



Eagleton Rock Syndicate Pty Ltd

**EAGLETON HARD ROCK
QUARRY**

Water Assessment

FINAL

October 2016

Eagleton Rock Syndicate Pty Ltd

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Water Assessment

FINAL

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Eagleton Hard Rock Syndicate Pty Ltd

Project Director: Peter Jamieson
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Quality
ISO 9001

This report was prepared using
Umwelt's ISO 9001 certified
Quality Management System.

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

Table of Contents

1.0	Introduction	1
1.1	Project overview	1
1.2	Water planning context	2
1.3	Potential water resource impacts	3
1.4	Report overview	4
1.5	Water management overview	4
1.6	Statutory and Regulatory Requirements	7
1.6.1	Secretary's Environmental Assessment Requirements (SEARs)	7
1.6.2	Hunter Water Special Areas Regulation 2010	9
2.0	Existing surface water environment	13
2.1	Rainfall and evaporation	13
2.1.1	Historical rainfall trends	14
2.1.2	Historical evaporation trends	16
2.1.3	Design rainfall for extreme events	17
2.2	Catchment areas and watercourses	17
2.2.1	Catchment overview	17
2.2.2	Watercourse characterisation	18
2.3	Water quality	20
2.3.1	Hunter Water Corporation monitoring	20
2.3.2	Project water quality monitoring – Seven Mile Creek	29
2.3.3	Water Quality Trigger Values	32
2.4	Water quantity	33
2.4.1	Mean annual runoff	33
2.4.2	Average dry weather flows	33
2.4.3	Flood regimes	34
2.5	Water use	34
3.0	Proposed water management system	42
3.1	Overview	42
3.2	Water management system performance criteria	42
3.3	Water management of quarry operations	45
3.3.1	Water management during construction phase to Year 1	45
3.3.2	Water management system – Year 1 to Year 3	46
3.3.3	Water management system – Year 5	46
3.3.4	Water management system – Year 6	46
3.3.5	Water management system – Ultimate development footprint and final landform	47
3.4	Surface water management for infrastructure areas	47

3.4.1	Offices and access control area	47
3.4.2	Workshops and washing plant areas	47
3.4.3	Access road crossing Seven Mile Creek	48
4.0	Groundwater	56
4.1	Groundwater modelling and peer review	56
4.2	Modelled groundwater inflow and potential impacts	57
4.3	Water Sharing Plan for the Sydney Basin – North Coast Fractured and Porous Rock Groundwater Sources	58
4.4	Aquifer Interference Policy	61
5.0	Water balance	64
5.1	Model input data and assumptions	64
5.2	Water Balance Simulation Results	66
5.3	Sensitivity analysis	76
5.4	Proposed water management operation procedure	76
6.0	Surface and groundwater water impacts and water management methods	78
6.1	Groundwater	78
6.1.1	Impact on nearby groundwater bores	78
6.1.2	Impact on baseflow	78
6.2	Annual flow volumes	79
6.3	Water quality	80
6.4	Downstream water users	80
6.5	Riparian and ecological values of the watercourses	81
6.6	Environmental flows	81
6.7	Flooding	81
6.8	Erosion and sediment control measures	81
6.8.1	Construction phase	82
6.8.2	Operational phase	82
6.9	Final landform and post-closure	83
6.10	Summary of potential impacts	84
6.11	Cumulative impacts	84
7.0	Monitoring, licensing and reporting	86
7.1	Monitoring erosion and sediment controls	86
7.2	Water balance monitoring	86
7.3	Groundwater monitoring	86
7.4	Surface water monitoring	87
7.5	Contingency measures	87
7.6	Decommissioning of the water management system	89
7.7	Licensing requirements	89

7.7.1	Protection of the Environment Operations Act	89
7.7.2	Water Management Act 2000	89
7.8	Reporting	89
8.0	References	91

Figures

Figure 1.1	Locality Plan	11
Figure 1.2	Project Overview	12
Figure 2.1	Location of Rainfall and Evaporation Gauges	36
Figure 2.2	Average Monthly Rainfall	37
Figure 2.3	Average Monthly Pan Evaporation	38
Figure 2.4	Water Catchments	39
Figure 2.5	Seven Mile Creek Flood Extents	40
Figure 2.6	100 Year Flood Extents Seven Mile Creek	41
Figure 3.1	Schematic Water Management at Year 1	49
Figure 3.2	Construction to Water Management Year 1	50
Figure 3.3	Water Management Year 1 – Year 3	51
Figure 3.4	Water Management Year 5	52
Figure 3.5	Water Management Year 6	53
Figure 3.6	Water Management Ultimate Development Footprint	54
Figure 3.7	Water Management Conceptual Final Landform	55
Figure 7.1	Water Monitoring Points	90

Plates

Plate 2.1	Catchment in the vicinity of the Project Area (July 2012)	17
Plate 2.2	Mature forest in the vicinity of the Project Area (July 2012)	18
Plate 2.3	Seven Mile Creek (July 2012)	20
Plate 2.4	Total Phosphorus concentrations in Seven Mile Creek and Nine Mile Creek	24
Plate 2.5	Turbidity concentrations in Seven Mile Creek and Nine Mile Creek	25
Plate 2.6	Ammonia concentrations in Seven Mile Creek and Nine Mile Creek	26
Plate 2.7	Nitrogen concentrations in Seven Mile Creek and Nine Mile Creek	27
Plate 2.8	E. Coli counts in Seven Mile Creek and Nine Mile Creek	28
Plate 2.9	Entrococci counts in Seven Mile Creek and Nine Mile Creek	29
Plate 5.1	Year 1 water balance statistics	68
Plate 5.2	Year 3 water balance statistics	70
Plate 5.3	Year 5 water balance statistics	72
Plate 5.4	Year 6 water balance statistics	74
Plate 5.5	Year 30 water balance statistics	76

Appendices

Appendix 1 a	Full technical details of surface and groundwater modelling
Appendix 1b	CV – Katarina David
Appendix 1c	Groundwater Model – Peer Review
Appendix 2	Water quality monitoring – Hunter Water Corporation – Seven Mile Creek and Nine Mile Creek
Appendix 3	Project-specific water quality monitoring – Seven Mile Creek

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 (m³) 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 $\mu\text{S}/\text{cm}$. 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 <i>Water Act 1912</i> and/or <i>Water Management Act 2000</i>	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

