Eagleton Quarry

Revised Water Assessment

Report Number 630.12046

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Eagleton Rock Syndicate

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1 INTRODUCTION

1.1 Background

The Eagleton Hard Rock Quarry proposal is for a hard rock quarry and associated infrastructure near Eagleton, some 10km north-east of Raymond Terrace in NSW. Components of the project include a resource extraction area, internal haul roads, product processing and stockpiling areas, offices, upgrading and sealing of an access road from Italia Road to the Project area, and water management dams.

An EIS for the proposed Eagleton Hard Rock Quarry was submitted in 2016, and included a Water Assessment prepared by consultants Umwelt. Exhibition of the EIS ended in early March 2017, and the NSW DPE has subsequently provided a ‘Request for Response to Submissions’ by letter dated 17 March 2017, which requests that the proponent prepare a Response To Submissions Report to address submissions made by agencies, special interest groups, and members of the community, and with particular consideration to the matters set out in Attachment A of the DPE letter.

Eagleton Rock Syndicate has engaged SLR Consulting to review the submissions relating to the Umwelt Water Assessment, and refine the surface water strategy to provide a robust solution which also adequately addresses to the submission comments.

This report replaces the original EIS Water Assessment prepared by Umwelt (Umwelt WA), although some parts of that assessment are still relevant, and for completeness a copy of the Umwelt WA is included at Appendix B of this report.

This report is structured as follows:

- Section 1 includes a summary of key changes to the strategy for water management
- Section 2 describes the existing surface water environment
- Section 3 describes the proposed water management system
- Section 4 describes groundwater
- Section 5 describes water balance modelling carried out to estimate the fluctuation in site dam and pit storage volumes over time, the distribution and volume of ‘planned discharges’, and the frequency of ‘unplanned discharges’.
- Section 6 discusses water quality in the receiving environment. This includes an assessment of compliance with the requirements of Hunter Water Corporation for Nil or Beneficial Effect (NorBE).
- Section 6 demonstrates that the site can comply with the requirements of Hunter Water Corporation for Nil or Beneficial Effect (NorBE).
- Section 7 describes provides monitoring, licensing and reporting requirements during the construction and operational phases of the quarry
- Section 8 lists references

For ease of comparison, the Section numbers in this report are the same as those in the Umwelt WA.

1.2 OVERVIEW OF REFINEMENTS TO WATER MANAGEMENT STRATEGY

Review of the Umwelt WA, and the EIS submission comments, has identified that some refinement and amendment is required to the strategy for water management on site. **Table 1** below identifies aspects of the Umwelt WA strategy requiring improvement, an overview of the proposed changes to the strategy, and where these are detailed in this report. A more detailed discussion on the changed aspects is provided in Section 3.

Table 1 Features of revised strategy

Water strategy feature in Umwelt WA *[Issue for improvement]*	**Revised strategy feature**	**Where detailed in this report**
'Nil discharge' until storage capacity exceeded. *[Inconsistencies and impracticalities as highlighted in the Submissions make this unfeasible.]*	'Planned discharges' of treated water from site to alleviate the accumulation of runoff volumes during wet years. Water will be treated to a standard consistent with both the EPL and NorBE requirements.	Section 2.1
Site discharge to environment and drinking water catchment occur on average once every 500 years. *[Proposed strategy may not have actually achieved this]*	'Unplanned discharges' (spillages of untreated water) from site would only occur in rainfall events more severe than the 500 year 24 hour, or the 500 year 72 hour rainfall event	Section 5
Excess water in the extraction area (pit) is contained by a 1m high bund, and ponded at shallow depth across pit floor. Reliance on evaporation to remove excess water. *[Extended duration of storage across pit floor likely to impede quarrying operations for extended periods of time.]*	Water will be stored within the extraction area (pit) in sumps excavated into the floor of the extraction area. Following major rainfall events large volumes of water will still need to be stored, and will still flood the floor. However, the frequency of floor flooding will be less, the maximum volume stored will be less, and duration of inundation will be reduced by the ability to treat and release water through planned discharges. Excess water accumulated within the extraction area will be pumped out to Dam 2, before being treated in Dam 1 and released from site.	Section 3.4
Water released from pit storage through low flow pipes. *[Lack of control over discharge from pit to dams]*	Water in pit sumps will be utilised for dust suppression within the extraction area, or pumped out to Dam 2.	Section 3.1.6
Reliance on reducing water volumes stored on site by evaporation /irrigation across quarry disturbance area. *[Impracticality of irrigating an operational quarry area, and site suitability for irrigation not assessed]*	No irrigation is proposed in the current strategy. Application of water to the extraction area, or any other site area, will be for dust suppression only.	Section 3.1.7
Two dams on site (Dams 1 and Dam 2) with a combined storage capacity of 57ML *[This capacity may not actually be sufficient to store a 100 year 24 hour storm if there is previous extended rainfall.]*	Dams 1 and 2 are retained, and made slightly deeper to accommodate sediment storage volumes. Additional Dam 3 located within quarry processing area of site, with a capacity of 28.6ML including sediment storage. Total dam storage capacity increased from 57ML to 85ML.	Section 5

No water quality controls within quarry product stockpile and processing area. *[Possible pollutants such as hydrocarbons and blasting residues potentially not contained]*	Surface runoff from the product stockpile and processing area will be captured in new Dam 3 and re-used for dust suppression within this area. Spills will be captured and managed in Dam 3, which will have an underflow weir on the outlet. The drain from workshop/processing areas will be fitted with a grease trap to retain hydrocarbons.	Section 3.1.3

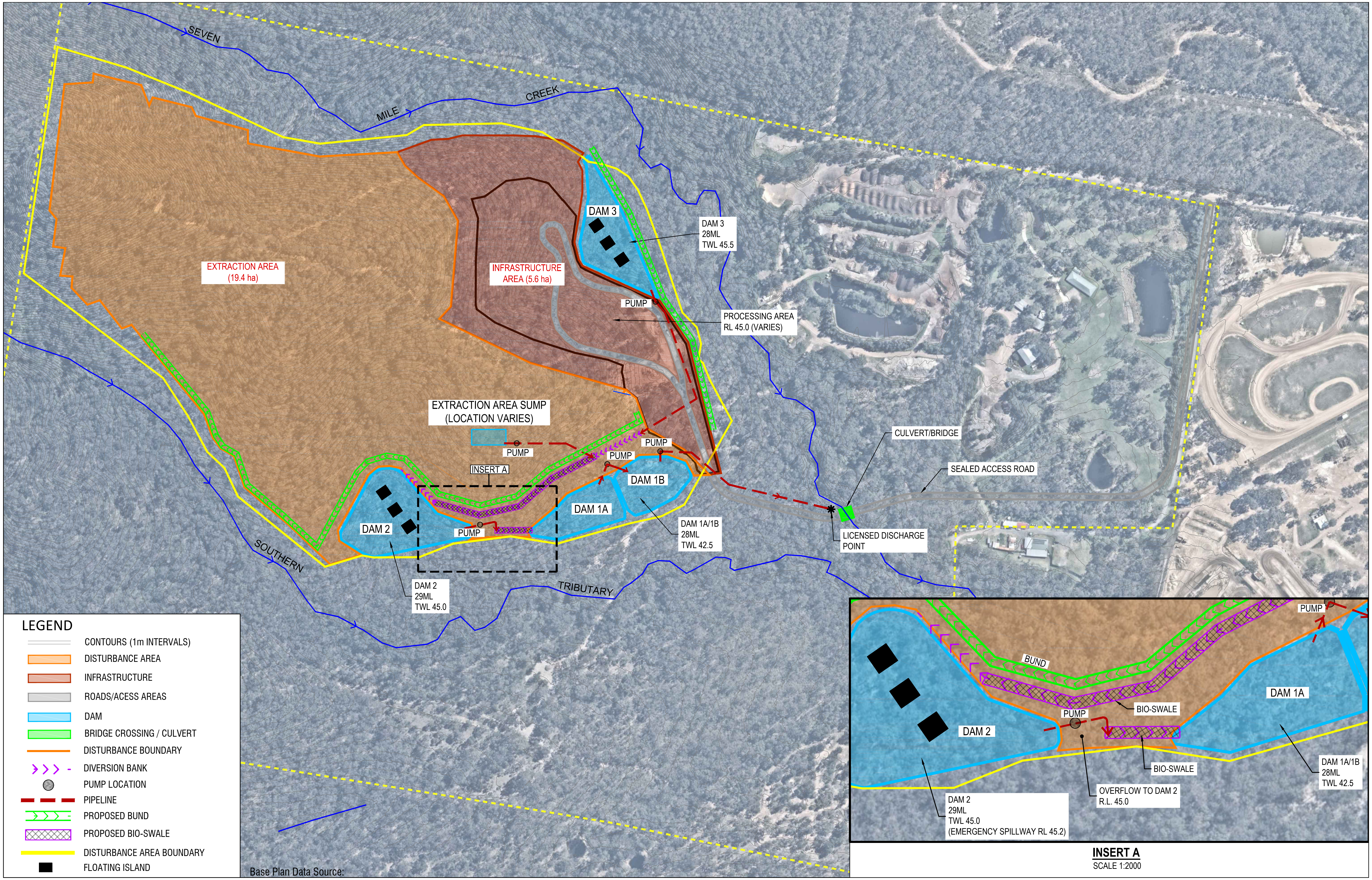
The proposed water management strategy is shown on **Figure 1**.

There are many aspects of the Umwelt WA which are still relevant and remain unchanged. These aspects are listed in **Table 2** with the cross-reference to the relevant Umwelt WA chapter/sections.

Table 2 Elements of Umwelt WA which are unchanged

Water strategy component in EIS (Umwelt WA)	Comments	Where detailed in Umwelt WA
Statutory and Regulatory Requirements	Unchanged	Section 1.6
Existing surface water environment	Unchanged	Section 2.0
Proposed water management system	Some elements changed as described in Table 1.	Section 3.,0
Groundwater	Unchanged	Section 4.0
Water Balance	Revised – Refer SLR Section 5	Section 5.0
Surface and groundwater impacts and water management methods	Groundwater - unchanged Annual flow volumes - unchanged Water Quality - Changes as described in SLR Section 6.3 including 'NorBE' Downstream water users – unchanged Riparian and ecological values of watercourses Environmental Flows – minor improvements as described in SLR Section 6.6 Flooding – unchanged Erosion and sediment control measures – unchanged Final Landform – unchanged Summary of potential impacts – unchanged Cumulative impacts - unchanged	Section 6.1 Section 6.2 - Section 6.4 Section 6.5 Section 6.6 Section 6.7 Section 6.8 Section 6.9 Section 6.10 Section 6.11
Monitoring. Licensing and reporting	Unchanged	Section 7.0

Figure 1 General Arrangement of Water Management



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EAGLETON QUARRY WATER MANAGEMENT

ULTIMATE DEVELOPMENT FOOTPRINT

FIGURE 1.1

2 EXISTING SURFACE WATER ENVIRONMENT

2.1 Umwelt WA

The existing surface water environment is described in the Umwelt WA – Chapter 2.

3 PROPOSED WATER MANAGEMENT SYSTEM

The proposed water management strategy has been refined in response to comments on the Umwelt WA. Key changes are summarised in Table 1, and described in more detail in the following sections.

3.1.1 'Uncontrolled Discharges' and containment of 500 year rainfall

Uncontrolled discharges are the unplanned spilling of untreated water from site when runoff volumes exceed the available storage capacity on site. The risk of uncontrolled discharge has been reduced by the following features of the revised water management strategy:

- The ability to actively manage water storage build-up during extended periods of wet weather through 'controlled releases' (see below).
- Total dam capacity increased from 57ML to 85ML by the addition of Dam 3 in the product processing and stockpiling area.
- As in the Umwelt WA, water will be stored within the extraction area in 'pit sumps' and contained within bunds to provide 180Ml of storage. The total overall storage volume on site will be 265ML.
- Discharge from sumps within the extraction area will be by pump rather than low flow pipes.

Water from the extraction area will be unable to discharge directly off site. It will be collected in the 'in-pit sump', then pumped to Dam 2, and overflow into Dam 1. Water from the processing / stockpiling area of the site will similarly be unable to discharge directly off site. It will be collected in Dam 3, then be pumped into Dam 2. The water quality of potential uncontrolled discharge water will be improved by passing through these upstream dams, through processes of settlement, hydraulic residence time, dilution and slug flow.

Water balance modelling as detailed in SLR Section 5 shows that uncontrolled discharges did not occur when the proposed system was modelled using 102 years of historical rainfall. There is also sufficient additional storage on site (total 265ML) to contain the 500 year 24 hour and 500 year 72 hour rainfall events, assuming conservative antecedent storages levels in the dams as indicated by the water balance modelling.

3.1.2 'Controlled Releases' of Treated Water

The Umwelt WA strategy was based on totally containing all water on site up to a 500 year event. Practical limitations on this strategy include the need to store over 200ML of water in pit during successive wet years.

The strategy has now been revised to allow the controlled release of treated water to Seven Mile Creek, via a Licensed Discharge Point subject to an Environmental Protection Licence (EPL) to be issued by the EPA. This possibility was identified as an option in the Umwelt WA. This is a very common approach to water management, with numerous precedents for environmental licensing.

This approach can also be tailored to comply with HWC's NorBE requirements by having an adequate storage on site to limit the frequency and volume of discharge, and an appropriate level of water treatment, as further detailed in Section 6 of this report.

On this site it is proposed that most of the site runoff will be retained on site, for operational purposes, with only a small proportion of annual runoff volumes to be discharged when necessary to reduce dam water levels so that available storage is replenished following extended wet weather.

3.1.3 Water quality

During quarrying operations a disturbed area within the area of resource extraction will be exposed to the weather, and potentially generate sediments which can be transported by rainfall runoff. For the purpose of estimating sediment loads within the site, as well as water quality that could discharge in an extreme event, it has been assumed that the sediment generation rates and water quality are typical of published data for quarries in NSW. This is considered to be conservative because of the nature of the rocks which will be exposed and stockpiled at Eagleton. The Preliminary Resource Assessment prepared by Qualtest, identified that most of the rock that will be exposed is hard igneous rock – comprising Rhyodaclte and Rhyolite – which will have a very low sediment generation rate. At lower levels of the extraction area some Boulder Conglomerate will be exposed, which has a matrix subject to weathering, and is likely to exhibit sediment generation rates which are more typical for quarries.

This strategy adopts the water quality targets identified in the Umwelt WA, based on monitoring of Seven Mile Creek and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000), which were:

- TSS 40mg/L in ANZECC [reduced to 30mg/L to achieve NorBE]
- pH 6.5 to 8.5
- EC less than 600us/cm.

The project should also demonstrate that the following water quality targets can be consistently achieved.

- Total Phosphorous 0.025 mg/L ANZECC Trigger Value from Umwelt WA
- Total Nitrogen 0.35 mg/L ANZECC Trigger Value from Umwelt WA
- Turbidity 50 NTU
- Ammonia 0.02mg/L

Initial monitoring over a 2 year 'characterisation period' would enable an evaluation of how the water quality controls are performing, and an assessment of the required frequency for continued monitoring of these pollutants in the longer term.

3.1.4 Nil or Beneficial Effect (NorBE)

Since the site is within a drinking water catchment, HWC require demonstration of NorBE. The HWC publication 'Protecting our Drinking Water Catchments 2017', outlines requirements for demonstration of NorBE, as 'post development pollutant loads discharged from the site should be equal to or less than the pre-development loads discharged from site'.

For pollutants which are in existence on the pre-development catchment, this can be demonstrated by comparison of predicted pre and post-development loads ie kg/ha/year of Phosphorous, Nitrogen and Total Suspended Solids. This analysis is included at Section 6.3 of this report.

NorBE also requires demonstration that pollutants which might threaten drinking water quality will either be not used onsite, or can be effectively contained within site. Potentially contaminating or hazardous materials that might be brought onto the site, and the proposed controls to minimise the risk of off-site discharge are outlined below.

- Fuel leakage – use of site fuel tanks which are self bunded, spill kits available on site, capture of first flush and hydrocarbon spills from the processing area in Dam 3. The overflow from Dam 3 to Dam 1 will have an 'underflow weir' to prevent the discharge of floating hydrocarbons.

- Oils and greases – workshop/garages bunded, oil separation tank on stormwater outlet from garage/workshop to Dam 3. The overflow from Dam 3 to Dam 1 will have an 'underflow weir' to prevent the discharge of floating oils and greases.

- Residues from explosives – runoff from stockpiles containing explosives residue can have elevated levels of Total Nitrogen. The runoff from processing and product stockpile areas will be captured in Dam 3, and re-used for processing water and dust suppression within this same area.

- Storage of chemicals on site – will be stored in accordance with Australian Standards.

- pesticides and herbicides - may be used on site for the control of insect infestations and weeds. The selection of chemicals, storage and use will be detailed in the quarry operational management plan and in accordance with industry best practice.

- Sewage – can be a potential source of pathogens and nutrients. This risk will be mitigated by the capture and removal of sewage from site, rather than on-site treatment.

To improve the quality of water in the site dams, and to reduce the quantity of flocculants needed to achieve the required water quality for controlled discharges from the site, it is proposed to incorporate additional water quality controls. Although these measures will significantly reduce Total Suspended Solids, Total Phosphorous, and Total Nitrogen, they are not intended to meet any specific water quality target or to achieve any specific capture rate of those pollutants. The quality of the water discharged off site will be achieved by flocculation in Dam 1B, and the flocculation program will be tailored to achieve the target discharge water quality. The additional measures are as described below:

- A GPT on discharges into Dam 3

- Floating wetlands within Dam 3

- A bio-retention swale located upstream of Dam 2, to receive pumped flows from Dam 3 and the Sump in the extraction area

- Floating wetlands within Dam 2

- A bio-retention swale located between Dam 2 and Dam 1B to receive pumped flows from Dam 2 into Dam 1B.

Floating wetlands are proposed within Dams 2 and 3 to allow macrophytic plants to remove nutrients, and especially nitrogen, from the water column. Because the water levels in these dams will be highly variable, it will be difficult to establish and sustain macrophyte zones around the perimeter of the dams.

The bio-retention swale upstream from Dam 2 will provide further removal of finer suspended soilds, phosphorous and nitrogen prior to discharge into Dam 2. The swale will receive pumped flows on a regular basis which will assist in maintaining biological function.

Images of typical floating wetlands and bio-swales are shown below.

Procedures for the management, monitoring and reporting of pollution will be detailed in a Pollution Incident Response Plan (PIRMP) prepared as a part of the Operational Management Plan.

3.1.5 Methods for water treatment and managing controlled discharges

Water will only be treated in Dam 1B when there is a need to discharge water off-site.

Dam 1 will be partitioned with an earth bund into two storages. Dam 1A will receive overflows from Dam 2, and very infrequently from Dam 3. When Dam 1A is more than 50% full, the water will be pumped into Dam 1B, flocculated, and discharged at the Licensed Discharge Point. Flocculants will be pre-mixed with water in a barrel and sprayed across the surface of the pond. Proposed flocculants are Gypsum and Alum.

Prior to discharge, water will be sampled and tested for compliance with requirements set out in the Environment Protection License, and any further water quality requirements detailed in the planning consent. Analytes tested and proposed limits are set out in Section 3.1.3 of this report.

To reduce the chance of accidental discharge controlled release from site will only be via pump, and at the licensed discharge point nominated in the EPL.

3.1.6 In Pit Sumps in Extraction Areas

The Umwelt WA contained water in the quarry disturbance area using shallow ponds behind 1m high bunds, which discharged via low flow pipes.

Adequate capacity should be provided within the extraction area (in-pit) to contain runoff from a 500 year 24 hour or 72 hour storm. Water balance modelling over 102 years for the ultimate development footprint indicates a maximum volume of water stored within the sump of 135ML, and that most of the time the volume of water stored is between 30ML and 60ML. Storage exceeds 70ML less than 10% of the time.

The 500 year 24 hour storm, with a rainfall depth of 330mm, assuming a runoff coefficient of 1.0 across the 19.4ha ultimate extraction area would generate approximately 64ML of runoff. Conservatively assuming that the in-pit sump has 70ML of water in it at the start of the event would require a total storage of 134ML to contain the 500 year 24 hour event. This is less than the proposed 180ML of total storage in the extraction area.

However, longer duration extreme rainfall events may have a higher total depth of rainfall, and require increased storage. For example, a 72 hour 500 year rainfall event may generate up to 100ML of water in the extraction area, requiring a storage volume of 170ML in the extraction area. To be conservative, it is proposed that the extraction area provide adequate storage to contain 180ML of water. This would be achieved by bunding on the perimeter of benches, plus a deeper 'sump' as described below.

It is also now proposed to include dedicated 'sump' water storage within the quarry extraction area, which ultimately will have a total capacity of approximately 60ML. The purpose of the sump is to provide longer term water storage within the extraction area, without frequent inundation of the floor of the extraction area. This water stored within the sump will be utilised for dust suppression within the quarry, or may be pumped down to Dam 3.

During extended wet weather or extreme rainfall events, runoff will accumulate and surcharge onto the quarry floor at shallow depth. This may impede quarry operations for short periods while water is pumped down to Dam 2 then Dam 1, and discharged from site after treatment. Bunds along the edges of quarry benches will be constructed to ensure that the required in-pit storage volumes can be achieved, with appropriate freeboard.

The number and location of in-pit sumps will need to be flexible so that arrangements can change over time to suit the configuration of quarrying operations. A 'calculator' of required in-pit storage for different areas of quarry disturbance is shown in **Table 3 In-pit storage requirements.**

Table 3 In-pit storage requirements

Nominal staging	Disturbance Area of Quarry Pit (ha)	Total In-Pit Storage (ML)	Suggested Minimum Size of Dedicated Sump (ML)
Initial (at Year 2)	9.7	90	30
Incremental staging	9.7 to 19.4	Increase at a rate of 9.28 ML per additional ha	Increase at a rate of 3.1ML per additional ha
Ultimate	19.4	180	60

3.1.7 Irrigation

The Umwelt WA contemplated irrigation of water across the 'Exposed Area' to reduce site water storage volumes. However, broad scale irrigation across pit floor may have operational issues associated with maintaining pipes, moving irrigation infrastructure, and excessive moisture affecting vehicle trafficability. Irrigation is <u>not part of the current proposal</u>. Water will be sprayed within exposed areas for dust suppression purposes only.

3.1.8 Staging of Water Management

The quarry will progress through stages with the extraction area increasing from an initial area of less than 6ha, increasing over approximately 30 years to an ultimate area of 19.4ha. The processing and product stockpiling area will also be staged.

Dams 3 and 1A/1B would be constructed initially, before commencement of quarry operations, and would function as sediment basins during the quarry construction phase. Runoff would be conveyed to Dam 1 by a catch drain along the edge of the haul road, and then an initial length of diversion drain constructed so that water discharges into Dam 1A.

Dam 2 would be added within the first 2 years of operation. The diversion drain would be extended through to Dam 2, so that all runoff from the haul road, and any overflow from the quarry disturbed area is conveyed to Dam 2.

The in-pit sump would be constructed as soon as part of the commencement of excavations for extraction. Bunding around the perimeter of the extraction area(s) will need to be completed progressively as extraction benches are established.

Clean water diversions would be constructed upslope of Dams 1 and 2 to divert clean water from undisturbed catchment into the Southern Tributary of Seven Mile Creek.

3.1.9 Schematic

A schematic for overall site management of water is shown on Figure 2.

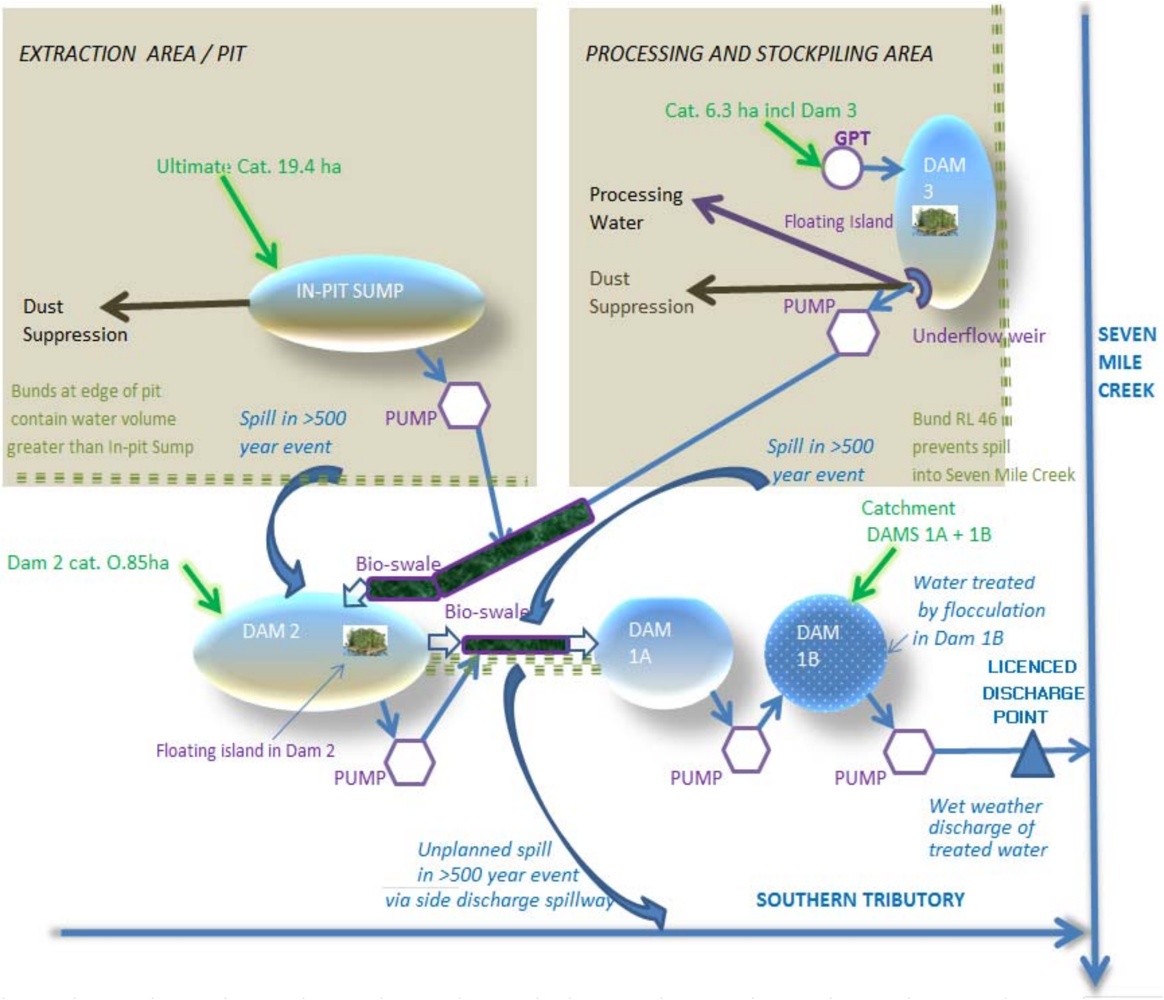

Figure 2 Schematic of Water Management System

4 GROUNDWATER

Groundwater is unchanged. Please refer to Section 4 of the Umwelt WA.

5 WATER BALANCE

5.1 Overview

An analysis of site water balance was carried out to assess the performance of the proposed water management system over historical rainfall and evaporation data. This section of the report identifies required dams & sump sizes, volumes of controlled discharge, and frequency of uncontrolled discharges.

5.1.1 Model Overview

The modelling software used to represent the Eagleton Quarry (EQ) water balance was GoldSim Version 11.1.2 (GoldSim Technology Group LLC). This software is a graphical, object oriented system simulation software for completing either static or dynamic systems. It is like a "visual spreadsheet" that allows the user to visually create and manipulate data and equations.

The model simulates daily changes in the volumes of mine 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 water balance modelling:

- Daily time steps over a simulation length of 102 years of historical rainfall recorded at the Raymond Terrace BOM station were used for the analysis. This station has very similar rainfall to the Grahamstown station utilised in the Umwelt WA, but has a much longer rainfall record;
- An evaporation pan coefficient of 0.8 was applied to the evaporation data;
- It was assumed that water could be transferred between sumps in the working pit as required. As such, these were modelled as a single water storage in GoldSim;
- Dam capacities utilised in the GoldSim model exclude sediment storage volumes. Sediment storage volumes have been estimated using RUSLE calculations as per the 'Blue Book', assuming that water structures will be desilted once a year. Dam construction will need to include these additional volumes which are shown in **Table 4**.
- RUSLEs parameters were established in accordance with the 'Blue Book' and it is assumed that the;
- It was assumed that a Gross Pollutant Trap (GPT) would be installed upstream of Dam 3, and that this GPT has a sediment capture rate of 50%;
- No allowance was made for leakage from the dams;
- Runoff from the catchment areas were modelled with a runoff coefficient of 1.0, as the soil on site is classified as well-compacted clay with a very shallow bedrock (0.5 - 1m);
- Dam 1 was modelled with two separate compartments labelled 1A & 1B. Dam 1B is to be used for treating water to be discharged from site by flocculation.

- It was assumed that dams 1A & 1B were at 10 percent of total capacity at the start of the GoldSim simulation. Similarly, dams 2, 3 & the Sump were at 25% of their total capacity at the start of the simulation. As these dams and Sump are proposed to be actively dewatered this assumption was considered to be suitable for this conceptual water balance investigation;
- Dust suppression was sourced from Dam 3 and the Sump; and,
- Groundwater make of 13.5ML/year

5.1.2 Processing Demand

Demand for crushing and screening is based on a rate of 0.03kL/tonne of production, with an ultimate production level of 600,000 tonnes per annum, which equates to 0.05ML/day. The ultimate demand and staging are as set out in Table 5.1 of the Umwelt WA.

It is imperative that water be available for processing and dust suppression, and if there is insufficient water available within Dam 3 then water may be drawn from the In-pit sump, or Dam 2. Any remaining shortfall would be made up by delivery of water to site by tanker.

5.1.3 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.

GoldSim modelling has been based on the following assumptions for dust suppression demands:

- no dust suppression is required on days with when greater than 5mm of rainfall,
- on days with less than 5mm of rainfall, up to 5mm of dust suppression is utilised a) within the extraction area across parts with traffic movement or without vegetative cover, b) across the process area, and c) the quarry haul road. Total 0.34ML/day average
- The area for application of dust suppression can be increased when the in-pit storage is above 20% volume, to include application onto non-active parts of the extraction area at an average rate of 4mm per day, when there is less than 5mm of rainfall depth. This increases the dust suppression to 0.52ML/day average.

5.1.4 Sediment loads and Dam sizing

Sediment loads were calculated using the Revised Universal Soil Loss Equation (RUSLE) in accordance with the 'Blue Book', and using the following parameters:

- An erosion control practice factor (P) of 1.3 corresponding to a compacted and smooth surface;
- A rainfall erosivity factor (R) of 2750 corresponding to the location of the site on the erosivity map for the area;
- A soil erodibility factor (K) of 0.05 corresponding to the 'Blue Book' safe/conservative value;,
- A ground cover and management factor (C) of 1 corresponding to a mostly disturbed with very limited grass cover surface; and,
- It is assumed that the water storages would be desilted on a yearly basis to avoid major sediment build up.

Required total water storages volumes including sediment storage and capacities assumed in the Goldsim modelling are shown below in **Table 4**.

Table 4 Sediment volume and required total water storage capacities

Water Storage	RUSLE calculated Sediment Volume (ML)	Reduction Factor & Comments	Number of years sediment storage	Factored Sediment Volume (ML)	Dam/Sump Volume [GOLDSIM] (ML)	Required Dam/Sump Volume including sediments (ML)
Sump	2.36	Nil	2	4	180	**184**
Dam 3	0.52	0.5[3]	3	1.6	28[2]	**29.6**
Dam 2	0.12	Nil	3	0.2	29	**29.2**
Dam 1A	0.1	Nil	3	0.2	14	**14.2**
Dam 1B	0	0.5[1]	3	0.1	14	**14.1**

1. Assume 50% sediments capture in Dam 1A
2. The total modelled capacity for Dam 3 includes 4ML of hardstand inundation, across parts of the processing and stockpiling areas, which will be contained by a bund which is 1.0m higher than the Dam 3 top of bank level.
3. A reduction factor of 50% has been applied to Dam 3 sediment loads as a GPT will be installed to pretreat the runoff coming into the Dam 3.

5.2 Dam Storage Management

Management of stored water on site will include pumping between water storages when they reach a certain capacity, shown as the 'operating water volume' in the table below. This helps to ensure that spare capacity is replenished so that it is available to capture runoff from subsequent rainfall events. Dam capacities, dimensions and reporting catchments are summarized into **Table 5** below.

Table 5 Dam System Volumes and Surface Areas as Modelled in GoldSim

Dam System	Storage Capacity (ML)	Surface Area (ha)	Initial Volume (ML)	Operating Volume (ML)	Reporting Catchment Area (ha)
Sump	180	5.1**	45	54 to 108 (Refer pumping rules below in Table 6)	18.9
Dam 1A	14	0.4	1.4	Emptied after 5 days	1.2
Dam 1B	14	0.4	1.4	7.0	0
Dam 2	29	0.85	7.25	5.4	0.35
Dam 3	28	0.8	7	16.8	4.6

**Sump surface area is within the reporting catchment

The total project area excluding the entry road is 30.5ha. The catchment area which reports to the site water management system is 27.5ha. There is approximately 3ha of clean catchment area around the perimeter of the site which will drain away from the quarry and report to the existing bushland.

Locations and rates for pumping from dams are shown in **Table 6**.

Table 6 Dams & Sump dewatering rules

From	To	Volume	Condition
Sump	Dam 2	1ML/day	When Sump is at 60% of total capacity
Sump	Dam 3	0.3ML/day	When Sump >30%
Dam 2	Dam 1A	0.75ML/day	When Dam 2 is at 20% of total capacity
Dam 2	Dam 3	0.3ML/day	If Dam 3 <10% volume
Dam 3	Dam 1A	1ML/day	When Dam 3 is at 60% of total capacity
Dam 1A	Dam 1B	5ML/day	When Dam 1A is at 50% of total capacity
Dam 1B	Off-site	Empty Dam 1B	Empty Dam after 5 days of water transfer from Dam 1A

5.3 Overall Water Balance Results

Average year results of the site water balance modelled over a 102 year period are summarised in **Table 7**.

Table 7 Summary of Water Balance Results

	Description	Average (ML/year)
Water Source (Inputs)	Total runoff	320.3
	Groundwater inflow	13.5
	External Water Requirements	1.9
	Total Input	**335.7**
Water Losses and Usage (Outputs)	Evaporation (from water storage)	24.0
	Processing Plant	18.3
	Haul road dust suppression	265.9
	Total Output	**308.2**
Off Site Discharge	Controlled release (treated)	48.3
	Off-site overflow (untreated)	0
	Total Off-Site Discharge	**48.3**

The above table indicates that in an average year (in the 102 years analysed) that 48.3ML of treated water would be released off-site.

The Goldism analysis also indicates that in an average year 1.9ML/yr of water would need to be tankered to site in order to cover the dust suppression and processing demands when there is insufficient water available in site dams from rainfall runoff. This may be higher in dry years, and zero in wet years.

The storage levels within each of the individual dam systems are also presented **Figures 1** to **5** below. These figures show the storage levels within each of the individual dam systems over the 102 year simulation period in relation to the total storage volumes.

