the time, baseline water data, local water use, the prevailing and preceding meteorological conditions and any other relevant factors.
  e) The preliminary investigation may deem that further additional investigation and monitoring is required to determine the cause of the breach and whether or not it is directly related to Development activities.
  f) If the investigations deem that triggers have been breached as a result of the Development, contingency measures may need to be implemented, and additional monitoring may be deemed necessary to measure the effectiveness of any contingency measure implemented.
- In the event that trigger levels or impact assessment criteria continue to be exceeded, further investigations may be undertaken (i.e. a process of continual development or adjustment of the relevant triggers if warranted).
- If regular exceedances occur, an action plan (corrective actions) will be developed in consultation with the relevant regulatory agencies.
- The results of any breaches of trigger levels and investigations will be documented for reporting and audit purposes.

11.6.2 Impact Mitigation

In the event that the preliminary and any follow-up investigations conclusively identify that the Project has adversely impacted a neighbouring water user (affected groundwater user of surface water resource), the proponent will work with the impacted user and the relevant regulatory agencies and attempt to negotiate suitable mitigation measures in a timely manner to rectify the problem identified.

The proponent may involve an appropriately qualified environmental specialist to assist with development of mitigation measures. The development of suitable mitigation measures will be based on the outcomes of an appropriate scientific investigation.

11.7 Storage and Use of Hydrocarbons and Chemicals

The storage and use of hydrocarbon fuels and other chemicals on site present a potential risk if spilled substances contaminate site soils or are mobilised and spread to the downstream receiving environment. Chemicals used onsite during both the construction and operational phases may include fuels, lubricants and (minimally) herbicides.

Accidental spill or discharge of hydrocarbons, such as fuels and oils in vehicles and/or earthmoving equipment, has potential to contaminate downstream waterbodies or groundwater. The risk of hydrocarbon contamination will be mitigated by:

- Storage of chemicals in accordance with the Australian Standard for the storage and handling of toxic substances AS/NZS 4452:1997.
- Storage of hydrocarbon fuels within bunded storage areas.
- Bunding of substations or other infrastructure that utilises oil.
- Minimise usage of herbicides and avoid spraying when rain is predicted.
- A Spill Management Plan, including emergency response and EPA notification procedures.

Requirements for the storage and use of hydrocarbon fuels and other chemicals on site will be documented in both the Construction and Operational Environmental Management Plans.

Overall, with the implementation of suitable controls these risks are low and considered readily manageable.

11.8 Nitrates from Explosives

There is potential for residual nitrates from explosives used during quarry extraction to be present in stormwater runoff from the extraction area. To address this potential impact, the following measures are proposed:

- Settlement of sediments within the Main Dam. Pollutants that are adhered to fine sediments will settle to the base of the Main Pit
- Stormwater discharges from the Main Dam into the Farm Dam will be passed through bio-filtration and vegetated swale drains located between the Main Dam and Farm Dam. These measures will reduce the nitrogen concentration in stormwater, particularly the soluble portion.
- Flocculation within the Farm Dam – if required to meet water discharge criteria.

The concentration of nutrients including total nitrogen and total phosphorous will be monitored in the Farm Dam. If the nutrient levels exceed the water quality discharge criteria, then additional water quality controls will be introduced. Additional water quality controls may also be considered if high levels of flocculation are required to achieve the required water quality.

11.9 Containment within Infrastructure Area

The Infrastructure Area will be graded inward towards the Infrastructure Sump. All runoff from the Infrastructure Area will be contained within that area, including during extreme rainfall events.

11.10 Unplanned Discharges

If an unplanned discharge occurs at the Project, reactive water quality sampling would be conducted immediately as outlined in **Section 11.4.2.** Consequently, The Impact Investigation Procedure detailed in **Section 11.6.1** will be activated to ensure that the potential impact of any unplanned discharge is assessed, the incident is reported to the appropriate regulatory agencies, and that remedial or mitigative measures are implemented as necessary.

11.11 Post Extraction Monitoring and Management

Water quality monitoring should continue following cessation of operations. The monitoring frequency would be reduced from what was followed during operations, and associated data review would also be conducted at a reduced frequency.

Reviews should involve assessment against long-term performance objectives that are derived from baseline conditions or a justifiable alternative, with allowance for climatic shift and variations. If objectives are not substantially met based on review, management measures would be revised and post-mining monitoring frequency either increased or the overall monitoring period prolonged.

11.12 Potential Contingency Measures

Potential contingency measures in the event of unforeseen impacts or impacts in excess of those predicted may include measures such as:

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

12.0 Environmental Impacts and Proposed Mitigation Measures

Potential impacts to surface water that could arise due to the Project include:

- reduced baseflow contributions from groundwater to Double Creek and Brewers Creek;
- runoff water quality degradation via erosion and sedimentation;
- spillage of hydrocarbons, chemicals and fuels could contaminate runoff/downstream water quality;
- water quality impacts resulting from flooding; and
- changes to catchment yield, environmental flows, and creek flows during major rainfall events.

To mitigate these potential impacts, an array of mitigation measures will be implemented at the Project. Potential impacts and associated mitigation measures are discussed in the following sections.

12.1 Baseflow Reductions

The Groundwater Assessment for the Project identified potential for groundwater drawdown (less than 1 m) in vicinity of Double Creek and Brewers Creek as well as upgradient of these watercourses. **Table 32** outlines the potential impacts to surface water and recommended mitigation measures.

Table 32: Impacts and Mitigation Measures – Baseflow Reductions

Aspect	Details
Risk/Cause:	Dewatering associated with quarrying at the Project has potential to cause drawdown and reduce groundwater throughflow to Double Creek and Brewers Creek which may reduce natural baseflow contributions to the creeks.
Potential Impact	Minor to moderate decrease in natural stage heights and flow conditions (the Groundwater Assessment predicts up to an 8% flow reduction in Double Creek and 19% in Brewers Creek).
Requirements for Mitigation	A discharge point will be established to release clean water to Double Creek to maintain flows.
Environmental Management	The proponent is to secure adequate WSP licence allocations for groundwater source zones predicted to experience water take.

12.2 Runoff Water Quality

Potential environmental impacts and mitigation requirements associated with erosion and sediment control during the construction and operational phases of the quarry are described in **Table 33.**

Table 33: Impacts and Mitigation Measures – Runoff Water Quality

Aspect	Details
Risk/Cause:	Soil disturbance during the construction and progressive development of the quarry has potential to cause erosion and the transport of nutrients and sediments in stormwater runoff to adjacent watercourses.

Aspect	Details
Potential Impact	Turbid water can reduce light penetration in downstream water bodies, impacting aquatic ecology. Increased nutrient loads can contribute to eutrophication, and an accumulation of coarse sediment can smother creek beds.
Requirements for Mitigation	• **Riparian zone** – aside from the road crossing of Double Creek, no construction activities will occur within the riparian zone of Double Creek; • **Sequencing of construction** – the quarry will be developed over four stages; • **Sediment basin in void** – during Stage 3 a sediment basin located on the floor of the excavation will receive and contain stormwater runoff from areas inside the batter of the external bund; • **Progressive revegetation of disturbed areas** – following formation the outside batters of the external bund will be revegetated to limit the potential for ongoing erosion. A mulch will used to promote early establishment of vegetative cover and root mass to stabilise the batter slope; • **Construction of engineered drains** – lined drains will be constructed to convey concentrated flows of water. Selection of lining materials will be subject to detailed design; • **Infrastructure Sump** - during Stage 2 the Infrastructure Sump will be established within the to receive and contain stormwater runoff from areas inside the processing pad.
Environmental Management – Construction Phase	An ESCP will be prepared as part of site CEMP. The ESCP and CEMP will prescribe requirements for: • Physical mitigation measures as outlined in **Section 8.0**; • Water quality in the sediment basin will be tested following rainfall and prior to release from site, and treated to achieve the required water quality; • Inspection of ESC measures following heavy rainfall; • Water quality monitoring and reporting requirements; and • Providing an appropriate level of resourcing for environmental management and monitoring.
Environmental Management – Operational Phase	The WMP will prescribe requirements for: • Monitoring and reporting of surface water quality in accordance with the EPL; • Monitoring and treatment of water quality in sediment basin prior to release from site, and treated to achieve the required water quality; • Inspection of site drains, sediment basin, and leachate pond following heavy rainfall; and • Providing an appropriate level of resourcing for environmental management and monitoring.

12.3 Chemical or Hydrocarbon Spills

Table 34 addresses the risk of hydrocarbon spills and leaks during the construction and operational phases.

Table 34: Impacts and Mitigation Measures – Chemical or Hydrocarbon Spills

Aspect	Details
Risk/Cause:	• Leaking fuel storage tanks or accidental spillages from plant/machinery. • Spillage of chemicals during use or from poor storage.
Potential Impact	• Hydrocarbon spills from fuel storage tanks can have significant environmental impacts on the receiving environment.

Aspect	Details
	• Potential to contaminate the receiving surface waters as well as groundwater.
Requirements for Mitigation	• **Fuel Tanks** – diesel tanks must not be located proximate to watercourses or overland flow paths. All fuel storage tanks must be located within a bund or be self-bunded tanks. • **Hazardous materials** – hazardous materials and equipment will be stored in accordance with Australian Standard AS/NZS 4452:1997, in bunded areas under roof and located away from watercourses. • **Spillage** – spill kits will be kept on site, and staff trained in their use. • **Spill Management Plan** – during construction and operations, the site will have a Spill Management Plan which details the emergency response and reporting requirements in the event of a spill.
Environmental Management	• The above requirements will be captured in the CEMP during the construction phase and a WMP during the quarrying operations. • Water quality monitoring of sediment dams will include a visual check for the presence of hydrocarbons (colouration, oil sheen/film).

12.4 Flooding Impacts

Table 35 examines the potential for flows in Double Creek to inundate the Project site.

Table 35: Impacts and Mitigation Measures – Flooding

Aspect	Details
Risk/Cause:	• Flood levels in adjacent creek inundate construction areas (safety issue). • Flood levels in adjacent creek inundate frequent-use access road. • Flood levels in adjacent creek contact pollutants or sediment.
Potential Impact	• Erosion of site areas disturbed during construction. • Safety risk to construction workers. • Wash away pollutants or sediment into watercourse.
Requirements for Mitigation	• A flooding assessment by SLR and is attached as Appendix A of this report. This study has found that the quarry footprint is not subject to flood inundation in a 1% AEP rainfall event. • The haul road along Maytoms Lane will be subject to inundation in a 1% AEP rainfall event. Mitigation measures are to include flood warning signs, depth indicators, and road embankments designed to safely withstand flow over the road.
Environmental Management	Nil.

12.5 Catchment Yield and Environmental Flows

Table 36 discusses how the completed Project may affect environmental flows to Double Creek.

Table 36: Impacts and Mitigation Measures – Catchment Yield and Environmental Flows

Aspect	Details
Risk/Cause:	The capture of surface runoff and containment on site can affect the environmental water regime in the downstream environment.

Aspect	Details
Potential Impact	A reduction in the quantity of water available in the downstream environment, and reduced frequency of low flow events along watercourses.
Requirements for Mitigation	• A discharge point will be established to release clean water to Double Creek to maintain flows. • A WMS has been developed which includes an array of water storages to contain and control runoff at the Project. The WMS has been strategically designed to ensure poor quality water does not leave the site and interact with Double Creek and the downstream catchment. • A WMP will be in place to ensure water quality at the site is tracked and within national/site-specific standards, and an investigation will be conducted in the event non-compliant water quality is detected to mitigate impacts to the catchment and downstream flows.
Environmental Management	• The above requirements will be captured in the CEMP during the construction phase and a WMP during the quarrying operations. • Water quality monitoring of sediment dams will include a visual check for the presence of hydrocarbons (colouration, oil sheen/film).

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Appendix A Flood Assessment Report

Hillview Hard Rock Quarry

Surface Water Assessment

Coast Wide Materials Pty Ltd

SLR Project No.: 630.V12117.00200

27 June 2024

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
v1.1	5 June 2024	Jack Jenness	Paul Delaney	Paul Delaney

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Tricon Mining Equipment Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

Executive Summary

This assessment of flooding for the development consent for a new hard rock quarry within Booral has been prepared to assess flooding constraints to the project and address the requirements of the project Secretary's Environmental Assessment Requirements (SEARs). The study has considered the contributing catchment, the existing environmental conditions, the proposed hard rock quarry, and the Double Creek access crossing.

Detailed hydrologic and hydraulic modelling of the catchment encompassing the quarry downstream to the confluence with Double Creek has confirmed the footprint of the proposed quarry will not lie within flood liable land up to and including the 1% AEP flood.

The modelling has confirmed the environmental impact of the project on hydrology, drainage lines, water courses, and riparian lands is a very low risk.

Table 1 below summarises the flooding and hydrological related conclusions across the Site and within riparian lands nearby to the Site.

Table 1: Summary of Potential Impacts on SEARs

SEARs	Potential Impact
Flooding liability of the Site and risk to property and life	The Site is located southeast of a series of ephemeral creeks which discharge to Double Creek upstream of the Licenced Discharge Point (LDP) of the Site. Backwater during a 1% AEP flood in Double Creek will not result in inundation of the Site or the Double Creek crossing downstream. There is no risk to property and life on the Site or the Double Creek crossing as a consequence of flooding.
Potential impacts to riparian lands nearby to the Site	Surface runoff from the Site currently discharges to the farm dam, overflowing to ephemeral riparian lands to the northeast. A perimeter drain and containment bund around the Site will ensure sediment-laden runoff is captured and does not enter the ephemeral creek. There are no expected increases in flood inundation or velocity of Double Creek with the development of the crossing.
Changes to pattern of runoff and discharges from Site	The Site will progress through many topographical changes over the life of the quarry. The runoff contribution from the catchment area of the Site to the ephemeral creek to the north will be captured and redirected in a series of dams, before reaching the farm dam for treatment. There will therefore be a reduction in peak flows downstream post development. There are no expected changes to discharge from the development of the Double Creek crossing.