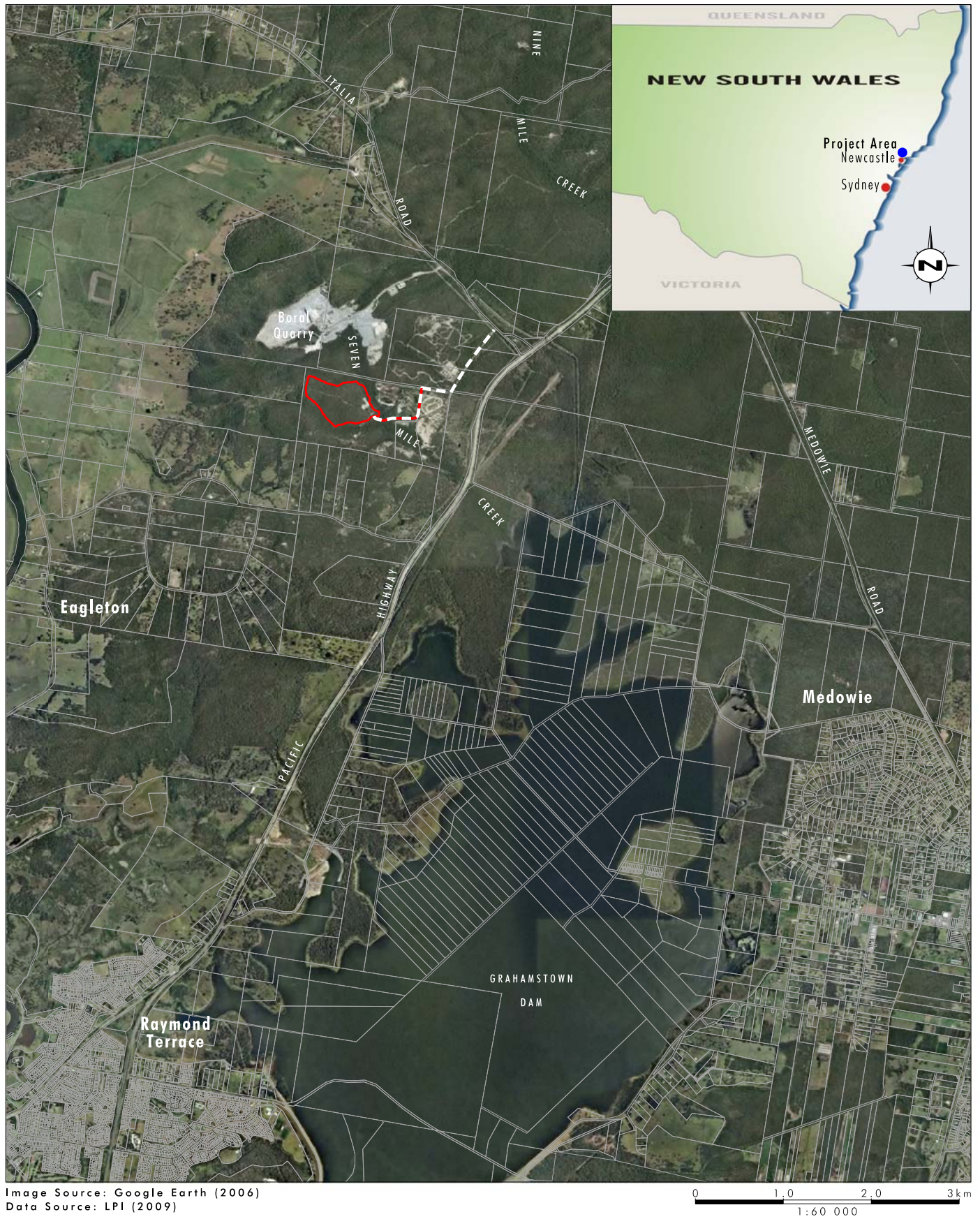
- (1) The owner or occupier of land in a special area must not erect, install or operate any on-site sewage management facility on the land.
Maximum penalty: 100 penalty units in the case of a corporation, or 70 penalty units in any other case.
- (2) This clause does not apply to anything done in accordance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



Legend

- Project Area
- Access Road

FIGURE 1.1
Locality Plan

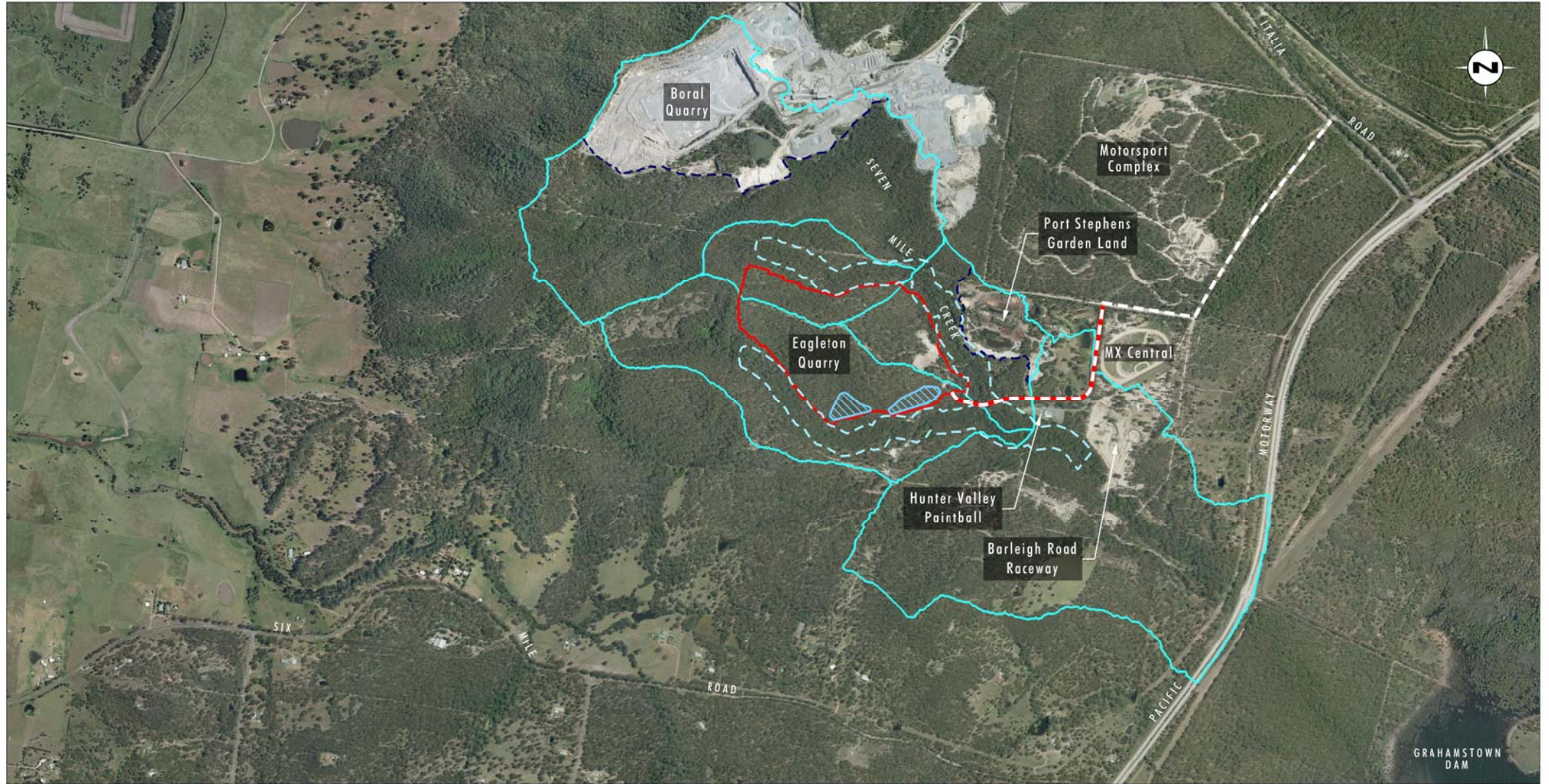


Image Source: Google Earth (2009)

Legend

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

FIGURE 1.2
Project Overview

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 Williamstown RAAF, together with the yearly average, is given in **Table 2.2**.