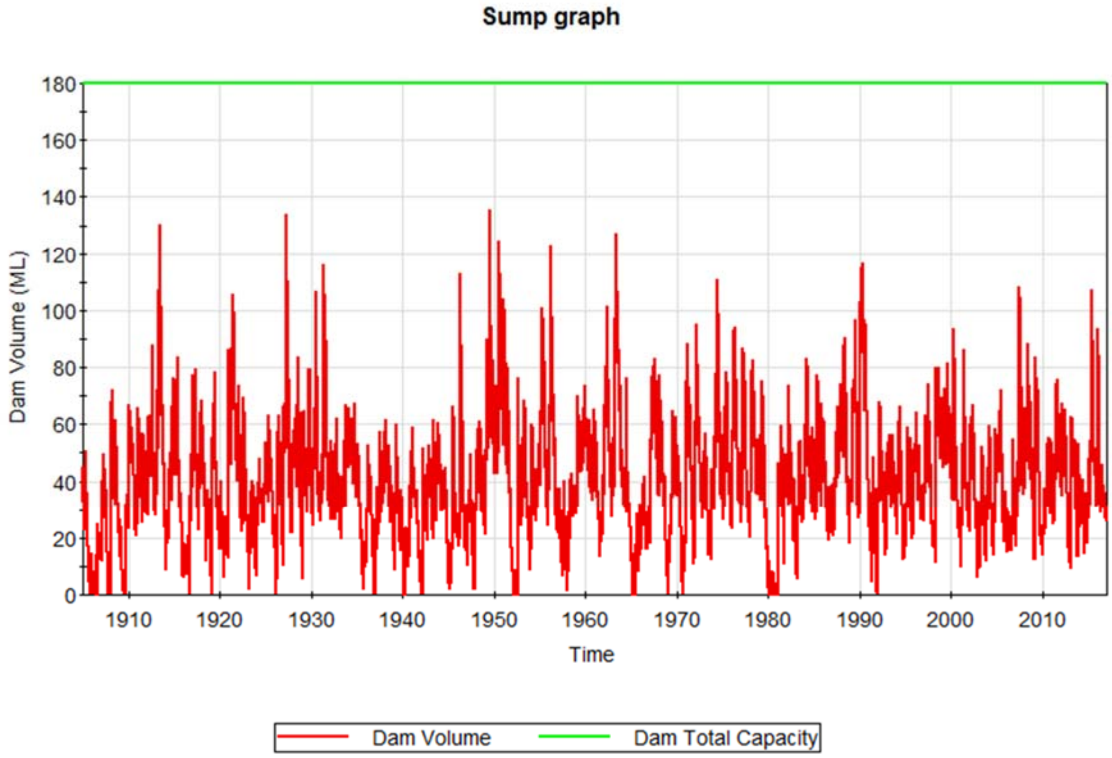

Figure 3 Extraction Area storage volume over the historical rainfall period

Figure 3 shows the total volume of water stored within the extraction area, including water within the dedicated deeper ‘Sumps’, plus any water that surcharges onto the floor of the extraction area. The modeling shows that volume stays well below the capacity of 180ML at any time during the 102 year period. The stored volume averages around 40ML, with the volume mostly below 60ML (the dedicated deeper ‘Sump’ volume). Exceedances above 60ML occur regularly across the 102 modelling period, but only for short durations.

Figure 3 above also shows that the sump would occasionally run dry.

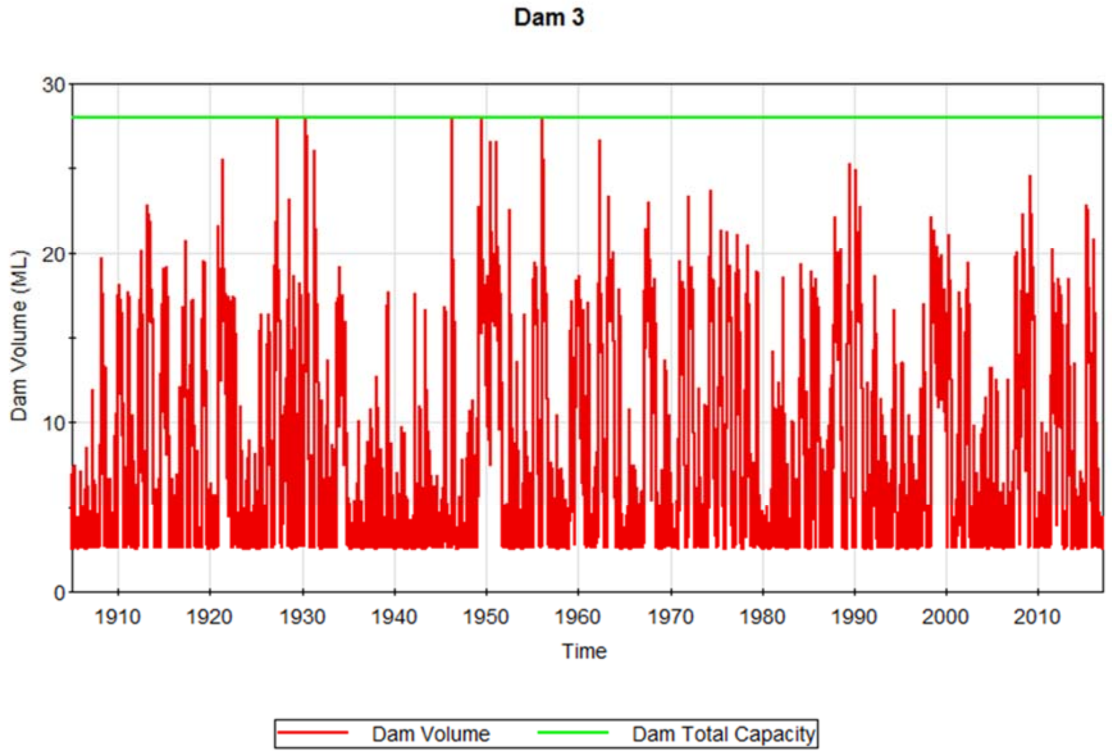

Figure 4 Dam 3 storage level over the historical rainfall period

Figure 4 indicates that Dam 3 reaches capacity over the 102 year modelling period. If the capacity of Dam 3 is exceeded, water will surcharge across the hardstand and spill towards Dam 2. Water can surcharge by gravity from Dam 2 into Dam 1A and 1B, via an overflow channel set at a slightly lower level than the emergency spillway.

Dams 2, 1A, and 1B have adequate spare capacity to receive surcharges from Dam 3 in a 500 year event without spilling over. The combined capacity of Dams 3, 2 and 1A/1B is 85ML, and these dams have a total catchment area of 8.6ha. In a 500 year 24 hour and 72 hour rainfall events the runoff volumes would be 28ML and 44ML respectively. Conservative antecedent water volumes in these dams total 35ML (Dam 3 18ML, Dam 2 9ML, Dam 1A 8 ML, and Dam 1A empty). This leaves a spare capacity of 50ML (85ML less 35ML), which is adequate to contain these 500 years rainfall events on site without uncontrolled discharge (dams spilling over).

The graph also suggests that the water levels in Dam 3 fluctuate considerably, due to the processing and dust suppression demands rapidly drawing down the water levels, which are then replenished by either rainfall or pumping from the Sump or Dam 2.

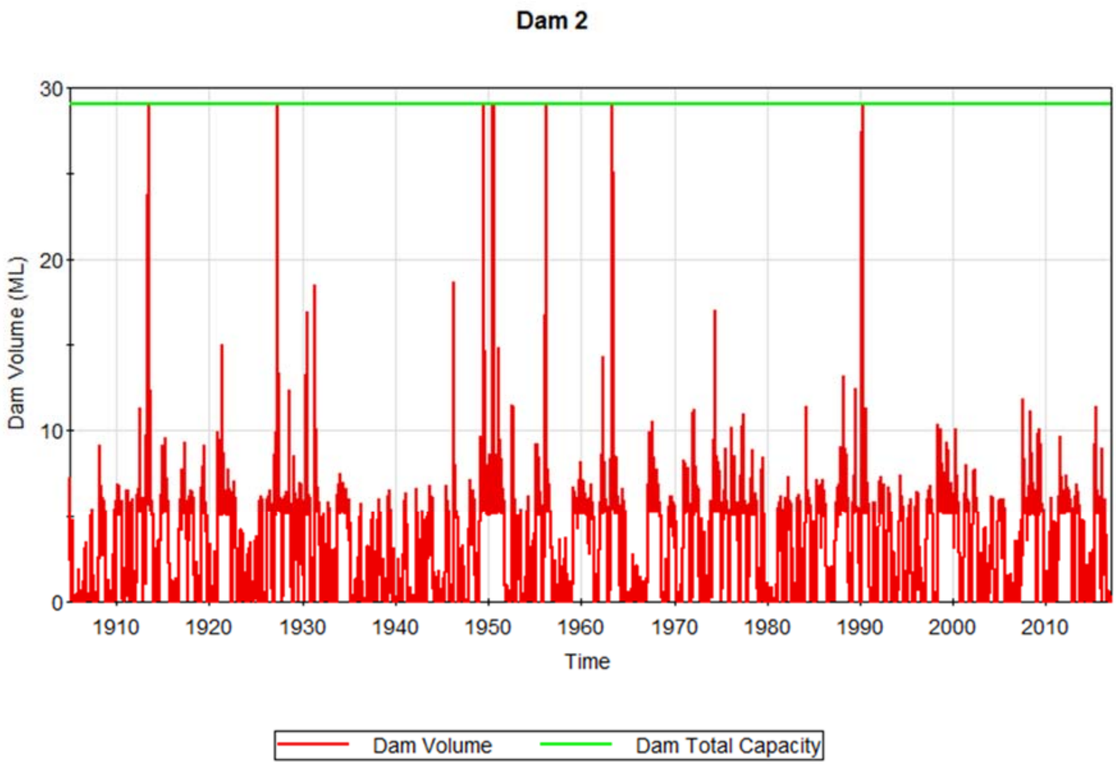

Figure 5 Dam 2 storage level over the historical rainfall period

Figure 5 shows that Dam 2 generally shows storage volumes in Dam 2 generally fluctuate between empty and 7ML. Dam 2 operates effectively to retain significant spare capacity to buffer the flow into Dam 1A/B during extreme rainfall events. The modelling indicates that Dam 2 reaches capacity and overflows into Dam 1A only 8 times during the 102 years of water balance modelling.

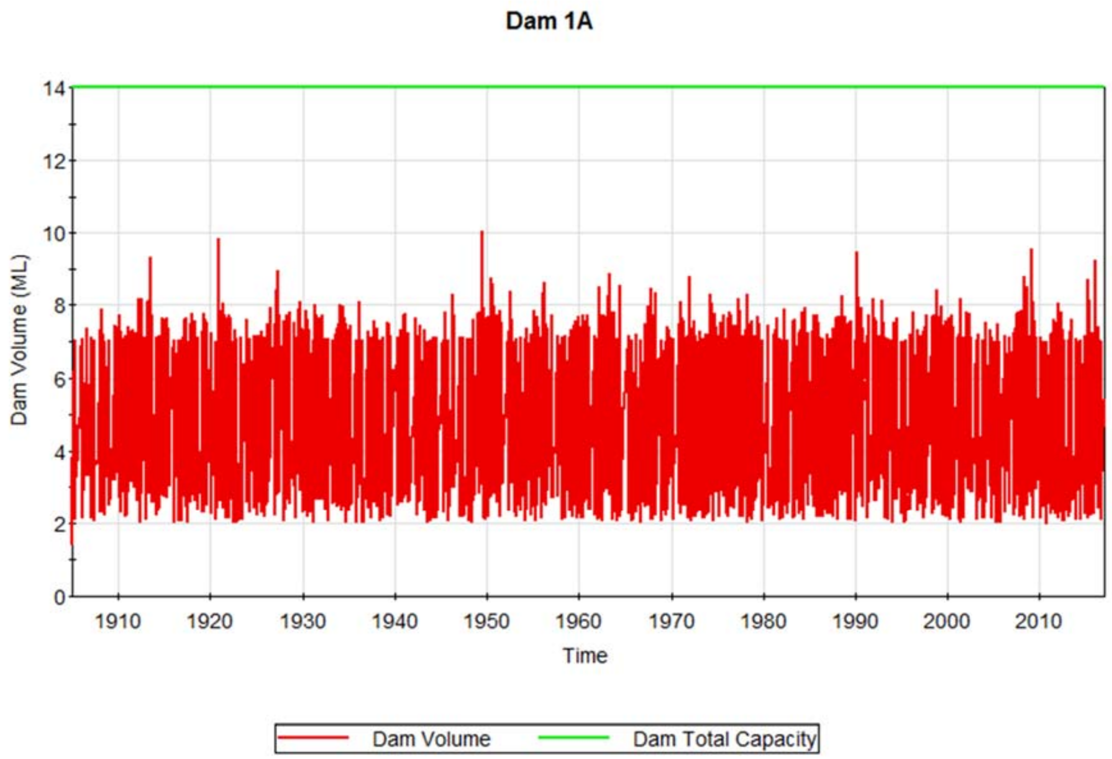

Figure 6 Dam 1A storage level over the historical rainfall period

Figure 6 shows that Dam 1A does not reach capacity during the 102 years of water balance modelling, and retains significant spare capacity to contain site runoff during events that are more extreme than those during the 102 years of water balance modelling.

Dam 1A never gets empty and the last 2ML of water in the bottom of the dam is not pumped out . Note that Dam 1A is the final water storage on site before treatment and off-site discharge via Dam 1B.

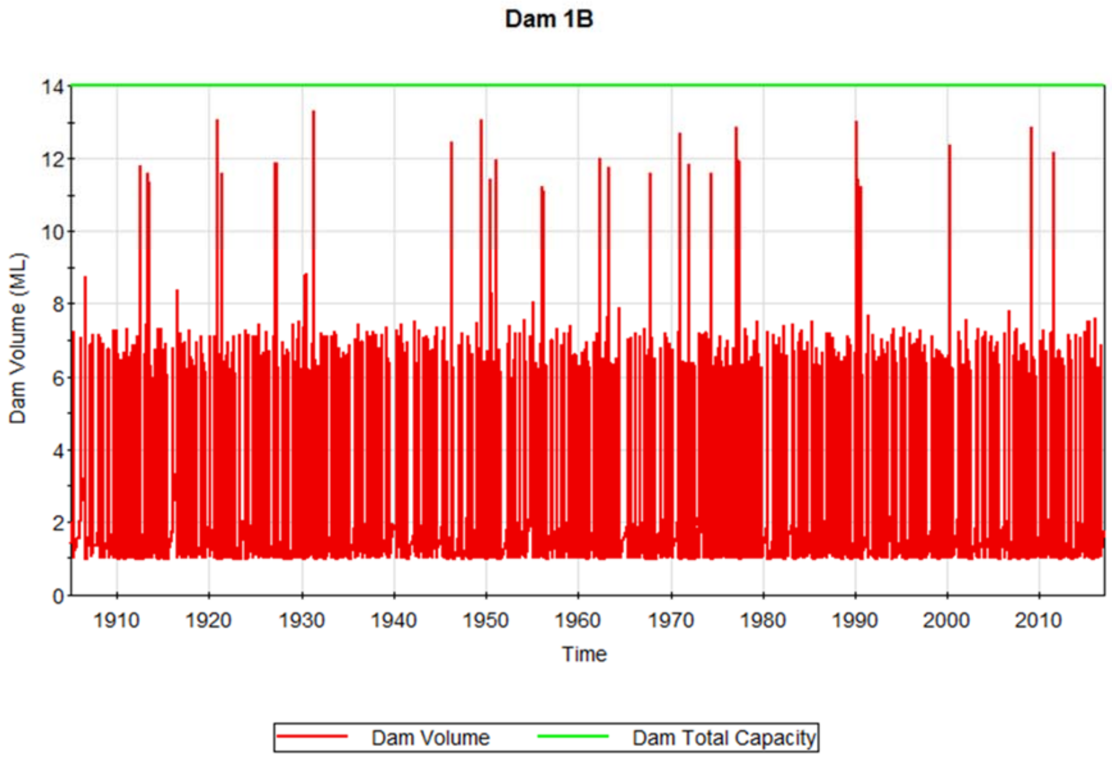

Figure 7 Dam 1B storage level over the historical rainfall period

Figure 7 presents Dam 1B storage level over the 102 year modelling period and indicates a regular pattern of this dam being then filled with 5ML of water pumped from Dam 1A, treated, and dewatered for off-site discharge to the sproposed licensed discharge point. The bottom 1ML within the dam is retained to reduce the chance of the pump inlet getting too close to the bottom sediment.

5.4 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.

- lower run-off coefficient of 0.9 rather than 1.0 used in the modelling
- water demands on site varied by plus and minus 10%

Detailed results of the sensitivity analysis are presented in **Table 8 Results of Sensitivity Analysis**

Table 8 Results of Sensitivity Analysis

	Demand (ML/year) (%change)			Runoff Coefficient	
	16.43 (-10%)	**18.25 (0%)**	**20.08 (+10%)**	**0.9**	**1.0**
Total Runoff (ML/year)	320.2	320.3	320.2	297.2	320.3
Total Controlled Discharge off-site (ML/year)	49.0	48.3	47.6	38.2	48.3
Total External Water Supply Requirement (ML/year)	1.90	1.89	1.89	3.18	1.89

The sensitivity analysis indicates that the quantities of water discharged from site, and the requirements for external water supply are not sensitive to a plus or minus 10% change in the water demand.

As expected, a reduction in the runoff coefficient increases the requirement for external water supply.

6 SURFACE AND GROUNDWATER IMPACTS AND WATER MANAGEMENT METHODS

6.1 Groundwater impacts

Groundwater aspects of the project are unchanged from the Umwelt WA. Refer to Section 6.1 of the Umwelt WA.

6.2 Annual flow volumes

The Umwelt WA identifies that the Project will reduce the catchment of Seven Mile Creek by approximately 10%, resulting in a reduction of creek flows. This impact will be slightly reduced in the revised strategy by the introduction of planned discharges.

The total project area is 30.5ha. Within this area approximately 3.0ha of land around the perimeter of the Project Area will either be clear of proposed works, or comprise vegetated batters that drain into the bush. The annual yield from the disturbed area of the project reporting to the water management system will be 27.5ha. The average annual runoff from this disturbed area of 27.5ha, using a volumetric runoff coefficient of 0.5, and for the average annual rainfall of 1127mm/year is 155ML/year.

Water balance modelling indicates that when the quarry is fully established at its ultimate size, that the average yearly discharge of treated water through controlled discharges at the licensed discharge point would be 48.3ML/year, or slightly less than 1/3 of the estimated runoff form the existing (pre-development) site (155ML/year).

6.3 Water Quality and 'Nil or Beneficial Effect (NorBE)' Requirements

6.3.1 Changes from Umwelt WA

The Umwelt WA contemplates a 'Nil Discharge' strategy to avoid water quality impacts on the environment, and the drinking water catchment of Grahamstown Dam. Inconsistencies and impracticalities in that strategy, as highlighted in the Submissions make this unfeasible.

Since the site is within a drinking water catchment, HWC require demonstration of NorBE. The HWC publication 'Protecting our Drinking Water Catchments 2017', outlines requirements for demonstration of NorBE, as 'post development pollutant loads discharged from the site should be equal to or less than the pre-development loads discharged from site'.

A description of how the risk from 'introduced pollutants' will be managed is provided in Section 3.2 of this report.

For pollutants which are in existence on the pre-development catchment, NorBE can be demonstrated by comparison of predicted pre and post-development loads ie kg/ha/year of Total Suspended Solids, Total Phosphorous, and Total Nitrogen.

6.3.2 Pre-development pollutant loads

The existing catchment is mostly natural bushland.

The concentration of pollutants in run-off from the existing or pre-development site has been conservatively estimated using professional judgement and with reference to three sources of water quality information:

- monitoring results summarised in the Umwelt WA, taken at Station 1 which has the least disturbed catchment
- additional monitoring results towards the headwater of the southern tributary (Station A5), reported by Marine Pollution Research in June 2017. The TSS value is not taken into account since the monitoring was taken in a pool following several days of dry weather.
- typical pollutant export rates for 'Forest' landuses taken from the publication 'Using MUSIC in Sydney's Drinking Water Catchment, A Sydney catchment Authority Standard'.

Water quality information from the three sources above, and the adopted values for pollutant export concentrations in the existing pre-development catchment are outlined in **Table 9**.

Table 9 Pre-development Catchment – Pollutant Export Rates

Pollutant	Typical Value in Umwelt WA Station 1	Marine Pollution research monitoring – Station A5	MUSIC Guidelines for Sydney's drinking Water Catchment	Adopted Value in NorBE analysis
Total Suspended Solids	12.2mg/L	-	Base flow 6mg/L Stormflow 40mg/L	12.0mg/L
Total Phosphorous	0.05mg/L	0.02mg/L	Base flow 0.03mg/L Stormflow 0.08mg/L	0.03mg/L
Total Nitrogen	1.4mg/L	0.6mg/L	Base flow 0.3mg/L Stormflow 0.9mg/L	0.5mg/L

6.3.3 Pollutant loads during quarry operation

Discharges from the proposed quarry site will include both regular treated 'controlled discharges' which will be treated as necessary to achieve a water quality discharge compliance standard, and extremely infrequent 'uncontrolled discharges' of untreated water.

For controlled discharges water will be treated to achieve Total Phosphorous and Total Nitrogen values as shown in **Table 10**. Water treatment prior to controlled discharge will achieve a TSS of 30mg/L, which is slightly better than the ANZECC trigger value for TSS of 40mg/L.

The assumed water quality for controlled discharges (treated) and uncontrolled discharges from the quarry water management system is also shown in **Table 10.**

Table 10 Post-development Catchment – Pollutant Export Rates

Pollutant	Controlled discharges (treated in Dam 1B)	Uncontrolled discharges (extreme storm event)
Total Suspended Solids TSS	30mg/L (ANZECC trigger value is 40mg/L)	500mg/L Conservative worst case estimate for water surcharged through site dams
Total Phosphorous TP	0.03mg/L	1.0mg/L **Quarry stormflow + 1Std Dev. is 0.9
Total Nitrogen TN	0.5mg/L	3.5mg/L **Quarry stormflow + 1Std Dev. is 3.4

**Note: Reference: Using MUSIC in Sydney's Drinking Water Catchment, A Sydney Catchment Authority Standard

6.3.4 Estimation of Existing and Operational Phase Pollutant Export Rates

Average yearly pollutant loads over a long period (500 years) have been estimated for two cases:

- Case A - During Quarry Operations – assuming the worst case which is for the ultimate extraction area size, giving a total disturbed area of 27.5ha.
- Case B - Existing Site – the undisturbed catchment, taking the same 27.5ha of area

This requires consideration of the following factors:

- Discharge volume
- Concentration of pollutants
- Frequency of those discharges. (every year is 1.0, once every 500 years is 1/500 or 0.002)

Multiplying these factors provides a pollutant export rate from the disturbed area of the site, for the existing case and during quarry operations. For Case A the planned (treated) and uncontrolled discharges are added together. These two cases are compared in **Table 11**.

Table 11 Estimated Pollutant Loads during quarrying operation and for existing site

Pollutant	Case A - During Quarrying Operations			Case B - Existing Site [B]	Percentage Reduction (B-A)/A*100
	Planned Discharges	Uncontrolled Discharges	Total [A]		
TSS					
Discharge Volume: (ML/year)	48.3	50		155	
Discharge Concentration: (mg/L)	30	500		12	
Frequency Factor (1/Years)	1.00	0.002**		1.00	
Average Pollutant Export Rate (kg/year)	1449	50	**1499**	**1860**	**20%**
TP					
Discharge Volume: (ML/year)	48.3	50		155	
Discharge Concentration: (mg/L)	0.025	1.0		0.03	
Frequency Factor (1/Years)	1.00	0.002**		1.00	
Average Pollutant Export Rate (kg/year)	1.2	0.12	**1.32**	**4.65**	**71%**
TN					
Discharge Volume: (ML/year)	48.0	50		155	
Discharge Concentration: (mg/L)	0.35	4.0		0.5	
Frequency Factor (1/Years)	1.00	0.002**		1.00	
Average Pollutant Export Rate (kg/year)	16.9	0.40	**17.3**	**77.5**	**78%**

The water balance modelling indicates that the water management system does not overtop during 102 years of modelling across historical recorded rainfall, and has spare capacity to cater for a 500 year 24 hour event and a 500 year 72 hour rainfall event. For the purpose of this analysis to **demonstrate NorBE, and to be very conservative, it has been assumed that up to 50ML of** uncontrolled discharge could occur every 500 years.

6.3.5 Compliance with NorBE Requirements

Table 11 above indicates compliance with NorBE requirements for Total Suspended Solids, Total Phosphorous, and Total Nitrogen, since the post development pollutant export rates are less than the existing levels for the pre-development scenario.

For other pollutants which are being introduced into the catchment, the risk of pollution will be adequately mitigated by the physical and management controls outlined in Section 3.2 of this report.

6.4 Downstream Water Users

As noted in the Unwelt WA, there are no known users on Seven Miles Creek between the Project Area and Grahamstown Dam. Consequently there are no predicted impacts on water users other than the Grahamstown Dam water storage. HWC's NorBE water quality requirements are addressed in Sections 3.3.1 and 6.3 of this report. The loss in yield to Grahamstown Dam is very small in comparison to the total catchment yield and flow pumped from the Williams River.

6.5 Riparian and ecological values of the watercourse

The impact from loss of yield noted in Umwelt WA Section 6.5 will be reduced by the regime of planned discharges, which will supplement flows during and following wet weather, followed by periods with no flow during extended dry weather. Consequently, the change in flow is unlikely to significantly alter the flow regime and associated existing ephemeral habitats.

6.6 Environmental Flows

As noted in the Umwelt WA, the watercourses are ephemeral, and the ecosystems are adapted to drying out.

The impacts from loss of environmental flows in the Umwelt WA will be reduced by the regime of proposed discharges.

6.7 Flooding

The downstream flooding on Seven Mile Creek will be unchanged from the assessment provided in the Umwelt WA. Refer to Section 6.7 of the Umwelt WA.

6.8 Erosion and Sediment Control

Refer to Section 6.8 of the Umwelt WA.

6.9 Final Landform and post-closure

Refer to Section 6.9 of the Umwelt WA.

6.10 Summary of Potential Impacts

The strategy for water management within the Project will mitigate potential impacts as summarised below:

There is a low risk of impacting the water quality of downstream watercourses since water will be treated prior to discharge to meet ANZECC guidelines, the ongoing monitoring of water qualities, and regular review of the adequacy and functioning of the water management system.

The environmental consequences of the reduction in site discharge will be limited due to ephemeral nature of the watercourses, and the proposal to release treated discharges during or following wet weather periods

The risk to the drinking water catchment is not significant. NorBE requirements have been satisfied since the long term average pollutant loads for TSS, TP and TN will be reduced, and the Project will include measures to mitigate the risk of introduced pollutants migrating into the drinking water catchment.

The reduction in annual catchment runoff volume to Grahamstown Dam is considered to be negligible based on a loss in yield in the order of 0.2%

No increase to the flooding regime and associated risks is predicted downstream of the Project as a consequence of the Project

Post closure the area will become largely vegetated and runoff may be slightly reduced compared to the pre-development case

6.11 Cumulative Impacts

As noted in the Umwelt WA, the Boral Quarry is an existing operational quarry with approximately 35ha within the catchment of Seven Mile Creek. Boral has approval to discharge to Seve Mile Creek under certain conditions.

The cumulative loss of yield to Seven Mile Creek for the Boral plus Eagleton quarries will be the runoff from up to 65ha of the catchment, less any licensed discharges from these quarries. As the stream is intermittent, and exhibits significant variation in flow volume and flow duration, it is considered that a reduction in flow volume in Seven Mile Creek will not significantly impact on the downstream ecosystems.

The proposed quarry has adequate water storage available to fully contain site runoff without the dams spoiling over as uncontrolled discharge, in up to the 500 year rainfall event. Most of the captured runoff will be stored and re-used on site for processing and dust suppression. If there is an accumulation of water volume in the site dams from prolonged rainfall, then it can be treated and released as controlled discharges in accordance with the requirements of the environmental license, and any further requirements of Hunter Water Corporation that might be incorporated into the planning consent.

7 MONITORING, LICENSING AND REPORTING

Monitoring, licensing and reporting are unchanged from the Umwelt WA, with the exception that the revised strategy will definitely require an Environmental Proetcion License which allows for controlled discharges to the environment.

Refer to Umwelt WA Section 7.0.

8 REFERENCES

1. Eagleton Hard Rock Quarry – Water Assessment, Umwelt, 2016 (Referred to herein as the Umwelt WA). [This report is included as Appendix B]

2. Protecting our Drinking Water Catchments – Guidelines for developments in the drinking water catchments, Hunter Water, 2017

3. Draft MUSIC Modelling Guidelines for New South Wales, BMT WBM, 2010

4. Using MUSIC in Sydney's Drinking Water Catchment – A Sydney Catchment Authority Standard, Sydney Catchment Authority, 2012

5. Managing Urban Stormwater – Soils and Construction, Volume 1, Landcom, 2008.

6. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries, Landcom, 2008.

7. Preliminary Resource Assessment, Proposed Eagleton Quarry, Qualtest, January 2016

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APPENDIX A

SUMMARY OF DPE AND SUBMISSION COMMENTS

DPE Attachment A

The DPE has identified the following comments in relation to the Water Assessment.

Comment	Response
The Hunter Water Corporation has requested that the following additional information be provided as part of the RTS: - Demonstration that the development will meet NorBE (Neutral or Beneficial Effect); - Demonstration that the proposed water management system is feasible and effective ; and - Detailed justification for the proposed level of containment.	Uncontrolled discharges of dirty water from the overall site will occur less than every 500 years. [Refer Sections 3 and 5] Pollutant export modelling demonstrates that the mass pollutant load of discharges from site will be less than that for the current site for pollutants already present at site – TSS, Total N, Total P. [Refer Section 6] Additional water quality controls have been included to manage and isolate introduced pollutants which may be potentially harmful to the environment and drinking water supplies. [Refer Section 3]
Port Stephens Council has requested that the development be designed to cater for the on-site detention of "dirty" water stemming from rainfall events up to and including the 1:500 year rainfall event.	Water balance modelling demonstrates that the site does not discharge during the modelling of 102 years of historical rainfall, and furthermore, that there is additional spare capacity to contain runoff from a 500 year 24 hour event, and a 500 year 72 hour rainfall event. This indicates that 'uncontrolled discharges' of dirty water will occur less than every 500 years. [Refer Sections 3 and 5]
The EPA has requested that the impacts of on-site application via spray irrigation be assessed if this continues to be a potential option for surface water management	Irrigation is no longer relied upon to manage water volumes in the current proposal. Water will be utilised for dust suppression with application depths limited to 5mm per day.
DPE identified that Grahamstown Dam was particularly important to members of the community, with over 55% of all submissions received to date raising the impacts of the project on the drinking water catchment. The Department requests that sufficient evidence be provided to show that Dams 1 and 2 are sufficiently capable of storing affected water without spillages into the water catchment , up to and including a 1:500 year rainfall event.	Uncontrolled discharges of dirty water from the overall site will occur less than every 500 years. HWC's requirements for Nil or Beneficial Impact on drinking water catchments have been satisfied by allowing the discharge of water from site which is treated to a high standard, such that the overall pollutant export load is reduced from that of the existing site.
Port Stephens Council has requested that further information is provided in relation to on-site sewage management.	This matter is outside the scope of this report
The Department requires a response to all issues raised in the Hunter Water submission dated 9th March 2017, including review of the Water Assessment undertaken by Alluvium	Refer to responses to HWC and Alluvium comments below

(8th March 2017) .

Hunter Water Corporation

HWC Comment	Response
Preference for a closed system (no discharge of water from site)	Uncontrolled discharges of dirty water from the overall site will occur less than every 500 years.
If water is to be discharged from site then the water quality of water discharged should be of the same or better quality than that currently leaving the site to demonstrate a Neutral or Beneficial Effect (NorBE)	The mass pollutant load of discharges from site will be less than that for the current site for pollutants already present – TSS, Total N, Total P. The water quality of controlled discharges will comply with the EPL and be appropriate for the ANZECC environmental value of the receiving environment
Further comments arising from Alluvium review – see below	Refer below

Port Stephens Council

Comment	Response
Council request that water management dams be designed to contain a 500 year design event	Uncontrolled discharges of dirty water from the overall site will occur less than every 500 years.

EPA

Comment	Response
A Pollution Incident response Plan (PIRMP) [6]	A PIRMP will be prepared prior to operation
Dam 1 and Dam 2 sized to contain a 100 year 24 hour event (259mm of rainfall), prior to wet weather discharge [22]	Site storages will have adequate capacity to contain this event, including Dams 1 and 2, new Dam 3, and the in pit sumps.
Monitor water quality of site discharges [23]	Water quality will be monitored at the Licensed Discharge Point in accordance with requirements of the EPL
Prepare a stormwater management plan in accordance with Managing Urban Stormwater: Soils and Construction: volume 2C Unsealed Roads and Volume 2E Mines and Quarries (DECCW 2008) [25]	These plans will be prepared prior to construction
Prepare a flood management plan [26]	This plan will be prepared prior to construction
Requirements for storage of environmentally harmful materials and fuel storage /refuelling areas [27-30]	Additional pollution control and management requirements have been added. Refer Sections 3 and 6

DPI Water

Comment	Response
A Water Management Plan is required for construction and operational phases, including a Surface Water Management Plan, Groundwater Management Plan, and Sediment and Erosion Control Plans.	These plans will be prepared prior to construction
Provide further detail on the volume of permanent water holding proposed in the final landform to determine licensing requirements	

Boral

The EMM report prepared for Boral identified a number of comments specific to water management, and these are paraphrased in the table below:

Comment	Response
The water balance identifies the need for long term (up to 3 year) storage of large volumes of water (up to 200ML). This is not considered to be practical, and if amended may conflict with the evaporation assumptions in the water balance [page 17]	The water management strategy has been refined so that in pit water is now mostly contained to defined sumps, rather than being spread at shallow depth across the pit floor.
Evaporation alone from only part of the site will not result in a zero discharge outcome in wet years [page 17]	The water management strategy has been refined to allow the controlled discharge of treated water, which reduces the reliance on evaporation
Evaporation losses appear overestimated [page 17]	The revised strategy does not rely on irrigation and evaporation losses are from the dam water surfaces only.
Volumetric runoff coefficients used in the water balance of 0.5 and 0.7 may be low since parts of the Exposed Area will be used for irrigation and to store shallow water	The water management strategy has been refined so that there is no longer any irrigation, and the in pit water is now stored in defined sumps, rather than being spread at shallow depth across the pit floor.
The in pit storage may be up to 200Ml, and the potential for embankment failure poses a risk to the downstream environment and motorists on the Pacific Highway	The water management strategy has been refined so that the in pit water is now reduced to 180ML. Long term storage of water in pit will be stored in defined sumps, which will be cut into the rock, so there will be no large earth embankment containing water for long durations. Water may surcharge these sumps for short durations.

Alluvium Report

HWC commissioned Alluvium to review the Water Assessment within specific terms of reference. The Alluvium report provided a comprehensive review of the Umwelt Water Assessment.