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Tables in Text

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1.0 Introduction

1.1 Purpose of this Document

This assessment has been prepared to address the flood and surface water related requirements of the Secretary's Environmental Assessment Requirements (SEARs), namely;

"An assessment of any likely flooding impacts of the development"

"An assessment of the likely impacts on the quality and quantity of existing surface and ground water resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives"

"An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users"

This surface water assessment defines the zone of influence from both local catchment flooding and backwater influence from Double Creek downstream of the Site. This information will provide guidelines for the proposed quarry footprint, surface water aspects during the construction, operation, and final landform phases of the project.

1.2 Project Overview

The proposal is for the construction of a hard rock quarry located in Booral in the Great Lakes Region of New South Wales. The progression of the hard rock quarry is separated into 7 stages. The Site is presently vegetated and bounded to the West by grassy rural landscapes, to the North by dense dry rainforest, and to the South and East by dense sclerophyll forest.

The proposed quarry footprint and staged progression is shown on **Figure 1.**

Figure 1 Proposed Quarry Layout Indicating 7 Key Stages

1.3 Assessment Methodology

The assessment was completed with a combination of desktop and Site-based assessments and measurements to define existing catchment conditions. A 1D/2D hydrologic and hydraulic model was prepared to simulate the flood behaviour of the existing natural environment including, soil infiltration, drainage structures, above ground infrastructure and modifications to the landforms.

The current study focuses on a southern tributary of Double Creek which passes through the quarry extent before discharging to the Double Creek. Additionally, the study defines the crossing of Double Creek for the Site access from Maytoms Lane.

Information on contributing catchment soils were obtained using initial loss – continuing loss parameters provided by ARR Data Hub. ARR Data Hub utilises a hierarchy of approaches depending on the available loss information near the Site. Due to a lack of required hydrological soil parameters provided from on-Site testing, the catchment soils utilised through the determination of losses through the ARR Data Hub are adopted.

The vegetation cover captured by the NSW Government's Six Maps aerial photography in November 2018 was utilised to describe the extent of vegetation cover in the contributing catchment. Site visits conducted in February and April of 2020 confirmed the density of ground cover required to estimate the 'Manning's n' roughness of the variation in vegetation cover over the contributing catchment.

A detailed SWMM 1D/2D model was prepared incorporating the desktop and Site-based data. Site rainfall was sourced from Australian Rainfall and Runoff 2019 (ARR2019). In accordance with the revised practices in ARR2019, the catchment performance was simulated for ten different rainfall temporal patterns (referred to as an ensemble) for every duration storm between 10 minutes and 168 hours to determine the mean of each ensemble. The maximum of the means is considered the critical duration storm for the catchment and all results are reported against this storm duration and temporal pattern.

2.0 Existing Topography, Site Soils, Structures, and Hydrology

2.1 Site Topography and Drainage Patterns

The Booral quarry is situated on former agricultural land, surrounded by undulating topography, with areas of bushland interspersed with land that has been cleared or partially cleared. The contributing catchment to the east and north of the Site is very steep and heavily forested with slopes in the mountainous regions up to approximately 40%. Extensive vegetation clearing has occurred for agricultural development. The remaining native vegetation comprises patches of forest and isolated paddock trees. The ground slopes in these cleared zones are typically 12 to 26%.

Figure 2 shows the drainage paths and catchments within the contributing catchment. The confluence of drainage paths from Double Creek is located just northeast of the quarry Site, where the contributing catchment at the confluence point is approximately 1.6 km^2.

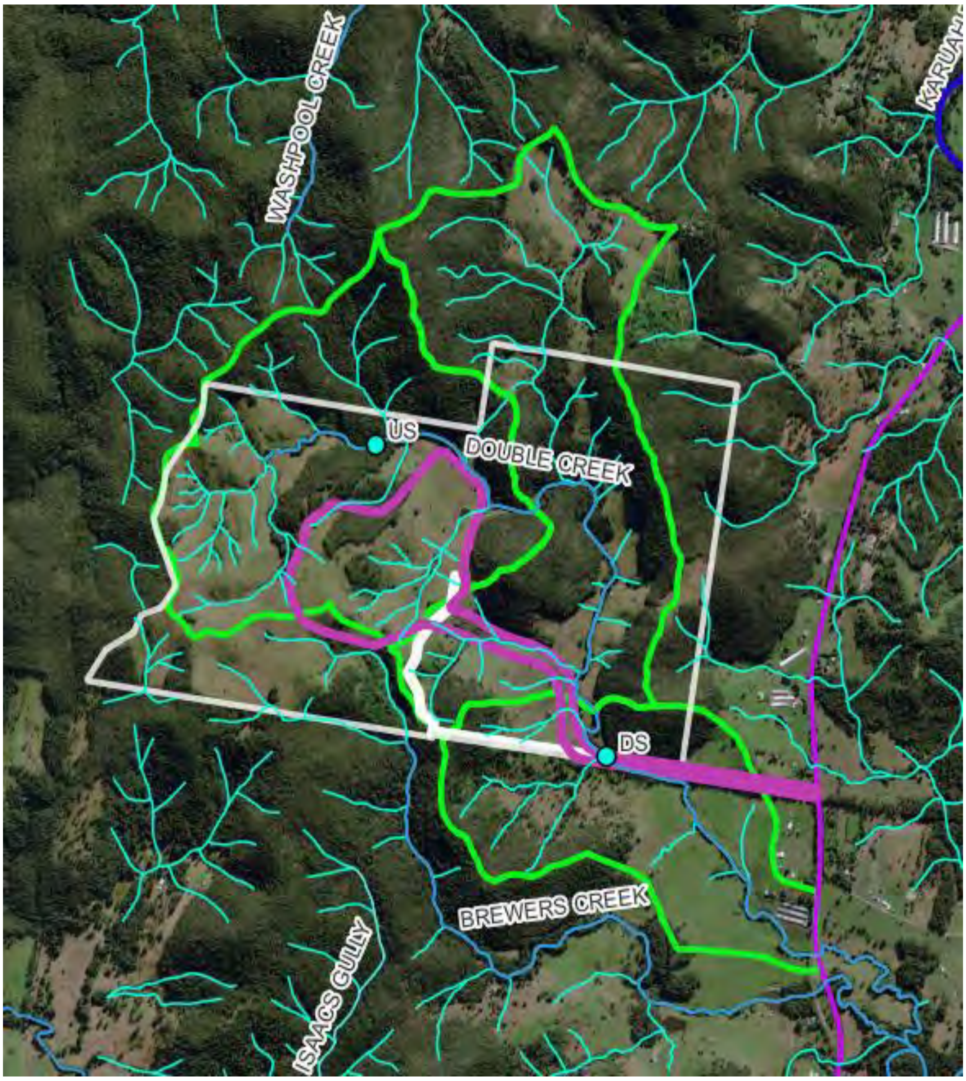

Figure 2: Drainage Lines and Catchments for the Site and Double Creek

The natural creek is formalised as it overflows the Farm Dam to the northeast of the quarry Site and then passes through to Double Creek. Ground slopes within this area are typically 3% to 20%.

2.2 Catchment Soils

Information on contributing catchment soils were obtained using initial loss – continuing loss parameters provided by ARR Data Hub. ARR Data Hub utilises a hierarchy of approaches depending on the available loss information near the Site. Due to a lack of required hydrological soil parameters provided from on-Site testing, the catchment soils utilised through the determination of losses through the ARR Data Hub are adopted.

2.2.1 Initial Loss - Continuing Loss infiltration parameters applied in the model.

The Initial Loss – Continuing Loss (IL/CL) is a commonly used infiltration model which simulates the initial catchment wetting process, when no runoff is produced. Continuing loss accounts for ongoing infiltration following initial losses. Design event initial loss (IL) and continuing loss (CL) values were sourced from the ARR2019 Data Hub. The following values for loss were applied to land use types in the project.

Table 2: Initial and Continuing Loss Parameters

Surface	IL (mm)	CL (mm/hr)
Hardrock (Quarried Site)	0	0.5
Farmlands (Grass)	22	2.7
Streambeds	0	0
Scattered trees	22	2.7
Forested areas	22	2.7
Water Bodies	0	0

2.3 Manning’s Roughness Parameters

Manning’s roughness coefficients represent the resistance to sheet and concentrated flows in channels, grassed flood plains, steep forested faces of the mountain range etc. Refinement of the Manning’s ‘n’ roughness values is normally performed during calibration when catchment pluviometer rainfall data and hydrograph gauging of the stream is entered in the model and actual gauged results are compared to the simulated results. The following industry standard surface roughness values were applied in this project.

Table 3: Manning’s ‘n’ values adopted in the model

Surface	Manning’s n
Hardrock (Quarried Site)	0.04
Farmlands (Grass)	0.035
Streambeds	0.04

Surface	Manning’s n
Scattered trees	0.07
Forested areas	0.11
Water Bodies	0.01

3.0 Flood Modelling Methodology

3.1 Previous Studies

There are currently no flood studies which cover the Project Site.

3.2 Guidelines and Codes

Assessment of the flow of surface water across the Project Site has been carried out in accordance with Book 3 of the online version of the Australian Rainfall and Runoff 2019 (ARR 2019) guideline.

3.3 Modelling Software

Hydrological and hydraulic modelling has been carried out using the XP-SWMM 1D/2D software to estimate the extent of inundation, overland velocities, surface shear stress and flood hazard during the critical duration 1% AEP flood (formally referred to as the 1 in 100-year ARI).

The flat slopes of the lower catchment, dendritic nature of the upper catchment drainage paths and narrowness and rapidly varying cross-sectional roughness and dimensions necessitated a combination of one and two-dimensional analysis.

3.4 Design Rainfall Data

The design rainfall data for the quarry catchment was sourced online from the Bureau of Meteorology's website. The recently revised estimates combine contemporary statistical analyses and techniques with an expanded database to provide a more accurate design rainfall estimate across Australia. They are based on a more extensive database, with more than 30 years of additional rainfall data and data from extra rainfall stations than the former 1987 estimates.

3.5 Design Rainfall Data and Effect of Climate Change

There is now widespread acceptance that human activities are contributing to observed climate change. Climate change (warming) has the potential to increase the prevalence and severity of rainfall extremes and needs to be considered in flood planning for long term projects. ARR2019 recommends adopting the 1 in 200 AEP design rainfall data for infrastructure operating for more than 50 years. As this project has an expected operational lifespan of 30 years, climate change effects will be disregarded and only the 1% AEP flood will be considered for assessment.

3.6 Critical Duration Storm

In November 2016 the Institution of Engineers introduced a revised protocol for hydrological assessment of catchments. The former procedure required the hydrologist to determine the storm duration which generates the greatest peak flow downstream of the catchment by adopting a common rainfall temporal pattern (percentage of rainfall fallen over time) for each duration storm.

The revised procedure now requires 10 different temporal patterns to be tested for each duration and each magnitude storm. The maximum of the means of each 10 temporal patterns (referred to as an ensemble) is considered the critical duration storm for the catchment. The outliers from each set of storms are not to be considered as they are a gross overestimation of flow.

The following bar and whisker chart shows the range of peak flows right before the confluence of Double Creek for 130 storms simulated for the 1% AEP event. The 20-minute duration storm with a No.9 temporal pattern generates the greatest peak flow.

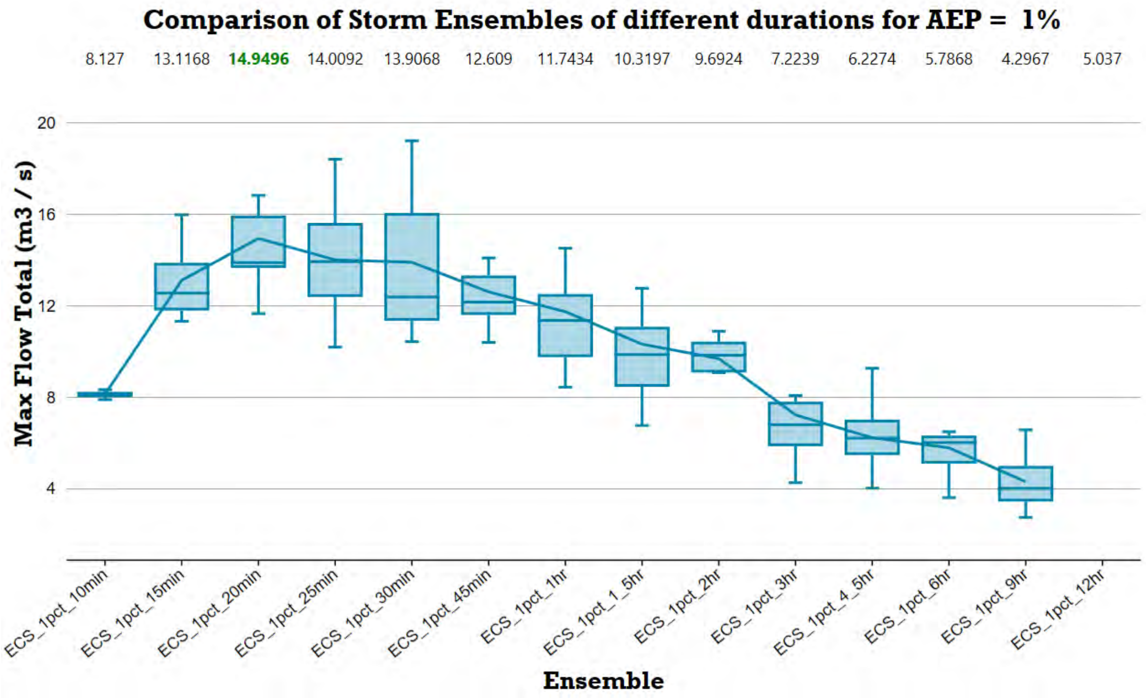

Figure 3: 1% AEP Peak Flow Ranges for Each Storm Duration Ensemble

- The 20-minute, temporal pattern No.9 produces the greatest peak flow just upstream of the confluence of Double Creek during the 1% AEP storm and is considered the critical duration event for this catchment.