Table 2.2 Average monthly rainfall depths at Williamstown 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 Williamstown 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 is 75% 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)

© Umwelt, 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)

© Umwelt, 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
<i>E. Coli</i> Seven Mile Creek (MPN/100 mL)	N/A	1470
<i>E. Coli</i> Nine Mile Creek (MPN/100 mL)	N/A	153
Enterococci Seven Mile Creek (col/100 mL)	N/A	365
Enterococci 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
<i>E. Coli</i> Seven Mile Creek (MPN/100 mL) (2015-2016)	15	1470	16328
<i>E. Coli</i> 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.

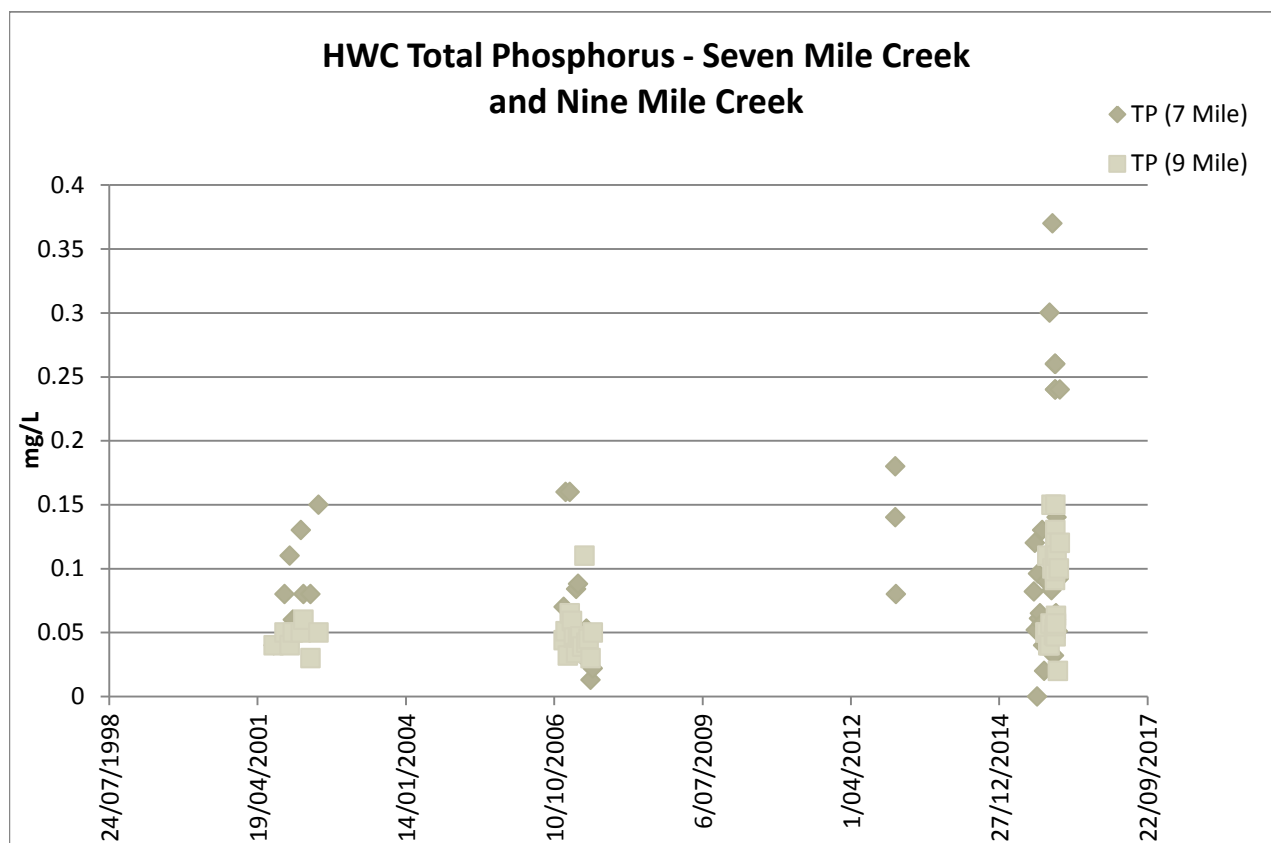


Plate 2.4

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.