Comment	Response
Section 2.2 of the Alluvium Report refers to the ‘Hunter Water Guidelines for Development in Drinking Water Catchments 2016’, in which HWC’s expectation is for water quality impacts to have Neutral or Beneficial Effect (NorBE).	An updated document titled ‘Development in Drinking Water Catchments 2017’ was released in March 2017.
Section 2.3 of the Alluvium Report identifies the key pollutants of concern as bacteria, viruses, protozoa, turbidity, suspended solids, nutrients, heavy metals, fuels, pesticides, organics, algal toxins, endocrine	The proposed quarry will not have any significant sources of organic loading which would produce bacterial or viral contamination. Sewage will be removed from site.

disrupting chemicals, and taste/odour compounds.	
Section 3.2 of the Alluvium Report identified the following points which are important, • 'While concentrations are important, it is the total load of pollutants generated from the development that is of most concern'. • We understand that if the applicant can demonstrate that the total catchment/pollutant load from the site following development with mitigation measures in place does not exceed the pre-development loads this would achieve the NorBE targets'. • This would also require the applicant to demonstrate that pollutants unlikely to be found in the current site (eg particular chemicals, fuel, oils etc) can be appropriately isolated from mixing with runoff' • Two assessment approaches would be acceptable to HWC: Approach 1: demonstrate no increase in pollutant loads, or Approach 2: contain all catchment loads up to an agreed rare flooding event within the site without discharge to Seven Mile Creek • It is our opinion (Alluvium's) that in circumstances where runoff is to be retained within a site rather than diverted around a drinking water storage…that an assessment based on Approach 1 is most appropriate. • Discussion in the WA about detaining the PMF appears to conflict with the strategy for managing the 100 year ARI, 24 hour event.	The water management strategy has been revised to align with 'Approach 1' involving treat and release of water during extended wet weather. Section 6 of the revised strategy demonstrates NorBE by showing that the total load of pollutants – TSS, TN and TPO will be reduced during the quarrying operations period. The containment of other potentially introduced pollutants is also addressed in Section 6. The PMF will not be detained on site.
Section 3.3 of the Alluvium Report: • *Limitations of event based modelling* - A strategy based on retention of a design storm event burst is not appropriate for managing water quality risks of the development. Additional rainfall before and after these storm bursts would result in additional runoff volume. • *Similar runoff volumes from more frequent design events* - It is also possible for wet weather to extend over a number of days or weeks that would cumulatively generate a large volume of runoff that would fill the proposed storages • *Antecedent water levels* - The ability of the proposed storages to retain all runoff volume depends on antecedent water level in the storages when the event occurs • *Operational impacts* – water stored in pit will restrict operations over significant periods and also reduce water demands	The strategy is based on Goldsim water balance modelling with an historical rainfall of 102 years. This allows a conservative estimate of the dam antecedent water levels at the commencement of a design event Refer Section 3 and 5.
Section 3.3 - There appears to be an error with the PMF runoff estimate	
Section 3.4 – Modelling Approach – a water	The revised assessment includes a Goldsim water balance using daily timesteps to estimate the volume

balance approach would yield better estimates of water storages required to minimise risks to the drinking water catchment (than an event based modelling)	of water which is treated and discharged.
Modelling results: • At year 5 the water balance indicates that 162Ml is required to be stored in pit. However, the extraction area may be too small to contain this volume with a 1m high bund. • At year 30 it is unclear how 189Ml of water could be stored in pit without impeding operations	The volume of water required to be stored in pit at Year 5 has been reduced to approximately 130ML. If required then additional storage will be constructed outside of the active pit area (but within the ultimate pit area). The year 30 storage requirement in pit has been reduced to approximately 180ML. Most of the time water in the extraction area will be stored within a deeper 'sump', which would reduce the area of inundation. The duration of inundation has also been reduced by treating and discharging water from site.
Section 3.5 • Seven Mile Creek Water Quality – monitoring points include disturbed catchments. No baseline water quality monitoring has been collected for the southern tributary of Seven Mile Creek that the development proposes to discharge into, and monitoring of this creek will provide more relevant baseline conditions. • Water quality data were compared against default ANZECC guideline trigger values for ecosystem protection. For this development in a drinking water supply catchment it is considered that alternative trigger values based on drinking water catchment protection should be considered. • While establishing trigger concentrations for pollutants is of interest, the total load of pollutants from the site is of concern for protecting drinking water catchment and specifically Grahamstown Dam • Establishment of water quality concentration targets for the development should be undertaken in conjunction with runoff discharge volume targets to enable comparison with NorBE targets	Water quality trigger values have been established to protect both the environment and comply with NorBE requirements.
Section 3.6 – Performance of proposed mitigation measures – Water balance calculations should adopt a reduced capacity to allow for sediment capture	Sediment capture volumes have been estimated separately and added to the water balance volumes to provide a total volume to be constructed.
Section 3.7 – Proposed monitoring program – proposed monitoring locations are downstream of Boral	The water quality of discharges will be measured at site.
Treated runoff from workshop and plant washing areas should be directed away from Dams 1 and 2 to minimise the potential for any mixing with runoff	Washdown from the workshop area will pass through a grease trap prior to discharge. Runoff within the processing and stockpiling are of the site will discharge via a gross pollutant trap to an additional storage – Dam 3. Water in Dam 3 will be re-used within the same area for dust suppression and processing.
Based on the water balance modelling included in the water assessment' it is our (alluvium) opinion that	Controlled discharges under license have been added to the strategy. An analysis of pollutant loads before and after

discharge of surface water (and entrained pollutants) would be necessary throughout the proposed development lifecycle to prevent areas of the site being inundated for lengthy periods. Without an evaluation of the existing and future catchment/pollutant loads from the site it is not possible to assess the ability of the development to achieve NorBE targets and confirm what potential cumulative impacts on the Grahamstown Dam drinking water catchment would be	development shows a reduction in pollutant loads, demonstrating compliance with NorBE.

APPENDIX B

COPY OF PREVIOUS WATER ASSESSMENT

PREPARED BY UMWELT IN 2016

(Referred to in main body of report as the ‘UMWELT WA’)

Eagleton Rock Syndicate Pty Ltd

EAGLETON HARD ROCK QUARRY

Water Assessment

FINAL

October 2016

Eagleton Rock Syndicate Pty Ltd

EAGLETON HARD ROCK QUARRY

Water Assessment

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Eagleton Hard Rock Syndicate Pty Ltd

Project Director: Peter Jamieson
Report No. 3102/R04/FINAL
Date: October 2016

Newcastle

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Abbreviations

AIP	Aquifer Interference Policy
ARI	Average recurrence interval
AWDS	Available Water Determinations
ANZECC Guidelines	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)
BOM	Bureau of Meteorology
DIPNR	Former Department of Infrastructure, Planning and Natural Resources
DP&E	Department of Planning and Environment
EIS	Environmental Impact Statement
EC	Electrical Conductivity
EPA	Environment Protection Authority
EPL	Environmental Protection Licence
GDE	Groundwater dependent ecosystem(s)
ha	hectare
HWC	Hunter Water Corporation
IFD	Intensity Frequency Duration
km	kilometres
MAR	Mean Annual Runoff
m^3/day	cubic metre per day
m^3/s	cubic metre per second
ML	Mega litres (1000 m^3)
ML/year	Mega litres per year
mAHD	metres Australian Height Datum
mg/L	milligrams per litre
mm	millimetres
mm/day	millimetres per day
NOW	New South Wales Office of Water
NSW	New South Wales

NorBE	Neutral or Beneficial Effect on water quality
NTU	Nephelometric Turbidity Units
OEH	Office of Environment and Heritage
pH	Measure of acidity or basicity
PMF	Probable Maximum Flood
Project	the Eagleton Hard Rock Quarry
SCS	Soil Conservation Services
SEARs	Secretary’s Environmental Assessment Requirements
TSS	Total Suspended Solids
Umwelt	Umwelt (Australia) Pty Limited
µS/cm	microsiemens per cm
WF	Watering factor
WSRC	Water Source Report Card
WSP	Water Sharing Plan

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Plates

Appendices

1.0 Introduction

Umwelt (Australia) Pty Limited (Umwelt) has been engaged by Eagleton Rock Syndicate Pty Ltd to prepare a Surface and Groundwater Assessment for the proposed Eagleton Quarry Project (the Project). The Surface and Groundwater Assessment will be included as part of the Environmental Impact Statement (EIS) required for the development application for State Significant Development Projects. Secretary's Environmental Assessment Requirements (SEARs) were provided for the Project on 6 November 2015.

The Project involves the establishment and operation of a hard rock quarry and associated infrastructure near Eagleton in New South Wales (NSW) some 10 km north-east of Raymond Terrace (refer to **Figure 1.1**).

The Project is located in the Seven Mile Creek catchment which lies within the Grahamstown Dam Special Area (Hunter Water Regulation (2010)). The Special Area exists by proclamation due to the use of Grahamstown Dam for potable water supply, and covers all of the catchment areas draining into Grahamstown Dam. The supply of potable water from Grahamstown Dam is undertaken by the Hunter Water Corporation (HWC).

1.1 Project overview

The proposed development is located on Lot 2 of DP 1108702 (Killaloe Lane, off Italia Road), Eagleton NSW. The Project proposes to extract Nerong Volcanic material and produce a range of rock, gravel and sand products. Resource extraction is estimated at 12 million cubic metres (m^3) of rock over a period of 30 years, with a maximum production rate of 0.6 million tonnes/year. The disturbance footprint is approximately 30.4 ha.

The Project Area (refer to **Figure 1.2**) is located within predominantly rural acreages. Various non-rural developments also exist in the general vicinity including Port Stephens Gardenland, Hunter Valley Paintball, Barleigh Ranch Raceway and MX Central to the east, Motorsport Complex to the north-east and Boral quarry to the north.

The catchment has been subject to significant areas of disturbance as shown on **Figure 1.2**. Soils within Seven Mile Creek catchment are from the Ten Mile Road soil landscape and tend to exhibit low fertility and high erodibility. Soils from the tm3 variant occur in Seven Mile Creek catchment to the south of the proposed Project Area. These soils exhibit sodicity and dispersive characteristics which impact on existing water quality downstream of the Project Area and on the quality of water draining to Grahamstown Dam.

Components of the Project include:

- a resource extraction area, which will comprise a cutting into the side of the hill that will be progressively lowered from a maximum elevation of approximately 130 metres Australian Height Datum (mAHD) to a floor elevation of RL 45 mAHD
- upgrading and sealing of an access road from Italia Road to the Project Area including the construction of culvert or bridge crossing of Seven Mile Creek
- internal haul roads
- product processing facilities, with adjacent product stockpiles

- management and sales offices including vehicle parking, access control, ablutions and a sewage pump-out system
- surface water and sediment control structures.

1.2 Water planning context

The following NSW Government public authorities have provided requirements for the Project for consideration in the EIS:

- Secretary of the Department of Planning & Environment (DP&E) – SEARs
- Department of Primary Industry Water (DPI Water)
- Department of Industry Resources and Energy
- Environment Protection Authority
- Office of Environment and Heritage
- Port Stephens Council
- Hunter Water Corporation.

The following is a list of requirements relating to surface water and where they are addressed in this report:

- statement as to where each element of SEARs is addressed (**Section 1.0**)
- a detailed description of the proposed water management system during and after construction – refer to **Section 3.0**
- a water balance for the Project – refer to **Section 5.0**
- a detailed assessment of the potential surface and groundwater impacts of the proposed Project on the drainage system – refer to **Section 6.0**
- a detailed assessment of the potential impacts on water users (including the environment) – refer to **Sections 6.4** and **6.5**
- annual volumes of surface and groundwater proposed to be taken – **Sections 4.0** and **6.0**
- volumetric water licencing requirements – **Section 7.0**
- identification of adequate and secure water supply – **Section 6.0**
- detailed and consolidated site water balance– **Section 5.0**
- full technical details of surface and groundwater modelling – **Appendix 1a**
- surface and groundwater monitoring activities and methods –**Section 7.0**
- management and disposal of produced or incidental water – **Section 5.0**

- details of final landform – **Section 3.3.5**
- details of works that may impact on fish passage – **Section 3.3.1**
- details of buffer requirements to watercourses and assessment of watercourses that may be impacted and selection of appropriate in accordance with DPI Water's Guidelines for Controlled Activities on Waterfront Land (2012) – **Section 1.5**
- assessment of potential cumulative impacts (**Section 6.11**)
- consideration of relevant policies and guidelines (**Sections 1.6** and **7.0**)
- adequate description of water management on-site including process and stormwater management, sedimentation ponds, potential for discharge and sensitivity of the receiving environment particularly given the location within Grahamstown drinking water catchment (**Sections 3.0** and **6.0**)
- description of existing surface water quality, Water Quality Objectives and indicators, criteria and trigger values for water quality (**Section 2.3)**
- impacts of development on flood behaviour, flow conveyance, flood hazard, community emergency management (**Section 6.7**)
- design of silt basins to considering risks associated with events up to Probable Maximum Flood (PMF) (**Section 3.0**)
- requirements of Hunter Water Regulation (2010) (**Section 1.6**).

1.3 Potential water resource impacts

The key features of the Project that have the potential to impact on water resources include:

- the development of the quarry, including the removal of overburden and blasting of rock with the generation of fine material increasing the Total Suspended Solids (TSS) in runoff with additional contamination possible due to the use of explosives
- haul roads constructed to facilitate the transportation of rock from the active quarrying areas to the rock processing areas and the transportation of product off site, with potential impacts from TSS in runoff from untarred roads
- the upgrading of existing roads and the construction of a new access road, including the crossing of Seven Mile Creek with associated erosion and contamination risks
- the water requirements of the quarry for both rock processing and dust suppression
- the construction of infrastructure including water management dams, a product washing and processing plant with adjacent stockpile area, and offices with associated parking areas
- the provision of services for the Project including a new transmission line, potable water supply from tankers, and pump out sewage facilities

- the use of mechanical equipment on site including excavation and hauling equipment with the potential for spillage of oils and fuel associated with the operation and maintenance of the mechanical equipment

- rehabilitation of disturbed areas at closure with the potential for elevated TSS until vegetation is established.

1.4 Report overview

This Surface Water Assessment Report is structured as follows:

- **Section 2.0** of this document provides information on the existing water resources within the Project area.

- The conceptual Water Management System for the project is described in **Section 3.0**.

- Groundwater modelling and management is in **Section 4.0**

- The Project water balance is detailed in **Section 5.0**.

- The potential impacts of the Project and proposed surface water management strategies are discussed in **Section 6.0**.

- The monitoring, licensing and reporting requirements for the Project are discussed in **Section 7.0**.

- References – **Section 8.0**.

1.5 Water management overview

The proposed Eagleton Hard Rock Quarry will occupy an area of approximately 30.4 ha and is located within Grahamstown Dam catchment. The site is located at the top of the catchment and has limited potential for upslope runoff to flow into the proposed quarry area.

Groundwater (see **Appendix 1** and URS (2014)) indicates that groundwater inflows to the quarry will be negligible with estimated groundwater make in the quarry ranging from approximately 2.9 ML/year to approximately 7.5 ML/year. In addition, groundwater modelling (see **Appendix 1**) indicates that quarrying will only have a minimal impact on baseflows in Seven Mile Creek with a maximum reduction predicted to be 0.27 ML/year after 25 years of extraction.

The quarried landform will be bunded around its perimeter to prevent upslope runoff from entering the quarry. The excavation area will be maintained throughout the life of the quarry to be free draining, with all runoff from disturbed areas being directed to two large sediment dams. The sediment dams (Dam 1 and Dam 2) will have a combined capacity of approximately 57 ML and will be located along the southern downslope perimeter of the quarry. The dams and on-site water management system will be sized to contain runoff from a 100 year Average Recurrence Interval (ARI) 24 hour rainfall event and safely convey runoff from a PMF event.

It is proposed that extraction within the quarry will occur to a minimum elevation of 45 mAHD. Top water level of Dam 1 will be 42.5 mAHD ensuring that all runoff from the quarry can drain to the sediment dams.

All catch drains conveying runoff from the quarry floor to the sediment dams will be designed to safely convey runoff from a 100 year ARI rainfall event. Rock weirs will be installed in the catch drains to help slow flows and minimise the potential for erosion and sediment re-entrainment. The drains will be largely founded in rock, or grassed where in soft material and provided with suitable erosion protection.

Water from the dams will be used on-site for dust suppression in the first instance. The water management system has been designed to enable all runoff up to the 1 in 100 ARI 24 hour event to be contained on-site without discharging to Seven Mile Creek. The system has been designed to include the ability to either store and reuse the runoff on-site or treat water in the dams prior to it being discharged to Seven Mile Creek. Any discharges to Seven Mile Creek will be monitored prior to discharge to ensure relevant discharge criteria as may be set by consent conditions or Environment Protection Licence (EPL) conditions are met.

The proposed water management system will also include provision to retain, treat and safely convey off-site runoff from rainfall events up to a Probable Maximum Precipitation event. This will be achieved by establishing in-pit storage and constructing bunds around the quarry floor of each of the extraction areas. The in-pit storage and bunds will be capable of detaining runoff from up to 910 mm of rainfall. Low flow pipes will be constructed in each of the bunds to allow controlled discharges to Dams 1 and 2. During extreme rainfall events, runoff in excess of the capacity of in-pit storage and the Dams will discharge to Seven Mile Creek in a safe and stable manner.

The water management system will be designed to contain all runoff from up to 100 year ARI 24 hour event. Runoff from events in excess of a 100 year ARI 24 hour event will be detained on-site where possible and discharged to Seven Mile Creek in accordance with EPL conditions.

The water management system will be designed so that it can be operated to minimise the potential for impacts on the flow regime and water quality of Seven Mile Creek and Grahamstown Dam and surrounding surface and groundwater users.

The water management system has been designed to enable the existing flow regime within Seven Mile Creek to be maintained if approval to discharge to Seven Mile Creek during events up to 100 year ARI event is granted. This will be achieved by maintaining the volume of water discharged to within approximately 20% of the Mean Annual Runoff volume (MAR) from the site prior to quarrying.

MAR based on DPI Water Farm Dam Calculator for this area is approximately 1 ML/ha or approximately 30.4 ML/year from the fully developed quarry site. The proposed quarry footprint occupies approximately 10% of the 302 ha Seven Mile Creek catchment upstream of the Grahamstown Dam. If discharges are controlled to be within 20% of the MAR from the site, the potential variation in annual flow volumes in Seven Mile Creek will be approximately 2%. If all runoff from the quarry is contained on-site as proposed, annual flows in Seven Mile Creek will be reduced by approximately 10%.

Grahamstown Dam has a direct catchment area of approximately 11,500 ha indicating that the operation of the quarry as proposed could potentially make between a 0.05% and 0.2% change in annual surface runoff into Grahamstown Dam. The actual impact on volumes in Grahamstown Dam will be less than this as typically approximately 50% of the water in the dam is pumped from Williams River via Balickera Canal.

The Project includes the quarrying of different rock types within a relatively small quarry area. The initial quarry pits will be expanded laterally to expose the underlying rock, after which the quarry floor will be progressively lowered. The majority of the total quarry footprint will be disturbed within the first five to six years of the Project.

The rock to be quarried is considered to be inert. While there are potential impacts on water quality relating to the potential for oil and diesel spills and the use of explosives, these impacts can be readily and suitably managed and will be contained in effectively a closed water management system. The main potential for impact on water quality is likely to be elevated sediment levels due to disturbance of 30.4 ha of woodland. This will be minimised by operating the quarry as a closed water management system for rainfall events up to and including the 1 in 100 year ARI 24 hour event.

As shown on **Figure 1.2**, the proposed quarry site is bounded by creeks to the north, east and south. Apart from the proposed access road that will cross Seven Mile Creek, the quarry footprint and associated water management infrastructure will be located in accordance with DPI Water's Guidelines for Controlled Activities on Waterfront Land (2012).

The strategy to prevent impacts on Grahamstown Dam involves the following:

- sealing of the access road from the proposed quarry entrance to Italia Road to prevent the potential for sediment runoff and dust generation from the access road
- the construction of water management Dam 1 at the downstream boundary of the quarry extraction area at the Project inception to collect runoff from the disturbance area
- construction of a central access road and catch drain to convey runoff from all extraction areas during the first approximately five years of operations to Dam 1
- location of the processing and stockpiling area upslope of Dam 1 so that runoff from this area can be conveyed to Dam 1
- construction of Dam 2 immediately to the west of Dam 1 at approximately Year 6 of operations to ensure sufficient storage capacity is maintained throughout the life of the quarry to contain runoff from a 100 year ARI rainfall event
- provision of bunding around the perimeter of the quarry floor to detain runoff from disturbed areas within the quarry floor. The bunding will be designed and constructed to detain and safely convey runoff from up to a Probable Maximum Rainfall event
- provision of bunding around the processing area to contain and control runoff from this area
- provision of a contingency volume of 10 ML of water in Dams 1 and 2 to assist with water supply during dry periods. During periods when there is insufficient water on-site to meet dust suppression needs, water will be imported to the site using a water contractor
- construction of clean water diversion and dirty water catch drains around the perimeter of the extraction area. The clean water diversions will drain back to the clean water catchment, while the dirty water catch drains will drain to the water management dams.

Water balance modelling using historic rainfall and evaporation records indicates that during the majority of the life of the quarry the volume of water available on site will be greater than demand. This excess water will either be evaporated on-site through irrigation or if approved, treated and discharged to Seven Mile Creek.

If water is to be discharged from the quarry, the target quality for the release of water proposed for this project is 40 milligrams (mg)/litre (L) TSS, pH between 6.5 and 8.5, electrical conductivity less than 900 µS/cm.. These targets have been set using the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) (Australian and New Zealand Environment and Conservation Council (ANZECC)) and site-specific water quality data based on monitoring in Seven Mile Creek and will be subject to consultation with the relevant government agencies. It is expected that the runoff water may need to be treated to meet the target qualities, potentially involving flocculation to reduce the TSS and pH adjustment if required.

Stripping vegetation from the quarry footprint will increase volume of runoff from rainfall and the water make from the Project Area compared to the current vegetated catchment. The treatment and release of the water make to Seven Mile Creek if approved, can be managed to result in there being no significant reduction in annual water flow volumes in Seven Mile Creek as a result of the proposed Project. Modelling indicates that the water surplus in the project area will be greater than the pre-quarrying yield even after the use of water for dust suppression (see **Section 5.1**).

If water is discharged to Seven Mile Creek, the volume of water discharged will be recorded either via a flow meter in the discharge line or by recording the change in the volumes of dams from where the discharge has occurred. As discussed, groundwater modelling indicates that the proposed quarry will have a minimal impact on baseflows in Seven Mile Creek with a maximum reduction of 0.27 ML/year predicted. This predicted maximum reduction is negligible in terms of annual flows in Seven Mile Creek or changes that will occur as a result of changes to the surface runoff regime. It is also not practical to measure or monitor.

Groundwater levels and groundwater quality will be measured over the life of the quarry using a network of monitoring bores. Groundwater level information will be compared with model predictions as the quarry develops to provide an indication of the actual versus predicted impacts.

Surface water quality will continue to be monitored upstream and downstream of the quarry for the life of the operation to provide ongoing information in regard to water quality in Seven Mile Creek.

The proposed quarry will be operated in accordance with Hunter Water Regulation (2010) requirements.

Contingency measures for the management of excess water on-site include in addition to treatment include increased usage for dust suppression and greater application to rehabilitated areas such as quarry benches. If approval is granted, water may also be treated and discharged.

The proposed quarry will use a pump out system for effluent generated from the office and ablutions, with quarrying and processing activities being operated within a closed water management system that will be capable of containing all runoff from up to and including a 1 in 100 Year 24 hour ARI. With these controls in place, it is considered the proposed quarry development will not have a detrimental effect on water quality of Seven Mile Creek or Grahamstown Dam and will achieve Neutral or Beneficial Effect on water quality (NorBE) as required by 'Protecting our Drinking Water Catchments: Guidelines for developments in the drinking water catchments (HWC 2015)'.

1.6 Statutory and Regulatory Requirements

1.6.1 Secretary's Environmental Assessment Requirements (SEARs)

The Secretary of the Department of Planning and Environment (DP&E) has provided requirements for the Project (Secretary's Environmental Assessment Requirements – SEARs) that identify key issues for consideration in the Environmental Impact Statement (EIS).

The SEARs relating to groundwater issues and water resources and where they are addressed in this report are set out in **Table 1.1**.

Table 1.1 Secretary's Environmental Assessment Requirements

Surface and groundwater assessment requirements	Section of report
A water management strategy, having regard to EPA's and DPI Water's requirements (see Attachment 2)	Sections 1.0 to 7.0
A detailed assessment of potential impacts on the quality and quantity of existing surface and ground water resources, including impacts on the regional water supply, having regard to the requirements of DPI Water and EPA (see Attachment 2)	Sections 1.0 to 7.0
A detailed site water balance and an assessment of any volumetric water licensing requirements, 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 5.0
An assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives	Sections 1.0 to 7.0
An assessment of the likely flooding impacts of the development, having regard to the requirements of OEH (Attachment 2)	Section 6.7
Identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*	Section 7.0
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), having regard to DPI Water's requirements (see Attachment 2)	Sections 5.0 and 6.0
A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo	Section 7.0
A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts	Section 3.0
Annual volumes of surface water and groundwater proposed to be taken by the activity (including through inflow and seepage) from each surface and groundwater source as defined by the relevant water sharing plan	Sections 4.0, 5.0 and 6.0
Assessment of any volumetric water licensing requirements (including those for ongoing water take following completion of the project)	Sections 4.0 and 7.0
The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased	Section 5.0
A detailed and consolidated site water balance	Section 5.0

Surface and groundwater assessment requirements	Section of report
A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework	Section 4.4
Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts	Sections 4.0, 5.0 and 6.0
Full technical details and data of all surface and groundwater modelling, and an independent peer review	Section 4.0, 5.0 and 6.0
Proposed surface and groundwater monitoring activities and methodologies	Section 7.0
Proposed management and disposal of produced or incidental water	Section 5.0
Details of the final landform of the site, including final void management (where relevant) and rehabilitation measures	Section 3.0
Details on buffer requirements to watercourses in accordance with the requirements of DPI Water's Guidelines for Controlled Activities on Waterfront Land (2012)	Section 1.6
Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts	Section 6.11
Consideration of relevant policies and guidelines	Sections 1.6 and 7.0

1.6.2 Hunter Water Special Areas Regulation 2010

The proposed quarry is located within Grahamstown Catchment Area as defined in Hunter Water Special Areas Regulation 2010. Relevant clauses of Hunter Water Special Areas Regulation are:

8 Sewage disposal

(1) The owner or occupier of land in a special area must not erect, install or operate any on-site sewage management facility on the land.
Maximum penalty: 100 penalty units in the case of a corporation, or 70 penalty units in any other case.

(2) This clause does not apply to anything done in accordance with:
- (a) an approval under Part 3A of, or a development consent under Part 4 of, the *Environmental Planning and Assessment Act 1979*,
or
- (b) an approval granted under the *Local Government Act 1993*, or
- (c) an environment protection licence

Development consent is being sought for the proposed quarry under Part 4 of the *Environmental Planning and Assessment Act 1979.*

12 Pollution of waters

(1) A person must not pollute any waters in a special area.
Maximum penalty: 200 penalty units in the case of a corporation, or 100 penalty units in any other case.

(2) A person does not commit an offence under subclause (1) in respect of anything that is done in accordance with an environment protection licence.

(3) The Director-General may give a direction for:

(a) the management or disposal of any substance in a special area that the Director-General considers may detrimentally affect any waters in the area concerned, or

(b) the removal of any such substance from a special area or the relocation of the substance to another place in that area.

(4) A person given a direction under subclause (3) must comply with it.
Maximum penalty: 100 penalty units in the case of a corporation, or
50 penalty units in any other case.

(5) In this clause:
pollute, in relation to waters, has the same meaning as ***pollution of waters*** has in the *Protection of the Environment Operations Act 1997*, but extends to include disturbing geological or other matter (whether natural or artificial) in such a manner as to change, or to be likely to change, the physical, chemical or biological condition of the waters.
Note. Section 7 of the *Interpretation Act 1987* provides that, if an Act or instrument defines a word or expression, other parts of speech and grammatical forms of the word or expression have corresponding meanings.
waters has the same meaning as it has in the *Protection of the Environment Operations Act 1997*.

The proposed development has been designed to prevent pollution of water as defined in Clause 12 of Hunter Water Special Areas Regulation 2010. The quarry development will also require an Environment Protection Licence.

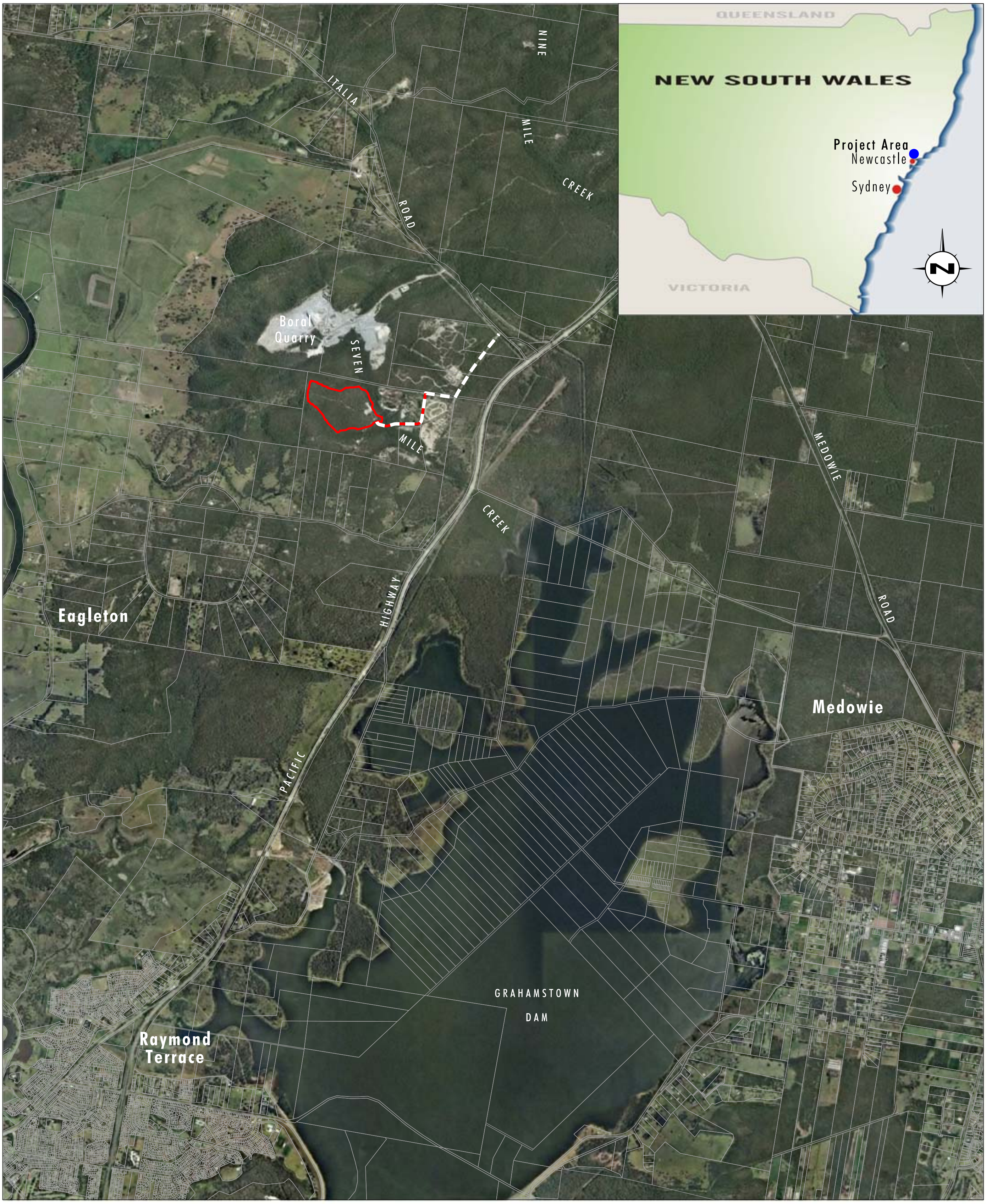

Image Source: Google Earth (2006)
Data Source: LPI (2009)

0 1.0 2.0 3km
1:60 000

Legend
Project Area
Access Road

FIGURE 1.1

Locality Plan

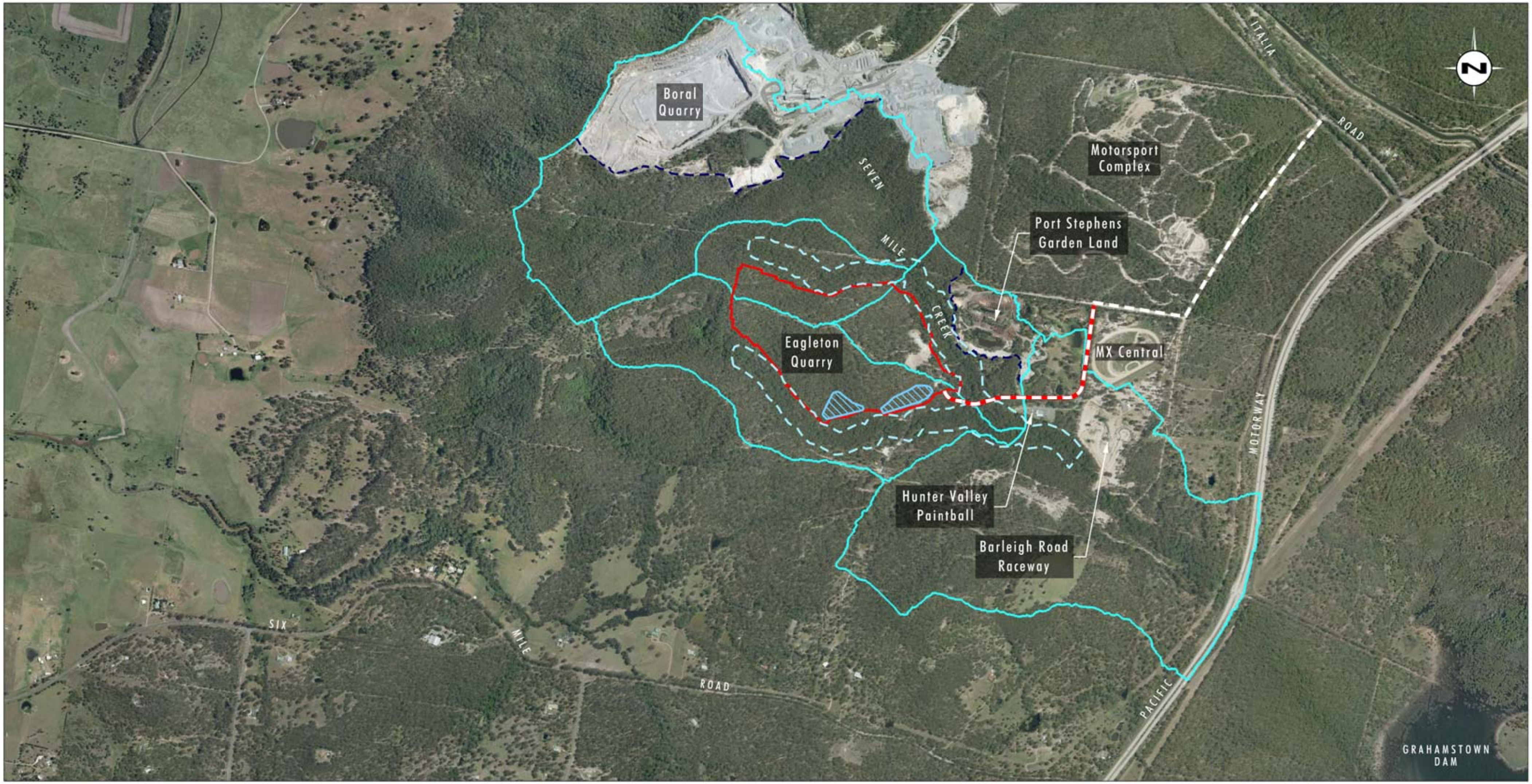

Image Source: Google Earth (2009)

0 0.25 0.5 1.0km
1:20 000

Legend

- Project Area
- Catchment Boundary
- Disturbed Catchment
- Dam Area
- Watercourse 40m Buffer
- Access Road

FIGURE 1.2

Project Overview

File Name (A4): R04/3102_046.dgn
20160919 9.50

2.0 Existing surface water environment

2.1 Rainfall and evaporation

Rainfall and evaporation data provide key inputs to many of the design parameters for water management systems and it is therefore important that the data used is from meteorological stations located as close to the Project Area as possible. The data also needs to be reliable without any significant anomalies and of sufficient duration so as to contain statistically significant rainfall events for the design of water management systems.

The locations of stations recording rainfall in the vicinity of the Project are shown in **Figure 2.1** with their proximity to the Project Area and the duration of rainfall data indicated in **Table 2.1**. Data from the meteorological stations were obtained from the Bureau of Meteorology (BoM).

Table 2.1 Rainfall stations within the surrounding area

Station	Station number	Distance to the Project Area (km)	Electronic data available from
Grahamstown (Hunter Water Board)	061311	8.9	May 1971
Clarencetown (Grey Street)t	061010	11.1	October 1895
Raymond Terrace (Kinross)	061031	11.2	April 1894
Williamtown RAAF	061078	12.2	October 1942
Clarencetown (Mill Dam Falls (Williams R))	061339	14.4	December 2000

The average monthly rainfall across the selected rainfall stations is given in **Figure 2.2**. The variation in monthly rainfall between gauging stations for any one month is typically of the order of 11% above and below the monthly average, with annual averages within 5% across all of the gauges.

As shown in **Figure 2.2**, the majority of rain falls between January and June with a monthly average of 112 mm for the first six months (range of 96 mm to 123 mm), compared to 66 mm for the second six months (range of 54 mm to 73 mm). The variation in rainfall has implications for the availability of water on site for reuse, as discussed in **Section 5.0**.