Table 4: Critical Duration Storm

Storm Magnitude	Critical Duration Storm	Temporal Pattern
1% AEP	20 minutes	No.9

- The short duration to peak shows the catchment to be very responsive due to the very steep upper catchments and low Manning’s n in both the upper and lower watersheds.

3.7 Modelling Pre and Post Development

The Site will progress through many topographical changes over the life of the quarry. The runoff contribution from the catchment area of the Site to the tributary of Double Creek will be intercepted and captured in sediment dams around the Site.

A pre-development flood model will provide the worst-case flood scenario for the existing landform and will be compared to a worst-case post-development flood model. The worst-case stage for development is determined to be Stage 7 of the quarry staging, operations during this stage are outlined in **Section 6.5** of the Surface Water Assessment. Outflows are assessed at the Licenced Discharge Point (LDP) in the Double Creek catchment.

Pre- and post-development flood models will provide comparison for assessment of the Double Creek crossing from Maytoms lane, in terms of inundation extents, velocities, and flood hazard, as outlined in **Section 7.0**.

4.0 Verification of Results

Calibration is the process of adjusting model parameters to enable the model to simulate the actual rainfall and runoff process accurately. As there was no pluviometer (tipping bucket rainfall data) and streamflow gauging data available to perform calibration, it was only possible to apply the following measures:

- incorporate soil loss parameters suggested by ARR 2019
- assign industry standard values of Manning's roughness
- compare output to the 2019 ARR Rational method peak flow estimation

Items one and two were discussed in **Section 2.0.**

The revised ARR2019 has compiled a database of gauged catchment results across Australia and developed an extensive multi-normal distribution fitting of the data which enables the user to retrieve guideline upper and lower confidence limit with an expected quantile of the peak flow for a catchment. As the catchment is very steep with relatively low Manning's roughness values, and an average infiltration in the mountainous regions it would be expected the peak flow would be greater than the expected quantile. **Table 5** shows the peak flow to be almost one seventh of the expected quantile, and a third of the lower confidence limit. Considering the likely decrease in peak flows caused by detention within the farm dam, the model is producing a flowrate which is consistent with regional flood studies. Note that these determinations of upper and lower confidence limits from ARR2019 are outside of the recommended catchment size of 0.5 to 1000 km^2.

Table 5: 1% AEP Peak Flow Estimate at the Farm Dam Overflow

Scenario	1% AEP Peak Flow
ARR2019 analysis 5% lower confidence limit	44.7 m^3/s
ARR2019 analysis expected quantile	108 m^3/s
ARR2019 analysis 95% upper confidence limit	264 m^3/s
Hydrological model Peak flow	15.0 m^3/s

Annexure B contains the calculations involved in the peak flow estimation using the Probabilistic Rational Method.

5.0 Existing Landform

5.1 Inundation, Outflows, Velocities, Shear Stress & Hazard

5.1.1 Site Inundation and Site Overland Flow Paths

The inundation of the Double Creek catchment would not extend upstream to the Site during the 1% AEP flood. **Figure 6** show an overview of the Site overland flow paths.

All overland flow from the Site boundary drains toward the Farm Dam to the northeast of the Site, which overflows into a tributary of Double Creek. The location of this overland flow path can be seen in **Figure 6**. Modelled flow depths outside of ponds reach up to 690 mm during the 1% AEP flood on-Site. This flow path does not inundate the proposed footprint for the quarry.

5.1.2 Outflows

Figure 4 shows the peak outflows at the LDP during the 1% AEP flood event. The peak flow from the Site would reach up to 14 m^3/s before reaching the confluence with Double Creek.

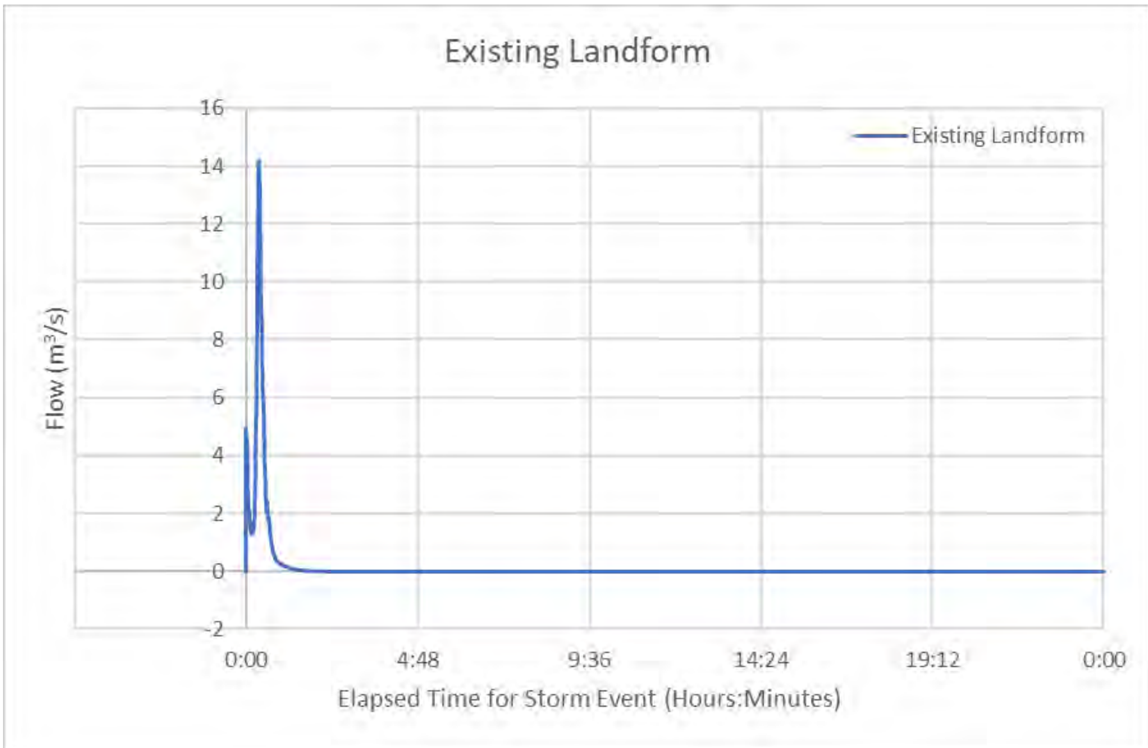

Figure 4: Peak Flow Hydrograph in the Existing Landform during the Critical Duration 1% AEP Event

5.1.3 Overland and In-Stream Velocities

Figure 6 shows the maximum velocity achieved in both creek and overland flow paths during the 1% AEP flood event. The small flow paths through the Site would reach velocities up to 1.2 m/s. The main overland flow path immediately south of the Site would reach velocities of 2.5 m/s on the slope and 0.4 m/s perpendicular to the main overland flow path. Peak velocities in the ephemeral creek could reach 4.2 m/s in sections where the creek narrows.

5.1.4 Surface Shear Stress

The shear stress is a measure of the soils shear resistance because of friction and interlocking of particles, and bonding at particle contacts. A shear stress exceeding 100 kPa on bare earth will result in material loss. **Figure 7** shows the surface shear stress across the Site slightly above 50 kPa. No area within or in proximity of the Site would be subjected to erosion from the 1% AEP flood.

5.1.5 Flood Hazard

ARR 2019 assigns flood hazard by the product of velocity and depth (refer **Figure 5**). A value of 0.4 m^2/s and below is considered low hazard for pedestrians and 0.6 m^2/s for small vehicles. Values above 0.6 are considered hazardous.

There are no locations within the Project Site or near the Site boundary which are considered hazardous during a 1% AEP flood.

Hazardous areas develop in Double Creek upstream of the Maytoms Lane crossing as depths exceed 1.2 m.

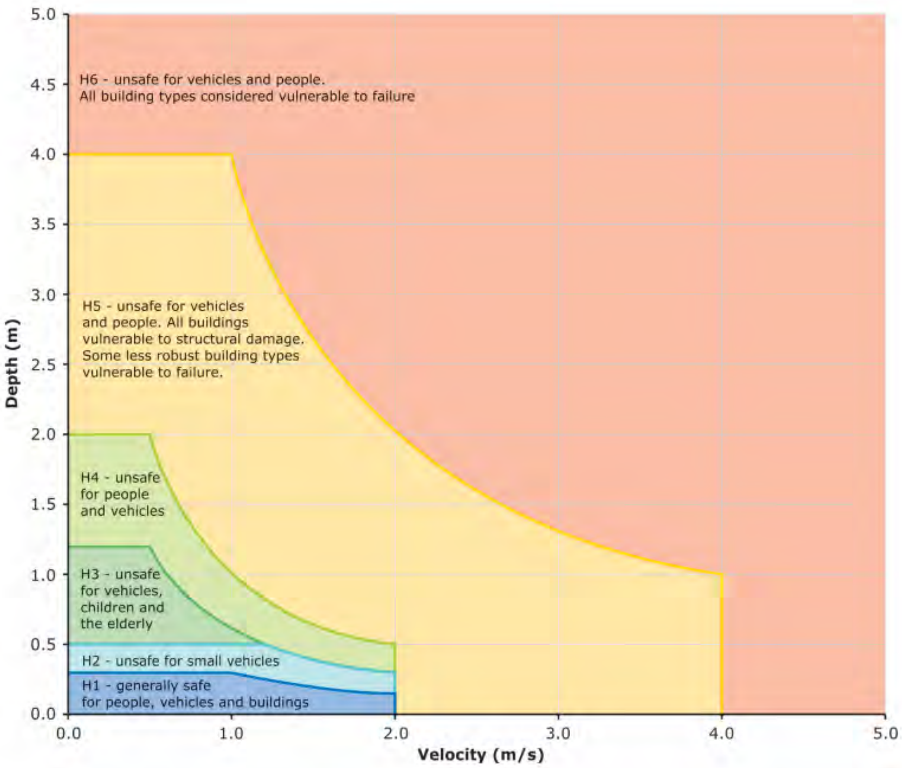

Figure 5: Flood Hazard Curves (ARR 2019, Smith et al 2014)

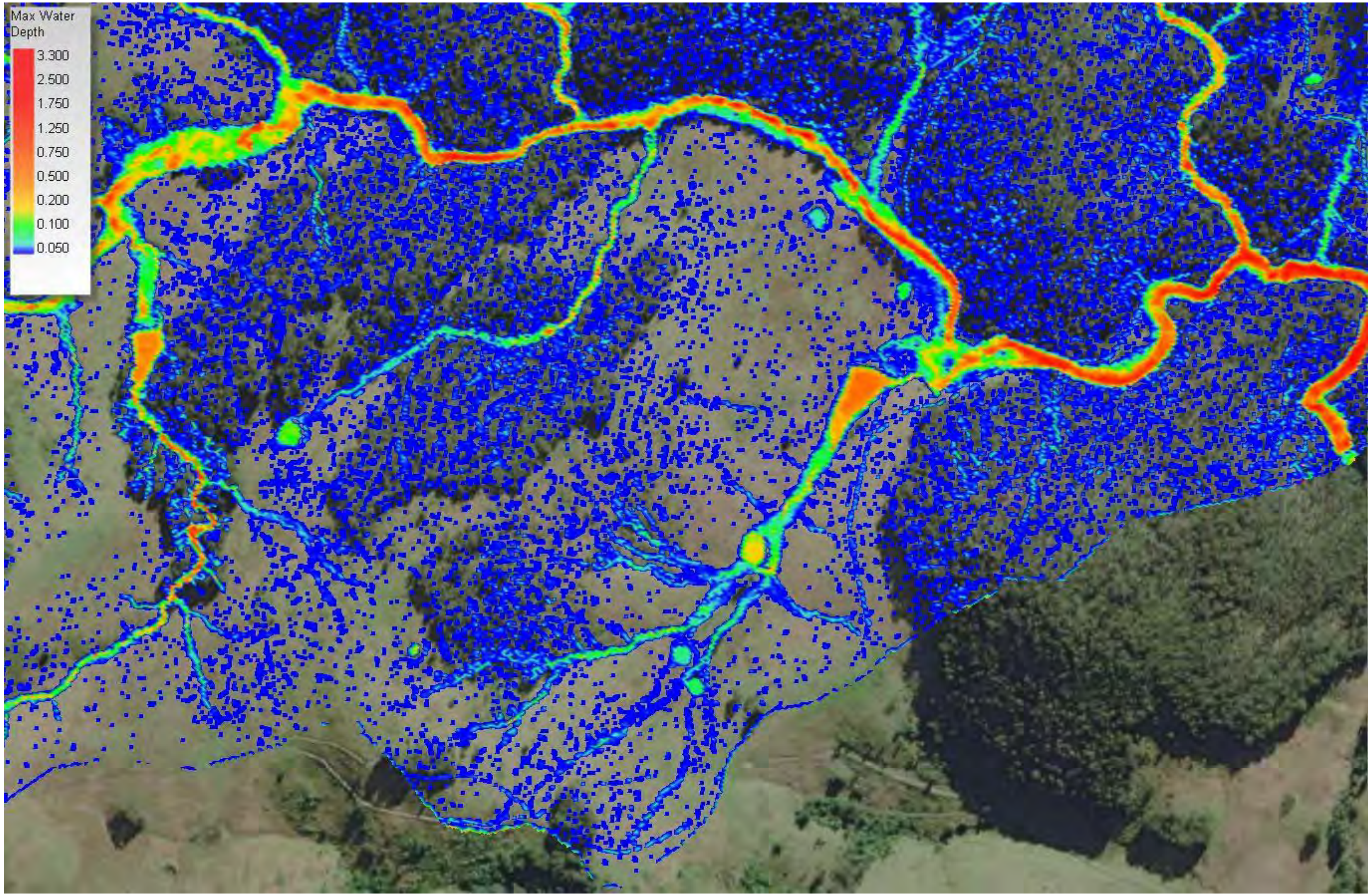

Figure 6: Flood Inundation in the Existing Landform during the Critical Duration 1% AEP Event