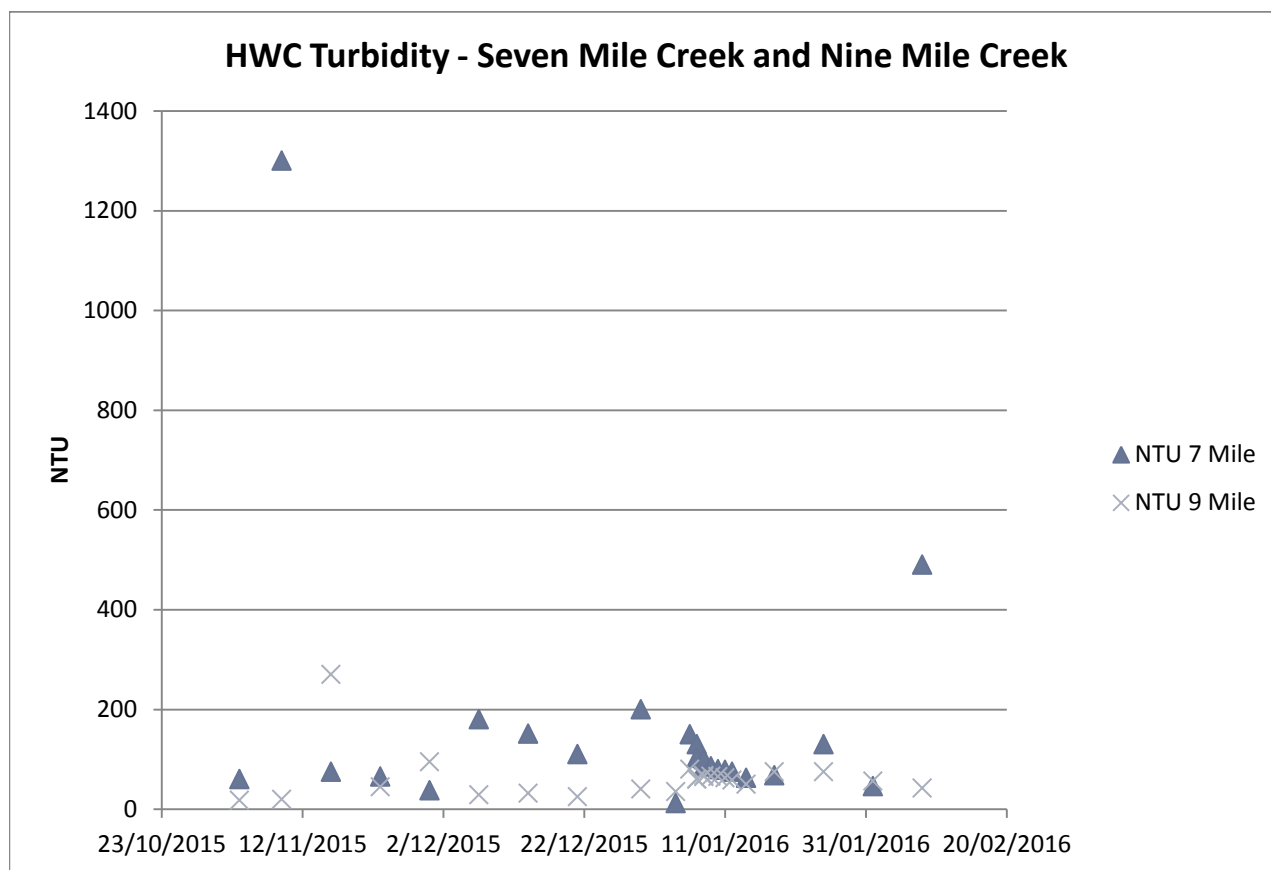


Plate 2.5

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**.

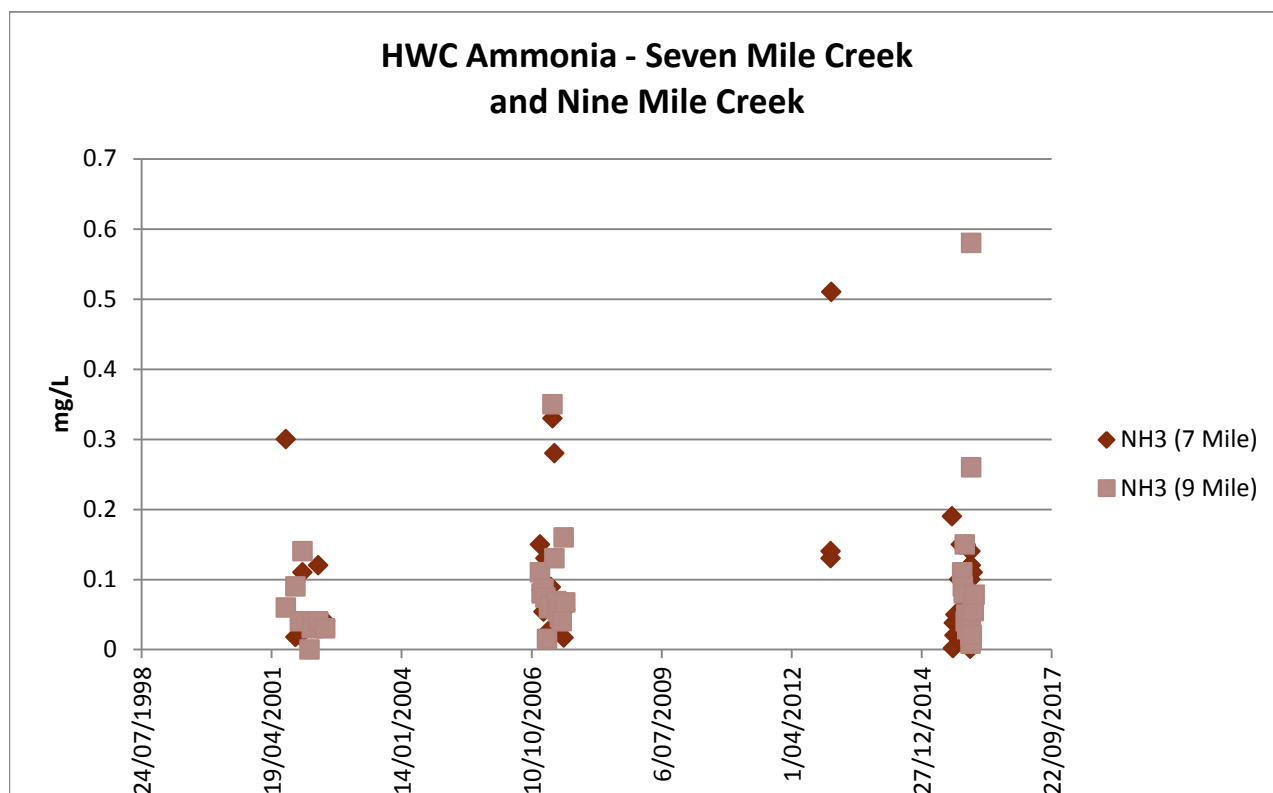


Plate 2.6

Ammonia concentrations in Seven Mile Creek and
Nine Mile Creek

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**.