The closest BoM station to the Project recording daily rainfall is Grahamstown Dam (BoM Station No 061311) however there is no evaporation data available for this site. Evaporation data is available for Williamtown RAAF (BoM Station No 061078) and this site has a longer length of continuous record than Grahamstown Dam and hence has been used to characterise rainfall at the Project Area.

Statistical analysis of the rainfall data indicates that the data contains significant extreme events as highlighted in **Section 2.1.1**. These events have been taken into account in the design of the water management system.

2.1.1 Historical rainfall trends

The average monthly rainfall at Williamtown RAAF, together with the yearly average, is given in **Table 2.2**.

Table 2.2 Average monthly rainfall depths at Williamtown RAAF (BoM Station 061078)

Month	Average rainfall (mm)
January	101.7
February	119.2
March	118.2
April	111.8
May	112.2
June	121.3
July	72.5
August	74.6
September	60.5
October	72.7
November	83.4
December	79.8
Average Yearly Rainfall	1126.7

As shown in **Table 2.2**, average annual rainfall at Williamtown RAAF for the period from 1942 is approximately 1127 mm. As shown in **Table 2.3** annual rainfall ranges from 541 mm to 1794 mm. Recorded monthly rainfall ranges from 0 mm (July and August) to 599.6 mm in February with the six month period January to June typically being significantly wetter than the period July to December.

Table 2.3 Historic Rainfall Statistics

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	101.7	119.2	118.2	111.8	112.2	121.3	72.5	74.6	60.5	72.7	83.4	79.8	1126.7
Lowest	2.2	5.6	2.2	4.4	2.3	14.6	0.0	0.0	0.4	1.0	6.8	14.2	541.0
5th %ile	12.0	13.2	24.9	13.0	12.2	25.1	14.7	6.8	6.3	7.2	12.5	19.5	763.5
10th %ile	18.7	28.0	32.2	21.6	26.2	29.6	17.4	10.2	15.8	25.5	20.8	27.7	820.4
Median	79.2	95.1	107.2	97.6	96.6	102.8	70.8	57.8	49.8	55.8	81.6	63.2	1096.6
90th %ile	204.1	247.4	215.0	233.1	205.7	229.4	139.2	168.0	132.0	154.3	149.1	157.8	1483.5
95th %ile	279.0	273.0	294.7	303.5	230.3	301.2	154.7	179.6	145.1	170.2	173.1	201.2	1556.4
Highest	422.4	599.6	398.5	364.0	410.2	414.2	190.4	427.5	179.2	237.5	246.4	238.0	1793.7

2.1.2 Historical evaporation trends

The closest BoM station to the Project recording daily evaporation is Williamtown RAAF Base (BoM Station No 061078). Daily pan evaporation has been recorded at Williamtown RAAF from 1974.

The average monthly 'A' pan evaporation at Williamtown RAAF (Station 61078) is given in **Table 2.4**.

Table 2.4 Average monthly 'A' pan evaporation at Williamtown RAAF (BoM Station 61078)

Month	Average 'A' pan evaporation (mm)	Approximate water body evaporation (mm)	Average Monthly Rainfall (mm)
January	214	161	101.7
February	180	135	119.2
March	152	114	118.2
April	114	86	111.8
May	84	63	112.2
June	75	56	121.3
July	81	61	72.5
August	109	82	74.6
October	141	106	60.5
October	171	128	72.7
November	189	142	83.4
December	223	167	79.8
Average yearly 'A' pan evaporation	**1731**	**1298**	1126.7

The variation in evaporation is shown in **Figure 2.3**. As can be seen from **Table 2.4**, the average 'A' pan evaporation is approximately 1.6 times the average annual rainfall.

Class 'A' pan evaporation is higher than evaporation from an actual water body. The values in **Table 2.4** have been derived assuming that evaporation from a water body is75% of 'A' pan evaporation.

From **Table 2.4**, on average rainfall is expected to exceed evaporation for two months of the year (May and June).

Average daily class 'A' pan evaporation is 4.7 mm/day, with peak evaporation rates of 7.2 mm/day in December.

2.1.3 Design rainfall for extreme events

Rainfall Intensity Frequency Data (IFD) for 24 hour duration design rainfall events for the proposed Eagleton Hard Rock Quarry has been derived from Australian Rainfall and Runoff (1987). Rainfall during a 100 year ARI 24 hour event is estimated to be 259 mm and during a 24 hour 500 year ARI event it is estimated to be 330 mm.

Design rainfall during a Probable Maximum Precipitation event at Eagleton has been calculated using 'The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method' (Commonwealth Bureau of Meteorology (2003)) to be 910 mm in six hour period.

2.2 Catchment areas and watercourses

2.2.1 Catchment overview

The Project Area is located in the Seven Mile Creek catchment. The Seven Mile Creek catchment is located within the Grahamstown Dam Special Area, Grahamstown Dam being some 2 km downstream of the Project (refer to **Figure 1.1**).

The catchment is typically steep with undulating hills covered with woodland areas and some pastoral grasses. The vegetation exhibits considerable variation in the density of the undergrowth. Typical views are shown in **Plates 2.1** and **2.2**.

Plate 2.1

Catchment in the vicinity of the Project Area (July 2012)

© Umwelt, 2012

Plate 2.2

Mature forest in the vicinity of the Project Area (July 2012)

Within the general area there is also some localised disturbance including:

- access roads on to the Project Area
- numerous excavations and disturbed areas associated with parts of the catchment formerly being used to train heavy earth moving equipment operators
- areas of erosion on drainage lines, including erosion downstream of the existing causeway across Seven Mile Creek, but also at water management channels adjacent to gravel roads
- bare areas associated with motorsport activities undertaken in the lower part of the catchment.

Soils in the catchment are from the Ten Mile Creek Soil Landscape. These soils have high erodibility and low fertility. In the upper section of the catchment where the quarry is proposed to be located the soils are from the tma variant of the Ten Mile Creek Soil Landscape. These soils are located on slopes of 10% to 20% and exhibit areas of localised shallow soils.

In the lower sections of the catchment there are several bare areas that exhibit sodic and dispersive soils which significantly impacts on water quality in this section of Seven Mile Creek.

2.2.2 Watercourse characterisation

Watercourse characterisation involves both the geomorphology of the watercourses and an assessment of their significance. The watercourse has been assessed using the Strahler ordering system, as described in *NSW Government Gazette no. 37* on 24 March 2006.

The Strahler system is a hierarchical numbering system based on the degree of branching within a waterway and provides an indication of the complexity of a creek system. The methodology used is as follows:

- At its origin, a watercourse is numbered as first order. The watercourse remains first order until it joins another watercourse.

- If the watercourse joins another first order watercourse, downstream of the confluence is deemed second order. The confluence of two watercourses with a similar order results in the order increasing by one, so that two second order streams joining will result in a third order stream, and so on, moving downstream.

- Where a watercourse of a higher order joins with a lower order watercourse, downstream of the confluence remains at the higher order.

The former Department of Infrastructure Planning and Natural Resources ((DIPNR) – 2005; has classified waterway orders into three schedules, namely:

- 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 Project is bounded by two second order watercourses immediately to the north and south, classified as Schedule 1. Seven Mile Creek on the eastern side of the Project Area, is a third order watercourse, classified as Schedule 2. Four first order drainage lines also traverse the area to be quarried.

Seven Mile Creek has been characterised based on analysis of LiDAR surveys and inspections of the creek undertaken by Umwelt personnel during the course of the project.

Seven Mile Creek originates to the west of the Project Area, with the watershed at an elevation of approximately 130 mAHD (refer to **Figure 2.4**). The upper slopes of the Seven Mile Creek catchment area have grades of between 10% and 20%.

The creek gradients in the upper sections of the catchment are relatively steep reducing in grade further downstream. Adjacent to the proposed quarry area, Seven Mile Creek has a base of stream width of typically 2 to 4 m with top of bank widths ranging from approximately 5 m to 10 m. The bed slope of Seven Mile Creek in the vicinity of the proposed quarry is variable with a mixture of pools and riffles along its length.

In terms of geomorphology, the Seven Mile Creek is largely confined with a sinuosity of around 1.2 and a steep valley profile. Seven Mile Creek typically has a shallow U shaped profile, becoming box shaped where incised, with stepped side slopes.

Seven Mile Creek is characterised by a diverse bed matrix, including side bars in areas of deposition comprising well rounded pebble sediments in a light brown sandy clay matrix, together with branches and debris from the woodland area.

A photograph of Seven Mile Creek is shown on **Plate 2.3** close to the proposed creek crossing. The photograph was taken looking upstream. Note the existing high levels of TSS in the creek.

Plate 2.3

Seven Mile Creek (July 2012)

Downstream of the Project Area, Seven Mile Creek flows in a south-easterly direction through woodland area, under the Pacific Highway and down to Grahamstown Dam (refer to **Figure 1.1**).

2.3 Water quality

Two primary characteristics of a watercourse that determine the environmental value of the watercourse are the quality of the available water and the volume of water. Seven Mile Creek flows intermittently and is therefore not a major stream in term of catchment yield for Grahamstown Dam. Water quality is of significance given the presence downstream of Grahamstown Dam.

HWC has noted that the use of the land for grazing within the Seven Mile Creek catchment can result in sediment and nutrient loading issues (*Catchment Management Plan*, HWC January 2011). Field observations show that other uses of the catchment such as the previous training areas for heavy earthmoving equipment operators and current use of parts of the catchment for motorsports are contributing to sediment and nutrient loads entering Grahamstown Dam from Seven Mile Creek.

As shown on **Figure 2.4**, Boral Quarry occupies approximately 35 ha of the upper most section of the catchment and has a permission to discharge to Seven Mile Creek catchment in accordance with its Environmental Protection Licence conditions.

2.3.1 Hunter Water Corporation monitoring

Hunter Water Corporation has monitored water quality data in Seven Mile Creek approximately 100 m downstream of Pacific Highway (see **Figure 2.5**) and Nine Mile Creek downstream of Pacific Highway (see **Figure 1.1**). Monitoring was undertaken at these sites between August 2001 and 8 February 2016 with monitoring comprising a series of event based campaigns and periods of regular monitoring. Monitoring results are summarised below and listed in full in **Appendix 2**.

Seven Mile Creek (Monitoring site GPS co-ordinates: -32.695259 E 151.808229 N)

Periods for which water quality monitoring has been undertaken in Seven Mile Creek are:

- Intermittent (predominately event-based) monitoring was carried out between 6 August 2001 and 4 June 2002;
- Fortnightly routine monitoring was carried out between 12 December 2006 and 26 June 2007;
- Weekly routine monitoring has been carried out at the site since 17 August 2015;
- Event-based monitoring was carried out between 6-18 January 2016 in response to a large storm event. This monitoring was in addition to the weekly monitoring program;
- In addition, three event-based samples were collected from other sites following the storm event in late January 2013. This comprised of one sample from 100 metres upstream of the abovementioned monitoring site on 25 January 2014, and two samples from 100 metres downstream of the abovementioned monitoring site on 25 and 30 January 2013. No comparable monitoring was undertaken in Nine Mile Creek at this time.

Nine Mile Creek (Monitoring site GPS co-ordinates: -32.673635 E 151.825856 N)

Periods for which water quality monitoring has been undertaken for Nine Mile Creek:

- Intermittent (predominately event-based) monitoring was carried out between 6 August 2001 and 4 June 2002 (coinciding with the program at Seven Mile Creek);
- Fortnightly routine monitoring was carried out between 12 December 2006 and 26 June 2007 (coinciding with the program at Seven Mile Creek);
- Weekly routine monitoring has been carried out at the site since 3 November 2015;
- Event-based monitoring was carried out between 6 to 18 January 2016 in response to a large storm event. This monitoring was in addition to the weekly monitoring.

A summary of the monitoring results is provided in **Table 2.5**. It should be noted that concentrations of many of the water quality parameters vary dramatically depending on flow and runoff conditions and as such represent a snap shot in time.

Table 2.5 HWC water quality average values – Seven Mile Creek and Nine Mile Creek

Water quality parameter and location	Average for sampling period 2001/2007	Average for sampling period 2015/2016
Total Phosphorus Seven Mile Creek (mg/L)	0.07	0.14
Total Phosphorus Nine Mile Creek (mg/L)	0.05	0.08
Turbidity Seven Mile Creek (NTU)	N/A	161
Turbidity Nine Mile Creek (NTU)	N/A	62
Total Nitrogen Seven Mile Creek (mg/L)	0.92	0.97
Total Nitrogen Nine Mile Creek (mg/L)	0.86	0.97

Water quality parameter and location	Average for sampling period 2001/2007	Average for sampling period 2015/2016
Ammonia Seven Mile Creek (mg/L)	0.10	0.06
Ammonia Nine Mile Creek (mg/L)	0.08	0.08
Conductivity Seven Mile Creek (µS/cm)	475	N/A
Conductivity Nine Mile Creek (µS/cm)	226	N/A
pH Seven Mile Creek	7.2	N/A
pH Nine Mile Creek	6.5	N/A
E. Coli Seven Mile Creek (MPN/100 mL)	N/A	1470
E. Coli Nine Mile Creek (MPN/100 mL)	N/A	153
Entrococci Seven Mile Creek (col/100 mL)	N/A	365
Entrococci Nine Mile Creek (col/100 mL)	N/A	234

Table 2.6 HWC water quality minimum, Average and Maximum – Seven Mile Creek and Nine Mile Creek

Water quality parameter and location	Minimum	Average	Max
Total Phosphorus Seven Mile Creek (mg/L) (2015 2016)	0.02	0.12	0.37
Total Phosphorus Nine Mile Creek (mg/L) (2015-2016)	0.02	0.08	0.15
Total Nitrogen Seven Mile Creek (mg/L) (2015-2016)	0.12	1.04	2.14
Total Nitrogen Nine Mile Creek (mg/L) (2015-2016)	0.05	0.97	1.85
Ammonia Seven Mile Creek (mg/L) (2015-2016)	0.0	0.06	0.15
Ammonia Nine Mile Creek (mg/L) (2015-2016)	0.01	0.08	0.58
Conductivity Seven Mile Creek (µS/cm) (2001-2007)	213	475	689
Conductivity Nine Mile Creek (µS/cm) (2001-2007)	127	226	657
pH Seven Mile Creek) (2001-2007)	6.1	7.2	7.7
pH Nine Mile Creek) (2001-2007)	5.7	6.5	7.6
E. Coli Seven Mile Creek (MPN/100 mL) (2015-2016)	15	1470	16328
E. Coli Nine Mile Creek (MPN/100 mL) (2015-2016)	10	153	365

Water quality parameter and location	Minimum	Average	Max
Entrococci Seven Mile Creek (col/100 mL) (2015-2016)	100	365	1700
Entrococci Nine Mile Creek (col/100 mL) (2015-2016)	0	234	710

From **Tables 2.5** and **2.6** and monitoring data provided by HWC (see **Appendix 2**), the following can be summarised:

Total Phosphorus

Average Total Phosphorus concentration in 2015/16 monitoring period was higher in both Seven Mile Creek and Nine Mile Creek than during the 2001/07 monitoring period. The 2015/16 sampling period included 11 samples over 12 days in January 2016 which was the wettest January on record. This sampling included five samples over four consecutive days (6 January to 8 January 2016) where Total Phosphorus concentrations of 0.24 mg/L or greater were recorded. The Eagleton area received approximately 408 mm of rainfall over this period. Average Total Phosphorus concentration in Seven Mile Creek was higher than in Nine Mile Creek for both monitoring periods. As shown **Table 2.6** and on **Plate 2.4**, maximum Total Phosphorus concentrations in Seven Mile Creek since 2001 have been approximately double that of Nine Mile Creek with this relationship remaining reasonably consistent over the period 2001 to 2016.

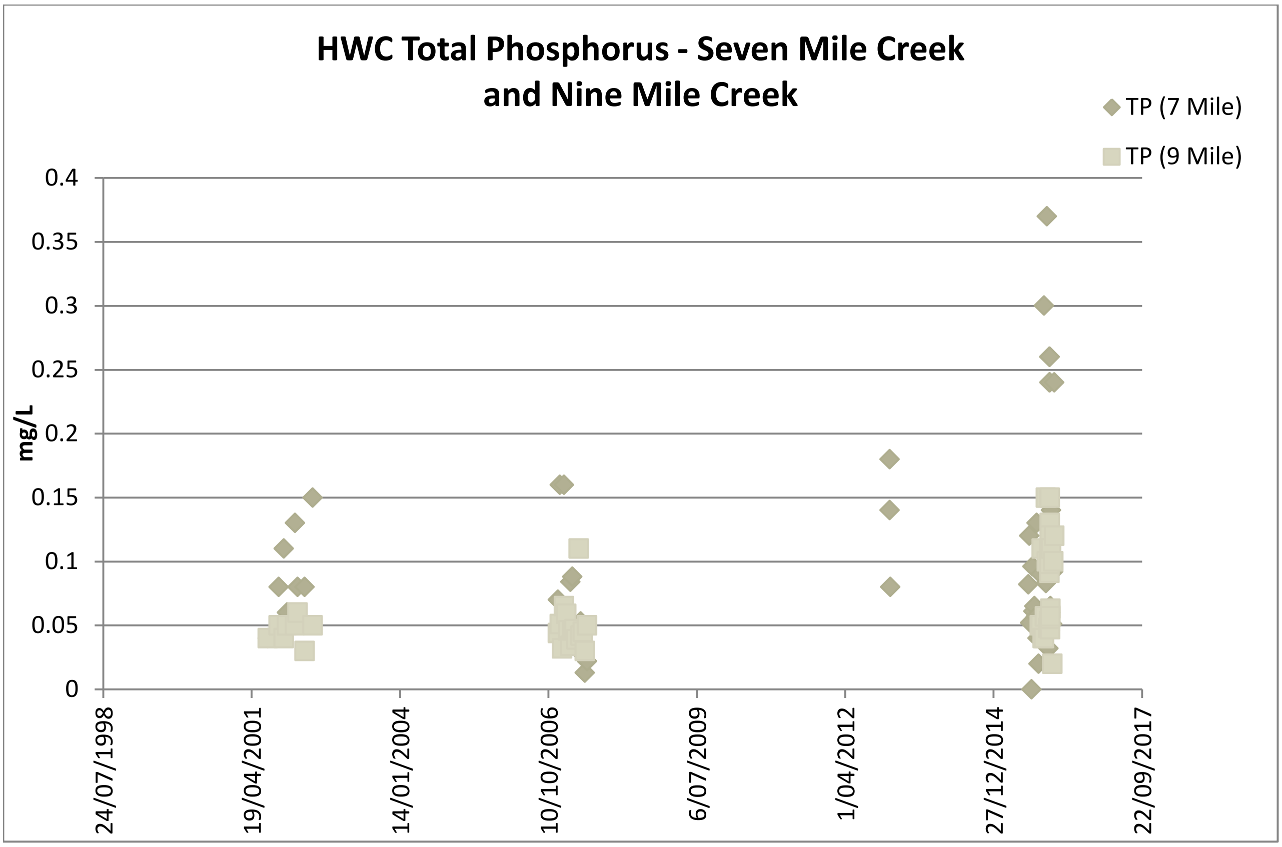

Plate 2.4

Total Phosphorus concentrations in Seven Mile Creek and Nine Mile Creek

Turbidity

Average turbidity levels in Seven Mile Creek as reported in **Table 2.5** are approximately 2.6 times that of Nine Mile Creek. As can be seen from **Plate 2.5**, significant areas of Seven Mile Creek catchment exhibit large bare areas with exposed dispersive soils. These areas make a significant contribution to turbidity levels during intense rainfall and large runoff events such as occurred between 5 January 2016 and 8 January 2016.

Turbidity monitoring results for Seven Mile Creek and Nine Mile Creek for the period October 2015 to February 2016 are shown on **Plate 2.5**. Maximum recorded turbidity in Seven Mile Creek during this period was 1300 NTU compared to 270 NTU for Nine Mile Creek.

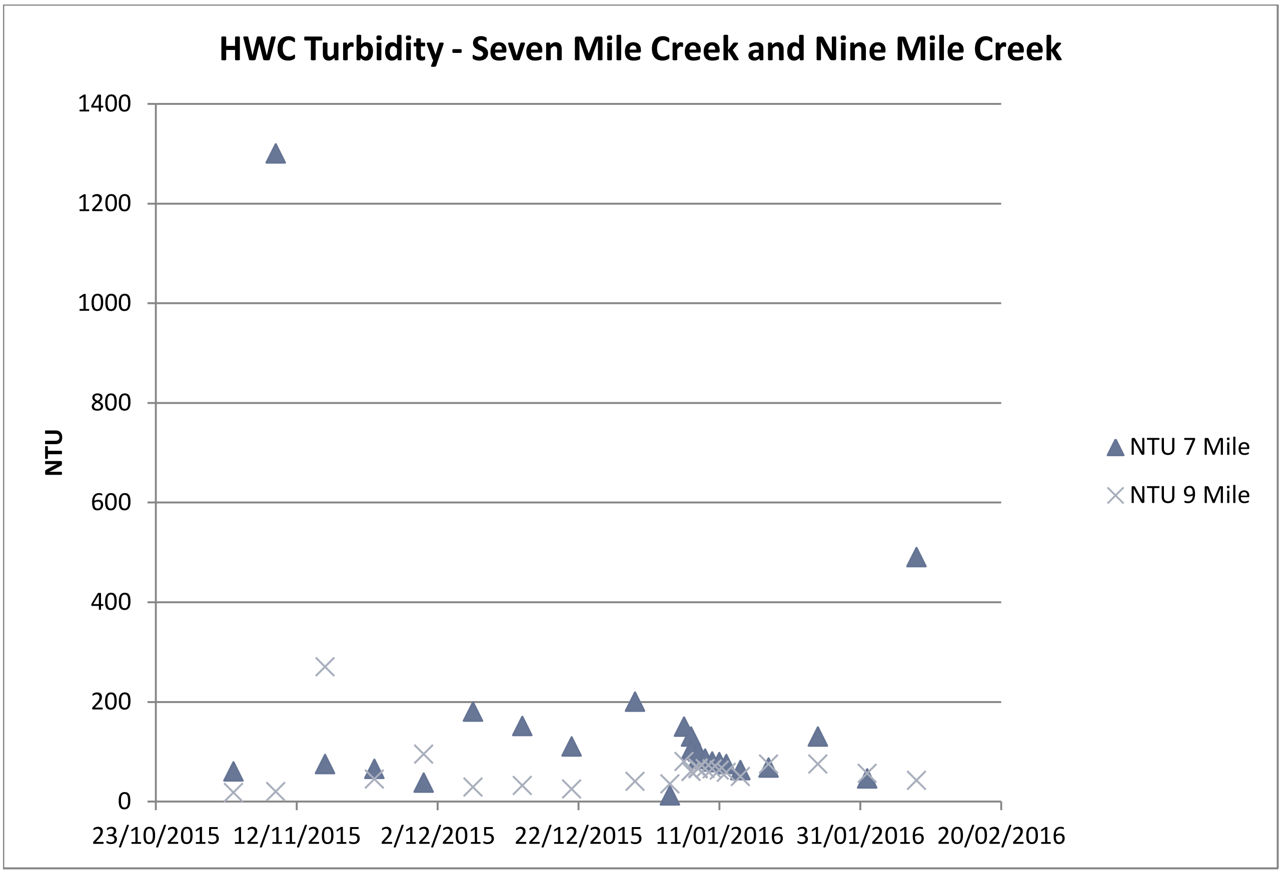

Plate 2.5

Turbidity concentrations in Seven Mile Creek and Nine Mile Creek

Ammonia

As shown in **Table 2.5**, average Ammonia concentrations in Seven Mile Creek are higher for the period 2001/07 (0.1 mg/L) than for the 2015/16 period (0.06 mg/L). Average ammonia concentrations in Nine Mile Creek remained consistent at 0.08 mg/L for both the 2001/07 period and 2015/16 period. Average recorded Ammonia concentrations in Seven Mile Creek are consistent with those recorded for Nine Mile Creek. Recorded ammonia concentrations for the period 2001 to 2016 are shown on **Plate 2.6**.

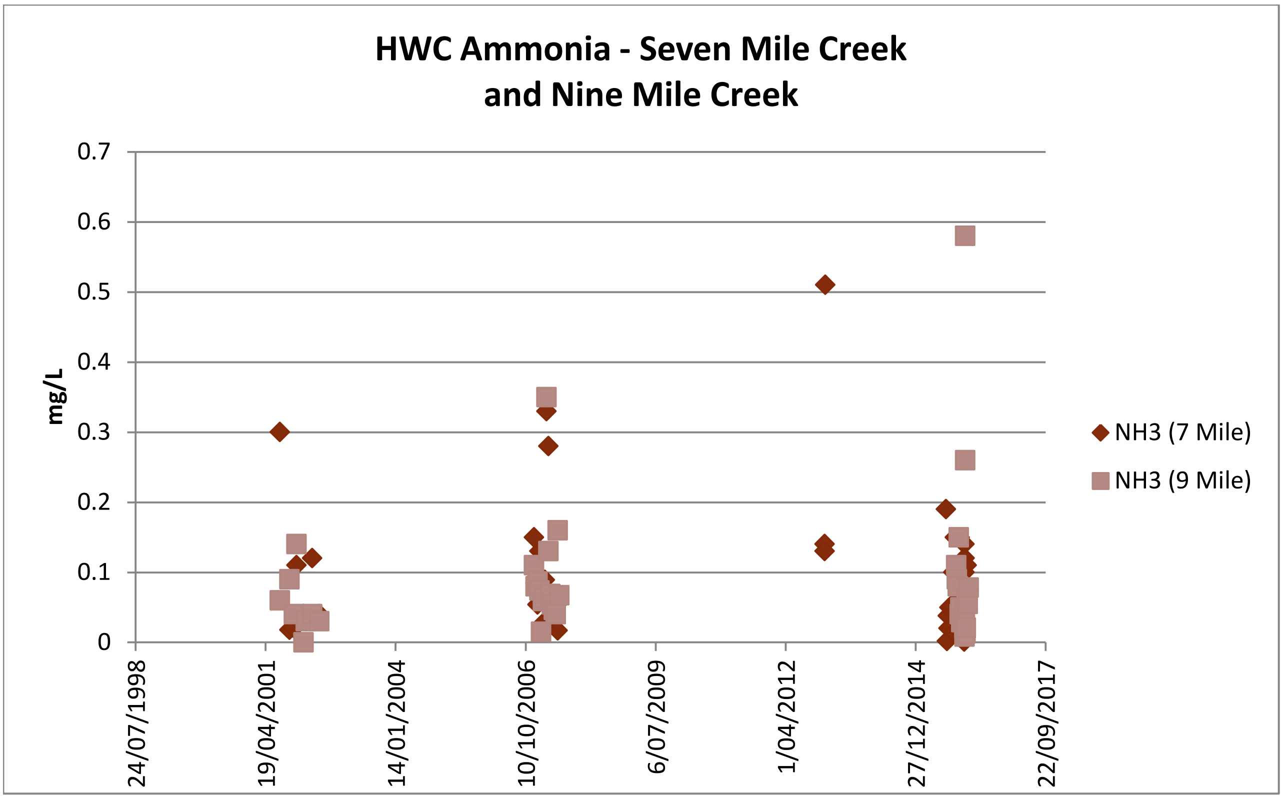

Plate 2.6

Ammonia concentrations in Seven Mile Creek and Nine Mile Creek

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Nitrogen

As shown in **Table 2.5**, average Nitrogen concentrations in Seven Mile Creek are slightly lower for the period 2001/07 (0.92 mg/L) than for the 2015/16 period (0.97 mg/L). Average Nitrogen concentrations in Nine Mile Creek increased from 0.86 mg/L in the 2001/07 period to 0.97 mg/L in the 2015/16 period. Average recorded Nitrogen concentrations in Seven Mile Creek are consistent with those recorded for Nine Mile Creek. Recorded Nitrogen concentrations for the period 2001 to 2016 are shown on **Plate 2.7**.

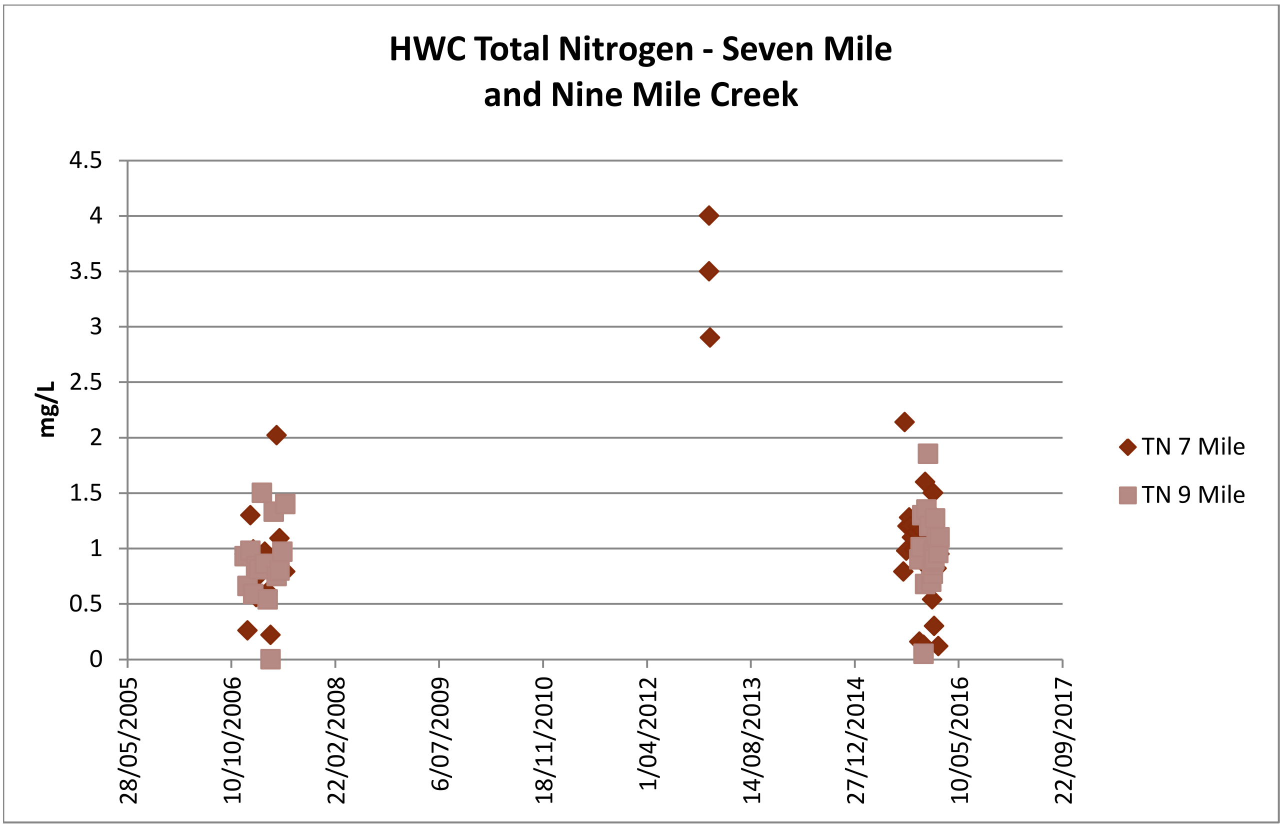

Plate 2.7

Nitrogen concentrations in Seven Mile Creek and Nine Mile Creek

E. Coli

As shown in **Table 2.5**, average *E. Coli* concentrations in Seven Mile Creek are nearly 10 times as high as those in Nine Mile Creek. Recorded *E. Coli* counts for the period 2015 to 2016 are shown on **Plate 2.8.** As can be seen from **Plate 2.8**, *E. Coli* counts in Seven Mile Creek and Nine Mile Creek are similar except for the period between 4 January 2016 and 11 January 2016 when a significant spike in *E. Coli* counts (up to 16328 MPN/100 mL) was recorded. The source of this sustained spike is unknown.

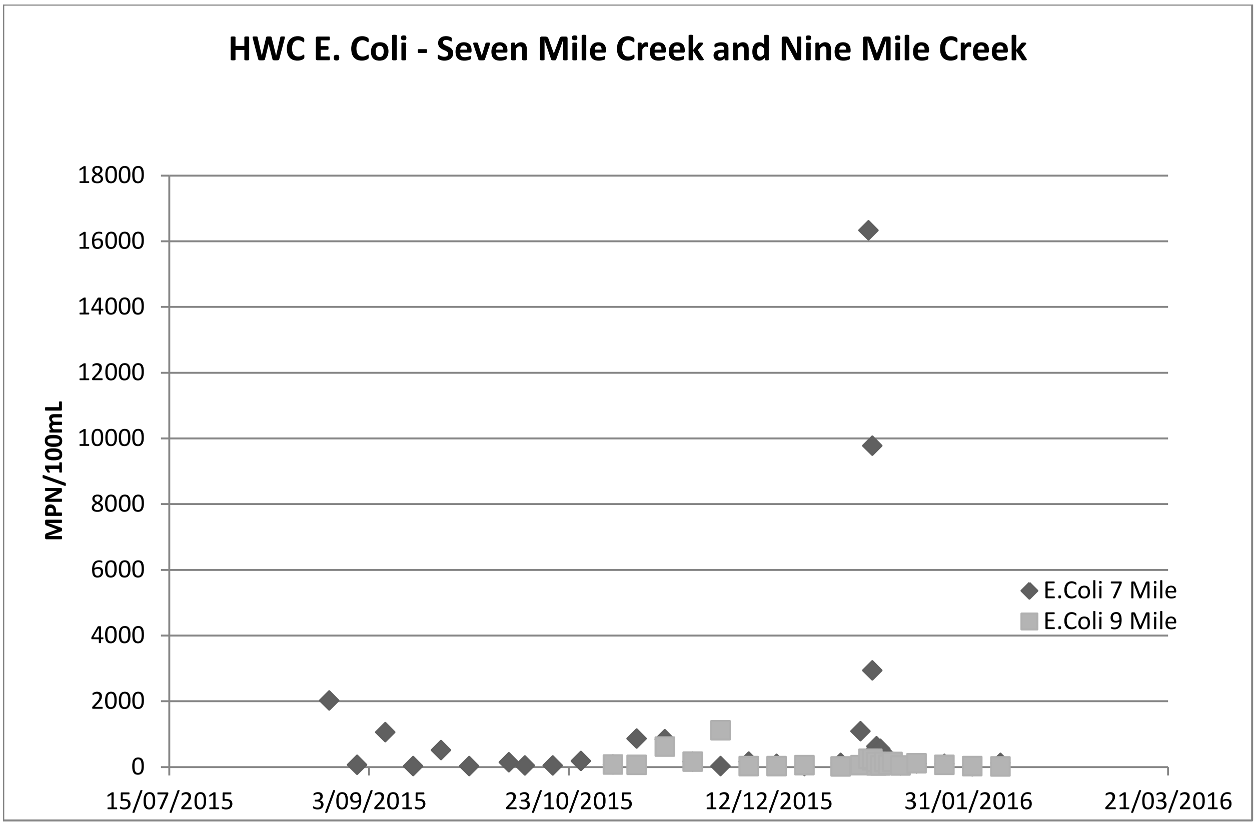

Plate 2.8

E. Coli counts in Seven Mile Creek and Nine Mile Creek

Entrococci

As shown in **Table 2.5**, average Entrococci counts in Seven Mile Creek are similar to those in Nine Mile Creek. Recorded Entrococci counts for the period 2015 to 2016 are shown on **Plate 2.9.**

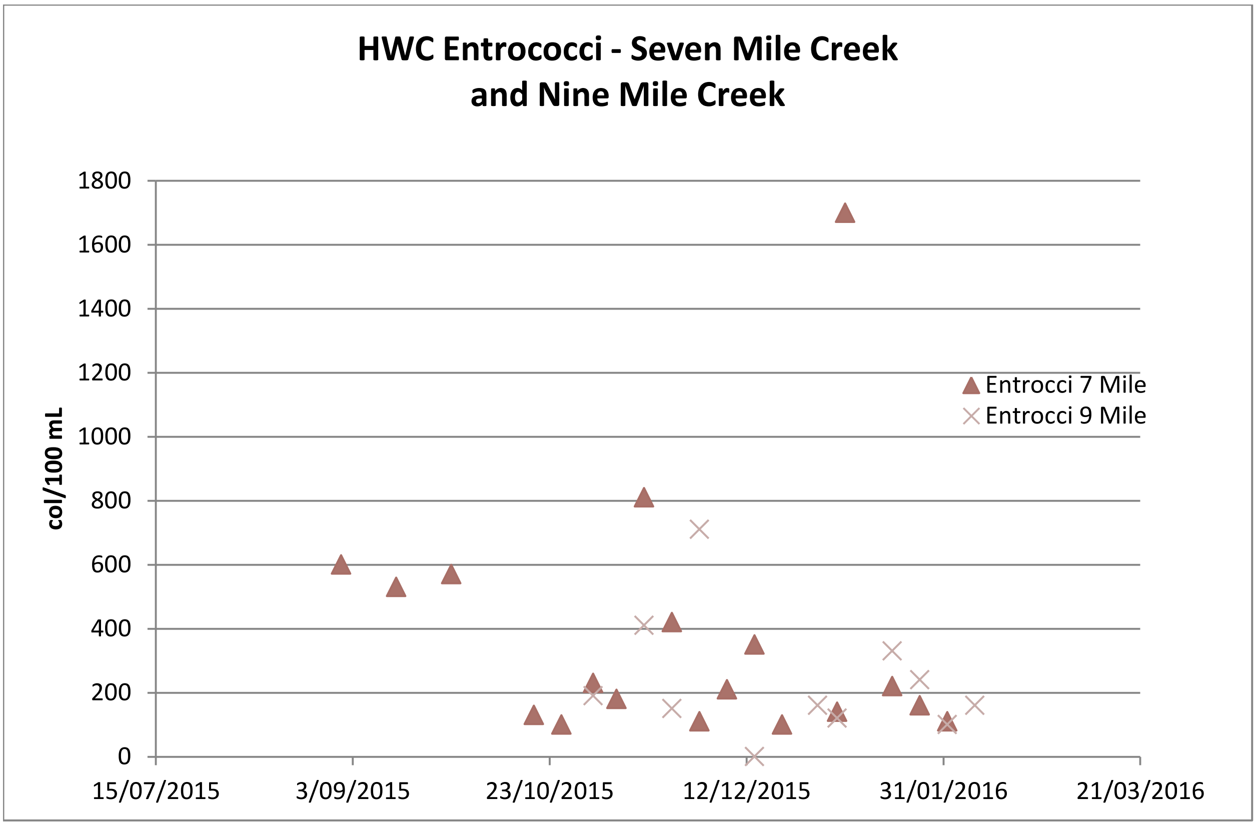

Plate 2.9

Entrococci counts in Seven Mile Creek and Nine Mile Creek

2.3.2 Project water quality monitoring – Seven Mile Creek

Water quality sampling was also undertaken within Seven Mile Creek as part of this project. Monitoring data is provided in **Appendix 3**. Sampling was undertaken at four sampling sites on six occasions between 4 November 2015 and 6 January 2016 coinciding with runoff events in Seven Mile Creek. Monitoring locations are shown on **Figure 2.5**. These were:

- Site 1 – upstream of Project site
- Site 2 – approximately 100 m downstream of the existing Seven Mile Creek crossing
- Site 3 – approximately 500 m upstream of Pacific Highway
- Site 4 – 50 m upstream of Pacific Highway.