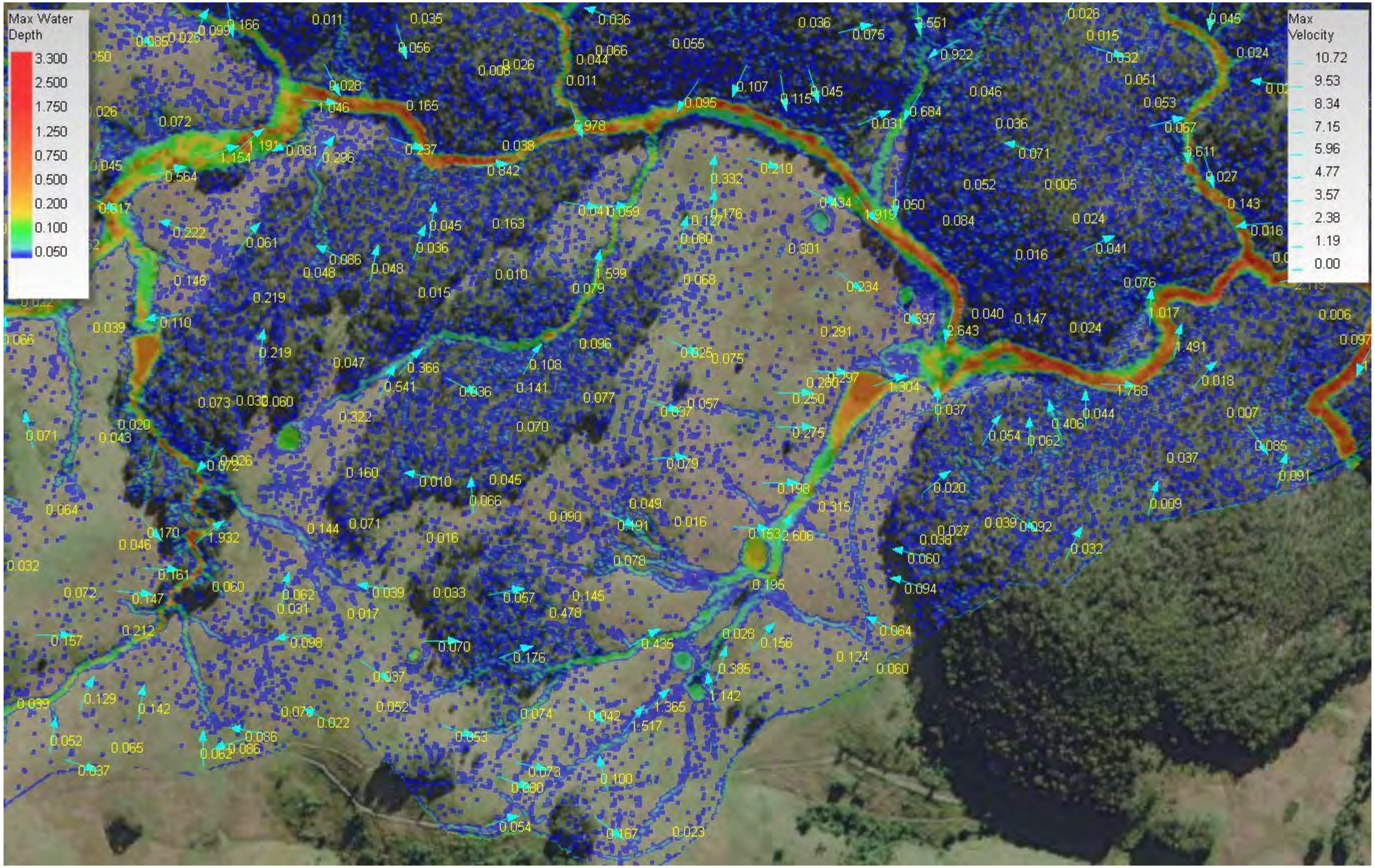

Figure 7: Overland and Mainstream Velocities in the Existing Landform during the Critical Duration 1% AEP Event

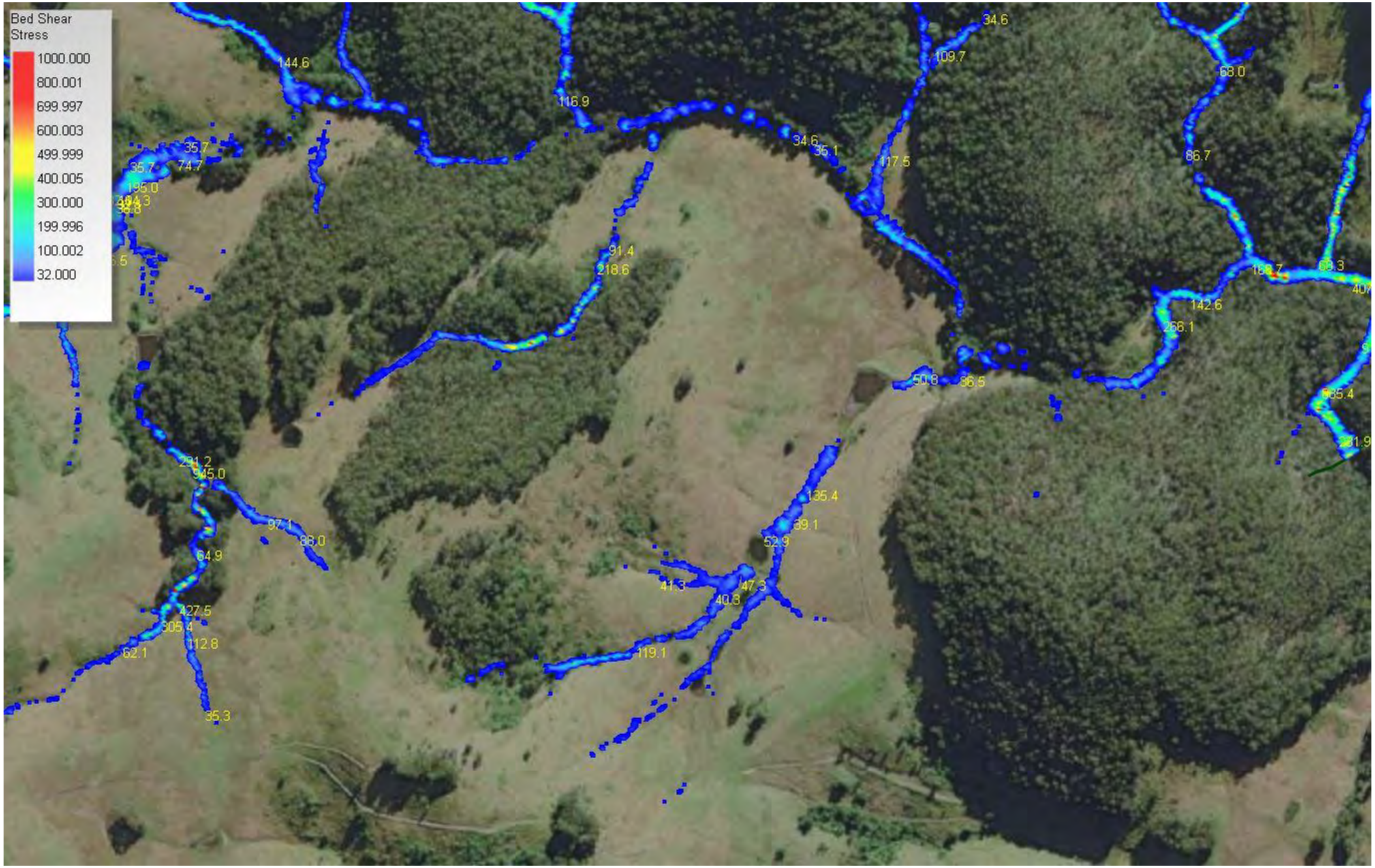

Figure 8: Shear Stress in the Existing Landform during the Critical Duration 1% AEP Event

6.0 Quarried Landform

6.1 Inundation, Outflows, Velocities, Shear Stress & Hazard

6.1.1 Site Inundation and Site Overland Flow Paths

The inundation of the Double Creek catchment would not extend upstream to the Site during the 1% AEP flood. **Figure 11** show an overview of the Site overland flow paths.

The proposed development will involve the construction of conveyance drains, containment bunds and sediment basins. These proposed changes to the topography will reduce the contributing catchment area and flood levels downstream of the Site will reduce. The minor drainage line which passes through the Site and discharges to the Farm Dam will be intercepted by the Infrastructure Sump.

The location of this overland flow path can be seen on **Figure 11**. Modelled flow depths are less than 160 mm during the 1% AEP flood. This flow path does not inundate the proposed footprint for the quarry.

6.1.2 Outflows

Figure 9 shows the peak outflows at the LDP during the 1% AEP flood event. The peak flow from the Site would reach up to 6 m^3/s before reaching the confluence with Double Creek.

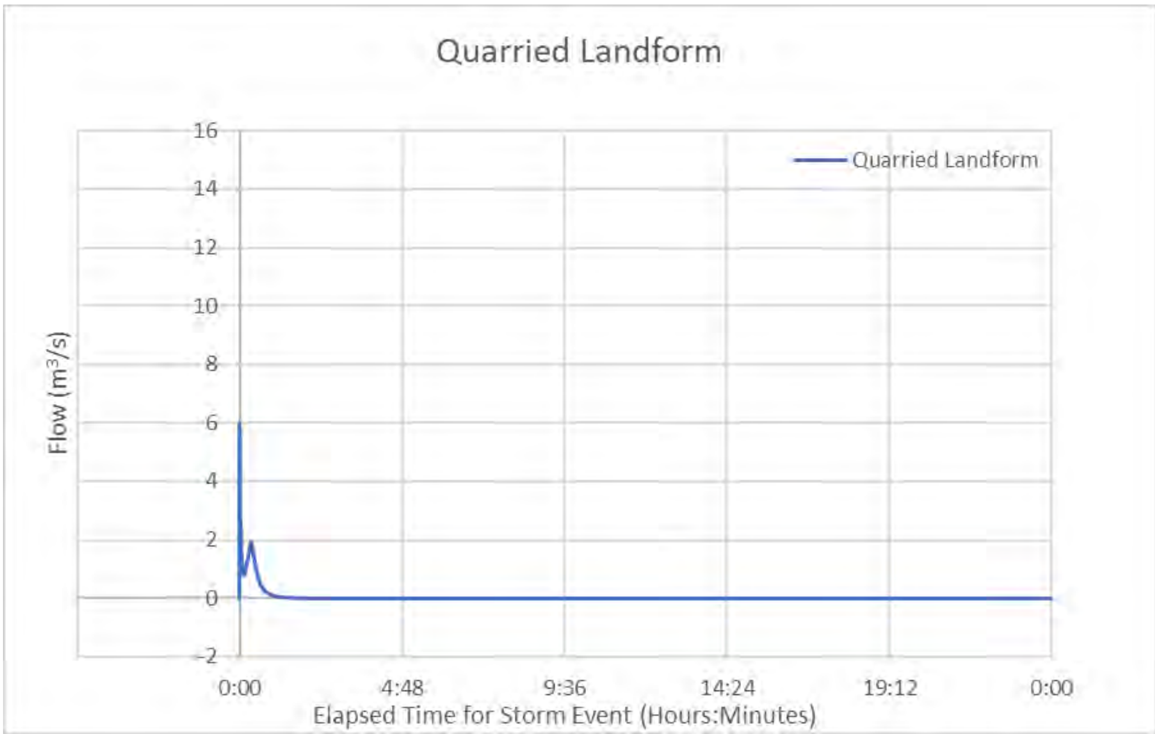

Figure 9: Peak Flow Hydrograph in the Quarried Landform during the Critical Duration 1% AEP Event

6.1.3 Overland and In-Stream Velocities

Figure 12 shows the maximum velocity achieved in both creek and overland flow paths during the 1% AEP flood event. The sheet flow paths through the Site would reach velocities of up to 0.6 m/s before being retained by sediment dams. Peak velocities in the ephemeral creek could reach 2.7 m/s in sections where the creek narrows.

6.1.4 Surface Shear Stress

The shear stress is a measure of the soils shear resistance because of friction and interlocking of particles, and bonding at particle contacts. A shear stress exceeding 100 kPa on bare earth will result in material loss. **Figure 13** shows the surface shear stress across the Site slightly above 50 kPa. No area within or in proximity of the Site would be subjected to erosion from the 1% AEP flood.

6.1.5 Flood Hazard

ARR 2019 assigns flood hazard by the product of velocity and depth (refer **Figure 10**). A value of 0.4 m^2/s and below is considered low hazard for pedestrians and 0.6 m^2/s for small vehicles. Values above 0.6 m^2/s are considered hazardous.

There are no locations within the Project Site or near the Site boundary which are considered hazardous during a 1% AEP flood.

Hazardous areas develop in Double Creek upstream of the Maytoms Lane crossing as depths exceed 1.2 m.