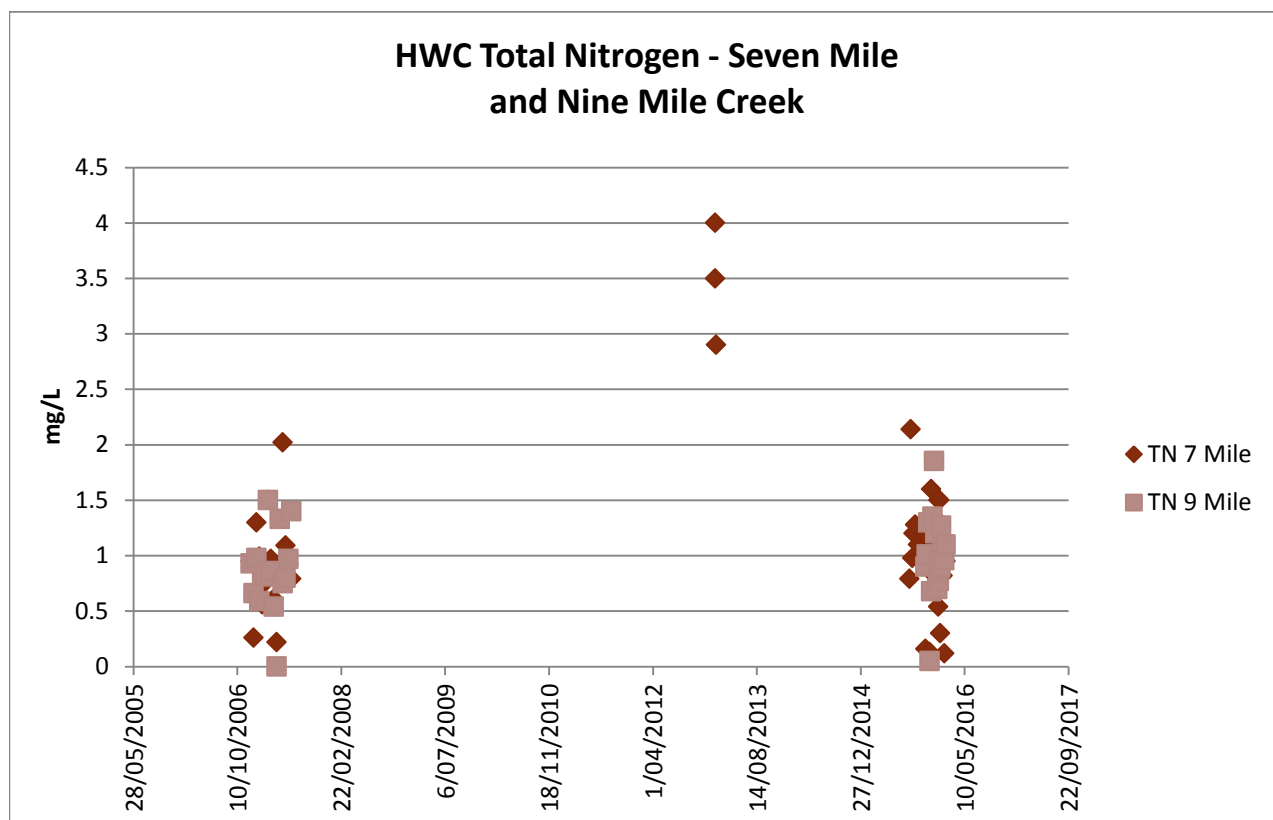


Plate 2.7

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.

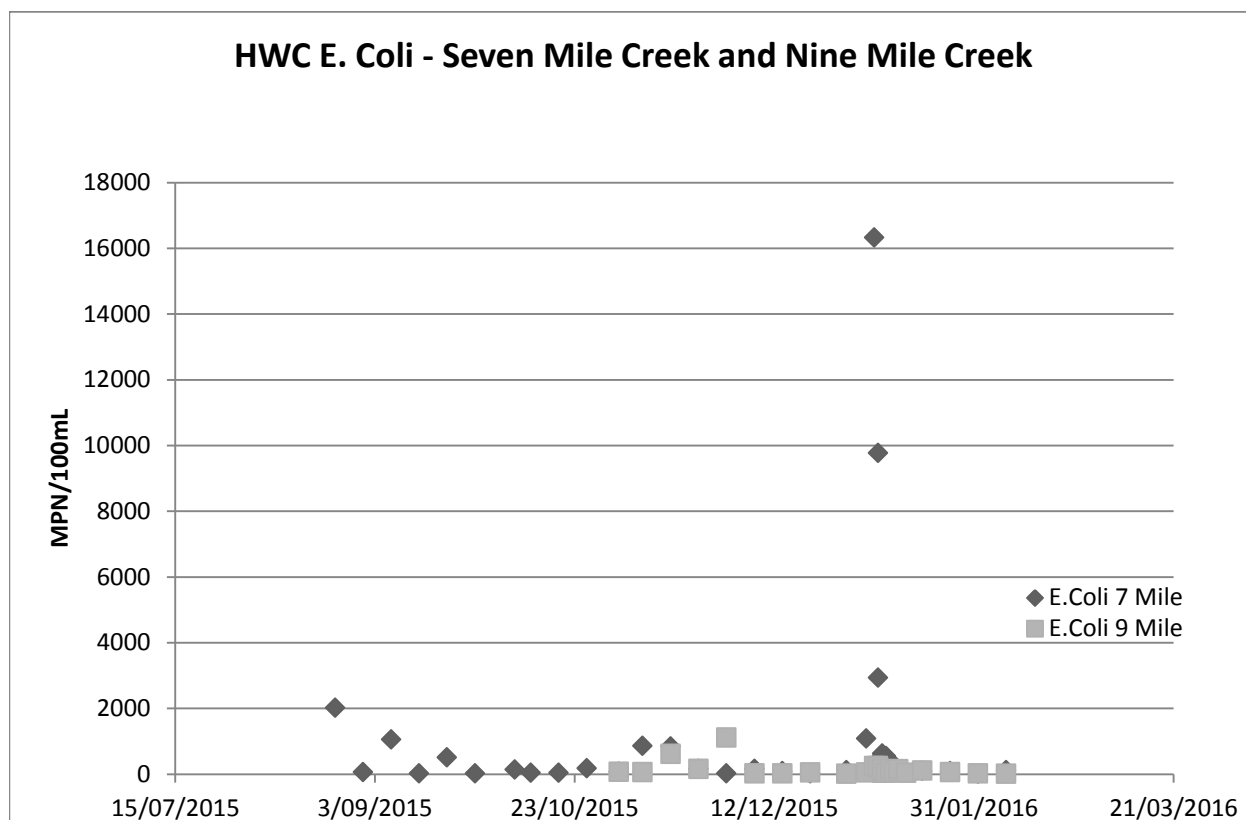


Plate 2.8

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**.