All sites were analysed for Total Petroleum Hydrocarbon, BTEX, Polycyclic Aromatic Hydrocarbons, Organochlorine Pesticides or Organophosphorus Pesticides on 4 November 2015 and no detectable concentrations of these chemicals were recorded in any samples.

In addition, key water quality parameters (pH, Electrical Conductivity, Total Suspended Solids, Total Dissolved Solids, Total Phosphorus and Total Nitrogen) were analysed. Water quality results for these key water quality parameters are set out in **Tables 2.6** to **2.11**.

Table 2.6 pH

Date sampled	Site 1	Site 2	Site 3	Site 4
4/11/2015	8.03	7.9	7.39	7.41
16/11/2015	7.84	7.61	7.57	7.51
23/11/2015	7.65	7.63	7.2	7.31
4/01/2016	7.87	7.66	7.47	7.36
5/01/2016	7.27	7.32	6.91	6.85
6/01/2016	7.35	7.27	7.08	7.07

From **Table 2.6** pH is slightly alkaline to neutral and typically decreases from upstream to downstream.

Table 2.7 Electrical Conductivity (µS/cm)

Date sampled	Site 1	Site 2	Site 3	Site 4
4/11/2015	605	563	417	432
16/11/2015	623	610	459	456
23/11/2015	418	459	250	341
4/01/2016	584	572	440	376
5/01/2016	306	280	228	201
6/01/2016	144	173	152	150

From **Table 2.7**, electrical conductivity is generally low and decreases from upstream to downstream.

Table 2.8 Total Suspended Solids (mg/L)

Date sampled	Site 1	Site 2	Site 3	Site 4
4/11/2015	<5	<5	998	372
16/11/2015	6	6	88	70
23/11/2015	16	19	1200	379
4/01/2016	<5	<5	708	870
5/01/2016	14	32	110	116
6/01/2016	32	29	67	93

From **Table 2.8**, Total Suspended Solids (TSS) are generally low at sampling Sites 1 and 2 and increase significantly at Site 3 where the surrounding area exhibits exposed dispersive soils. TSS levels are typically lower at Site 4 than at Site 3 indicating the source of increased sediment is in the vicinity of Site 3.

Table 2.9 Total Dissolved Solids (mg/L)

Date sampled	Site 1	Site 2	Site 3	Site 4
4/11/2015	336	320	271	281

From **Table 2.9**, Total Dissolved Solids typically decreases from upstream to downstream consistent with Electrical Conductivity trends set out in **Table 2.7**.

Table 2.10 Total Phosphorus

Date sampled	Site 1	Site 2	Site 3	Site 4
16/11/2015	0.01	0.05	0.13	0.27
23/11/2015	0.04	0.05	0.26	0.16
4/01/2016	0.02	0.02	0.02	0.07
5/01/2016	0.06	0.04	0.08	0.07
6/01/2016	0.1	0.41	0.26	0.25

From **Table 2.10**, Total Phosphorus concentrations typically increases from upstream to downstream and show a marked increase at Sites 2, 3 and 4 on 6 January 2016 when several days of intense rain had been received in the catchment.

Table 2.11 Total Nitrogen

Date sampled	Site 1	Site 2	Site 3	Site 4
16/11/2015	1.4	0.9	1.5	1.4
23/11/2015	1.6	1.2	2.3	1.5
4/01/2016	1.2	0.6	2.9	3.7
5/01/2016	1.2	1.2	1.3	1.3
6/01/2016	1.6	2.7	2.2	2.2

From **Table 2.11**, Total Nitrogen typically increases from upstream to downstream.

2.3.3 Water Quality Trigger Values

Trigger values for assessing potential water quality impacts of the proposed quarry can be derived from site specific water quality information or ANZECC guidelines as set out in **Table 2.12** or a combination of both.

Table 2.12 ANZECC Guidelines default trigger values for key water quality parameters

Water quality variable	Trigger value
pH	6.5 to 8.0, but up to 8.5 for NSW east flowing Lowland Rivers
Electrical Conductivity (µS/cm)	125 to 2200, but typically in the range of 200 to 300 for NSW east flowing Lowland Rivers
Total Suspended Solids (TSS) (mg/L)[1]	40
Total Phosphorus (mg/L)	0.025
Total Nitrogen (mg/L)	0.35

Source: ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Lowland coastal flowing rivers in NSW).

Note 1: The TSS reported is for aquaculture, which includes downstream fishing. Most other guideline values use turbidity, with typically 6 to 50 Nephelometric Turbidity Units (NTU) indicated as a trigger value for Lowland Rivers. The conversion of NTUs to TSS (mg/l) is material specific, but typically in the range of 1 mg/L = 1 to 1.5 NTU's.

As can be seen from the water quality information provided for Seven Mile Creek and Nine Mile Creek in **Section 2.3.1** based on Hunter Water Corporation monitoring and **Section 2.3.2** and monitoring undertaken for the Project, water quality within both creeks is frequently outside the trigger values set out in **Table 2.12** for pH, Conductivity, Turbidity, Total Phosphorus and Total Nitrogen. This indicates that site-specific values will need to be determined for assessment of potential impacts of the quarry over the life of the quarry.

2.4 Water quantity

Catchment sizes for Seven Mile Creek and its associated tributaries are given in **Table 2.13**.

Table 2.13 Catchments areas

Catchment description	Catchment area (ha)
Seven Mile Creek, adjacent to the Project Area.	108
Seven Mile Creek, at the Pacific Highway.	284
Northern Tributary sub catchment, immediately upstream of the confluence with Seven Mile Creek (see **Figure 2.4**).	12
Southern Tributary sub catchment, immediately upstream of the confluence with Seven Mile Creek (see **Figure 2.4**).	54

The Mean Annual Runoff (MAR), dry weather flow rates and flood flows for the surface water environment surrounding the Project Area are discussed in **Sections 2.4.1** to **2.4.3**.

2.4.1 Mean annual runoff

The MAR for the local catchment areas are given in **Table 2.14**, with the catchments shown in **Figure 2.4**.

Table 2.14 Pre-quarrying MAR for the local catchments

Catchment description	MAR (x $10^6 m^3$)
Seven Mile Creek, just upstream of the confluence with the Southern Tributary.	0.1
Seven Mile Creek, at the Pacific Highway.	0.3
Northern Tributary sub catchment, immediately upstream of the confluence with Seven Mile Creek.	0.01
Southern Tributary sub catchment, immediately upstream of the confluence with Seven Mile Creek.	0.05

The estimated MAR is based on a fixed runoff depth using the DPI Water Farm Dam calculator.

2.4.2 Average dry weather flows

Seven Mile Creek and its tributaries are ephemeral in nature. No detailed flow records exist for Seven Mile Creek.

2.4.3 Flood regimes

The flood peak calculations for Eagleton Hard Rock Quarry were determined using the software package XPStorm® to undertake hydrodynamic modelling of the creek systems. A 1D hydrodynamic model was used for the analysis in order to simulate natural rainfall-runoff processes and the performance of natural systems.

The peak discharge values were used to compute the flood extent using the 1D hydrodynamic model. Flood extents for Seven Mile Creek and associated tributaries are shown in **Figure 2.5** for the 100 year ARI nine hour storm event. The nine hour storm event was computed as the critical duration storm for Seven Mile Creek immediately downstream of the Project area. The computed peak flows for the 10 year, 20 year, 50 year and 100 year ARI (Average Recurrence Interval) nine hour storm event are given in **Table 2.15**

Table 2.15 Peak flows

Catchment description	Peak flows (m^3/s) for ARI flood events				
	10 year	20 year	50 year	100 year	500 year
Seven Mile Creek, just upstream of the confluence with the Southern Tributary.	6.4	7.5	8.6	9.8	12.5
Seven Mile Creek, at the Pacific Highway.	16.2	19.34	22.2	25.3	32.4
Northern Tributary sub catchment, immediately upstream of the confluence with Seven Mile Creek.	6.4	7.53	8.7	9.9	12.7
Southern Tributary sub catchment, immediately upstream of the confluence with Seven Mile Creek.	11.0	13.1	15.1	17.2	22.0

Peak velocities during the flood events vary in Seven Mile Creek adjacent to the Project Area, but are typically in the range of 1.0 m/s to 1.6 m/s for flows up to the 100 year ARI critical duration flood event based on XPStorm® modelling.

A catchment area based relationship for peak flows during a 500 year has been derived by extrapolation from 100 year ARI peak flows.

2.5 Water use

The *Water Management Act 2000* sets out water access and water sharing strategies. Consequently, as part of the implementation of these water sharing strategies, Water Sharing Plans (WSPs) have been developed across NSW to protect the health of rivers, whilst at the same time securing sustainable access to water for all users. The *Hunter Unregulated and Alluvial Water Sources (2009)* covers the use of surface water resources within the Hunter River catchment while the Sydney Basin – North Coast Fractured and

Porous Rock Water Sharing Plan covers the use of groundwater resources. The WSP's specify maximum water extractions and allocations.

The Project Area lies within the water source management area of Newcastle. Each water source management area has a Water Source Report Card (WSRC) which provides information on the catchment, the limitations on water usage, and the manner in which the limitations on the water source management area have arisen.

Land use surrounding the Project Area includes grazing land, rural residential land, a motor sport facility, a composting facility, and an existing hard rock quarry (see **Figure 2.4**). Water to supply these various activities is drawn from a range of sources including:

- the Balickera Canal, through private agreement with HWC
- surface runoff, through harvestable rights
- supplementary potable water supplied by tanker truck.

Seven Mile Creek flows to Grahamstown Dam, from where water is abstracted, treated, and supplied to the Lower Hunter region. Grahamstown Dam has a direct catchment of 11,500 ha, of which the Seven Mile Creek catchment comprises 2.6%. Water supply to Grahamstown Dam is augmented by extraction of water from the Williams River via the Balickera Canal, which contributes approximately 50% of the total average inflow to Grahamstown Dam (HWC 2011).

Grahamstown Dam supplies a significant proportion of the regions potable water requirements, varying from 30% to 75%, depending on the rainfall.

Image Source: Natmap, Geoscience Australia (2008)

0 2.0 4.0 8km

1:175 000

Legend

- Project Area
- 5km Radius
- BOM Rainfall Gauge
- BOM Rainfall and Evaporation Gauge

FIGURE 2.1

Location of Rainfall and Evaporation Gauges

File Name (A4): R04/3102_055.dgn
20160919 9.50

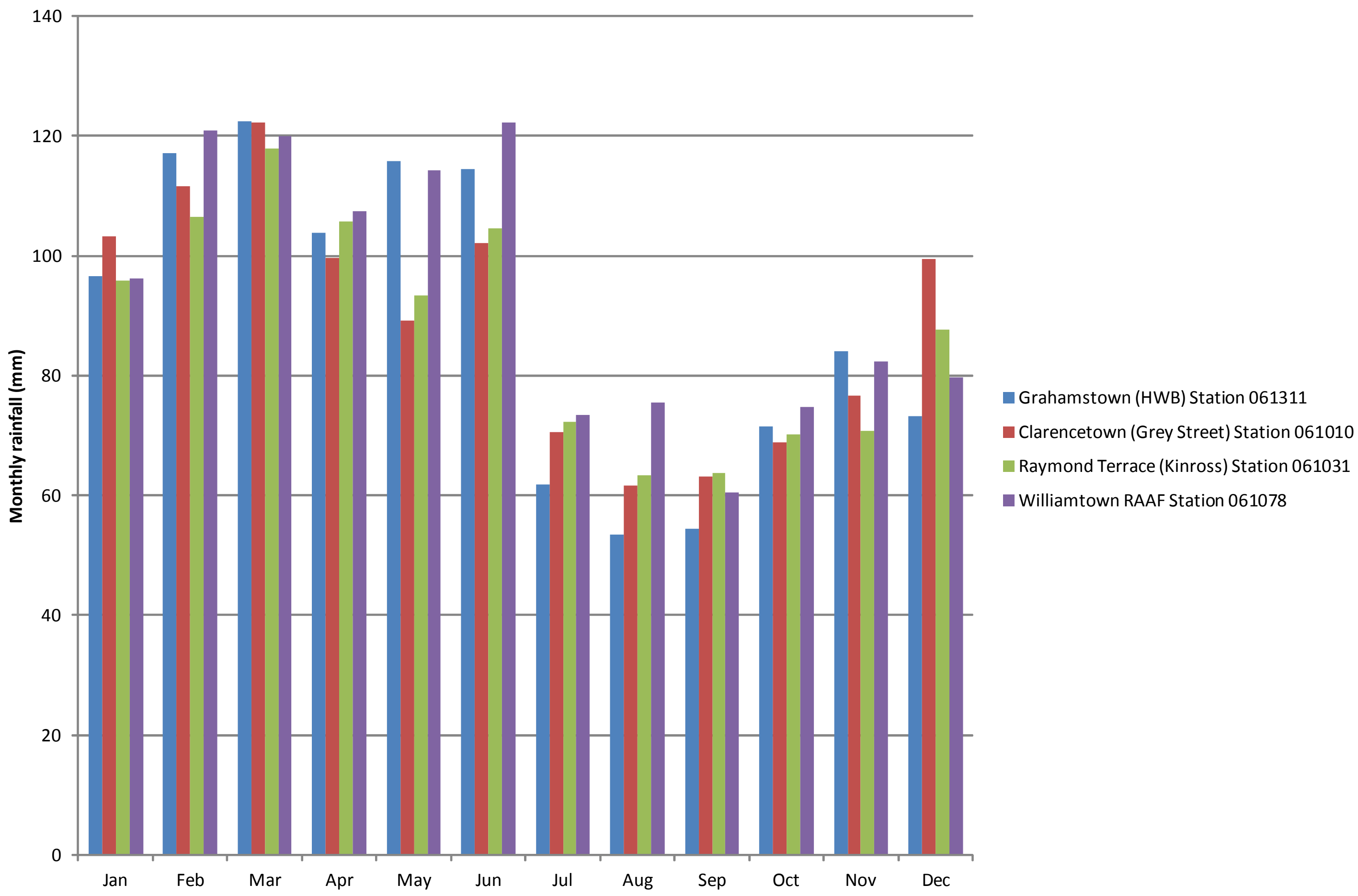

FIGURE 2.2

Average Monthly Rainfall

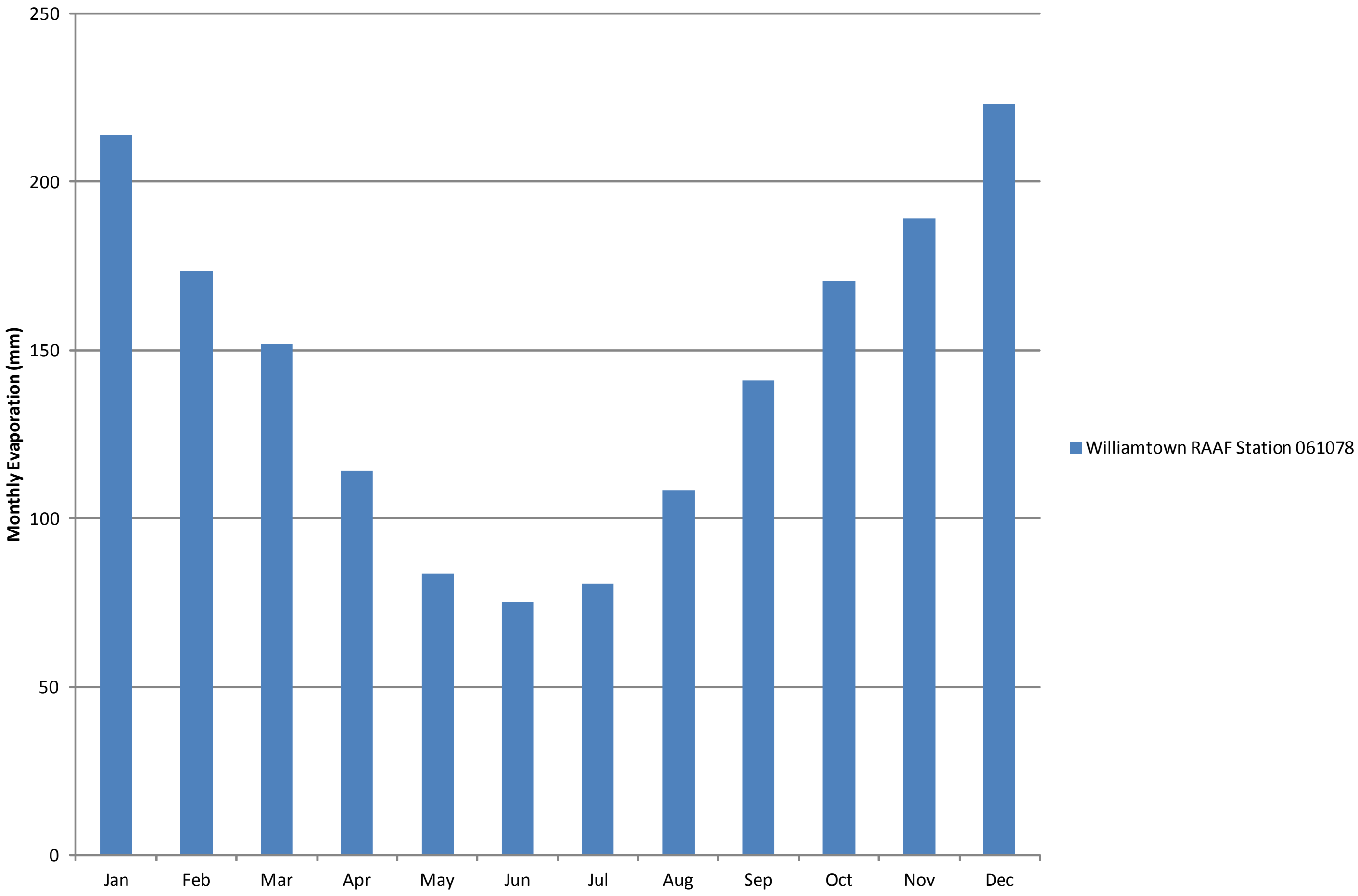

FIGURE 2.3

Average Monthly Pan Evaporation

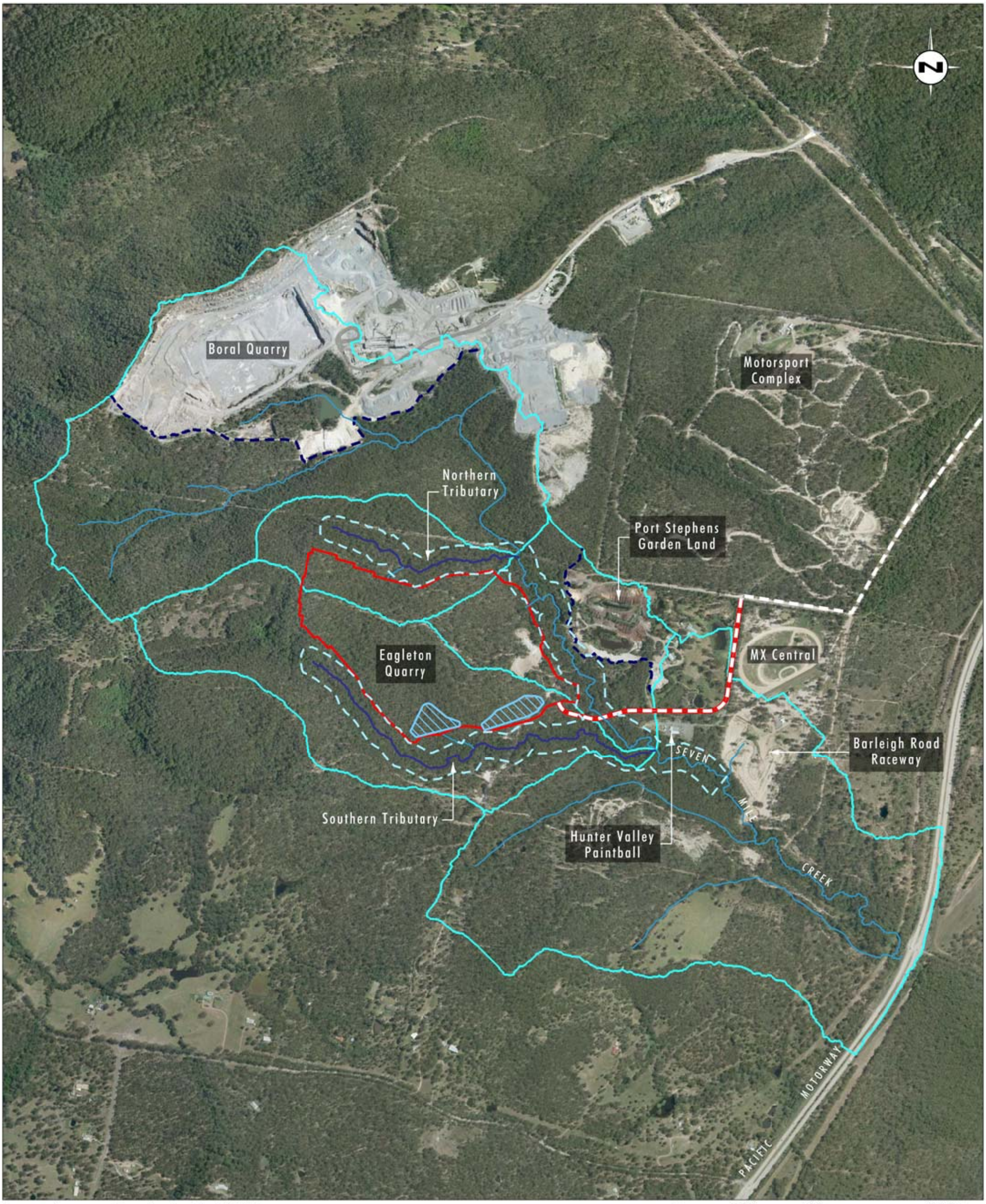

Image Source: Google Earth (2009)

0 200 400 800m
1:16 000

Legend

- Project Area
- Dam Area
- Catchment Boundary
- Disturbed Catchment
- Drainage Line
- Tributaries
- Watercourse 40m Buffer
- Access Road

FIGURE 2.4

Water Catchments

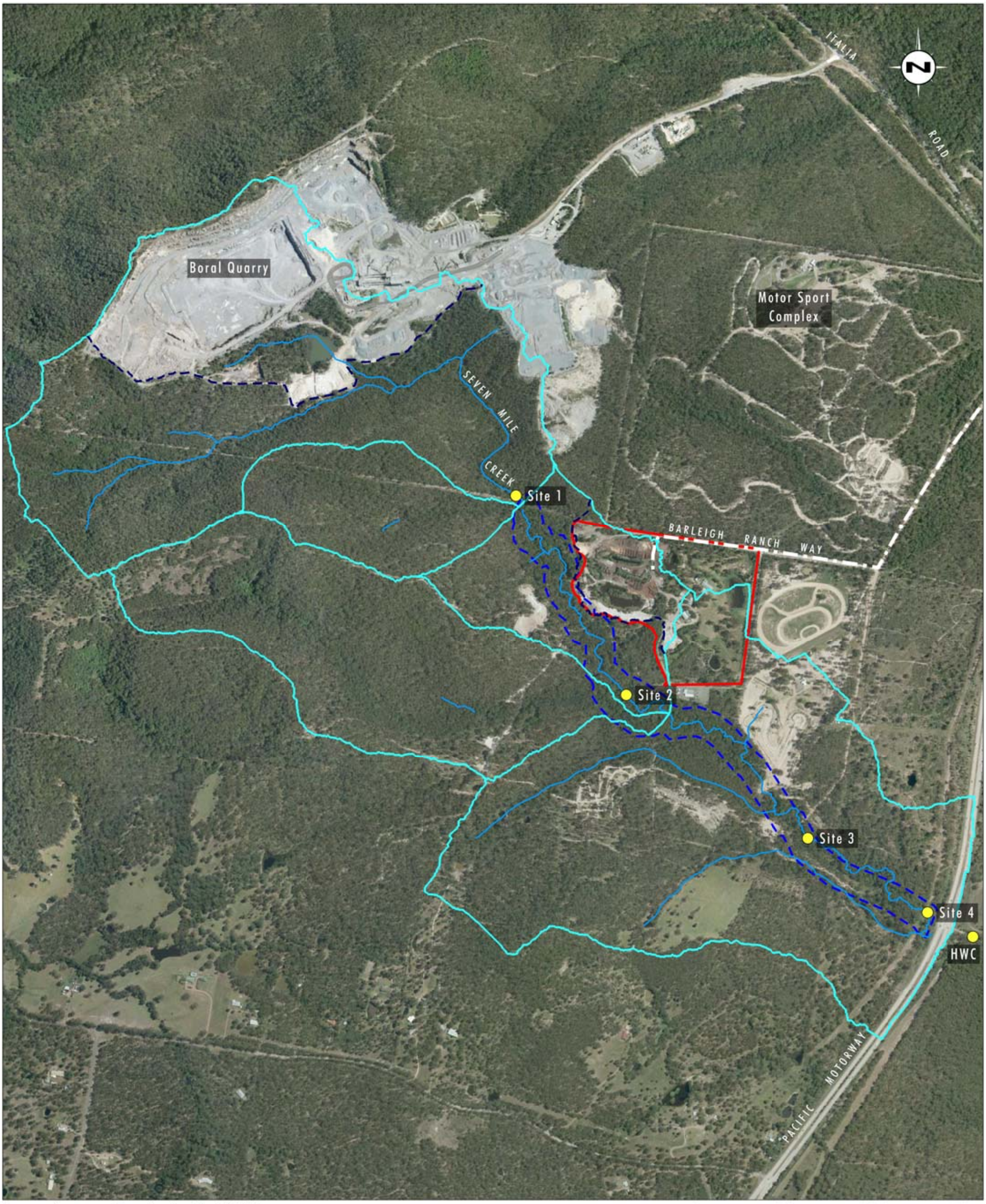

Image Source: Google Earth (2009)

0 250 500 750m
1:15 000

Legend

- Port Stephens Gardenland
- Watercourse Buffer
- Catchment Boundary
- Disturbed Catchment
- Drainage Line
- Access Road
- Water Quality Monitoring Site

FIGURE 2.5

Seven Mile Creek Flood Extents

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20160919 11.05

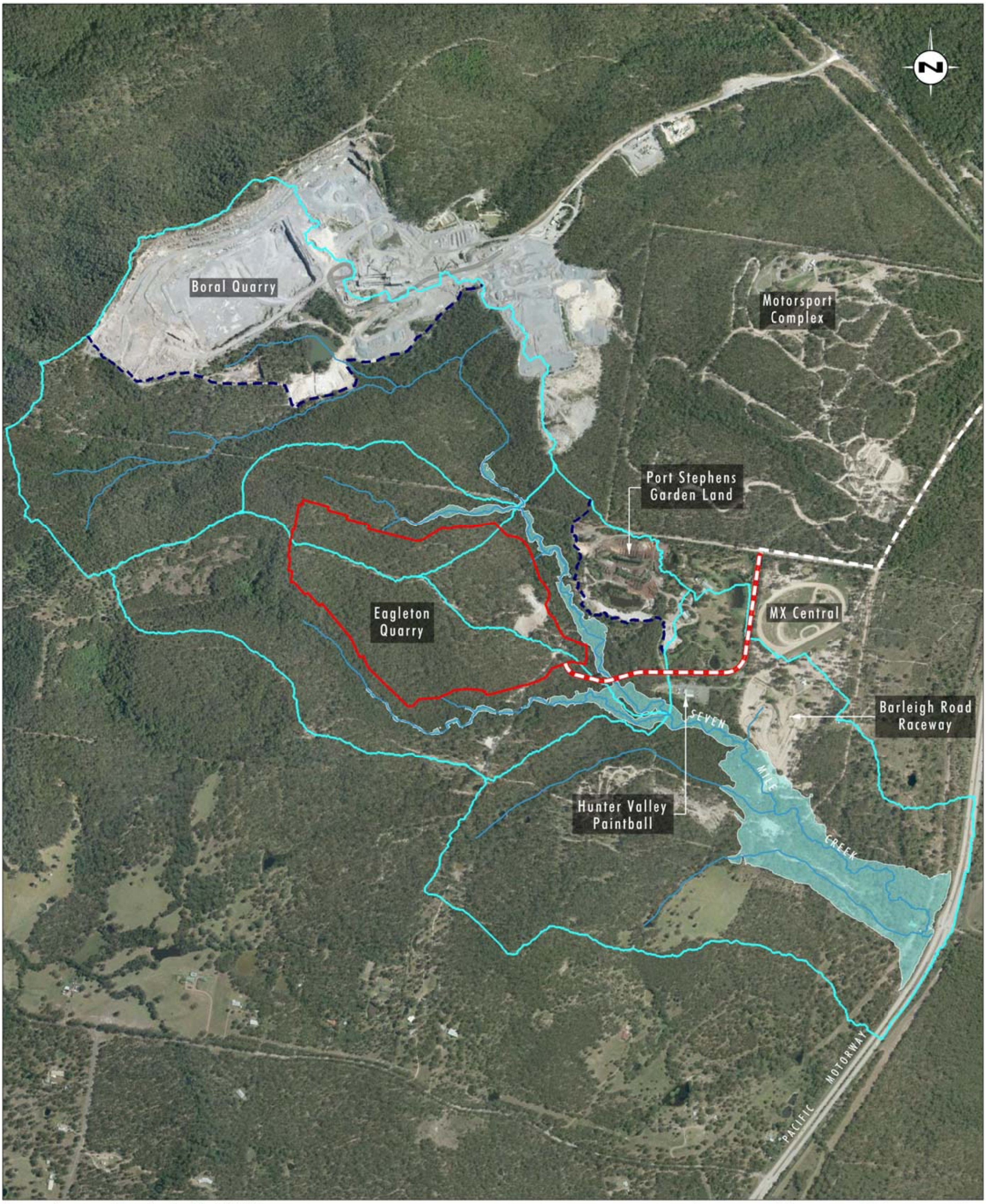

Image Source: Google Earth (2009)

0 250 500 750m
1:15 000

Legend

- Project Area
- Catchment Boundary
- Disturbed Catchment
- 100 Year Flood Extent
- Drainage Line
- Access Road

FIGURE 2.6

**100 Year Flood Extents
Seven Mile Creek**

File Name (A4): R04/3102_053.dgn
20160919 11.14

3.0 Proposed water management system

3.1 Overview

The proposed construction and operational activities for the Eagleton Hard Rock Quarry are located upslope of Seven Mile Creek, with the potential to impact on the existing watercourse system and downstream water bodies.

The proposed water management system is intended to contain runoff from the quarry area to prevent impacts on primarily the water quality of the downstream catchment whilst seeking to minimise potential impacts on Seven Mile Creek.

The principal features of the proposed water management system include (refer to **Figure 3.1**):

- a clean water diversion channel on the western side of the quarry to divert clean water from the quarry. The clean water diversion channel has a small catchment area estimated at around 0.2 ha
- dirty water catch drains constructed on the perimeter of the quarry extraction and infrastructure area, being primarily channels excavated in rock or with a grassed invert and rock erosion protection, depending on the founding conditions
- two primary water management dams (Dam 1 and Dam 2) located downstream of the dirty water catch drains outside of the quarry extraction area, providing a total water storage capacity of around 57 ML once constructed
- additional channel sediment traps constructed on the dirty water catch drains at the change in grade
- excavation during the operational phase of additional 'sumps' formed as part of excavation of the quarry floor. The 'sumps' or in-pit storage will be created by excavating the quarry floor on a slope of approximately 2.5% away from the central access road with a 1 to 1 .5 m high bund maintained around the perimeter of the extraction area.

The quarry floor will be progressively lowered, some of the higher located sections of the dirty water catch drains on the western side of the Project Area will become redundant once the active quarry floor levels are excavated below channel invert levels.

3.2 Water management system performance criteria

Under Section 120 of the *Protection of the Environment Operations Act 1997*, it is an offence to pollute waters or cause harm unless licensed to do so. Inherent in the concept of not causing harm is the need to manage the risk of spilling from water management dams or related infrastructure.

The Project will generate runoff and seepage from the following areas:

- catchments not disturbed by the Project, but limited to a small clean area upslope of the quarry and some undisturbed areas within the quarry footprint in the initial development phase
- active quarry extraction areas and associated infrastructure areas, with the potential for elevated TSS as well as some possible contamination related to the blasting process, and the potential spillage of oils and fuels associated with the operation and maintenance of mechanical equipment

- rehabilitated areas where vegetation is still being established that are suitable for discharge except for potentially elevated TSS. It is expected that, due to the topography to be quarried and the fact that the quarry floor will be continually lowered, rehabilitation of the quarry floor will only occur during decommissioning and closure of the site. Benches at the western end of the quarry will be progressively rehabilitated as the quarry floor level is progressively lowered and each new extraction bench is established.

The target design criteria for the typical catchments are summarised in **Table 3.1**.