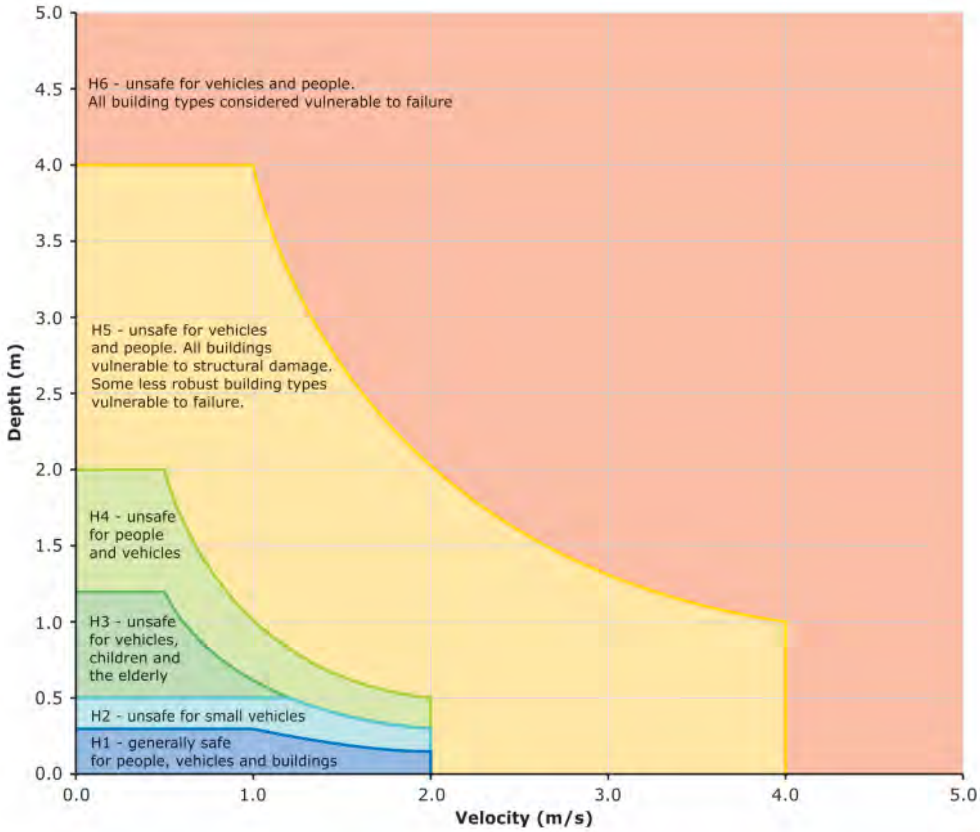

Figure 10: Flood Hazard Curves (ARR 2019, Smith et al 2014)

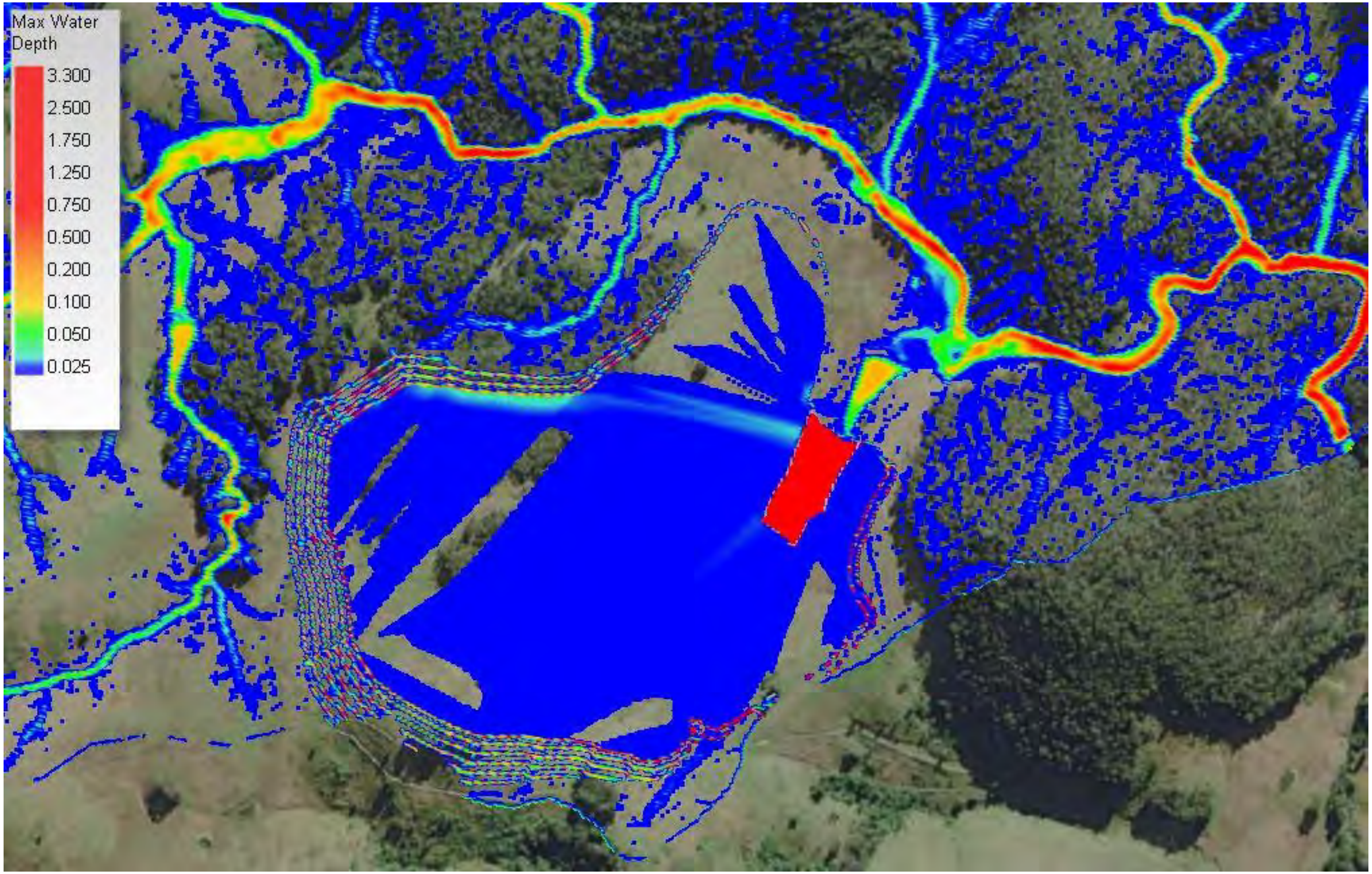

Figure 11: Flood Inundation in the Quarried Landform during the Critical Duration 1% AEP Event

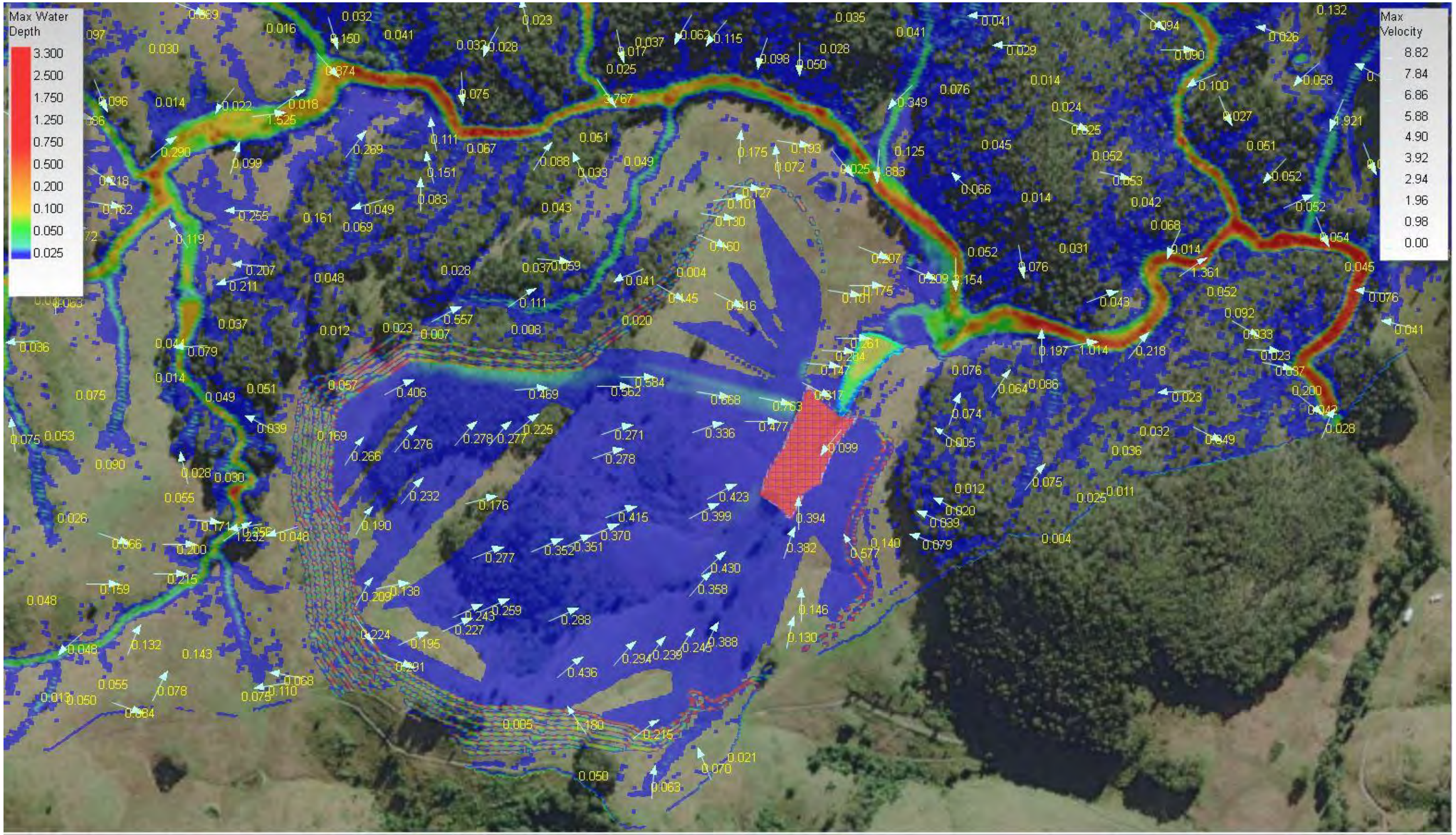

Figure 12: Overland and Mainstream Velocities in the Quarried Landform during the Critical Duration 1% AEP event

Figure 13: Shear Stress in the Quarried Landform during the Critical Duration 1% AEP Event

7.0 Double Creek Crossing

7.1 Baseline Inundation, Outflows, Velocities, Shear Stress & Hazard

The development of the haul road from Maytoms Lane is required to cross Double Creek to access the Site. The inundation, outflow, bed velocities, shear stresses, and hazard are determined for the location before the construction of the crossing, and are outlined in **Sections 7.1.1** to **7.1.3**.

7.1.1 Site Inundation and Site Overland Flow Paths

The inundation of Double Creek at the location of the proposed crossing would not extend upstream to the Site during the 1% AEP flood. **Figure 15** shows an overview of the Site overland flow paths.

7.1.2 Overland and In-Stream Velocities

Figure 15 shows the maximum velocity achieved in the creek during the 1% AEP flood event.

7.1.3 Flood Hazard

ARR 2019 assigns flood hazard by the product of velocity and depth (refer **Figure 14**). A value of 0.4 m^2/s and below is considered low hazard for pedestrians and 0.6 m^2/s for small vehicles. Values above 0.6 are considered hazardous.

There are locations in the undeveloped Site which are considered hazardous during a 1% AEP flood.

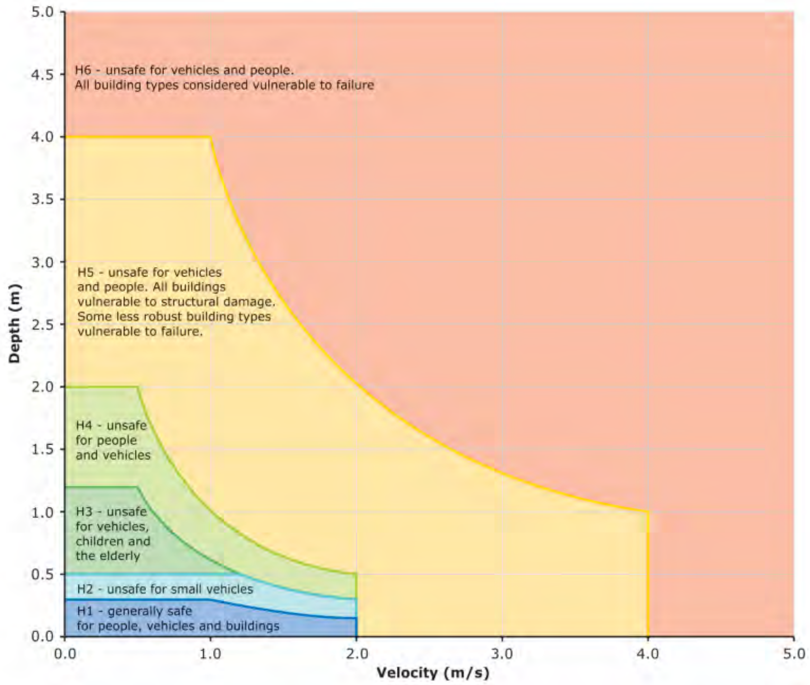

Figure 14: Flood Hazard Curves (ARR 2019), Smith et al 2014)