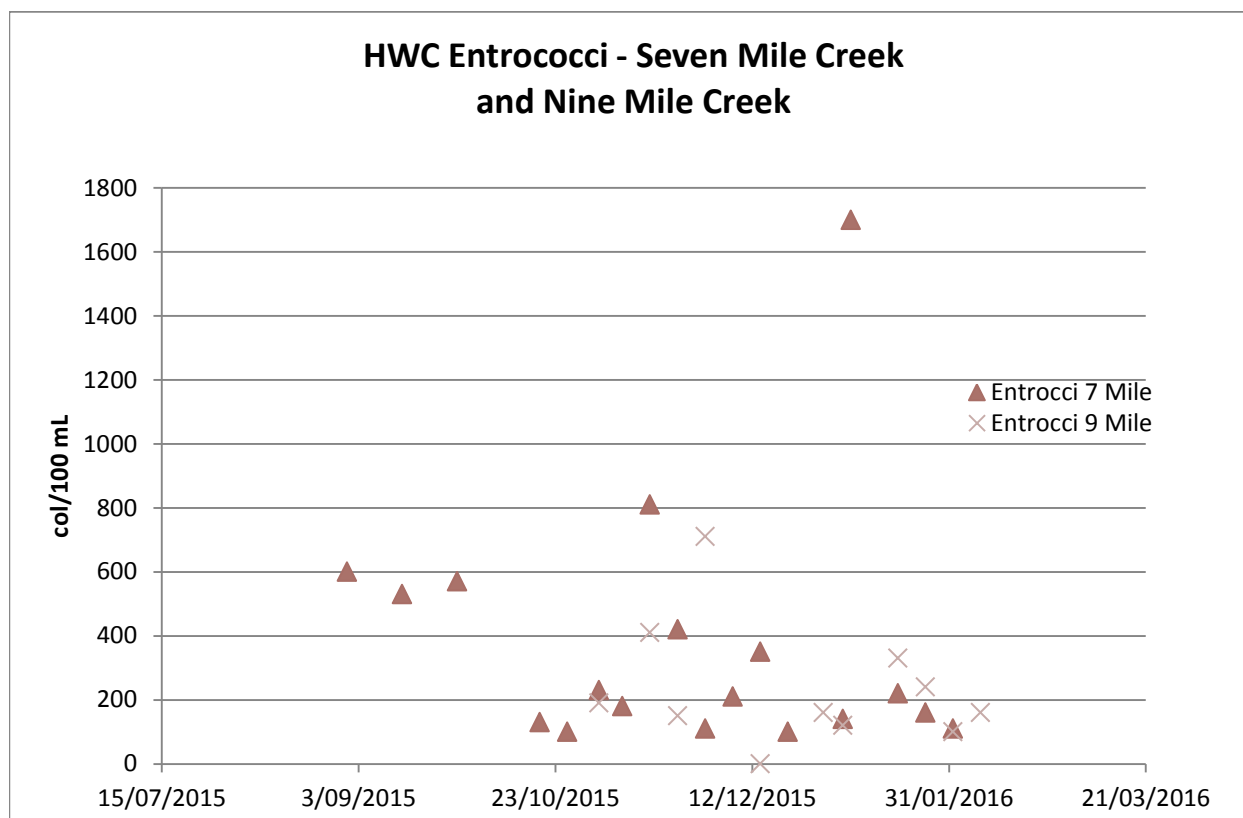


Plate 2.9

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 ($\mu\text{S}/\text{cm}$)

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 ($\times 10^6 \text{m}^3$)
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.

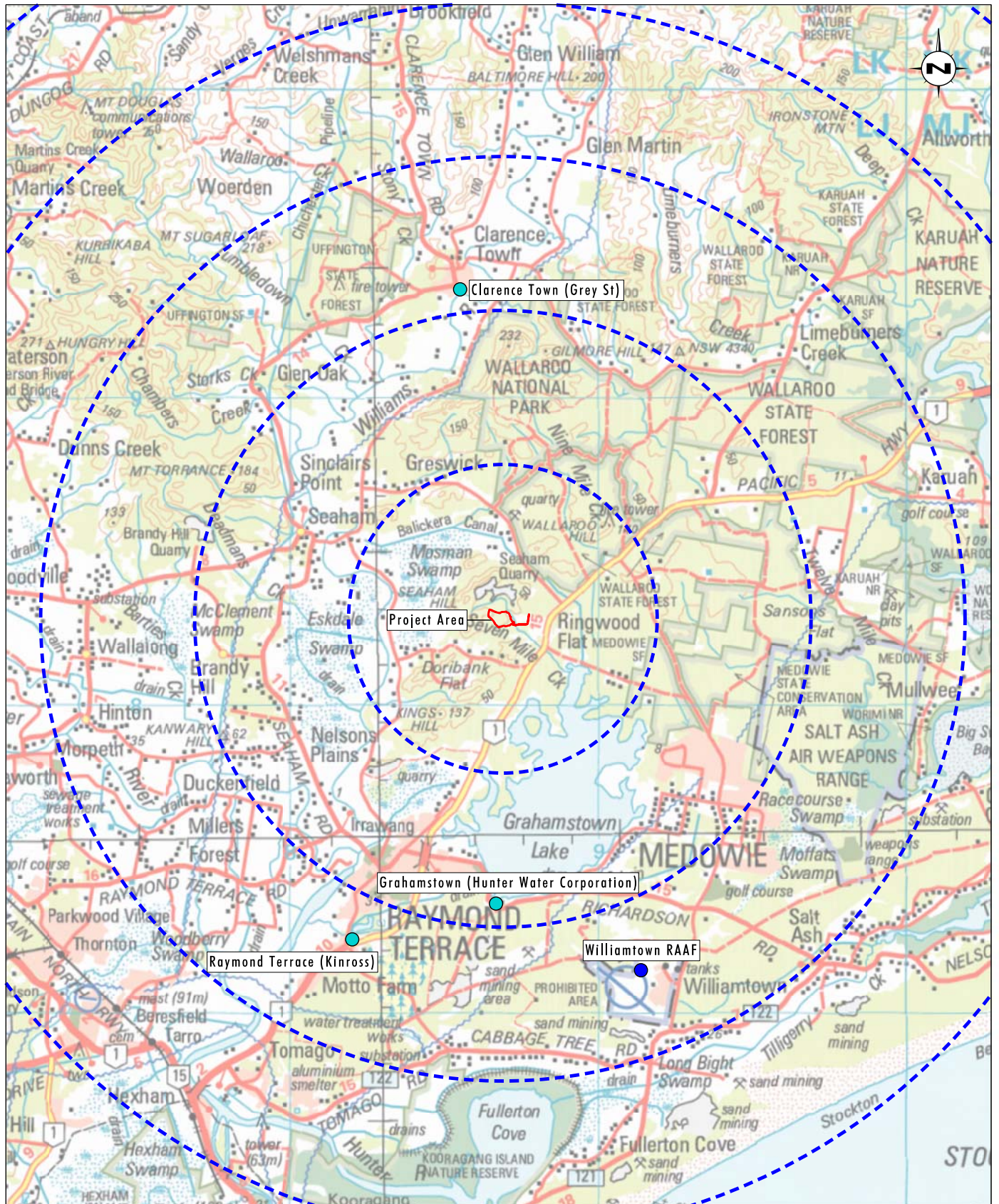


Image Source: Natmap, Geoscience Australia (2008)