Table 3.1 Design criteria for components of the WMS

Catchment type	Potential pollution risk	Target design criteria
Clean water catchments.	None	Divert around disturbed areas where practical, risk of spilling 100 year ARI critical duration storm event.
Active quarry extraction areas, quarry processing areas, and infrastructure areas.	TSS and other potential contaminants such as nitrates, hydrocarbons	Contain runoff from Quarry during a 100 year ARI 24 hour flood event and make provision throughout the life of the quarry to be able to safely convey runoff from a Probable Maximum Rainfall event.
Runoff from rehabilitated areas where vegetation is being established.	TSS, nutrients from fertiliser	95^{th} percentile 5 day rainfall event – in line with *Managing Urban Stormwater*; *Soils and Construction* (*Department of Environment and Climate Change NSW*), *Volume E – Mines and Quarries – Blue Book*.
Whole of Quarry	Runoff from extreme storm events	Ability to safely convey runoff for events up to a Probable Maximum Precipitation event from quarry site to Seven Mile Creek.

Estimated runoff volumes during a 1 in 100 year ARI, 1 in 500 year ARI and Probable Maximum Precipitation events from the quarry at various stages of development are summarised in **Table 3.2**.

Table 3.2 Estimated runoff volumes (ML)

Design Storm	100 ARI 24 hour	500 ARI 24 hour	Probable Maximum Precipitation 6 hour
Rainfall	259 mm	330 mm	910 mm
Catchment area (ha)	Runoff (ML)	Runoff (ML)	Runoff (ML)
5	11.4	14.5	91.3
10	22.8	29.0	182.7
15	34.2	43.6	274.0
20	45.6	58.1	365.3
25	57.0	72.6	456.6
30.4	69.3	88.3	555.3

As shown in **Table 3.2**, estimated runoff volume during a Probable Maximum Precipitation event of 910 mm of rainfall over 6 hours from the quarry at full development (30.4 ha) is approximately 555 ML. This is equivalent to approximately twice the average annual runoff from the entire Seven Mile Creek catchment. The quarry has been designed to detain and control this volume of runoff.

In terms of the proposed design criteria, it should be noted that:

- All dirty water catch drains conveying runoff to the water management dams will be sized for the critical duration 100 year ARI event.
- For the water management dams, it is proposed to be able to have no discharge from the site during events up to the 100 year ARI 24 hour storm event.
- The proposed storage capacity of Dams 1 and 2 for Eagleton Quarry is 57 ML. This will be supplemented by additional in-pit and processing area storage capacity for runoff. This will provide for
  - operational water requirements, that is, ensuring there is adequate water from the wet months to sustain the required usage in the dry months
  - retention of 10 ML of water as a contingency for drier than average years
  - the containment of a 100 year ARI 24 hour storm event.

The water balance for the quarry and performance of the proposed storage capacity is discussed further in **Section 5.0**.

3.3 Water management of quarry operations

The conceptual water management system associated with the Project is discussed in **Sections 3.3.1** to **3.3.3**. A schematic of the overall management system is shown on **Figure 3.1**. As shown on **Figure 3.1**, provision will be made for emergency discharges when the storage capacity of the dams and proposed in pit storages are exceeded. This system has been designed to ensure that this does not occur in events less than a 1 in 100 year ARI 24 hour event.

3.3.1 Water management during construction phase to Year 1

The conceptual design of water management infrastructure for construction phase through to end of Year 1 is shown on **Figure 3.2**.

Key aspects of the water management system to end of Year 1 are described in **Table 3.3**.

Table 3.3 Water management system components to end of Year 1

Aspect	Indicative description
Description of Initial Quarry Development	Initial quarry development will involve: • clearance of vegetation, earth works, construction of a sealed haul road between Barleigh Ranch Way and the quarry processing area including construction of a bridge over Seven Mile Creek • clearance of vegetation, excavation and construction of processing area • construction of Dam 1 and emergency overflow to Seven Mile Creek • clearance of vegetation, earthworks and construction of internal haul road • clearance of vegetation, bunding and commencement of extraction in Area A.
Description of Overburden	Soft overburden will be stripped ahead of quarrying, and used in constructing bunding around the processing area and extraction area with the remainder being stockpiled for future use.
Clean Water Management Facilities	Clean water diversion channels will be constructed on the western boundary of Extraction Area A and to the west of the processing area to divert clean water from upslope of the site around the quarry.
Quarry Water Management Facilities	Vegetated bunds will be constructed around the perimeter of the extraction area and the processing area to contain the runoff from disturbed areas. A catch drain will be constructed adjacent to the internal haul road to convey sediment laden runoff from the extraction area to Dam 1. The floor of the extraction area will be constructed to slope at approximately 2.5% away from the internal haul road to provide additional sediment trapping capacity and in-pit storage for runoff. Runoff collected in Dam 1 and in-pit storages will be used for dust suppression on the haul road, processing area and quarry floor.

The following key aspects of the water management system should be noted:

- Bridge over Seven Mile Creek will be constructed to not disturb potential fish passage in Seven Mile Creek.
- The water management system established in the initial stage of quarry development will largely remain in place over the 30 year life of quarry with no changes required other than to changes in the elevation of the internal haul road as the quarry floor is lowered with each new extraction bench and the ultimate removal of the cleanwater diversion drain located to the west of the processing area. An additional dam (Dam 2) and additional in-pit storage will be created as the quarry expands over time. The longevity of the water management system is considered advantageous in that the majority of the system is constructed at the start of the Project and the performance and capacity established early in the Project life.
- The establishment of 1 to 1.5 m high bunds on the perimeter of the Project area will ensure runoff from quarry and processing areas during events up to the Probable Maximum Flood will be contained and controlled.
- Water will be abstracted from the various water management dams and in-pit sumps for dust suppression and rock processing.
- Topsoil and overburden stripped in establishing access roads, haul roads, processing area and extraction areas will be used to construct bunds around the perimeter of disturbance areas. Vegetation cleared from these areas will be placed on or adjacent to the bunds. Stockpiled topsoil, overburden and vegetation will be used for rehabilitation of quarry benches and the final quarry floor.

3.3.2 Water management system – Year 1 to Year 3

The conceptual water management system for Years 1 to 3 is shown on **Figure 3.3**. The water management schematic will be predominantly the same as for Year 1 except for the further expansion of the processing area and Extraction Area A and the establishment of Extraction Area B. Topsoil, overburden and vegetation stripped to establish the extraction area will be placed around the perimeter of the area for ultimate reuse in rehabilitating quarry benches and the quarry floor.

3.3.3 Water management system – Year 5

The conceptual water management system for Year 5 is shown on **Figure 3.4**. The water management schematic remains the same as for previous years. Extraction with Extraction Area A and Extraction Area B continues to expand and the processing area is extended to its final footprint. Topsoil, overburden and vegetation stripped during expansion of the extraction area will continue to be placed around the perimeter of the areas for ultimate reuse in rehabilitating quarry benches and the quarry floor.

3.3.4 Water management system – Year 6

The conceptual water management system for Year 6 is shown on **Figure 3.5**. The water management schematic will be predominantly the same as for previous years with the addition of Dam 2 to the west of Dam 1. A high level emergency spillway will be constructed between Dam 2 and Dam 1. Extraction within Extraction Area A and Extraction Area B will continue to expand the footprint of these areas. Topsoil, overburden and vegetation stripped to establish the extraction area will be placed around the perimeter of the area for ultimate reuse in rehabilitating quarry benches and the quarry floor.

3.3.5 Water management system – Ultimate development footprint and final landform

The conceptual water management system for the ultimate development footprint is shown on **Figure 3.6** and conceptual final landform is shown on **Figure 3.7**. Between Year 6 and the ultimate development footprint, quarry development will involve the progressive lowering of the quarry floor until quarrying reaches its final extent. Vegetation, topsoil and overburden will continue to be stripped and placed around the perimeter of the quarry as the quarry footprint expands with a 1 m high bund being maintained around the perimeter of the quarry. The quarry floor will continue to be excavated with approximately a 2.5% slope away from the access road to provide in-pit storage for extreme rainfall events.

As the quarry approaches its ultimate extraction level of 45 mAHD, the floor of the quarry will be progressively shaped to provide a central drainage line that has a bedslope of between 0.1% and 0.5% draining from west to east. The bunding around the perimeter of the quarry will be maintained until the final shape of the landform is achieved. Stockpiled overburden and then topsoil followed by remaining components of the vegetation that was stripped at the time of clearing will then be progressively placed on the shaped final landform as part of final rehabilitation of the area. The shape of the final landform will be designed to slow surface runoff, assist infiltration into the underlying fractured rock aquifer and enhance habitat value of the once quarried surface.

Apart from small pools that may be established along the drainage line on the quarry floor to enhance habitat value and sediment trapping potential, the final landform will be free draining and with no final void.

3.4 Surface water management for infrastructure areas

The various infrastructure areas are discussed in this section.

3.4.1 Offices and access control area

The offices and Project Area access control area will be located within the main infrastructure area at the south-eastern corner of the processing area as shown on **Figure 3.2**. Localised drainage will be provided around building and parking areas, all of which will drain via the dirty water catch drain to the Dam 1.

Sewage will be collected in a commercially available pump out facility, with the sewage to be pumped out on a regular basis, removed off site and disposed of at an approved treatment facility.

3.4.2 Workshops and washing plant areas

The workshops and washing plant areas will be within the dirty water catch drains upstream of Dam 1. Runoff and wash down water from these areas can potentially contain oils and hydrocarbons from the maintenance of mechanical equipment. Localised drainage from the workshop and washing plant will direct flow to a commercially available oil skimming system.

The runoff and wash down water will then flow via the dirty water catch drains to Dam 1 for containment and reuse.

3.4.3 Access road crossing Seven Mile Creek

It is proposed to construct a bridge over Seven Mile Creek immediately to the east of the processing area as shown on **Figure 3.2**. Details of the access road and bridge crossing of Seven Mile Creek are provided in the conceptual design by PCB Surveyors. Key aspects of the bridge design include:

- The conveyance capacity that can accommodate the peak runoff in Seven Mile Creek from the 100 year ARI nine hour storm event before overtopping the access road.
- The width of the bridge is such that the flow in Seven Mile Creek will not be constrained for normal low flow events.
- For more extreme floods, the potential for erosion exists due to the relatively high dispersiveness of the soils in the broader catchment. Provision has been made for erosion protection downstream of the culverts.
- The bridge will be constructed clear of Seven Mile Creek so as to not impact on the flow regime or fish passage.
- The longitudinal profile of the access road crossing Seven Mile Creek will drain towards the south-western side of the creek, where runoff will be contained in the access road sediment dam. Water will be abstracted from this facility for dust suppression to ensure the risk of spilling is in line with the overall water management system design requirements.

The internal access road will be upgraded for the proposed quarry. During construction activities the sediment and erosion controls as set out in **Section 5.8** will be applied.

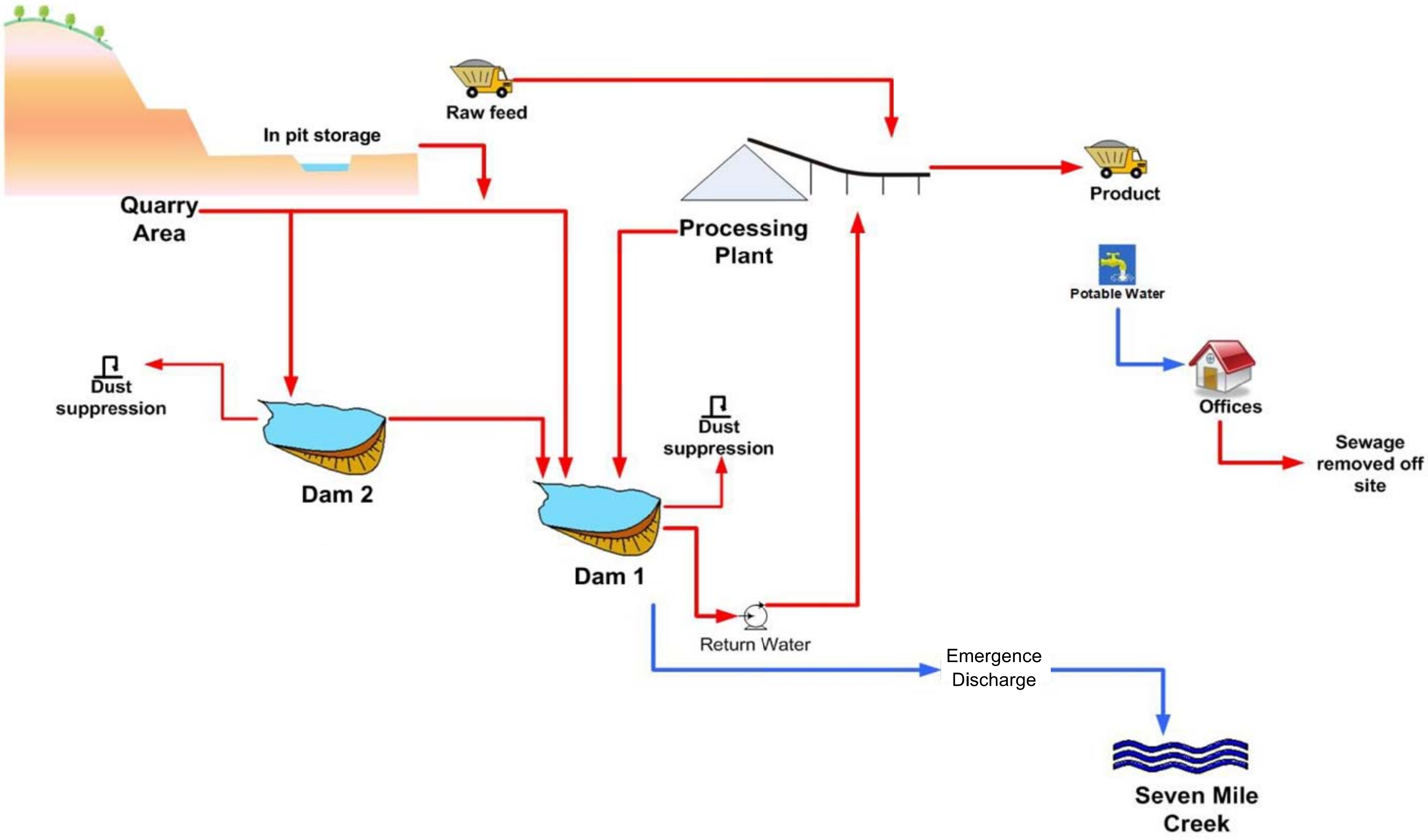

FIGURE 3.1

Schematic Water Management at Year 1

Note: 1) Discharge refers to controlled discharge in terms of an approved EPL
2) Western and Eastern Dams includes sumps excavated in the basin or immediately upstream of the dam basin but outside the active quarry footprint

File Name (A4): R04/3102_054.dgn
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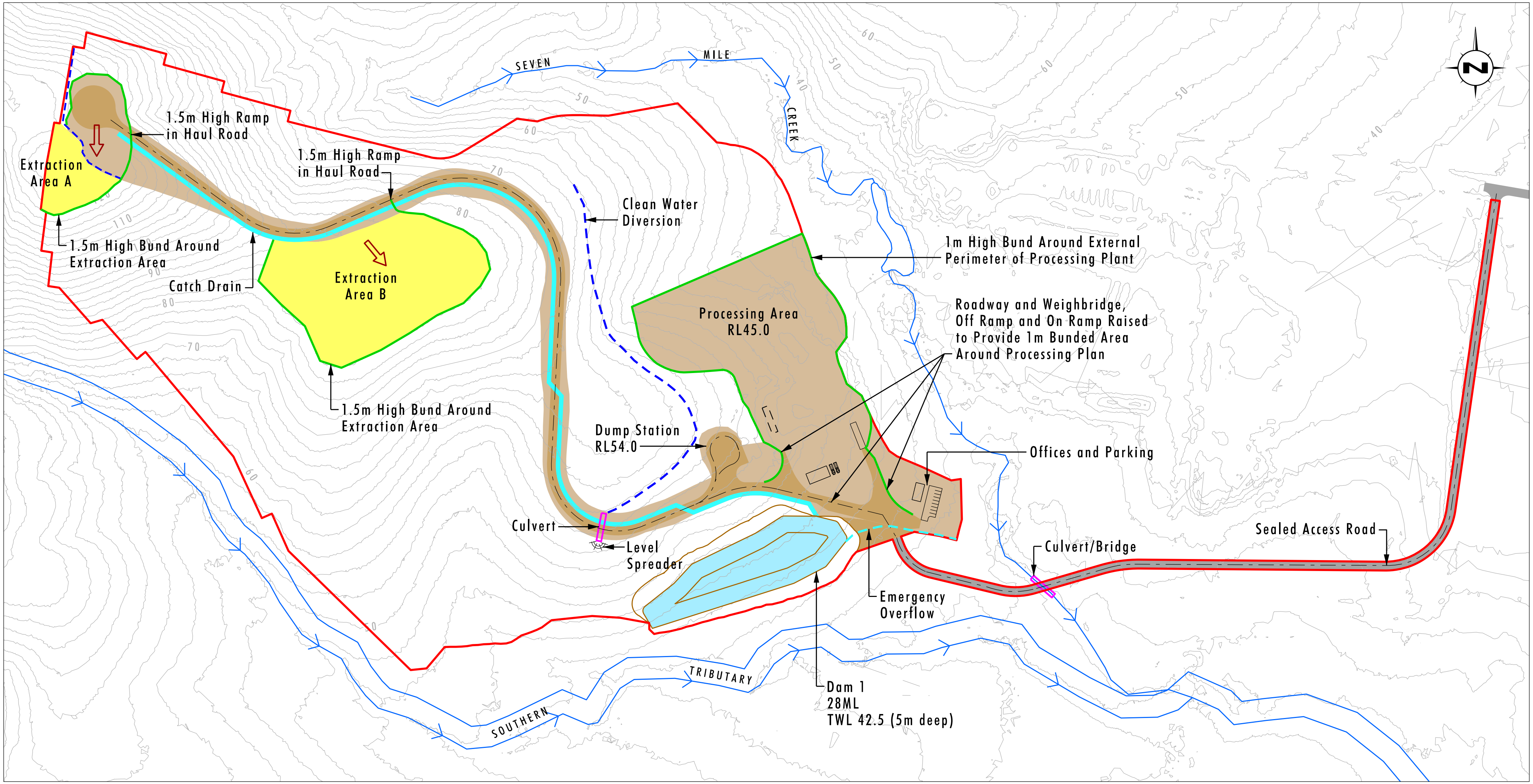
umwelt



Data Source: Eagleton Rock Synd (2016)
Note: Contour Interval 2.5m

0 50 100 200m
1:5 000

Legend

- Project Area
- Disturbance Area
- Gravel Road
- Sealed Road
- Dam 1
- Catch Drain
- Extraction Area
- Culvert
- Bund
- Road Centreline
- Drainage Line
- Infrastructure
- Clean Water Diversion
- Quarry Floor Slope at 2.5% Away from Access Road
- Level Spreader

FIGURE 3.2

Construction to Water Management Year 1

File Name (A4): R04/3102_047.dgn
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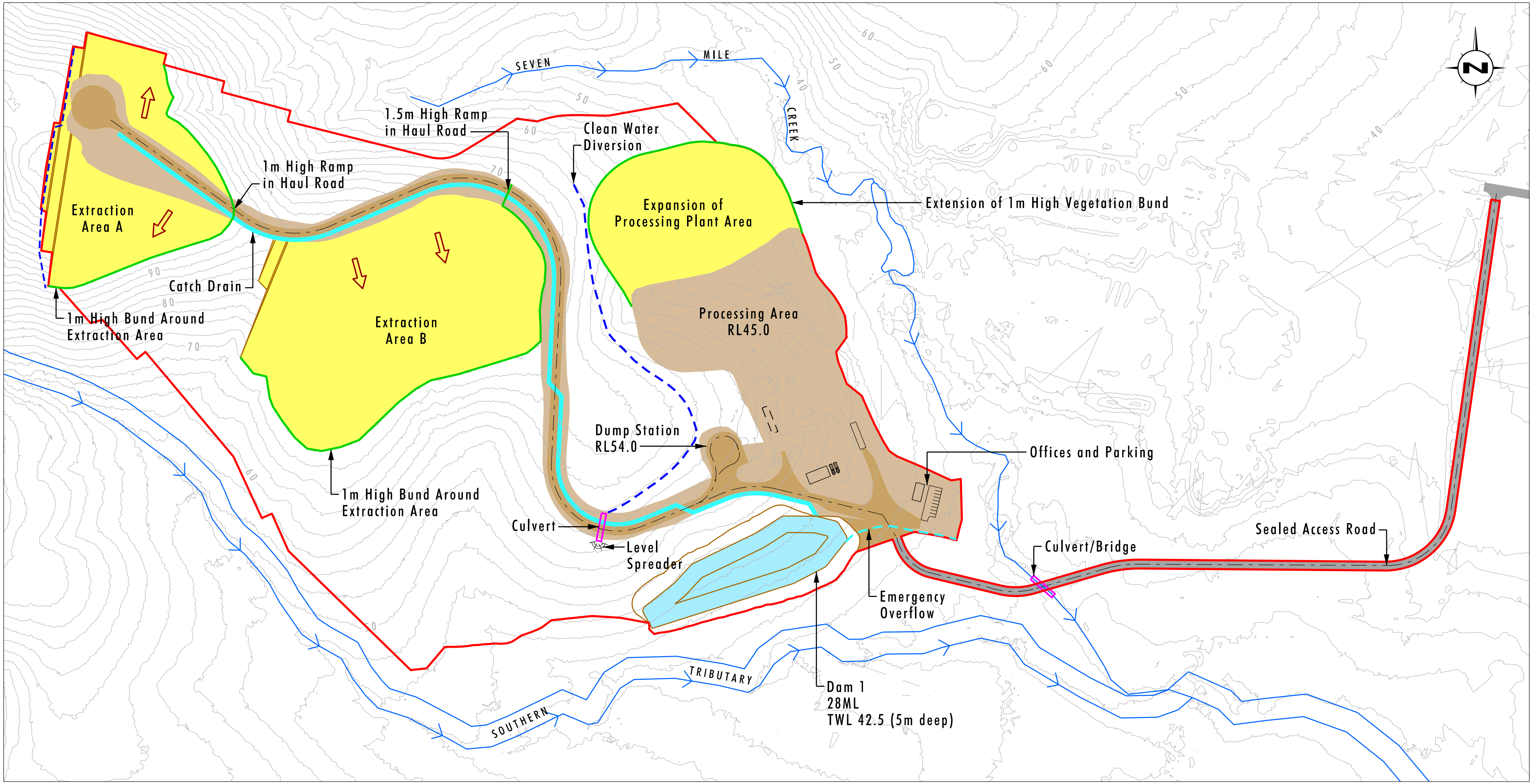

Data Source: Eagleton Rock Synd (2016)
Note: Contour Interval 2.5m

Legend

- Project Area
- Disturbance Area
- Gravel Road
- Sealed Road
- Dam 1
- Catch Drain
- Extraction Area
- Culvert
- Bund
- Road Centreline
- Drainage Line
- Infrastructure
- Clean Water Diversion
- Quarry Floor Slope at 2.5% Away from Access Road
- Level Spreader

FIGURE 3.3

Water Management Year 1 - Year 3

File Name (A4): R04/3102_048.dgn
20160919 12.36

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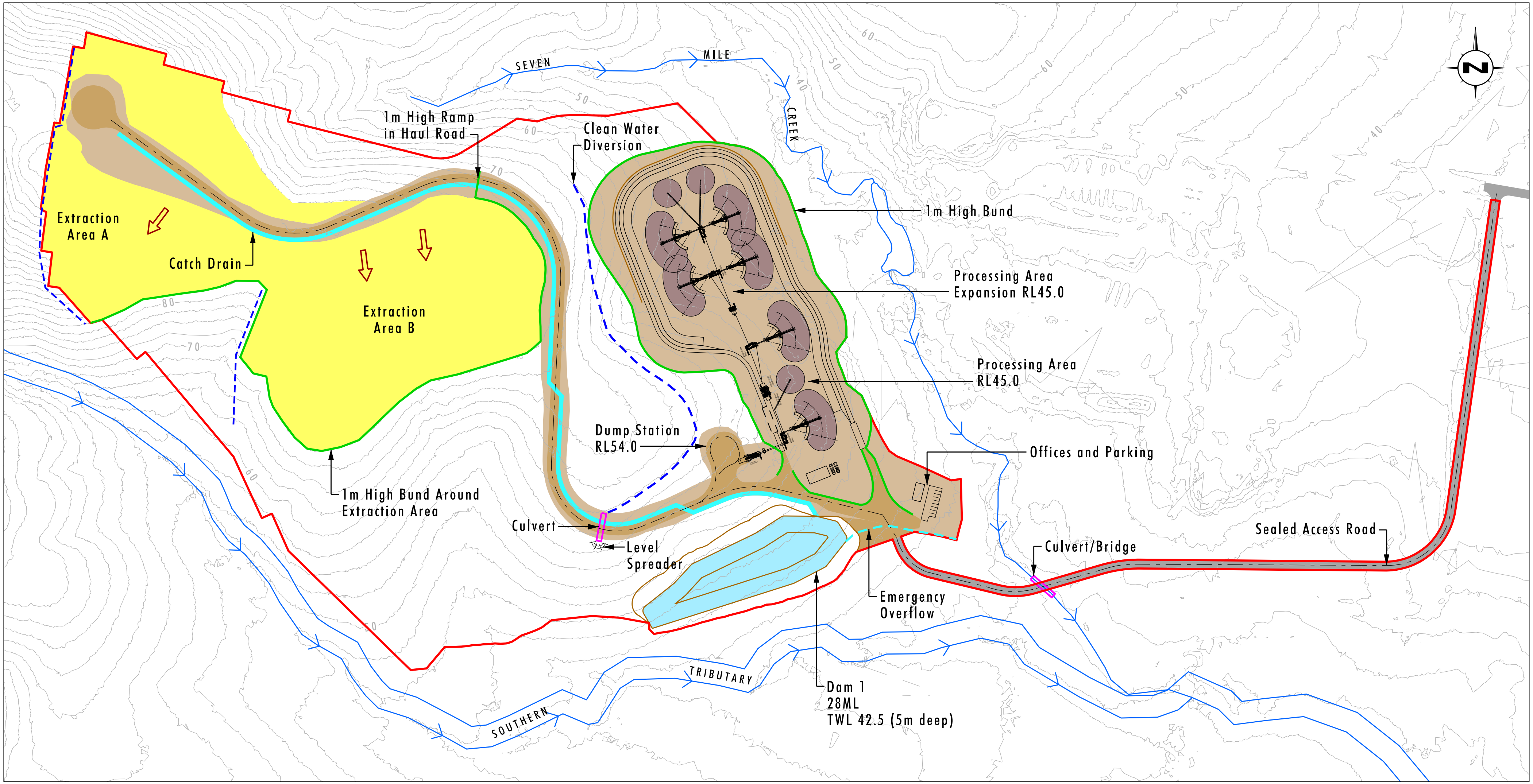


Data Source: Eagleton Rock Synd (2016)
Note: Contour Interval 2.5m

0 50 100 200m
1:5 000

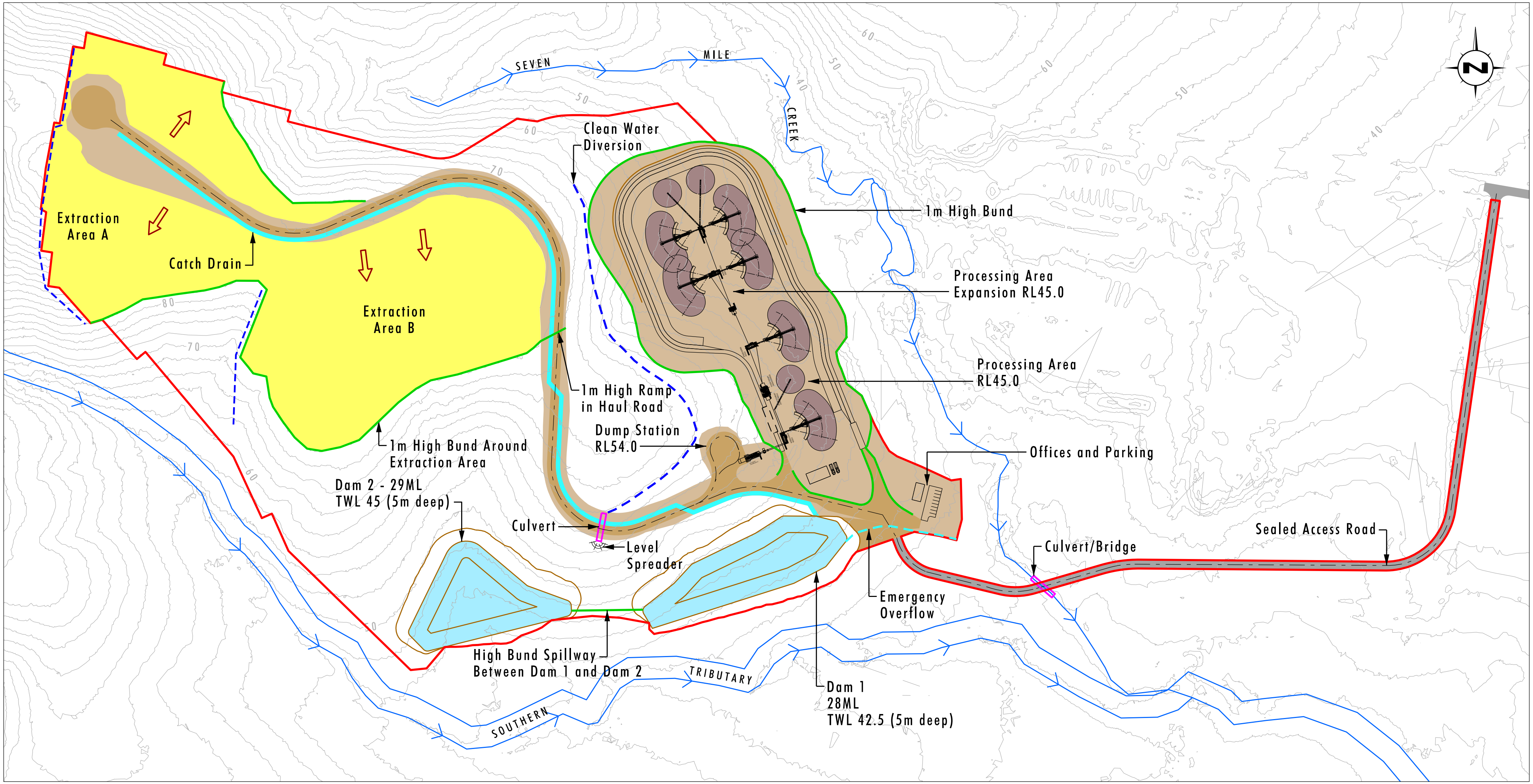
Legend

- Project Area
- Disturbance Area
- Gravel Road
- Sealed Road
- Dam 1
- Catch Drain
- Extraction Area
- Culvert
- Bund
- Road Centreline
- Drainage Line
- Infrastructure
- Clean Water Diversion
- Quarry Floor Slope at 2.5% Away from Access Road
- Level Spreader

FIGURE 3.4

Water Management Year 5

File Name (A4): R04/3102_049.dgn
20160919 13.16



Data Source: Eagleton Rock Synd (2016)
Note: Contour Interval 2.5m

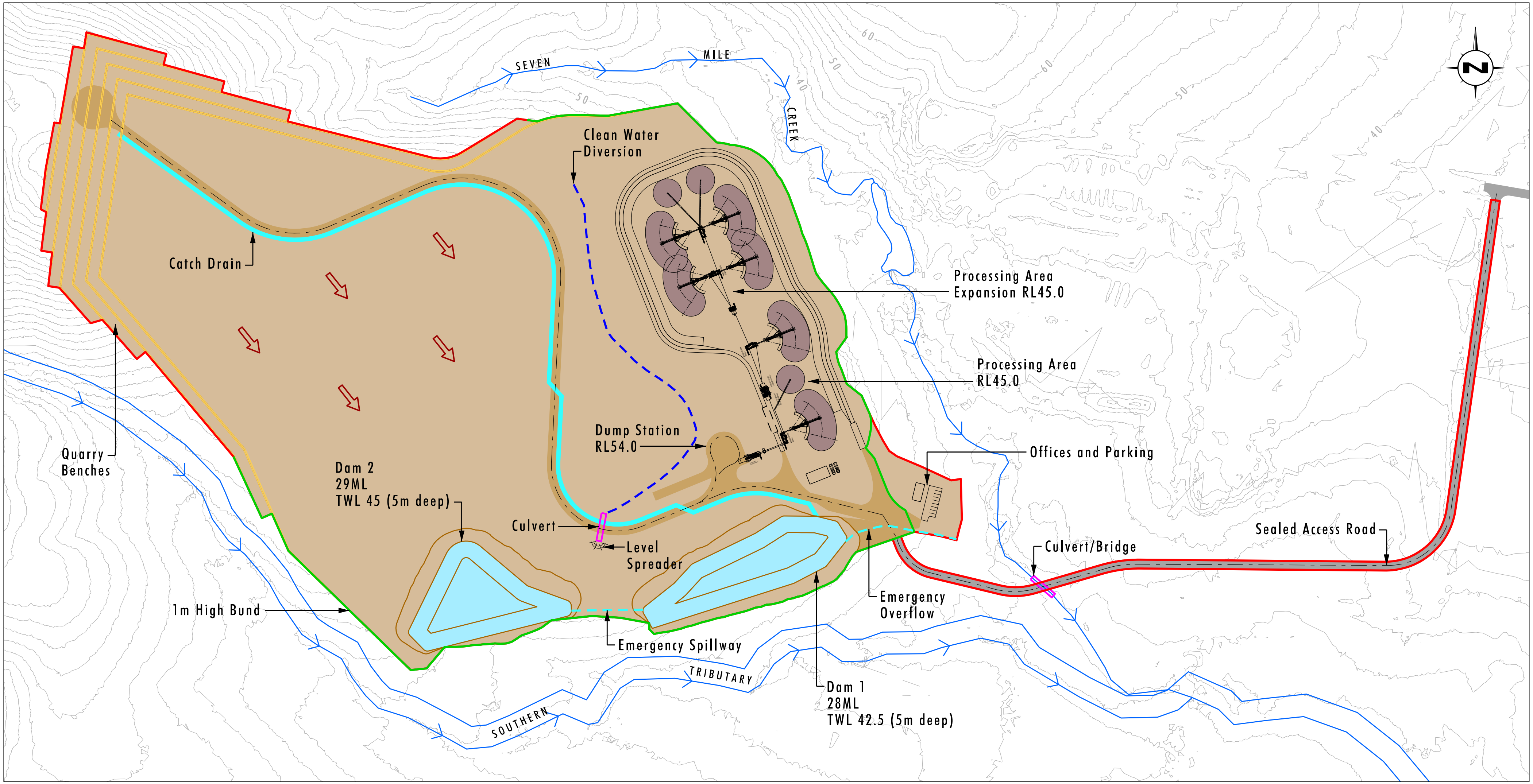
Legend

- Project Area
- Disturbance Area
- Gravel Road
- Sealed Road
- Dam 1
- Catch Drain
- Extraction Area
- Culvert
- Bund
- Road Centreline
- Drainage Line
- Infrastructure
- Clean Water Diversion
- Quarry Floor Slope at 2.5% Away from Access Road
- Level Spreader

FIGURE 3.5

Water Management Year 6

File Name (A4): R04/3102_050.dgn
20160919 13.14



Data Source: Eagleton Rock Synd (2016)
Note: Contour Interval 2.5m

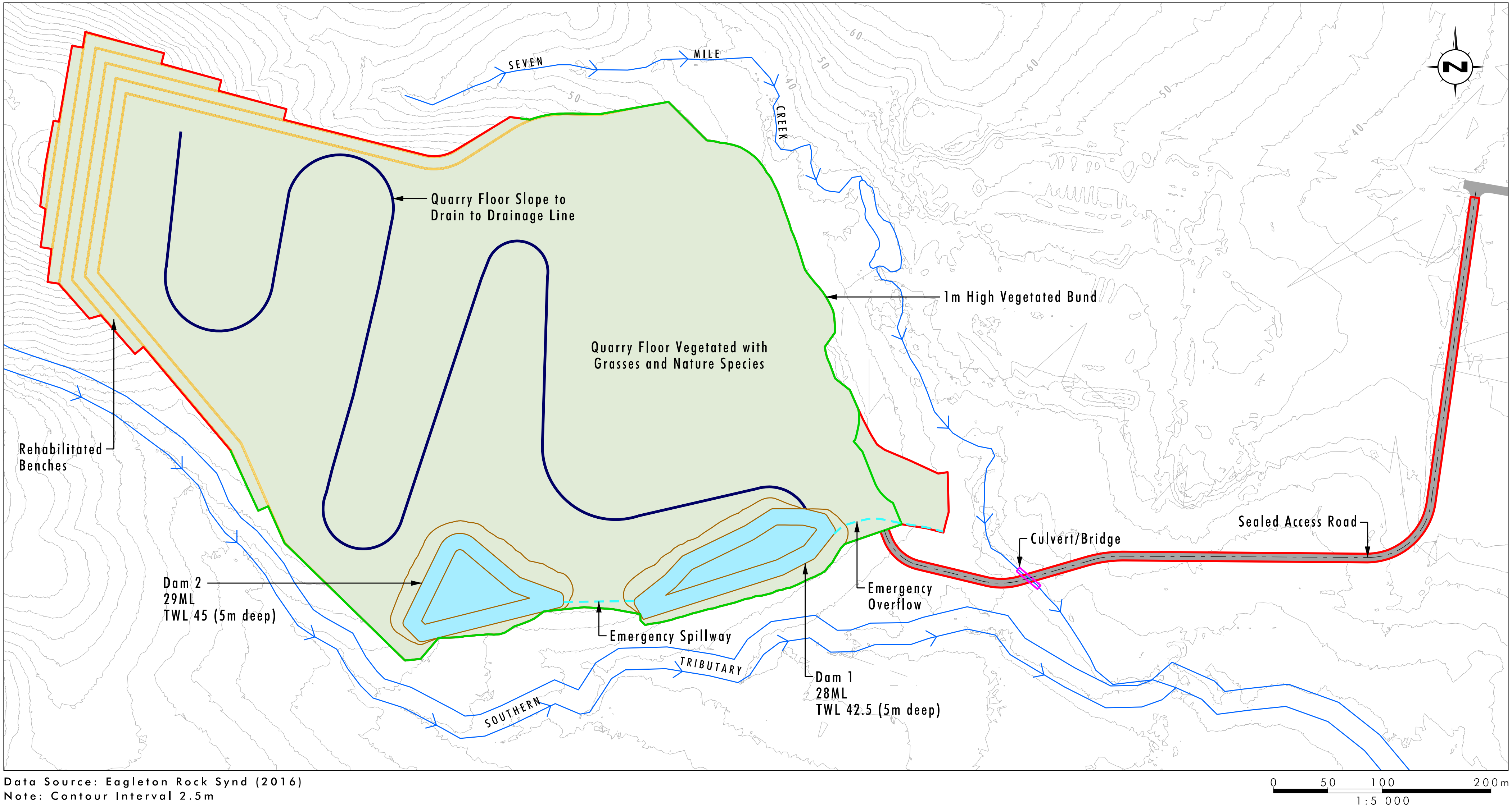
Legend

- Project Area
- Disturbance Area
- Gravel Road
- Sealed Road
- Dam 1
- Catch Drain
- Culvert
- Bund
- Road Centreline
- Drainage Line
- Infrastructure
- Clean Water Diversion
- Quarry Floor Slope at 0.5%
- Level Spreader

FIGURE 3.6

Water Management Ultimate Development Footprint

File Name (A4): R04/3102_051.dgn
20160919 13.36



Data Source: Eagleton Rock Synd (2016)
Note: Contour Interval 2.5m

FIGURE 3.7

Water Management Conceptual Final Landform

File Name (A4): R04/3102_064.dgn
20160919 13.36

4.0 Groundwater

4.1 Groundwater modelling and peer review

In February 2014 URS undertook a hydrogeological investigation for Eagleton Hard Rock Quarry. In accordance with SEARS for the project, the report was peer reviewed by Brian Rask of SLR Global Environmental Solutions (SLR) and the findings of the peer review set out in a report dated 9 February 2016 is provided in **Appendix 1c**. The peer review raised a number of issues in regard to the 2014 URS report. The conceptual geological model that was used by URS had to be revised and a new groundwater model built for the site and recalibrated. Umwelt and Katarina David were requested to address the issues raised in the peer review.