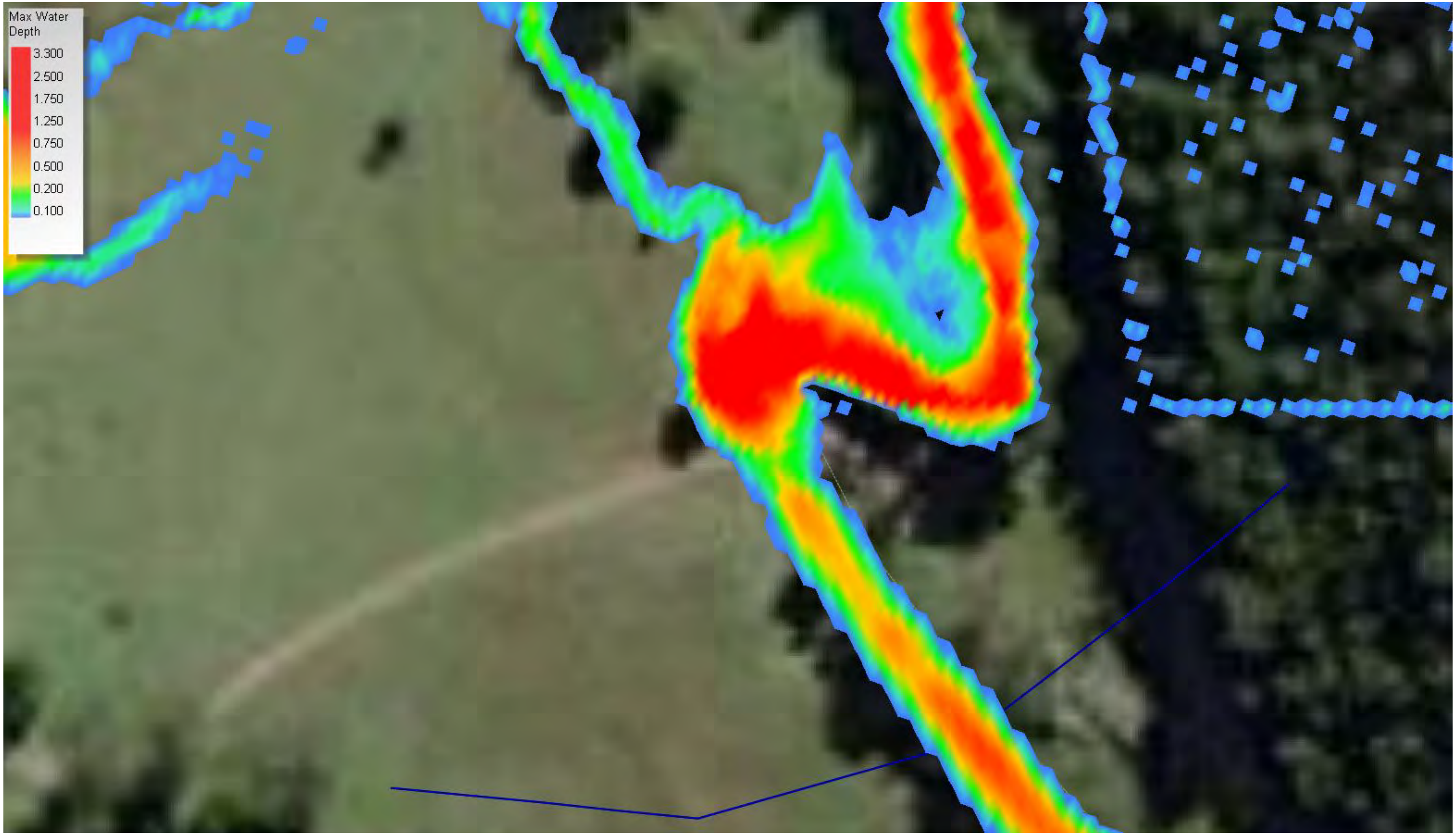

Figure 15: Flood Inundation at the Proposed Crossing Location during the Critical Duration 1% AEP Event

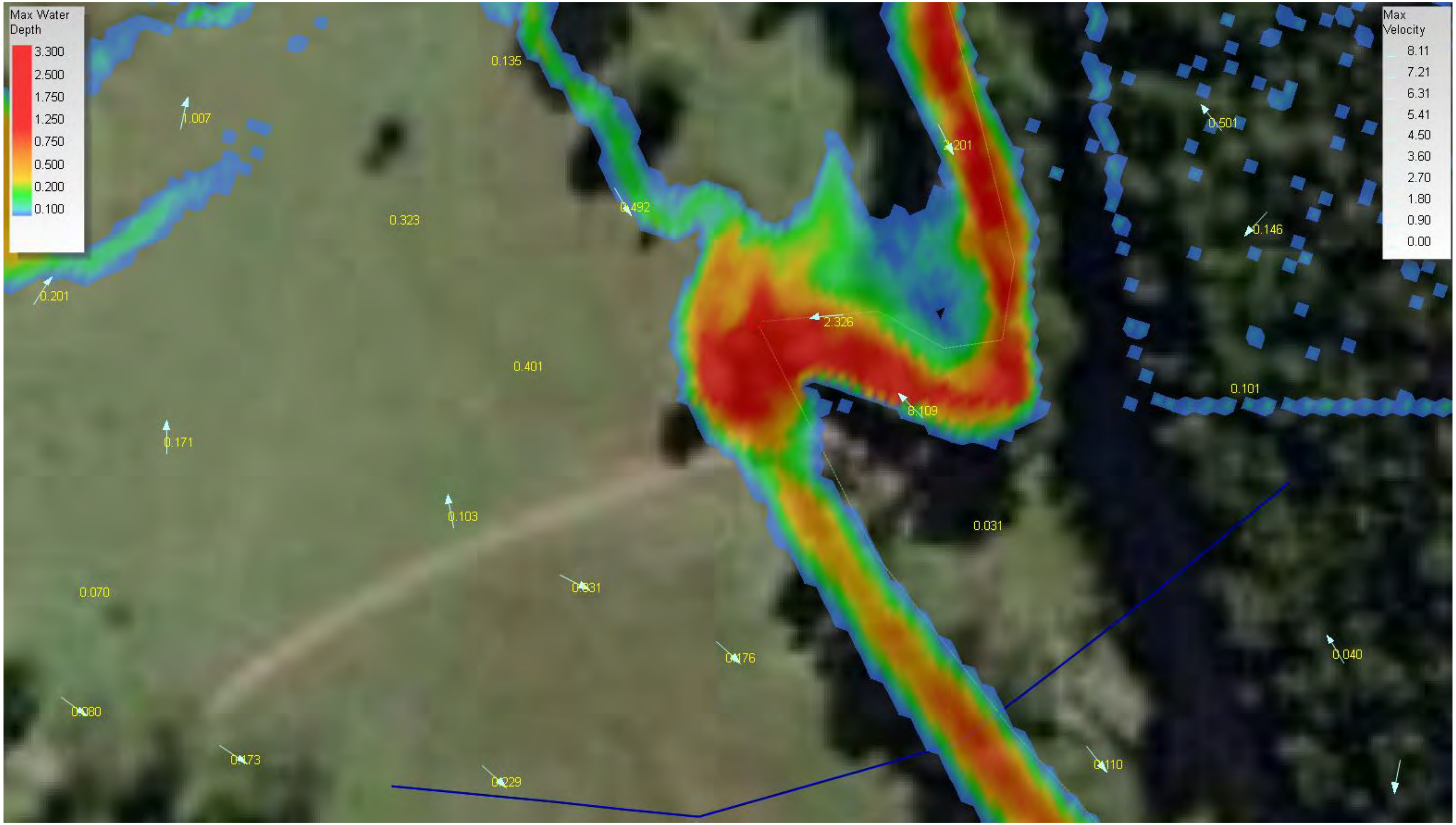

Figure 16: Overland and Mainstream Velocities at the Proposed Crossing Location during the Critical Duration 1% AEP Event

7.2 Crossing Inundation, Outflows, Velocities, Shear Stress & Hazard

The development of the haul road from Maytoms Lane is required to cross Double Creek to access the Site.

The bridge was modelled as a twin 12 m span super T with a 1 m wide central pier soffit at RL 32.35 m, orientated at a 45-degree skew to the creek line. The deck level was at an RL of 33.25 m with a deck thickness of 900 mm. An entry loss of 0.7 and exit loss of 1.0 was assumed to represent losses surrounding the central pier. A manning's n of 0.04 was assumed on all banks to represent a rip rap style erosion protection.

The inundation, outflow, bed velocities, shear stresses, and hazard are determined for the designed crossing.

7.2.1 Site Inundation and Site Overland Flow Paths

The inundation of the Double Creek crossing would not extend upstream to the Site during the 1% AEP flood. **Figure 18** shows an overview of the Site overland flow paths. This flow does not overtop the crossing.

Figure 19 outlines the flood level difference between the developed and undeveloped Sites. Modelled flow depths upstream of the crossing do not increase with the development of the crossing, while flow depths increase slightly downstream.

7.2.2 Overland and In-Stream Velocities

Figure 20 shows the maximum velocity achieved in the creek during the 1% AEP flood event.

7.2.3 Flood Hazard

ARR 2019 assigns flood hazard by the product of velocity and depth (refer **Figure 17**). A value of 0.4 m^2/s and below is considered low hazard for pedestrians and 0.6 m^2/s for small vehicles. Values above 0.6 are considered hazardous.

There are no locations atop the crossing which are considered hazardous during a 1% AEP flood.

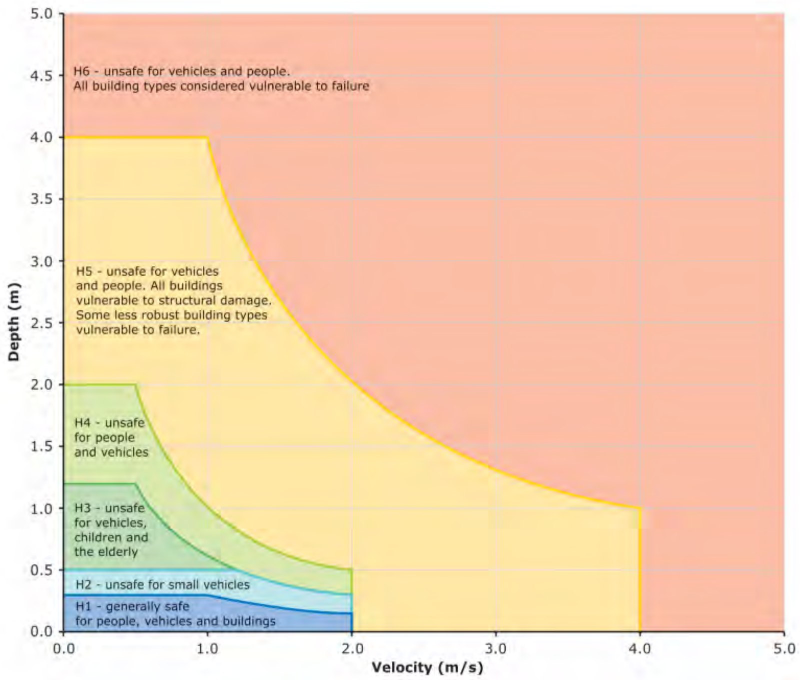

Figure 17: Flood Hazard Curves (ARR 2019, Smith et al 2014)

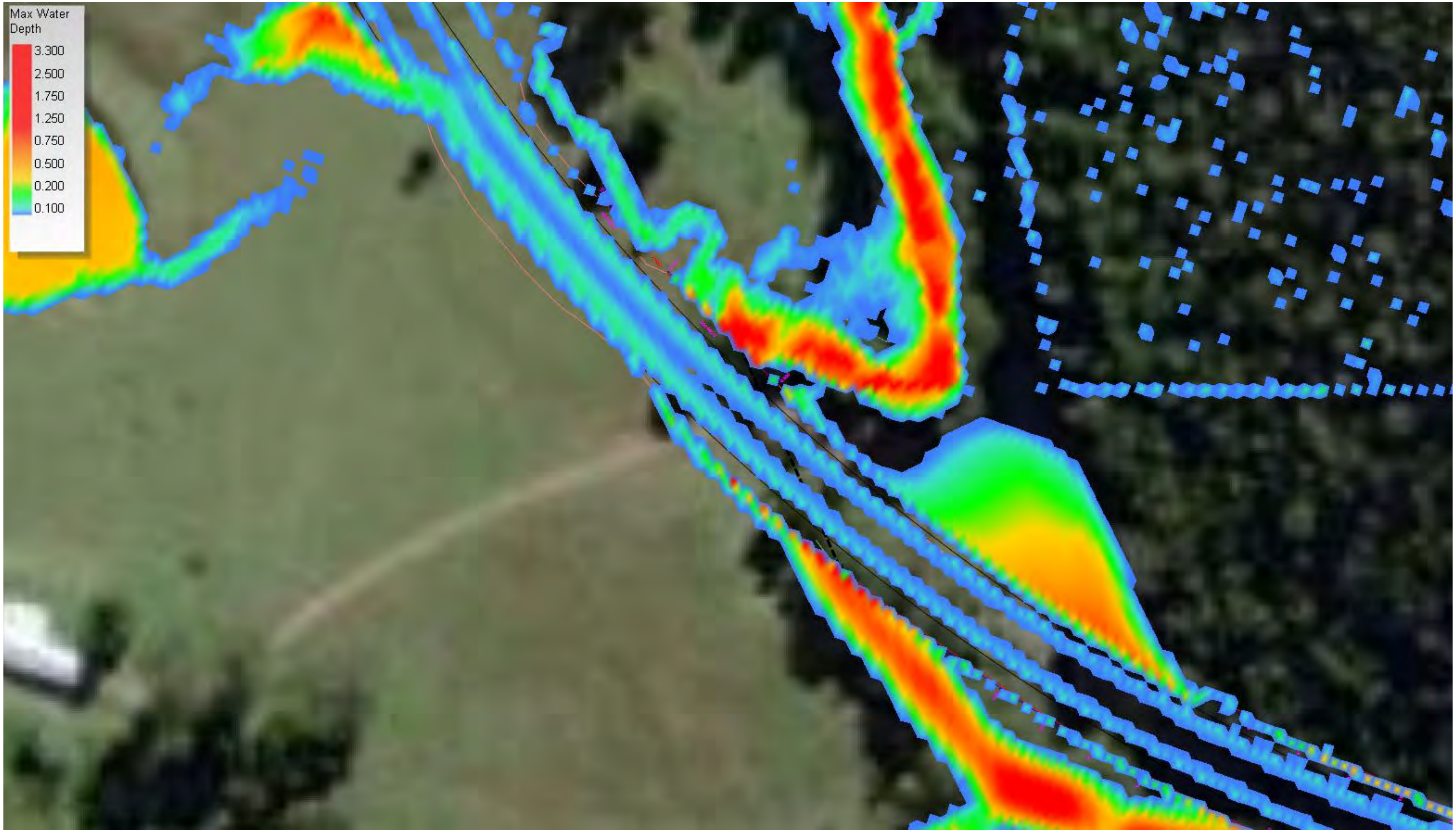

Figure 18: Flood Inundation at the Crossing during the Critical Duration 1% AEP Event