0 2.0 4.0 8 km
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

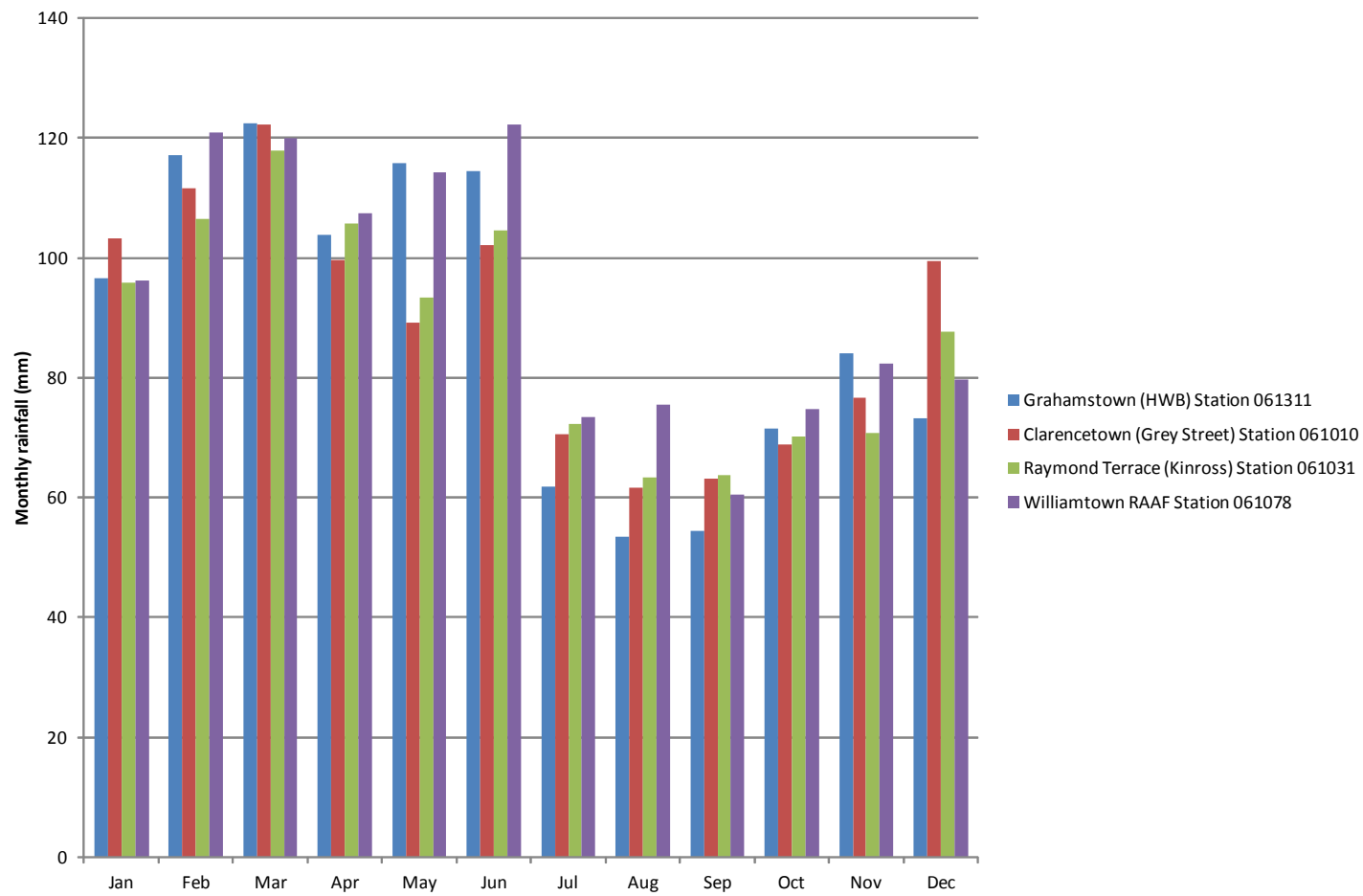


FIGURE 2.2
Average Monthly Rainfall

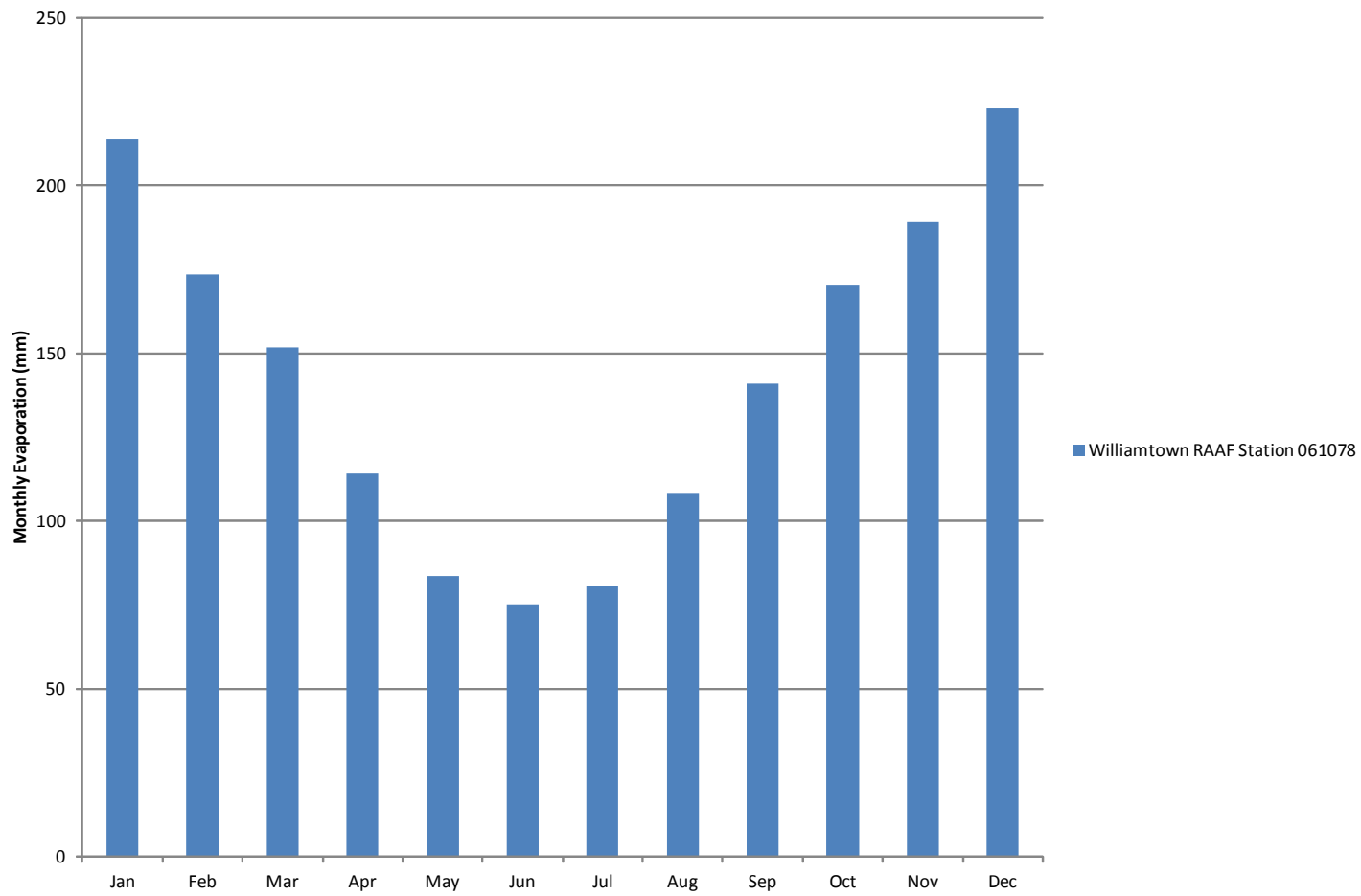


FIGURE 2.3
Average Monthly Pan Evaporation

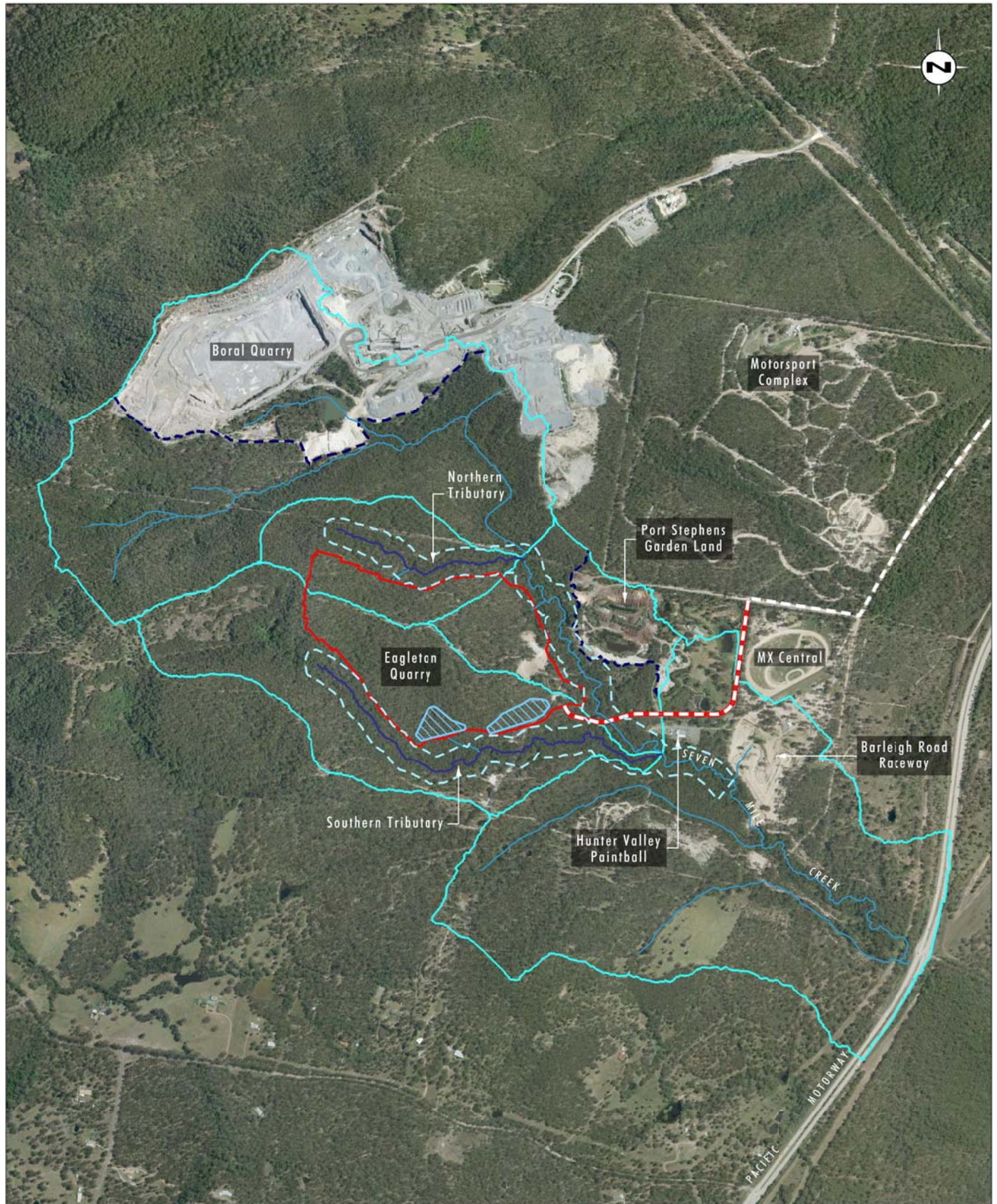