Details of the conceptual geological model that was developed and revised groundwater model are set out in the report 'Numerical Groundwater Model for Eagleton Quarry (October 2016)' which was prepared on behalf of Umwelt (Australia) Pty Limited by Katarina David. A copy of this report is provided as **Appendix 1a**. A copy of Katarina David's CV is provided in **Appendix 1b**.

The conceptual geological modelling, model description and modelling results set out in **Appendix 1a** supersedes and replaces the information provided in Sections 4.0 and 5.0 of the URS report (February 2014).

Responses to matters raised in the peer review are summarised in **Table 4.1**.

Table 4.1 Summary of responses

Matter raised	Response
Annual groundwater volume to be taken	See **Section 4.2**
Assessment of volumetric water licensing requirements	See **Section 4.2**
Detailed assessment against Aquifer Interference Policy	See **Section 4.4**
Full technical details of groundwater modelling	See **Appendix 1b**
Proposed groundwater monitoring	See **Section 4.3**
Details of final landform and final void	See **Section 3.3.5**
Assessment of cumulative groundwater impacts	See **Appendix 1a**
Groundwater modelling deficiencies in regard to: • conceptual model • risk of project • numerical model.	See **Appendix 1a**

4.2 Modelled groundwater inflow and potential impacts

As discussed in **Section 4.1** and detailed in **Appendix 1a**, the conceptual geological model used to build the groundwater model for the project was revised and the model recalibrated. Simulation of groundwater conditions and changes to the groundwater regime of the 30 year life of the quarry was undertaken and groundwater inflow rates at various times over the life of the quarry estimated. Results of the groundwater model simulation are set out in **Table 4.2**.

Table 4.2 Predicted inflow during simulation period

Year	Inflow Rate (m^3/day)	Inflow Rate (ML/year)
Year1	8.1	3.0
Year2	13.3	4.9
Year 3	12.7	4.6
Year 4	18.7	6.8
Year 5	21.3	7.8
Year 6	19.8	7.2
Year 8	17.7	6.5
Year 10	18.6	6.8
Year 12	20.1	7.3
Year 14	20.7	7.6
Year 24	21.1	7.7
Year 30	20.6	7.5

As can be seen from **Table 4.2**, groundwater inflow is estimated to range from approximately 3.0 ML/year in Year 1 to a maximum of approximately 7.7 ML/year at Year 24.

Sensitivity analysis considerations indicates that predicted groundwater inflow estimates are likely to be +/- 10% (see **Appendix 1a**).

Modelling indicates that maximum drawdown of the groundwater table as a result of the proposed quarry is limited to within the Project boundary with the relatively slow extraction progress over 30 years reducing the impact of drawdown significantly.

Modelling also shows that there is limited impact of drawdown outside of the Project Area boundary with a maximum impact on the south-western boundary of the site. Modelling indicates that drawdown of less than 1 m is likely to extend to approximately 200 m to the west, north and south of the quarry extraction area.

Modelling (**Appendix 1a**) indicates that the potential for cumulative impact is minor based on the limited propagation of drawdown outside of the property boundary with depressurisation of 1 m or less in the underlying fractured rock aquifer predicted within the property boundary.

The location of nearby groundwater bores is shown in Figure 3 of **Appendix 1a**. Groundwater Atlas (BoM 2016) and DPI Water database indicate the closest private bore is located about 400 m to the south-east of the Site (GW79737). The bore is installed at 20 m depth however no other information is available. Next closest private bore is located approximately 1.4 km south-west of the Site, installed in fractured rock aquifer and used for stock and domestic purpose (GW66683). The prediction simulation indicates that drawdown outside of the Site boundary is zero; therefore negligible impact is predicted at any of the surrounding private bores.

In terms of impact on baseflows, discharge to Seven Mile Creek calculated for three segments in the groundwater model as detailed in **Appendix 1a**:

- the first segment includes Seven Mile Creek upstream to the confluence with its southern tributary
- the second segment consists of the southern tributary up to the confluence with Seven Mile Creek
- the third segment starts at the confluence of the Seven Mile Creek and its tributary to Grahamstown Dam.

Seven Mile Creek is mainly ephemeral and loses water in its upper reaches however does receives minor baseflow contribution from groundwater mainly in its lower reach. Results from predictive simulations indicate that there is minor baseflow loss to Seven Mile Creek as a result of the proposed quarry with a decrease of 0.75 m^3/day (0.27 ML/year) over the period of 30 years of Project.

4.3 Water Sharing Plan for the Sydney Basin – North Coast Fractured and Porous Rock Groundwater Sources

Groundwater within the proposed Eagleton Hard Rock Quarry site is managed by Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources under the *Water Management Act 2000*. The plan commenced in July 2016 and operates for a period of 10 years. The plan establishes rules for sharing water between different types of water and provides users with opportunities to trade water through separation of land and water.

An analysis of the consistency or otherwise of the proposal with the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources rules for this groundwater source area is provided in **Table 4.3**. The analysis indicates that the proposal is consistent with the rules.

Table 4.3 Analysis of Proposal Consistency with Water Sharing Plan Rules

Water Sharing Rules		Analysis
Access Rules		
Available Water Determinations (AWDs) to be made at the commencement of each water year	• Domestic and stock, local water 100% stock and domestic, local and major utilities and specific purpose access licences • Aquifer access licences – 1 ML/unit share or a lower amount as a result of a growth in use response • Supplementary water ('storage') access licences.	Modelling indicates that groundwater inflow to the quarry will vary between 3.0 ML/year at Year 1 and 7.5 ML/year at Year 30. Eagleton Rock Syndicate will need to either purchase an existing licence or apply for a zero share water access licence and combined approval.
Granting of access licences	• Specific purpose licences including local water utility, major water utility, domestic and stock, and town water supply. *These are specific purpose access licences in clause 19 of the Water Management (General) Regulation 2004.* • Aquifer (Aboriginal cultural), up to 10 ML/yr. • Supplementary Water ('Storage') access licence.	• Eagleton Rock Syndicate will need to either purchase an existing licence or apply for a zero share water access licence and combined approval. The Water Sharing Plan identifies that groundwater licences can be acquired and permits transfer of licence. • Granted in accordance with a controlled action order made under the provisions of the NSW Policy for Managing Access to Buried Water Sources.

Water Sharing Rules		Analysis
Rules for granting and amending water supply works approvals		
To minimise interference between neighbouring water supply works	No water supply works (bores) to be granted or amended within the following distances of existing bores: • 400 m from an existing bore that is not used for basic rights • 100 m from a bore that is used for existing rights • 50 m from the boundary of the property(unless consent gained from the neighbour) • 1000 m from a local or major water utility bore • 200 m of a bore used by Department for monitoring purposes. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*	• There are no water supply works within the specified distances of the proposed quarry for each of the categories listed. • Water supply works as required by the proposed quarry can be granted or amended.
Rules for bores located near high priority groundwater dependent ecosystems	No water supply works (bores) to be granted or amended within the following distances of high priority groundwater dependent ecosystems (GDEs) or river or stream: • 100 m of high priority GDE for ores that are used for basic rights • 200 m of high priority GDE for bores that are not used for basic rights • 500 m of high priority karst environment GDE • 40 m from top of high bank of a river or stream • 100 m of an escarpment. *The plan lists circumstances in which these distance conditions may be varied.*	• There are no high priority karst environment GDE or High Priority Groundwater Dependent Ecosystems mapped within Appendix 3 of the Plan that are within 500 m of the proposed quarry. The closest high priority GDE is located approximately 4 km to the southwest on the Williams River and will not be impacted by the proposed development. • Water supply works as required by the proposed quarry can be granted or amended.

Water Sharing Rules		Analysis
Rules for bores located near groundwater dependent culturally significant sites	No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites: • 100 m for bores used for extracting for basic landholder rights or • 200 m for bores used for all other aquifer access licences. *The plan lists circumstances in which these distance conditions may be varied.*	• The results of the Aboriginal archaeological and cultural heritage assessment indicated that there are no groundwater dependent culturally significant sites within 200 mm of the Project Area.

Based on the above, water supply works required for the proposed quarry can be granted, amended or acquired.

4.4 Aquifer Interference Policy

The Aquifer Interference Policy (AIP) provides details of the role and requirements of the Minister administering the *Water Management Act 2000* in the water licensing and assessment processes for aquifer interference activities under *the Water Management Act 2000* and other relevant legislative frameworks.

The AIP applies to all activities that either penetrate, interfere, obstruct, take or dispose with/of water in an aquifer. The proposed quarry will penetrate the local aquifer through extraction operations.

The groundwater source category at Eagleton Hard Rock Quarry is defined as being 'less productive', based on the yield data from surrounding groundwater bores (see **Appendix 1a**).

The AIP requires that proponents demonstrate that minimal impact considerations specified under the AIP can be met. **Table 4.4** provides an assessment against the minimal impact considerations as set out in the AIP for a 'less productive' groundwater source category. The assessment is based on the results of the groundwater modelling reported in **Attachment 1a**.

Table 4.4 Assessment of Minimal Impact Considerations for Less Productive Porous Rock Groundwater Source at Eagleton Hard Rock Quarry

Minimal Impact Consideration	Assessment
Water table	
1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: (a) high priority groundwater dependent ecosystem or (b) high priority culturally significant site listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at any water supply work.	There are no high priority groundwater dependent ecosystems (GDEs) within proximity to the area potentially impacted by the proposed. There are no listed high priority culturally significant sites within proximity to the proposed quarry. Further, groundwater modelling indicates that there will be no impacts to any offsite water supply works.
2. If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: (a) high priority groundwater dependent ecosystem or (b) high priority culturally significant site listed in the schedule of the relevant water sharing plan if appropriate studies demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2 m decline cumulatively at any water supply work then make good provisions should apply.	There is no listed high priority GDEs or high priority culturally significant sites within proximity to the proposed extraction areas that could be affected by drawdown from the quarry. Groundwater modelling (**Appendix 1a**) indicates the variation in water table as a result of the proposed quarry development would be less than 10% at the project site boundary.
Water pressure	
1. A cumulative pressure head decline of not more than a 2 m decline, at any water supply work.	Groundwater modelling (**Appendix 1a**) indicates that the drawdown in the water table will not extend to or impact adversely on any surrounding groundwater supply bores.
2. If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	Predicted pressure head decline is less than requirement 1 (refer above).

Minimal Impact Consideration	Assessment
Water quality	
1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.	The proposed quarry will not use groundwater and is highly unlikely to affect groundwater quality or the beneficial use category of the area.
2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.	Condition 1 has been met.

In summary, the assessment of the Project against the minimal impact considerations of the AIP as set out in **Table 4.4** indicates that the Project will meet all conditions and as such have a minimal impact on the aquifer at the site, which forms part of the Sydney Basin – North Coast Fractured and Porous Rock Groundwater Source.

5.0 Water balance

5.1 Model input data and assumptions

The predictive water balance model for the Project uses a daily time step model developed in Goldsim. The model utilises daily rainfall and evaporation data from historical rainfall and evaporation records from Williamtown RAAF (BOM Station 61078) for the period 1972 to 2015. The rainfall data was supplemented with daily rainfall data recorded at Eagleton for the period August 2014 to December 2015. This data included 21 and 22 April 2015 when 595 mm was recorded in two days with a total of 708 mm being recorded in the 15 day period to 6 May 2015.

The runoff volumes from rainfall were determined using the Soil Conservation Services (SCS) methodology adjusted for antecedent rainfall (United States Department of Agriculture – USDA), which is consistent with the methodology used in the Blue Book runoff determinations.

Inflows from groundwater were drawn from predicted groundwater inflows volumes set out in **Section 4.0**.

Evaporation rates were determined taking into account daily pan evaporation, the volume of water and wetted surface area of dams and in-pit storages on a daily basis and the volume of water applied for dust suppression and irrigated within the perimeter of the quarry.

The daily data set was then used to generate statistics on predicted range of runoff water usage and dam storage volumes for each stage of development described as shown on **Figure 3.2** to **3.7**. Simulation for each stage used 43 years of daily rainfall and evaporation data.

The Goldsim water balance model is modular.

The model incorporates likely water uses and likely water makes from:

- the Eagleton quarry area using the proposed quarry plan
- the associated crushing, stockpiling and loading areas
- the water use requirements for the washing plant and dust suppression
- groundwater inflows.

In developing the model the following assumptions were made in regard to daily water demand:

- the haul road is unsealed and is 10 m wide and 1 km long for the life of the operation
- maximum daily water application rate is given by
    - Evaporation volume = (Evaporation – Rainfall) x Watering Factor (WF) where
        - Evaporation = Pan evaporation * 0.8
        - WF ranges from 1 to 1.45 in Year 1
        - WF ranges from 1 to 1.4 in other all other years

- WF linearly interpolated for site water storage from 10 ML to 58 ML
  - Below 10 ML WF is 1
  - Above 58 ML WF is 1.45 for Year 1 and 1.4 for all other years

- Processing Plant
  - dust suppression demand for crushing and screening has been assumed to be 0.03 kL/tonne of production
- Extraction Area and Processing Area
  - watering is applied to the exposed sections of the Extraction Area and Processing Area whenever pan evaporation exceeds rainfall
  - maximum daily water rate determined as per haul road
- assumed annual Production levels for each stage of development are set out in **Table 5.1**.

Table 5.1 Modelled annual production levels

Year	Production (T)
1	225,000
2	300,000
3	350,000
4	425,000
5	525,000
6 onwards	600,000

The volume of water stored in dams and in-pit storages will vary over the life of the quarry in response to changes in production, quarry configuration, rainfall and evaporation rates. This will impact on the surface area of the water bodies on-site which in turn impacts on evaporation rates and volumes. To contain runoff from the quarry on-site it is proposed to use a combination of storages including Dam 1 which will be constructed prior to commencement, Dam 2 which will be constructed in approximately Year 6, in-pit storage in the extraction area which will vary over the life of the quarry and the floor of the processing area which will initially have a surface area of approximately 30,500 m^2 increasing to approximately 46,500 m^2 by approximately Year 3.

To enable changes in storage volumes and the area of water bodies on-site to be taken into consideration, a series of storage area versus volume relationships have been developed for the various components of the proposed water storage infrastructure. The various surface area–volume relationships that have been developed for each component of the quarry infrastructure used to store water are set out in **Table 5.2**

Table 5.2 Storage area versus Volume Relationships

Storage Infrastructure	Year 1	Year 3	Year 5	Year 6	Year 30
Dam 1	A = (V - 3000)/2.989				
Dam 2				A = (V - 3400)/3.112	
Extraction Area	$A = (V \times 31{,}923)^{0.5}$	$A = (V \times 80{,}408)^{0.5}$	$A = (V \times 94{,}410)^{0.5}$	$A = (V \times 94{,}410)^{0.5}$	$A = (V \times 226{,}823)^{0.5}$
Processing Area	30,500 m^2 (0.8 m bund)	46,300 m^2 (0.8 m bund)			

Where:
A is surface area in m^2
V – Volume in KL

5.2 Water Balance Simulation Results

Water balance simulations have been undertaken for Years 1, 3, 5, 6 and 30 using 43 years of daily rainfall and evaporation data for each of the operational years modelled. Results of the modelling are provided in **Tables 5.3** to **5.7** and shown graphically in **Plates 5.1** to **5.5** respectively. The modelled system has been designed to contain all runoff on-site with no discharges to Seven Mile Creek.

Table 5.3 Year 1 water balance statistics

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Water Balance Excluding Overflows (ML)	-44.4	-23.4	0.2	23.0	45.6	0.7
Water Balance Including Overflows (ML)	-44.4	-23.4	0.2	23.0	45.6	0.7
Water Balance Including Overflows and Volume Change (ML)	0.0	0.0	0.0	0.0	0.0	0.0

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Demands						
Processing Plant Demands (ML)	6.8	6.8	6.8	6.8	6.8	6.8
Haul Road Demands (ML)	5.0	6.4	8.8	10.9	14.0	9.0
Exposed Area Demands (ML)	12.6	21.2	31.7	46.2	49.8	32.5
Evaporation from Water Storages (ML)	2.1	2.5	6.3	44.7	59.7	15.7
Rainfall Runoff						
Rainfall Runoff (ML)	25.6	42.1	60.2	100.7	106.9	64.6
Overflows						
Total Number of Overflows					0.0	
Maximum Overflow Volume (ML)					0.0	
Stored Volume (ML)	1.6				108.8	

Modelling indicates that under the range of rainfall and evaporation conditions experienced over the 43 year simulation period, the volume of water stored onsite on any day would range from 1.6 ML to 108.8 ML indicating that the quarry at Year 1 could be operated without the need to import significant volumes of water for processing or dust suppression and without the need for discharges from the site to Seven Mile Creek.

Modelling also indicates that modelled average (50%) total annual demand (processing, dust suppression, exposed areas and evaporation from water bodies) is 53.6 ML/year with approximately 60.2 ML of runoff being generated from the site with this runoff being contained in on-site storages.

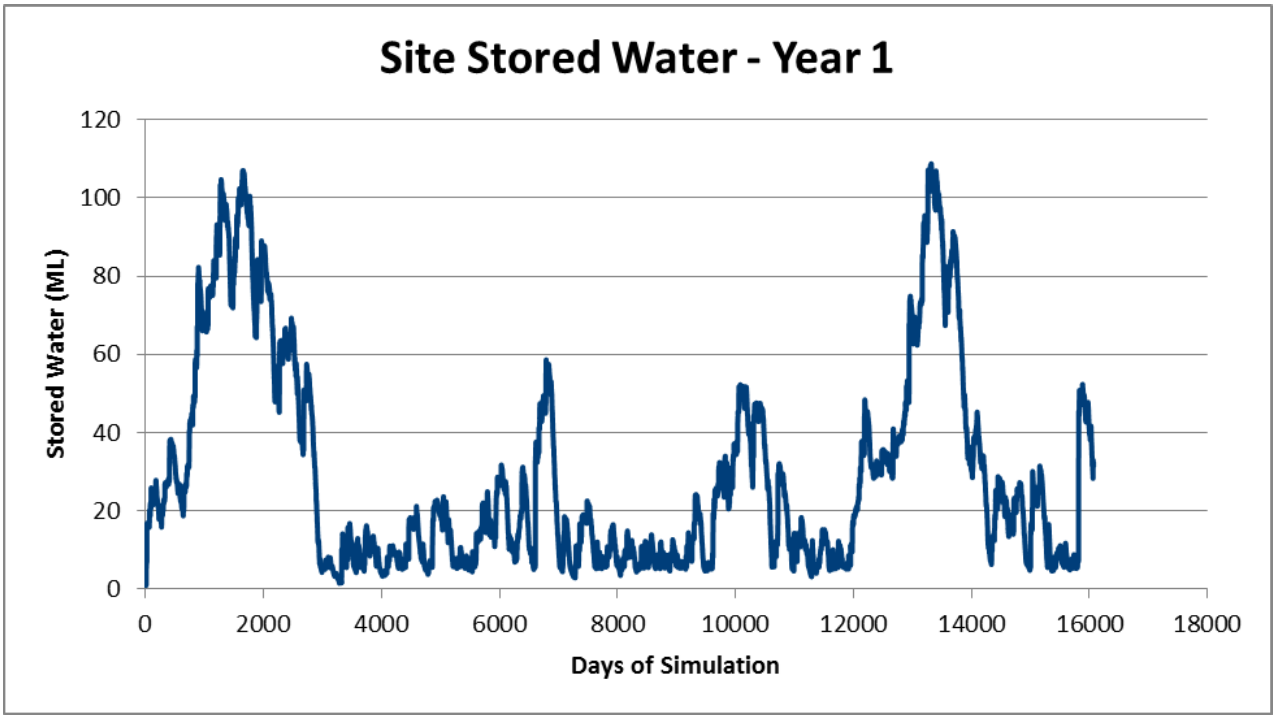


Plate 5.1

Year 1 water balance statistics

Plate 5.1 shows the variability in water storage over the 43 years of simulation.

Table 5.4 Year 3 water balance statistics

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Water Balance Excluding Overflows (ML)	-80.1	-41.3	0.6	37.7	78.8	1.3
Water Balance Including Overflows (ML)	-80.1	-41.3	0.6	37.7	78.8	1.3
Water Balance Including Overflows and Volume Change (ML)	0.0	0.0	0.0	0.0	0.0	0.0

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Demands						
Processing Plant Demands (ML)	10.5	10.5	10.5	10.5	10.5	10.5
Haul Road Demands (ML)	5.4	6.4	9.0	11.3	13.6	9.1
Exposed Area Demands (ML)	15.9	41.1	54.9	76.8	89.6	56.6
Evaporation from Water Storages (ML)	4.0	4.8	15.4	91.6	114.6	34.2
Rainfall Runoff						
Rainfall Runoff (ML)	-68.4	67.0	101.3	179.3	195.1	111.7
Overflows						
Total Number of Overflows					0	
Maximum Overflow Volume (ML)					0.0	
Maximum Stored Volume (ML)	6.4				179.1	

Modelling indicates that under the range of rainfall and evaporation conditions experienced over the 43 year simulation period, the volume of water stored onsite on any day would range from 6.4 ML to 179.1 ML indicating that the quarry at Year 3 could be operated without the need to import significant volumes of water for processing or dust suppression and without the need for discharges from the site to Seven Mile Creek.

Modelling also indicates that modelled average (50%) total annual demand (processing, dust suppression, exposed areas and evaporation from water bodies) is 89.8 ML/year with approximately 101.3 ML of runoff being generated from the site with this runoff being contained in on-site storages.

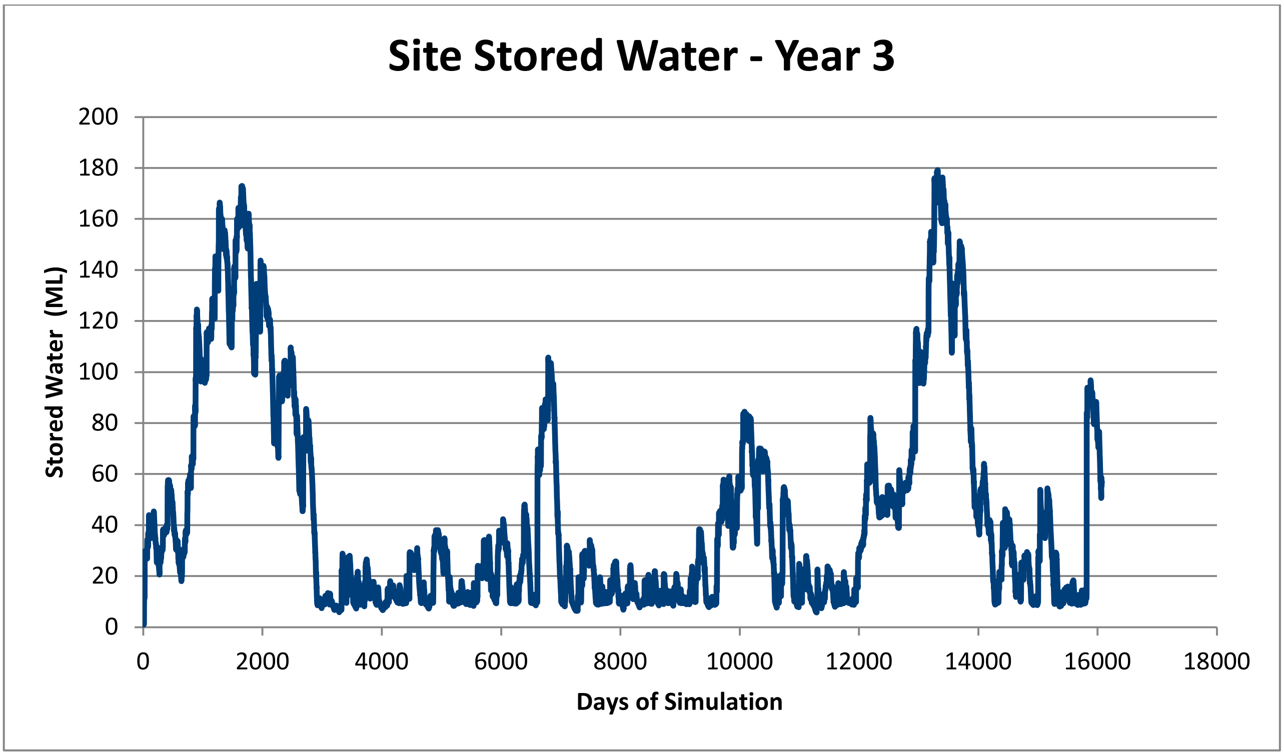


Plate 5.2

Year 3 water balance statistics

Plate 5.2 shows the variability in water storage over the 43 years of simulation.

Table 5.5 Year 5 water balance statistics

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Water Balance Excluding Overflows (ML)	-76.4	-45.0	0.4	37.9	81.5	1.3
Water Balance Including Overflows (ML)	-76.4	-45.0	0.4	37.9	81.5	1.3
Water Balance Including Overflows and Volume Change (ML)	0.0	0.0	0.0	0.0	0.0	0.0

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Demands						
Processing Plant Demands (ML)	15.8	15.8	15.8	15.8	15.8	15.8
Haul Road Demands (ML)	5.5	6.4	8.9	11.3	13.6	9.1
Exposed Area Demands (ML)	15.8	41.8	60.9	78.8	96.2	59.9
Evaporation from Water Storages (ML)	4.2	5.0	16.8	97.6	130.0	35.7
Rainfall Runoff						
Rainfall Runoff (ML)	45.4	73.5	105.8	194.4	215.8	121.8
Overflows						
Total Number of Overflows					0	
Maximum Overflow Volume (ML)					0.0	
Stored Volume (ML)	9.1				179.9	

Modelling indicates that under the range of rainfall and evaporation conditions experienced over the 43 year simulation period, the volume of water stored onsite on any day would range from 9.1 ML to 179.9 ML indicating that the quarry at Year 5 could be operated without the need to import significant volumes of water for processing or dust suppression and without the need for discharges from the site to Seven Mile Creek.

Modelling also indicates that modelled average (50%) total annual demand (processing, dust suppression, exposed areas and evaporation from water bodies) is 102.4 ML/year with approximately 105.8 ML of runoff being generated from the site with this runoff being contained in on-site storages.

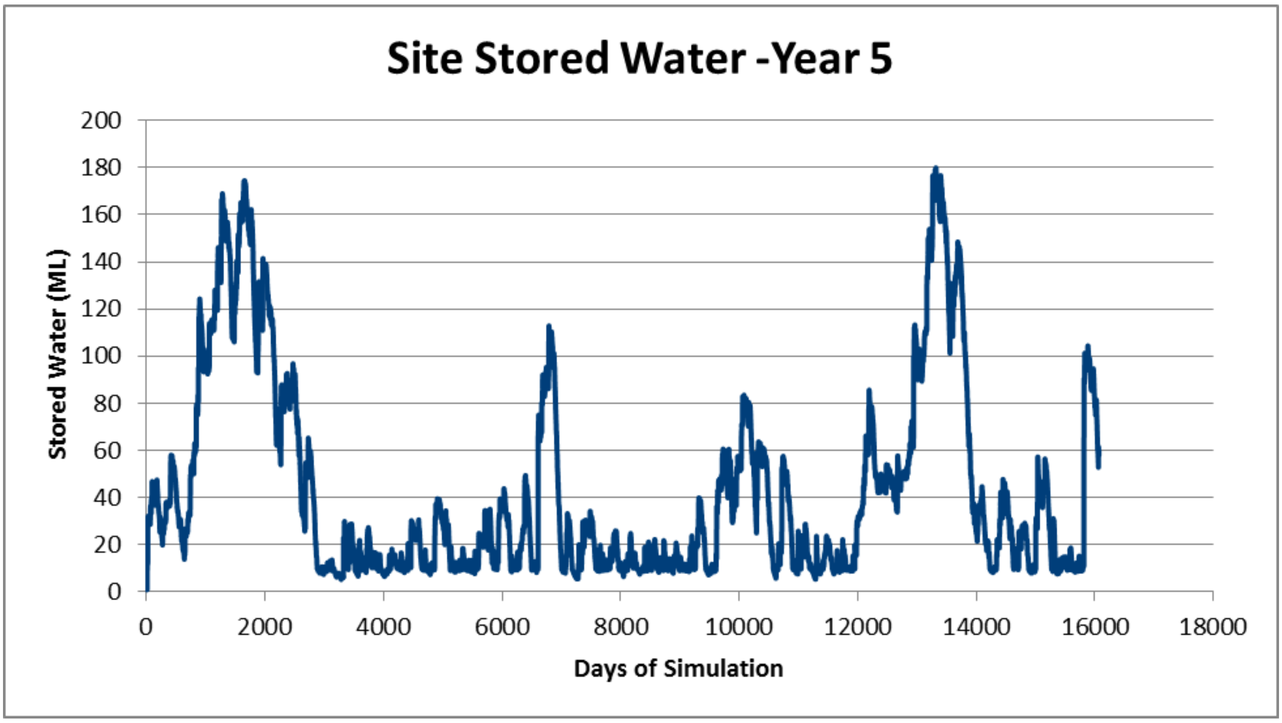


Plate 5.3

Year 5 water balance statistics

Plate 5.3 shows the variability in water storage over the 43 years of simulation

Table 5.6 Year 6 water balance statistics

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Water Balance Excluding Overflows (ML)	-57.8	-13.0	-1.1	25.2	59.9	1.0
Water Balance Including Overflows (ML)	-57.8	-13.0	-1.1	25.2	59.9	1.0
Water Balance Including Overflows and Volume Change (ML)	0.0	0.0	0.0	0.0	0.0	0.0

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Demands						
Processing Plant Demands (ML)	18.0	18.0	18.0	18.0	18.0	18.0
Haul Road Demands (ML)	5.2	6.2	8.8	10.8	12.6	8.7
Exposed Area Demands (ML)	12.9	43.0	66.2	89.8	120.4	66.2
Evaporation from Water Storages (ML)	3.8	4.6	7.2	45.3	96.7	16.4
Rainfall Runoff						
Rainfall Runoff (ML)	44.7	72.6	100.2	175.3	202.5	110.4
Overflows						
Total Number of Overflows					0	
Maximum Overflow Volume (ML)					0.0	
Stored Volume (ML)	4.8				137.5	

Modelling indicates that under the range of rainfall and evaporation conditions experienced over the 43 year simulation period, the volume of water stored onsite on any day would range from 4.8 ML to 137.5 ML indicating that the quarry at Year 6 could be operated without the need to import significant volumes of water for processing or dust suppression and without the need for discharges from the site to Seven Mile Creek.

Modelling also indicates that modelled average (50%) total annual demand (processing, dust suppression, exposed areas and evaporation from water bodies) is 100.2 ML/year with approximately 100.2 ML of runoff being generated from the site with this runoff being contained in on-site storages.