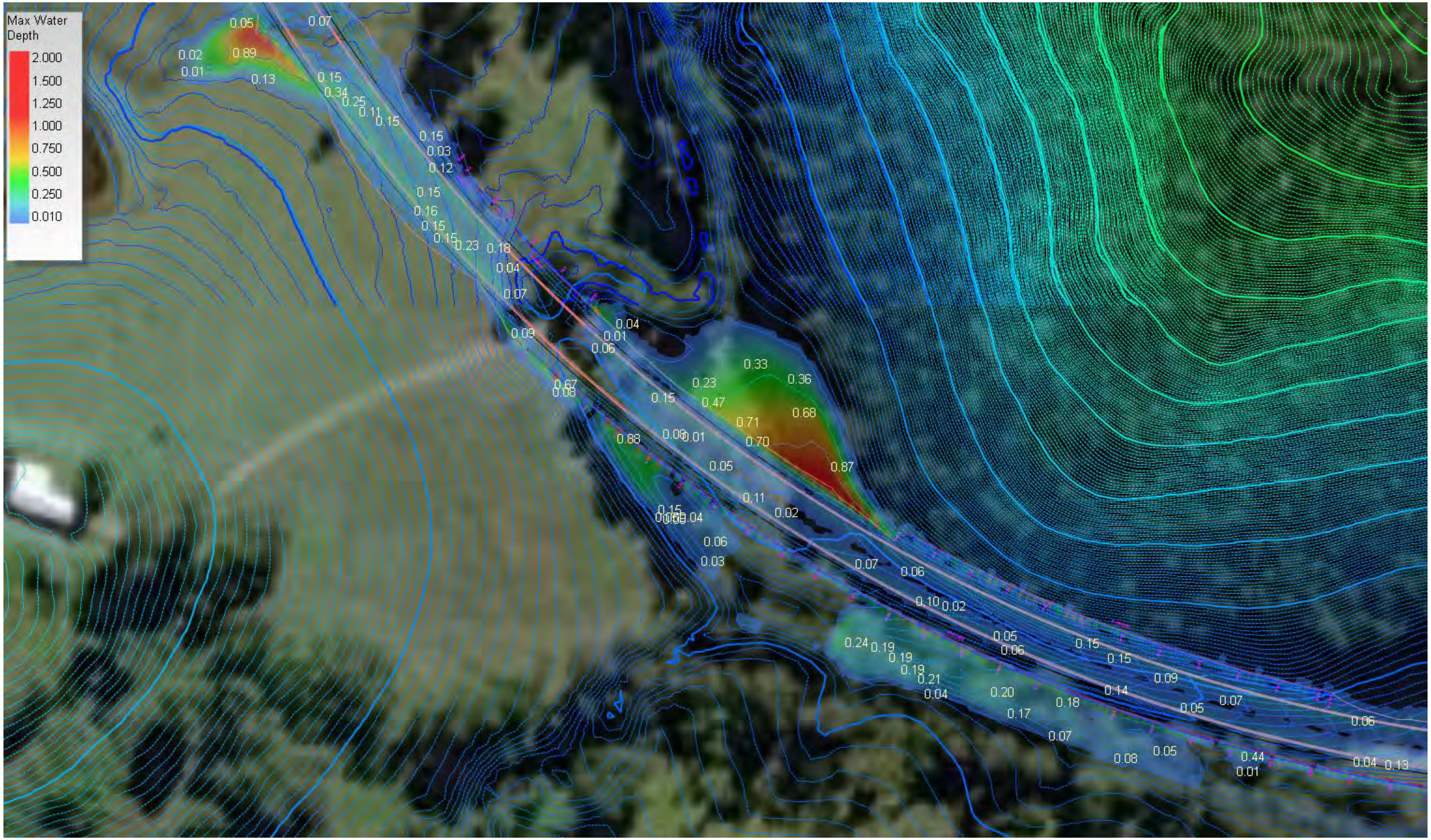

Figure 19: Pre and Post Development Flood Level Difference for the Double Creek Crossing

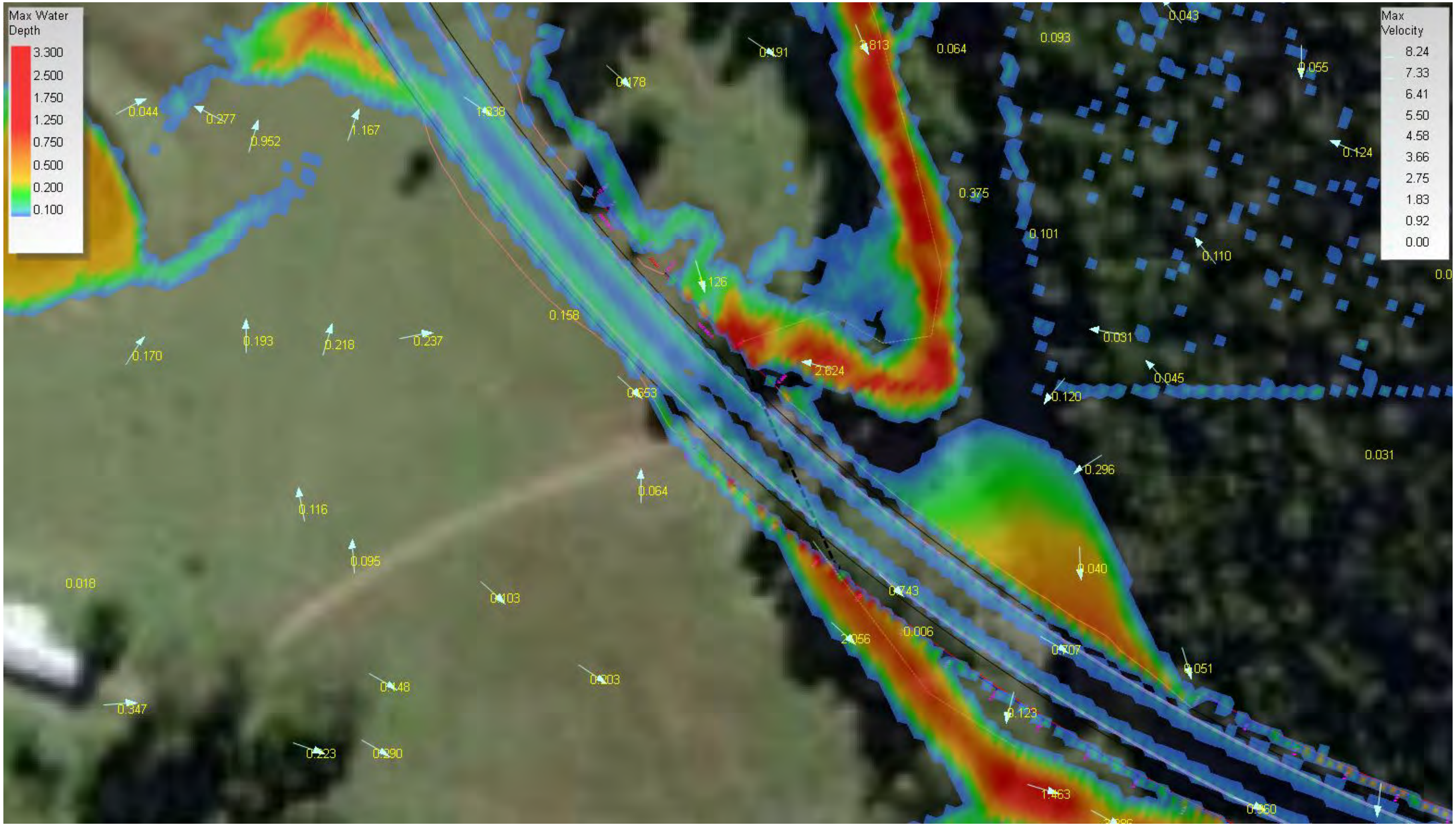

Figure 20: Overland and Mainstream Velocities at the Crossing during the Critical Duration 1% AEP Event

8.0 Comparison of Results

Comparison of **Sections 5.0** and **6.0** indicate that there is an approximate 9 m^3/s reduction in peak flow from the LDP after development occurs. Additionally, there are further reductions in overland and in-stream velocities, shear stress, and flood hazard post-development. These results show that there will not be an increase in likelihood of flooding due to the development of the quarry.

Section 7.0 shows no overtopping of the Double Creek crossing in a 1% AEP storm event. Additionally, there are no increases in overland and in-stream velocities, and flood hazard post-development of the crossing.

9.0 Conclusion

The following flood and surface water related requirements of the SEARs have been addressed in this report;

"An assessment of any likely flooding impacts of the development"

"An assessment of the likely impacts on the quality and quantity of existing surface and ground water resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives"

"An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users"

Detailed hydraulic modelling has confirmed the Site is unaffected by floodwaters up to and including the 1% AEP flood. This conclusion includes both backwater influences from the Double Creek catchment, and potential ponding upstream of the Maytoms Lane crossing.

Hydraulic modelling of overland flow over the Site has confirmed erosion and mobilisation of fines is unlikely to occur after stripping vegetation cover.

The proposed development will involve the construction of conveyance drains, containment bunds, a creek crossing, and sediment basins. These proposed changes to the topography will reduce the contributing catchment area and flood levels downstream of the Site will reduce. The minor drainage line which passes through the Site and discharges to the Farm Dam will be intercepted by the Infrastructure Sump. As the contributing catchment to this drainage path upstream of the Infrastructure Sump is small, changes to the runoff volume entering the riparian corridor will be negligible.

The development of the Double Creek crossing does not impede on outflow, and bed velocities, while providing a reduction in flood hazard.

10.0 References

Australian Rainfall and Runoff, Institution of Engineers, November 2019 (ARR 2019)

NSW Government, SEED, online environmental database: https://www.seed.nsw.gov.au/ (SEED 2022)

Australian Bureau of Meteorology, Climate Data Online
http://www.bom.gov.au/climate/cdo/about/cdo-rainfall-feature.shtml

Australian Bureau of Meteorology, IFD Data Online

http://www.bom.gov.au/water/designRainfalls/revised-ifd/

Regional Flood Frequency Estimation Model. ARR Software. http://rffe.arr-software.org/

Appendix B Water Quality Data

Hillview Hard Rock Quarry

Surface Water Assessment

Coast Wide Materials Pty Ltd

SLR Project No.: 630.V12117.00200

27 June 2024

Double Creek Upstream Monitoring Point (DC-US)

Date	Temperature	pH (pH unit)	Electrical Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Suspended Solids (mg/L)
24-01-2019	21.1	7.2	849	2.1	21	30
21-03-2019	20.3	6.6	331	4.3	7.2	7
18-04-2019	16.9	6.6	670	3.2	0.95	<2
16-05-2019	12.4	7.6	758	6.2	2.3	4
13-06-2019	12.9	6.7	460	4.4	5	<2
11-07-2019	10.4	6.9	371	8.2	6.9	<2
09-08-2019	10.8	6.7	586	4.5	5.5	13
06-09-2019	13.5	6.7	721	3	18	21
11-10-2019	14.1	6.7	661	4.6	7.3	6
29-11-2019	No water flowing, no sample taken.					
19-12-2019						
24-01-2020						
28-02-2020	20.8	6.6	428	3.2	1.8	11
20-03-2020	21.9	6.8	366	6.5	6.2	<2
17-04-2020	20.4	6.6	404	3.2	2	4
15-05-2020	16	6.5	605	3.7	17	3
12-06-2020	17.4	6.9	235	9.5	17	6
10-07-2020	14.4	6.7	400	3.6	1.8	<2
07-08-2020	12.4	6.7	332	9.7	6.5	<2
04-09-2020	17.2	6.5	449	2.4	11	3
02-10-2020	14.8	6.6	672	3.2	3.1	<2
27-11-2020	18.4	6.6	710	2.8	2.8	6

Date	Temperature	pH (pH unit)	Electrical Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Suspended Solids (mg/L)
10-12-2020	18.2	6.7	798	3	8.8	4

Date	Fluoride (mg/L)	Total Alkalinity (mg/L)	Sodium - Dissolved (mg/L)	Potassium - Dissolved (mg/L)	Calcium - Dissolved (mg/L)	Magnesium - Dissolved (mg/L)	Total Hardness (mg/L)
24-01-2019	0.2	170	100	7.4	36	23	190
21-03-2019	0.1	36	28	3.1	14	8.8	71
18-04-2019	0.1	60	84	3.6	30	23	170
16-05-2019	0.1	67	82	3.5	29	22	160
13-06-2019	0.1	63	60	2.9	19	14	110
11-07-2019	0.2	51	49	2.4	16	12	89
09-08-2019	0.1	71	71	3	29	21	160
06-09-2019	0.1	69	78	4	35	26	190
11-10-2019	0.1	81	80	3.5	30	21	160
29-11-2019	No water flowing, no sample taken.						
19-12-2019							
24-01-2020							
28-02-2020	<0.1	35	49	3.1	12	9.5	69
20-03-2020	0.1	36	76	1.8	10	16	90
17-04-2020	0.1	42	42	2.7	13	10	74
15-05-2020	<0.1	61	53	3.2	25	19	140
12-06-2020	<0.1	<30	30	1.7	5.8	4.8	34
10-07-2020	<0.1	37	44	2.3	14	12	82
07-08-2020	<0.1	<30	38	1.9	9.1	8	56
04-09-2020	0.1	38	51	2.6	14	12	83

Date	Fluoride (mg/L)	Total Alkalinity (mg/L)	Sodium - Dissolved (mg/L)	Potassium - Dissolved (mg/L)	Calcium - Dissolved (mg/L)	Magnesium - Dissolved (mg/L)	Total Hardness (mg/L)
02-10-2020	<0.1	62	76	3.2	26	20	150
27-11-2020	<0.1	83	72	3.7	27	20	150
10-12-2020	<0.1	88	92	4.1	34	25	190

Date	Ammonia as N (mg/L)	Nitrite as N (mg/L)	Nitrate as N (mg/L)	Total Nitrogen (mg/L)	Phosphate as P (mg/L)	Total Phosphorus (mg/L)	Total Cyanide (mg/L)
24-01-2019	2.1	<0.005	<0.005	7.5	0.042	0.5	<0.004
21-03-2019	0.14	<0.005	0.01	1.4	<0.005	0.05	<0.004
18-04-2019	0.016	<0.005	<0.005	0.2	<0.005	<0.05	<0.004
16-05-2019	0.009	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
13-06-2019	<0.005	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
11-07-2019	0.006	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
09-08-2019	<0.005	<0.005	0.005	0.2	<0.005	<0.05	<0.004
06-09-2019	0.03	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
11-10-2019	0.032	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
29-11-2019	No water flowing, no sample taken.						
19-12-2019							
24-01-2020							
28-02-2020	<0.005	<0.005	0.007	0.4	<0.005	<0.05	<0.004
20-03-2020	0.01	<0.005	0.005	0.3	<0.005	<0.05	<0.004
17-04-2020	<0.005	<0.005	0.008	0.2	<0.005	<0.05	<0.004
15-05-2020	<0.005	<0.005	<0.005	0.4	<0.005	<0.05	<0.004
12-06-2020	<0.005	<0.005	0.13	0.3	<0.005	<0.05	<0.004
10-07-2020	<0.005	<0.005	0.02	0.2	<0.005	<0.05	<0.004

Date	Ammonia as N (mg/L)	Nitrite as N (mg/L)	Nitrate as N (mg/L)	Total Nitrogen (mg/L)	Phosphate as P (mg/L)	Total Phosphorus (mg/L)	Total Cyanide (mg/L)
07-08-2020	<0.005	<0.005	0.03	0.4	<0.005	<0.05	<0.004
04-09-2020	0.006	<0.005	0.008	0.2	<0.005	<0.05	<0.004
02-10-2020	0.018	<0.005	<0.005	0.2	<0.005	<0.05	<0.004
27-11-2020	0.025	<0.005	<0.005	0.3	<0.005	<0.004	<0.004
10-12-2020	0.069	<0.005	<0.005	0.3	<0.005	<0.004	<0.004

Date	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)
24-01-2019	<0.01	0.003	0.22	<0.0001	<0.001	0.001	<0.001	0.78
21-03-2019	0.06	<0.001	0.08	<0.0001	<0.001	0.001	<0.001	0.34
18-04-2019	<0.01	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.05
16-05-2019	<0.01	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.05
13-06-2019	0.01	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.02
11-07-2019	<0.01	<0.001	<0.02	<0.0001	<0.001	<0.001	<0.001	0.01
09-08-2019	<0.01	<0.001	<0.02	<0.0001	<0.001	<0.001	<0.001	0.08
06-09-2019	1	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.8
11-10-2019	0.22	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.26
29-11-2019	No water flowing, no sample taken.							
19-12-2019								
24-01-2020								
28-02-2020	0.01	<0.001	0.03	<0.0001	<0.001	<0.001	0.002	0.02
20-03-2020	0.05	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.08
17-04-2020	0.02	<0.001	<0.02	<0.0001	<0.001	<0.001	<0.001	0.14
15-05-2020	<0.01	<0.001	0.03	<0.0001	<0.001	0.002	<0.001	0.1

Date	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)
12-06-2020	0.08	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.15
10-07-2020	0.01	<0.001	<0.02	<0.0001	<0.001	<0.001	<0.001	0.09
07-08-2020	0.02	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.02
04-09-2020	<0.01	<0.001	<0.02	<0.0001	<0.001	<0.001	<0.001	0.11
02-10-2020	0.02	<0.001	<0.02	<0.0001	<0.001	0.001	<0.001	0.44
27-11-2020	0.03	<0.001	0.04	<0.0001	<0.001	0.001	<0.001	0.82
10-12-2020	0.03	<0.001	<0.02	<0.0001	<0.001	0.002	<0.001	1.1

Date	Lead (mg/L)	Manganese (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Tin (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
24-01-2019	<0.001	0.64	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.068
21-03-2019	<0.001	0.21	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.053
18-04-2019	<0.001	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02
16-05-2019	<0.001	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021
13-06-2019	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021
11-07-2019	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019
09-08-2019	<0.001	0.041	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.018
06-09-2019	<0.001	0.19	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.005
11-10-2019	<0.001	0.098	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.004
29-11-2019	No water flowing, no sample taken.								
19-12-2019									
24-01-2020									
28-02-2020	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.022
20-03-2020	<0.001	0.015	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019

Date	Lead (mg/L)	Manganese (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Tin (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
17-04-2020	<0.001	0.043	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.018
15-05-2020	<0.001	0.31	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.023
12-06-2020	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.023
10-07-2020	<0.001	0.03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017
07-08-2020	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.015
04-09-2020	<0.001	0.059	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.019
02-10-2020	<0.001	0.21	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
27-11-2020	<0.001	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
10-12-2020	<0.001	0.23	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004

Double Creek Downstream Monitoring Point (DC-DS)

Date	Temperature	pH (pH unit)	Electrical Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Suspended Solids (mg/L)
24-01-2019	22.8	7.9	1150	2	3.1	3
21-03-2019	20.3	7.3	1350	2.3	9.5	9
18-04-2019	16.3	7.5	703	6.4	0.95	<2
16-05-2019	12.6	7.5	767	6.3	2	7
13-06-2019	12.4	7.5	510	8	2.5	2
11-07-2019	9.6	7.5	457	9.9	2.1	4
09-08-2019	11	7.2	919	5.5	3.4	3
06-09-2019	13.1	7.5	991	6.5	2.2	<2
11-10-2019	14.2	7.6	789	8.2	2.3	<2
29-11-2019	20.6	8	2140	5.3	4.1	4
19-12-2019	19.5	7.5	1460	3.5	8	4
24-01-2020	24.6	7.5	1680	2.1	7.9	7
28-02-2020	20.7	7.2	497	5.8	2.4	3
20-03-2020	21.1	7.3	405	7.9	3.1	<2
17-04-2020	19.4	7.1	472	6.1	1.8	<2
15-05-2020	15.5	7.5	634	8.6	0.75	<2
12-06-2020	17.3	7.3	249	9.9	11	4
10-07-2020	13.9	7.1	471	9.7	0.8	<2
07-08-2020	11.4	7.3	394	12.1	3.8	<2
04-09-2020	16.3	7.4	586	7.8	0.9	2
02-10-2020	14.1	7.5	808	6.8	0.75	<2
27-11-2020	20.5	7.5	936	3.2	3.3	6
10-12-2020	19	7.7	1100	4.4	3.1	4

Date	Fluoride (mg/L)	Total Alkalinity (mg/L)	Sodium - Dissolved (mg/L)	Potassium - Dissolved (mg/L)	Calcium - Dissolved (mg/L)	Magnesium - Dissolved (mg/L)	Total Hardness (mg/L)
24-01-2019	0.4	450	170	6.9	43	38	270
21-03-2019	0.6	530	180	2	65	54	380
18-04-2019	0.2	180	110	3.2	24	24	160
16-05-2019	0.2	220	120	3.3	29	29	190
13-06-2019	0.1	140	78	2.7	18	18	120
11-07-2019	0.1	130	66	2.4	18	18	120
09-08-2019	0.3	350	120	2	49	40	290
06-09-2019	0.2	230	140	4.3	40	37	250
11-10-2019	0.2	190	120	4	29	26	180
29-11-2019	0.9	470	300	5.2	55	69	420
19-12-2019	0.6	630	180	1.5	66	62	420
24-01-2020	0.6	580	170	3.1	81	68	480
28-02-2020	0.1	69	51	3.2	13	12	80
20-03-2020	<0.1	58	280	4	28	58	310
17-04-2020	0.1	85	66	2.8	14	13	90
15-05-2020	<0.1	140	75	3	20	20	130
12-06-2020	<0.1	32	32	1.6	5.8	5.6	37
10-07-2020	0.1	100	67	2.3	15	15	100
07-08-2020	<0.1	60	46	2	11	11	70
04-09-2020	0.1	130	74	2.8	18	17	120
02-10-2020	<0.1	200	110	3.3	25	25	170
27-11-2020	0.2	260	120	6	28	27	180
10-12-2020	0.3	310	160	4.5	39	35	240

Date	Ammonia as N (mg/L)	Nitrite as N (mg/L)	Nitrate as N (mg/L)	Total Nitrogen (mg/L)	Phosphate as P (mg/L)	Total Phosphorus (mg/L)	Total Cyanide (mg/L)
24-01-2019	0.015	<0.005	<0.005	1.1	0.007	<0.05	<0.004
21-03-2019	0.013	<0.005	0.007	0.3	0.013	<0.05	<0.004
18-04-2019	0.013	<0.005	0.006	0.5	<0.005	<0.05	<0.004
16-05-2019	0.011	<0.005	<0.005	0.3	0.006	<0.05	<0.004
13-06-2019	<0.005	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
11-07-2019	<0.005	<0.005	<0.005	0.2	<0.005	<0.05	<0.004
09-08-2019	<0.005	<0.005	0.01	0.2	<0.005	<0.05	<0.004
06-09-2019	0.013	<0.005	<0.005	0.4	0.01	<0.05	<0.004
11-10-2019	0.039	<0.005	<0.005	0.5	0.029	0.06	<0.004
29-11-2019	0.018	<0.005	<0.005	0.8	<0.005	<0.05	<0.004
19-12-2019	0.066	<0.005	<0.005	0.2	0.006	<0.05	<0.004
24-01-2020	0.023	<0.005	<0.005	0.7	0.014	<0.05	<0.004
28-02-2020	<0.005	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
20-03-2020	0.007	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
17-04-2020	<0.005	<0.005	0.01	0.3	<0.005	<0.05	<0.004
15-05-2020	<0.005	<0.005	<0.005	0.3	<0.005	<0.05	<0.004
12-06-2020	<0.005	<0.005	0.23	0.4	<0.005	<0.05	<0.004
10-07-2020	<0.005	<0.005	0.007	0.2	<0.005	<0.05	<0.004
07-08-2020	<0.005	<0.005	0.03	0.3	<0.005	<0.05	<0.004
04-09-2020	<0.005	<0.005	0.01	0.2	<0.005	<0.05	<0.004
02-10-2020	<0.005	<0.005	<0.005	0.2	<0.005	<0.05	<0.004
27-11-2020	0.16	<0.005	<0.005	1	<0.005	<0.004	<0.004
10-12-2020	0.076	<0.005	<0.005	0.5	<0.005	<0.004	<0.004

Date	Aluminium (mg/L)	Arsenic (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)
24-01-2019	<0.01	0.001	0.09	<0.0001	<0.001	<0.001	<0.001	0.16
21-03-2019	<0.01	<0.001	0.2	<0.0001	<0.001	<0.001	<0.001	0.09
18-04-2019	<0.01	<0.001	0.05	<0.0001	<0.001	<0.001	0.002	0.04
16-05-2019	<0.01	<0.001	0.04	<0.0001	<0.001	<0.001	<0.001	0.09
13-06-2019	<0.01	<0.001	0.04	<0.0001	<0.001	<0.001	<0.001	0.03
11-07-2019	<0.01	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.07
09-08-2019	<0.01	<0.001	0.04	<0.0001	<0.001	<0.001	<0.001	0.13
06-09-2019	0.03	<0.001	0.04	<0.0001	<0.001	<0.001	<0.001	0.25
11-10-2019	<0.01	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.12
29-11-2019	<0.01	0.001	0.1	<0.0001	<0.001	<0.001	<0.001	0.05
19-12-2019	<0.01	<0.001	0.06	<0.0001	<0.001	<0.001	<0.001	0.04
24-01-2020	<0.01	<0.001	0.08	<0.0001	<0.001	<0.001	<0.001	0.01
28-02-2020	<0.01	<0.001	0.04	<0.0001	<0.001	<0.001	<0.001	0.06
20-03-2020	0.02	<0.001	0.04	<0.0001	<0.001	<0.001	<0.001	0.14
17-04-2020	<0.01	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.06
15-05-2020	<0.01	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.07
12-06-2020	0.07	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.18
10-07-2020	<0.01	<0.001	0.03	<0.0001	<0.001	<0.001	<0.001	0.03
07-08-2020	0.01	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.08
04-09-2020	<0.01	<0.001	<0.02	<0.0001	<0.001	<0.001	<0.001	0.02
02-10-2020	0.02	<0.001	0.02	<0.0001	<0.001	<0.001	<0.001	0.04
27-11-2020	0.04	<0.001	0.06	<0.0001	<0.001	<0.001	<0.001	0.24
10-12-2020	0.03	0.001	0.04	0.0001	<0.001	<0.001	<0.001	0.31

Date	Lead (mg/L)	Manganese (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Tin (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
24-01-2019	<0.001	0.52	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019
21-03-2019	<0.001	0.13	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.04
18-04-2019	<0.001	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.024
16-05-2019	<0.001	0.048	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.014
13-06-2019	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.015
11-07-2019	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.015
09-08-2019	<0.001	0.14	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012
06-09-2019	<0.001	0.082	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003
11-10-2019	<0.001	0.022	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002
29-11-2019	<0.001	0.088	0.002	<0.001	<0.001	<0.001	<0.001	0.005	0.011
19-12-2019	<0.001	0.14	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
24-01-2020	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
28-02-2020	<0.001	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.016
20-03-2020	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.015
17-04-2020	<0.001	0.015	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.014
15-05-2020	<0.001	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.015
12-06-2020	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02
10-07-2020	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016
07-08-2020	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016
04-09-2020	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.012
02-10-2020	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
27-11-2020	<0.001	0.11	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004
10-12-2020	<0.001	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003

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