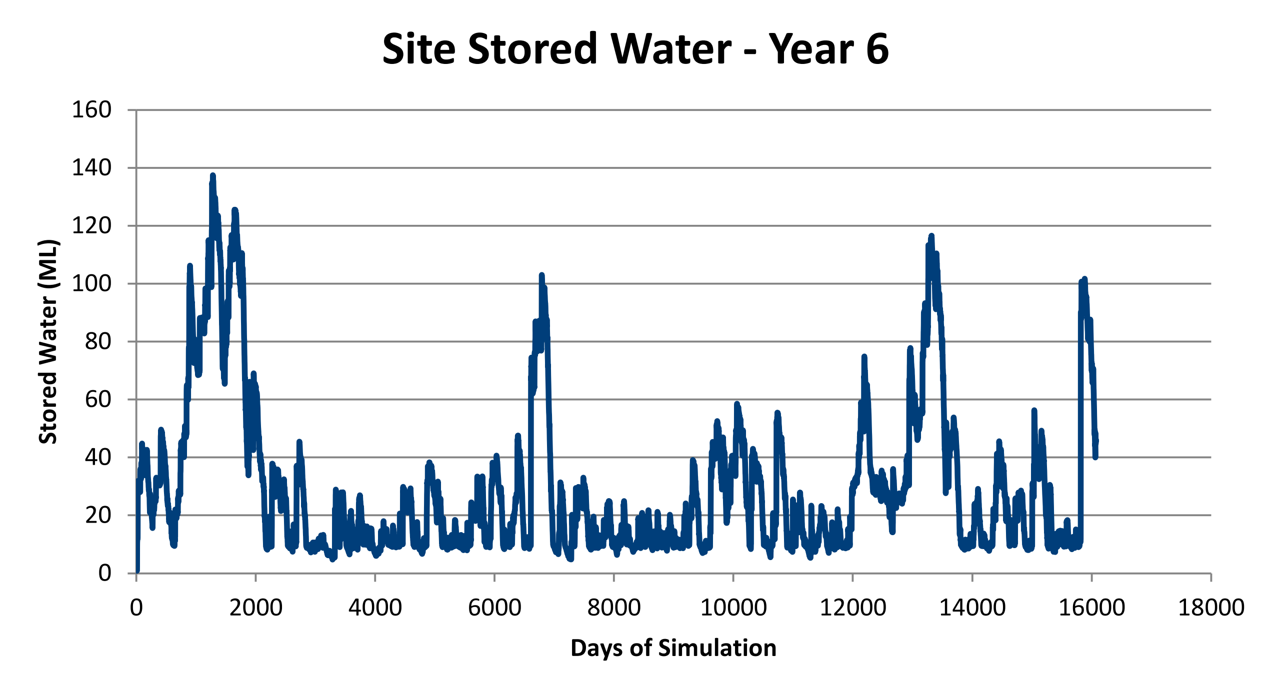


Plate 5.4

Year 6 water balance statistics

Plate 5.4 shows the variability in water storage over the 43 years of simulation.

Table 5.7 Year 30 water balance statistics

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Water Balance Excluding Overflows (ML)	-56.5	-31.7	-0.6	35.3	114.5	2.0
Water Balance Including Overflows (ML)						
Water Balance Including Overflows and Volume Change (ML)	0.0	0.0	0.0	0.0	0.0	0.0

Water Balance (ML)						
Statistic	**Minimum**	**10th %ile**	**50th %ile**	**90th %ile**	**Maximum**	**Average**
Demands						
Processing Plant Demands (ML)	18.0	18.0	18.0	18.0	18.0	18.0
Haul Road Demands (ML)	5.1	6.4	8.8	10.8	12.6	8.8
Exposed Area Demands (ML)	30.8	84.2	125.8	171.7	208.7	129.5
Evaporation from Water Storages (ML)	6.1	7.6	13.8	132.1	197.4	36.4
Rainfall Runoff						
Rainfall Runoff (ML)	68.2	117.2	171.5	321.9	407.4	194.7
Overflows						
Total Number of Overflows					0.0	
Maximum Overflow Volume (ML)					0.0	
Stored Volume (ML)	8.7				246.0	

Modelling indicates that under the range of rainfall and evaporation conditions experienced over the 43 year simulation period, the volume of water stored onsite on any day would range from 8.7 ML to 246.0 ML indicating that the quarry at Year 30 could be operated without the need to import significant volumes of water for processing or dust suppression and without the need for discharges from the site to Seven Mile Creek.

Modelling also indicates that modelled average (50%) total annual demand (processing, dust suppression, exposed areas and evaporation from water bodies) is 166.4 ML/year with approximately 171.5 ML of runoff being generated from the site with this runoff being contained in on-site storages.

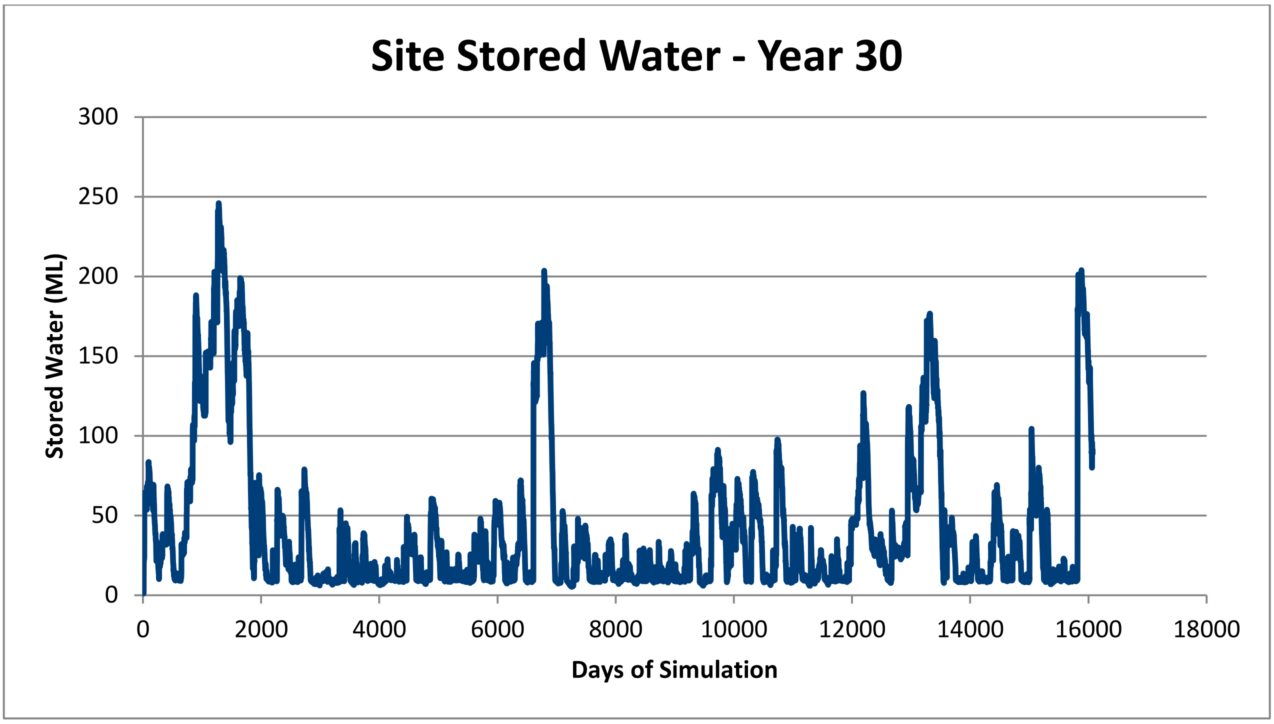


Plate 5.5

Year 30 water balance statistics

Plate 5.5 shows the variability in water storage over the 43 years of simulation

5.3 Sensitivity analysis

The sensitivity of the availability of water on-site and ability to contain runoff on-site has been explored for a range of operation stages balance using 43 years of daily rainfall and runoff data. This water balance modelling has shown the availability of water for processing and dust suppression and the volume of water stored on-site vary significantly. Analysis also shows that the proposed quarry water management system can accommodate this significant variation without the need to discharge water from the site. As set out in **Appendix 1a** sensitivity considerations indicate that groundwater make is within approximately 10% of estimated inflows to the quarry.

5.4 Proposed water management operation procedure

The proposed water management strategy is as follows:

- Construct sufficient storage initially to accommodate surplus water as predicted by the water balance model. A total Dam capacity of 57 ML is proposed to be constructed with this capacity supplemented through provision of in-pit storages.

- The quarry has been designed to contain runoff from in excess of a 1 in 100 Year ARI 24 hour event with this capacity demonstrated by the water balance modelling undertaken by the project which includes rainfall periods equivalent to back to back 1 in 100 Year ARI events.

- Retain sufficient water for one year's supply to the washing plant on site, although the volume will be reduced at the start of the wet season, and increased towards the end of the wet season, with a dry weather buffer storage of 10 ML.

- Maintain a freeboard equivalent to the 10 year ARI 24 hour storm event at all times, except immediately after an equivalent or more extreme event. Dam levels will then be drawn down through the reuse of water on-site.

Contingency plans to address the surplus water make or a water deficit are discussed in **Section 7.5**.

6.0 Surface and groundwater water impacts and water management methods

The Project and associated water management system has the potential to impact on surface and ground water systems. These potential impacts are discussed further in **Sections 6.1** to **6.11**.

6.1 Groundwater

The proposal to extract rock down to 45 mAHD will result in groundwater above this elevation seeping to the floor of the excavation. This will cause drawdown within the connected groundwater source. The main impact from the Project on the groundwater levels will occur in the central area of the Project boundary. Maximum predicted drawdown within the Project boundary is 15 m at the end of 30 years of extraction. Relatively slow extraction progress over 30 years (considering the area) reduces the impact of drawdown significantly.

There is limited impact of drawdown outside of the Site boundary with a maximum impact of less than 1 m at 300 m from the eastern, south and western Project Area boundary.

Groundwater modelling, as set out in **Appendix 1a**, indicates that the cumulative impact of the proposed quarry and surrounding developments and activities will be minor due to the limited propagation of drawdown of groundwater outside of the property boundary.

Modelling indicates that the underlying rhyolite/rhyodacite will remain confined with depressurisation of 1 m predicted within the Project boundary. This also indicates that the potential for cumulative impact of the proposed quarry and surrounding developments is low as the modelling indicates zero drawdown outside the property boundary.

6.1.1 Impact on nearby groundwater bores

Figure 3 of **Appendix 1a** shows the location of the bores in the vicinity of the Project. Groundwater Atlas (BoM 2016) and DPI Water database indicate the closest private bore is located about 400 m to the south-east of the Site (GW79737). The bore is installed at 20 m depth however no other information is available. Next closest private bore is located approximately 1.4 km south-west of the Site, installed in fractured rock aquifer and used for stock and domestic purpose (GW66683).

The prediction simulation indicates that drawdown outside of the Site boundary is zero; therefore negligible impact is predicted at any of the private bores.

6.1.2 Impact on baseflow

To explore potential impacts on baseflow in Seven Mile Creek, discharge to the creek was calculated for three segments in the groundwater model:

- the first segment includes Seven Mile Creek upstream to the confluence with its southern tributary
- the second segment consists of the southern tributary up to the confluence with Seven Mile Creek
- the third segment starts at the confluence of the Seven Mile Creek and its tributary to Grahamstown Dam.

Figure 5 of **Appendix 1a** shows Seven Mile Creek represented in the model.

The overall change in combined flow to these three segments is presented in Figure 16 of **Appendix 1a**. Although Seven Mile Creek is mainly ephemeral and losing in its upper reaches, it also receives minor baseflow contribution from groundwater, mainly in its lower reach. Results from predictive simulations using the numerical groundwater model for Eagleton Quarry show that there is minor baseflow loss to Seven Mile Creek from the Project with a decrease of 0.75 m^3/day (0.27 ML/year) over the period of 30 years of Project.

6.2 Annual flow volumes

The Project has the potential to impact on annual flow volumes (i.e. yield) due to the need to control runoff from disturbed areas, including quarry extraction areas and the various rock processing areas.

Table 6.1 indicates the catchment areas for Seven Mile Creek as measured at Grahamstown Dam for the following situations:

- prior to the Project
- with the maximum operational disturbance, expected to be from approximately Year 6 until the end of the Project with a net loss of catchment associated with the quarry of some 30.4 ha
- post-closure, with the quarry area free draining back to the Seven Mile Creek catchment.

Table 6.1 Predicted impacts on Seven Mile Creek catchment

Catchment	Total catchment area (ha)	Modified catchment area as a per cent of existing Seven Mile catchment area	Modified catchment area as a per cent of existing direct catchment to Grahamstown Dam
Existing Seven Mile Creek	302	100%	100%
Seven Mile Creek with the maximum quarry operational disturbance	272	90%	99.75%
Seven Mile Creek post-closure	302	100%	100%

Note: Catchment Area calculated at Grahamstown Dam wall.

The assessment indicates that the Project will reduce the catchment area of Seven Mile Creek and Grahamstown Dam for the life of the quarry with the net loss in catchment area being small relative to the total catchment of Grahamstown Dam. The direct catchment of Grahamstown Dam typically contributes approximately 50% of the total water make to the Dam with the remainder of the water being pumped to the dam from Williams River via Balickera Canal. The direct loss in yield is estimated to be less than 0.3% of net runoff into Grahamstown Dam.

In terms of the direct impact without considering the discharge of water, the small extent of the quarry will result in only a limited impact on the catchment area draining to Grahamstown Dam. However, for Seven Mile Creek, the reduction in catchment area is greater, being approximately 10% as set out in **Table 6.1**.

6.3 Water quality

The water management measures detailed in **Section 3.0**, including storage and containment of potentially affected water, reuse of water and the management of the overall water balance are intended to prevent uncontrolled spillage of water affected by quarry operations.

The water management system set out in **Section 3.0** includes provision of a significant water storage volume for the Project to prevent spilling for events at least up to the 10 year ARI 24 hour storm event.

The water balance detailed in **Section 5.0** indicates that the Project can be operated without discharging with water surplus of dust suppression and processing needs being reused in other areas on-site.

The following strategies are proposed:

- as indicated in **Section 3.0** water from the Project Area will be contained within in-pit storages and Dams 1 and 2
- internal treatment systems will be installed to contain and treat TSS and hydrocarbons should oil spillages occur
- sewage will be contained within a pump out system and removed off site.

Consequently, the Project can be operated with no impact on water quality in Seven Mile Creek.

In addition the Project will utilise a series of erosion and sediment control measures during construction, operation and rehabilitation phases of the Project to manage water quality (refer to **Section 6.8**).

The site is located within Grahamstown Dam catchment. In accordance with Hunter Water Corporation's recently prepared guidelines, 'Protecting our Drinking Water Catchments: Guidelines for developments in the drinking water catchments (HWC 2015)' the proposed development is required to demonstrate Neutral or Beneficial Effect on water quality (NorBE) which is defined as:

a) having no identifiable potential impact on water quality

b) will contain any water quality impact on the development site and prevent it from reaching any water course, water body or drainage depression on the site.

As discussed above, the proposed Eagleton Hard Rock Quarry facility will be operated with effectively a closed water management system and can be operated without discharging to Seven Mile Creek and Grahamstown Dam during storm events up to and including the 1 in 100 Year ARI 24 hour event. Water balance modelling using 43 years of daily rainfall and evaporation data shows that the proposed water management system can accommodate without discharge back to back 1 in 100 Year ARI 24 hour storm events as occurred at Eagleton on 21 and 22 April 2016. The proposed development has no identifiable potential impact on water quality and will contain any water quality impact on-site and therefore can achieve Neutral or Beneficial Effect on water quality (NorBE) as required by 'Protecting our Drinking Water Catchments: Guidelines for developments in the drinking water catchments (HWC 2015)'.

6.4 Downstream water users

There are no known water users on Seven Mile Creek between the Project Area and Grahamstown Dam. Consequently, there are no predicted impacts on water users between the Project Area and Grahamstown Dam.

The loss in yield to Grahamstown Dam is considered to be small in comparison to total volumes draining or pumped to Grahamstown Dam. .

6.5 Riparian and ecological values of the watercourses

Seven Mile Creek is a diverse ephemeral creek system with areas of ponding associated with erosion and deposition on Seven Mile Creek. The creek includes small gravel bars and pools that are likely to provide useful ecological habitats.

The loss of yield predicted for Seven Mile Creek will potentially impact on the drying and wetting cycles within the creek, however the reduction in yield is well within the normal seasonal and yearly rainfall variations. As such, the change in flow is unlikely to dramatically alter the flow regime and existing habitats.

6.6 Environmental flows

All of the creeks that originate on the Project area are ephemeral. The associated ecosystems supported by the creeks are thus adapted to drying out.

There are no known ecosystems within the ephemeral creeks that are dependent on environmental flows. Consequently, it is considered that there is no need for any special provisions for environmental flows within Seven Mile Creek.

The proposed bridge over Seven Mile Creek will be constructed so as to not impede flows or fish passage.

6.7 Flooding

Proposed changes to the catchment areas and landform associated with the Project have the potential to impact on flooding in the adjacent and downstream watercourses.

In order to determine the potential impacts of the Project on flooding, the XP-Storm® software was used to develop and run a 1D hydrodynamic flood model of Seven Mile Creek (refer to **Section 2.4.1**).

The flood modelling indicated that the peak velocities within the creek system are not excessive, typically within the range of 1.0 to 1.6 m/s, and that there are no areas of significance currently impacted by flooding.

Based on the flood extents presented in **Figure 2.6** and an anticipated reduction in catchment area, no additional impacts are expected due to flooding.

It is also noted that the bridge crossing proposed for the Seven Mile Creek has been designed to accommodate the 100 year critical duration flood without overtopping the access road. Erosion protection is proposed downstream of the culverts to reduce the risk of erosion. There are no areas of significance upstream of the bridge that may be impacted by increased ponding upstream of the bridge.

6.8 Erosion and sediment control measures

The risk of erosion and an increased sediment load downstream exists for both the construction and operational phases of the Project. Erosion and sediment control strategies and measures are discussed for each phase of the Project in **Sections 6.8.1** and **6.8.2**.

6.8.1 Construction phase

The construction phase erosion and sediment control measures will be carried out in accordance with relevant guidelines for erosion and sediment control, including the relevant volumes of the Blue Book, as follows:

- Landcom, 2004. Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.
- Department of Environment and Climate Change (DECC), 2008. Managing Urban Stormwater – Soils and Construction, Volume 2A – Installation of Services.
- DECC 2008. Managing Urban Stormwater – Soils and Construction, 2C – Unsealed Roads.
- DECC 2008. Managing Urban Stormwater – Soils and Construction, 2D – Main Road Construction.
- DECC 2008. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

The erosion and sediment control strategies and measures to be implemented for construction activities will include:

- ensuring that the water management dams required for sediment control are constructed downstream of proposed construction areas prior to other construction activities in order to prevent sediment movement off site
- use of sediment fences, catch drains and other appropriate collection and interception measures during the construction of the water management dams and other water management components
- addition of gypsum to soils in the Project area to reduce their dispersivity as and where required prior to the rehabilitation of the soils
- ongoing inspection and maintenance on the sediment control measures, including improvements to the rehabilitation of areas that are eroding, desilting activities, and other general maintenance.

Particular attention will be paid to areas outside of the quarry water management system such as the entrance road and associated creek crossing. Any contractor undertaking work on the Project will be required to prepare a detailed construction Erosion and Sediment Control Plan which meets the requirements of the Blue Book Volumes 1 and 2 (Landcom 2004 and DECC 2008).

6.8.2 Operational phase

During the operational phase, additional water management components will be constructed as work progresses, but additional components (sediment dams) will remain within the perimeter of the initial water management system. The operational phase will involve the ongoing management of the water management system, and be consistent with:

- Landcom 2004. Managing Urban Stormwater – *Soils and Construction, Volume 1, 4th Edition*
- DECC 2008. *Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries*.

Specific erosion and sediment control strategies and measures for the operational phase of the Project will include:

- ensuring that the measures set out in **Section 3.0** to divert clean runoff away from the Project area and those required to contain affected runoff are constructed as appropriate
- identifying and delineating disturbance areas and ensuring that these are minimised, for example, where clearing vegetation ahead of quarry extraction activities
- limiting the number of roads and tracks on undisturbed areas, outside of the quarry extraction area
- reviewing the performance of the sediment dams in terms of the volume of sediment collected, and ensuring compliance of the water quality during spill events
- assessing the adequacy of the maintenance on the sediment control system, including channel maintenance, frequency of desilting of dams, and related issues that could impact on the performance of the water management system
- ensuring adequate freeboard is maintained to contain runoff from the 100 year ARI 24 hour storm event
- managing erosion on topsoil stockpiles and other disturbed areas, including a review of the rehabilitation practices both on a regular basis and when issues are identified.

6.9 Final landform and post-closure

The proposed quarry operation will result in a final landform that comprises a series of 10 m wide and 15 m high benches at the western end of the quarry. The floor of the quarry will have an overall slope of approximately 0.5% and will drain along varying drainage line alignment from the benched section at the western end of the quarry to Dams 1 and 2 at the south-eastern boundary of the extraction area. The floor of the quarry will be predominantly free draining and will not have a final void. Several minor depressions will however be created along the in the alignment of the drainage line. These minor depressions will help reduce erosion potential, enhance the sediment trapping capacity and in the longer term increase habitat value of the quarry floor which is to be vegetated with native species.

The minor depressions will also provide a passive mechanism for groundwater recharge into the underlying stratum. This will assist in offsetting the predicted 7.5 ML/year reduction groundwater recharge at Year 30 (see **Attachment 1a**) as a result of groundwater seeping from the elevated benched area the western edge of the proposed quarry onto the quarry floor.

The proposed final landform will be 80 to 90% grassed area the impact on surface water is not expected to be significant. However, the flatter profile of the area post-closure compared to pre-development will potentially reduce the runoff from the area. The exact vegetation to be established has also still to be determined, and the extent to which the area is woodland or grassland could also impact on the runoff volumes.

It is proposed that:

- a minimum slope of the order of 0.5% will be applied to the quarry floor to ensure that runoff from the Project Area occurs post-closure

- the water management system will remain in place until the water quality from the Project area meets the target objectives for the area. With the use of vegetation and only limited exposed inert rock, it is expected that there will be limited risk of impacts on surface water post-closure.

6.10 Summary of potential impacts

The Project, as with any quarry, has the potential to impact on the runoff to and water quality of the downstream watercourses, as well as affecting the flood peaks. In broad terms, the assessment indicates that:

- With the implementation of the proposed water management system for the Project, it is estimated that there is a low risk of impacting on the water quality of the downstream watercourses due to the proposed construction of water management dams and sumps, ongoing monitoring of water qualities, and regular review of the adequacy and functioning of the water management system (refer to **Sections 3.0** and **7.0**).

- The reduced catchments in the operational phase and post-closure will impact on the annual flow volumes of Seven Mile Creek. The environmental consequences of the loss in catchment area are predicted to be limited due to the ephemeral nature of Seven Mile Creek.

- The impact on annual catchment runoff volume to Grahamstown Dam is considered to be negligible based on a loss in yield estimated to be of the order of 0.3%.

- The reduction in catchment area to Seven Mile Creek and Grahamstown Dam can potentially be mitigated by the discharge of water of a suitable quality in terms of an EPL if authorised.

- No significant change to the flooding risk downstream of the Project area is predicted as a consequence of the proposed Eagleton Quarry. Some small changes are expected due to the slightly reduced catchment area to Seven Mile Creek, and the presence of an access road crossing Seven Mile Creek.

- Post-closure, the area will become largely vegetated with slightly reduced runoff volumes compared to the pre-development due to flatter slopes.

6.11 Cumulative impacts

Eagleton Quarry, if approved, will not be the only quarry operating within the Seven Mile Creek catchment. Boral Quarries already operate within the Seven Mile Creek catchment upstream of the proposed Project.

It is estimated from aerial photography that approximately 35 ha of Boral Quarry is located within Seven Mile Creek catchment. It is understood that Boral has approval to discharge to Seven Mile Creek under certain conditions with these discharges contributing to flow volumes in Seven Mile Creek.

The cumulative loss of yield to Seven Mile Creek at full development of the proposed Eagleton Hard Rock Quarry will be the runoff from approximately 65 ha of the catchment if no discharges from either Boral Quarry or proposed Eagleton Hard Rock Quarry occur. As the stream is intermittent and exhibits significant variation in flow volume and flow duration, it is considered that a reduction in flow volume in Seven Mile Creek will not significantly impact on downstream ecosystems.

The proposed quarry has been designed to fully contain runoff from up to a 1 in 100 year ARI 24 hour event with the captured runoff stored and reused on-site. The quarry can also be operated, if approval is granted to allow controlled discharges of suitable quality water from Dam 1 to Seven Mile Creek to assist in maintaining flow volumes in the creek system. Modelling indicates that suitable quality water could be discharged from Eagleton Hard Rock Quarry at a rate equal to or in excess of the current contribution to flows in Seven Mile Creek from the Project area.

7.0 Monitoring, licensing and reporting

The monitoring proposed in **Sections 7.1** to **7.4** will be detailed, including monitoring frequency, and analysis and reporting methods in the Surface and Groundwater Monitoring Program for the Project which will be prepared as part of the implementation of the Project.

The ANZECC guidelines and site-specific water quality monitoring data for Seven Mile Creek will be used to inform review of monitoring data. Monitoring will also compare upstream and downstream water qualities.

7.1 Monitoring erosion and sediment controls

Erosion and sediment controls will be monitored during construction and operation in accordance with the Blue Book (Landcom 2004 and DECC 2008) including regular inspections and inspection after rainfall events causing runoff during construction.

7.2 Water balance monitoring

As part of the water management system Eagleton Rock Syndicate Pty Ltd will monitor water imported, water use, volumes stored, and any discharges from the Project in accordance with NOW reporting requirements.

7.3 Groundwater monitoring

Monitoring of groundwater level, pH, Conductivity, alkalinity, salinity, Chloride, Calcium, Magnesium, Sodium, Potassium, Metals, Nutrients, PAHs, TPH, TRM and VOCs was undertaken by URS (February 2014) at groundwater bores, GWB01, GWB02, GWB03, GWB04 and GWB05 (see **Figure 7.1**).

Quarrying will disturb these bores GWB03, GWB04 and GWB05 within approximately the first three years of operations. All bores will continue to be monitored until they are disturbed. Groundwater bores GWB03 and GWB05 will not be replaced. GW04, which is located within the proposed processing plant area, will be replaced once the rock to be quarried from the processing area is extracted. Monitoring results from GWB03, GWB04 and GWB05 prior to being disturbed will be cross-referenced with results from GWB01 and GWB02 which will not be quarried through for in excess of 10 years. Once GWB04 is re-established it will also continue to be monitored and cross-referenced with results from GWB04 prior to it being quarried and GWB01 and GWB02 after it is replaced. At least two years prior to GWB01 and GWB02 being quarried through, an additional replacement groundwater monitoring bore will be established within or adjacent to the quarry footprint.

It is proposed to monitor groundwater levels at these bores quarterly and the following water quality parameters six monthly:

- pH
- Conductivity
- Total Dissolved Solids
- Chloride

- Arsenic
- Total Phosphorus
- Total Nitrogen, NOx, Ammonia.

Groundwater level and quality results will be analysed, compared with groundwater model predictions and reported annually.

7.4 Surface water monitoring

Surface water quality monitoring will be undertaken at upstream and downstream locations on Seven Mile Creek. For the Project, ongoing surface water quality monitoring will aim to:

- Record and document the water qualities upstream and downstream of the Project so as to highlight any areas of concern or impact. Proposed surface water monitoring points are shown on **Figure 7.1**. Water quality in Seven Mile Creek will be monitored monthly and if discharges occur from the proposed quarry. Parameters monitored will include pH, Electrical Conductivity (EC), TSS, Total Phosphorus and Total Nitrogen.
- Monitor the performance of the water management systems and associated sediment control measures. This monitoring will be undertaken monthly and after major storm events. Flow monitoring of Seven Mile Creek will be undertaken by visual observation during water quality sampling, the visual flow data observations will be used to inform the assessment of water quality data.
- Document rainfall depths, water usages, dam volumes and any discharges that may occur during extreme events or in accordance with approval conditions together with other data that will facilitate updating of water balances, assessment of spill risk and associated water management requirements.
- Review and monitor the performance of erosion and sediment controls at construction areas, including the creek crossing and associated water management measures.
- Undertake safety and maintenance checks biennially (every two years) on all water management dam walls to assess structural integrity and maintenance requirements, including removal of any trees and shrubs that may impact on the integrity of the walls, and ensuring adequate erosion protection is in place.
- Report results of surface water monitoring activities in the Annual Environmental Review which will be distributed to the relevant government agencies and made available to the public. All monitoring data will be retained in an appropriate database.

7.5 Contingency measures

The process of detailed design, construction and monitoring/maintenance of the proposed water management system during the operational phase is designed to reduce the risks associated with unplanned spillages or unforeseen circumstances taking into consideration the range of potentially relevant environmental factors and variables that may reduce the risk of the implemented system not performing as planned.

The following key components will be used as required during the Project, to address potential surface water impacts:

- Water shortages: The water balance modelling has indicated that there is a low risk that sufficient water will not be available for the washing plant, with the main risk of a water shortage for the washing plant being during the initial Project development.

  Further, in drier than average years, water balance modelling indicates that there is potential for a shortfall in the water required for dust suppression. It is predicted that a buffer storage of 10 ML for the washing plant will allow the inflows during drier than average periods to be used for dust suppression.

  The analysis of dry periods using the historic rainfall record indicates that during extreme dry periods, the availability of water for dust suppression will reduce to roughly 50% of the targeted water usage. To meet these potential shortfalls, water will be imported to the site using contract water cart operators and additional dust suppression measures will be explored. These measures will include the use of surface sealants and additives in dust suppression water.

  If, for whatever reason, there is a water shortage, the Project will utilise external water sources such as contract water tankers, or obtaining additional water supply from the Balickera canal. Additional water sources would be utilised in accordance with relevant licences and approvals.

  Any dust suppression additives used will be subject to agreement with the authorities to ensure there are no significant water quality impacts due to the use of these additives.

- Water surplus: The risk of spilling from the water management dams has been assessed as part of detailed water balance modelling which indicates that through the provision of dams and in pit storages the quarry can be operated without discharging to Seven Mile Creek. A number of additional contingency measures could be included if required
  - obtain an EPL to treat and discharge water as required to maintain sufficient freeboard in the dams for the 100 year ARI 24 hour storm event including the identification of a range of alternative treatment technologies that could be employed if required
  - excavation of additional water sumps within the quarry floor, both to increase the available storage, as well as to reduce the water make by reducing the area for which high runoff volumes occur with additional evaporation area
  - possible supply of water not suitable for release to Seven Mile Creek to other quarries or industries in the area that currently abstract water for use, where such supply is authorised by the relevant government agencies
  - possible increased water usage, including options such as fixed irrigation systems in dirty areas, and increased dust suppression.

- Unforeseen failure or catastrophic events: In the event of an unforeseen spillage such as associated with accidental damage, operational failures or extreme catastrophic occurrences, the hazard notification protocols in the proposed Water Management Plan will be followed.

- Possible impacts of climate change: The water balance assessment does not include a direct evaluation of the possible impacts of climate change on the water balance due to the small volumes of water involved. The broad range of rainfall and evaporation conditions considered in designing the quarry is considered representative of changes that may occur over the life of the quarry. In addition the quarry has been designed to safely contain and convey runoff from a Probable Maximum Flood event that provides significant flexibility in the capacity to management water on a day to day basis.

7.6 Decommissioning of the water management system

As part of decommissioning the quarry at the end of the Project, water management dams will either remain in use for identified and approved future land uses or will be removed. If the dams are to be retained, the required capacity of the dams will be assessed and modified as necessary. Some of the proposed diversion drains and channels will remain in place as part of the final landform in circumstances where they are considered to be stable in the long term and where required to minimise erosion.

All areas disturbed by removal or modification of water management structures will be reshaped and revegetated. The measures required to effectively decommission the water management system and the water management controls required in the final landform will be considered in further detail as part of the detailed quarry closure planning process.

7.7 Licensing requirements

7.7.1 Protection of the Environment Operations Act

The proposed mine water management system, along with the total proposed quarry operations, will be licensed under the *Protection of the Environment Operations Act 1997* Section 120.

7.7.2 Water Management Act 2000

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* applies to the areas in the vicinity of the Project area including all surface water flows from the Project area. Therefore, the surface water of the Project area is governed by the *Water Management Act 2000.* All water proposed to be used on-site will be sourced from the quarry's dirty water management system.

Groundwater at the site is managed by Water Sharing Plan for North Coast Fractured and Porous Rock Groundwater Sources under the *Water Management Act 2000*. Eagleton Rock Syndicate Pty Ltd will need to acquire a licence to take 7.5 ML of groundwater from the groundwater source.

Eagleton Rock Syndicate Pty Ltd proposes to operate the Project using a containment and reuse process for captured affected water used to provide for the water requirements.

Potable water needs for the Project will be supplied via tanker truck.

7.8 Reporting

Performance of the water management system will be reported annually as part of an Annual Environmental Review. The Annual Review will report against development consent condition requirements and, if required, as part of annual reporting to the Environmental Protection Authority (EPA) as part of EPL conditions. The Annual Review will be made available to the public as well as being distributed to relevant government agencies.

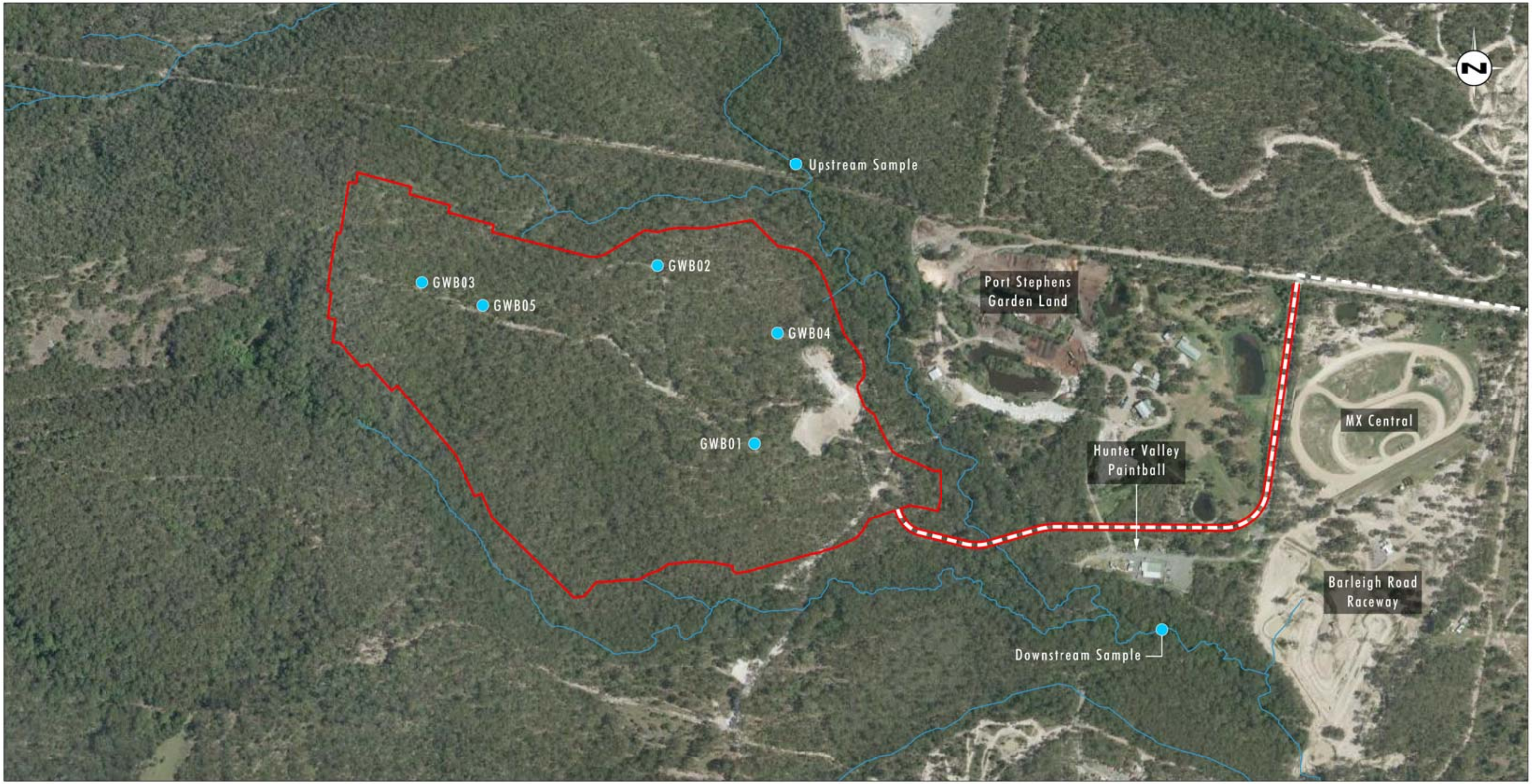


Image Source: Google Earth (2009)

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Legend

- Project Area
- Dam Area
- Drainage Line
- Access Road
- Water Monitoring Point

FIGURE 7.1

Water Monitoring Points

File Name (A4): R04/3102_059.dgn
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