Image Source: Google Earth (2009)

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

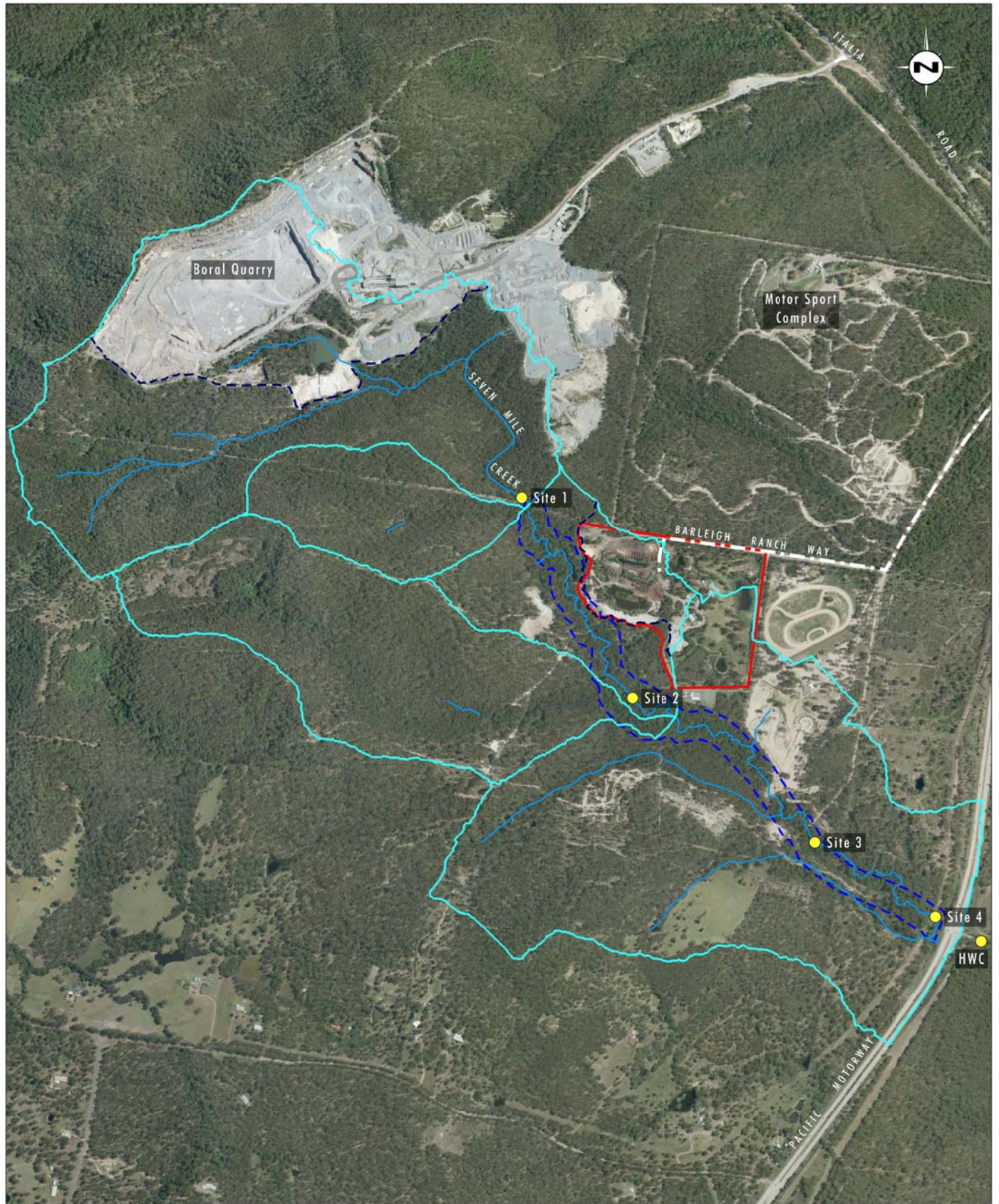


Image Source: Google Earth (2009)

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

File Name (A4): R04/3102_063.dgn
20160919 11.05

FIGURE 2.5
Seven Mile Creek
Flood Extents

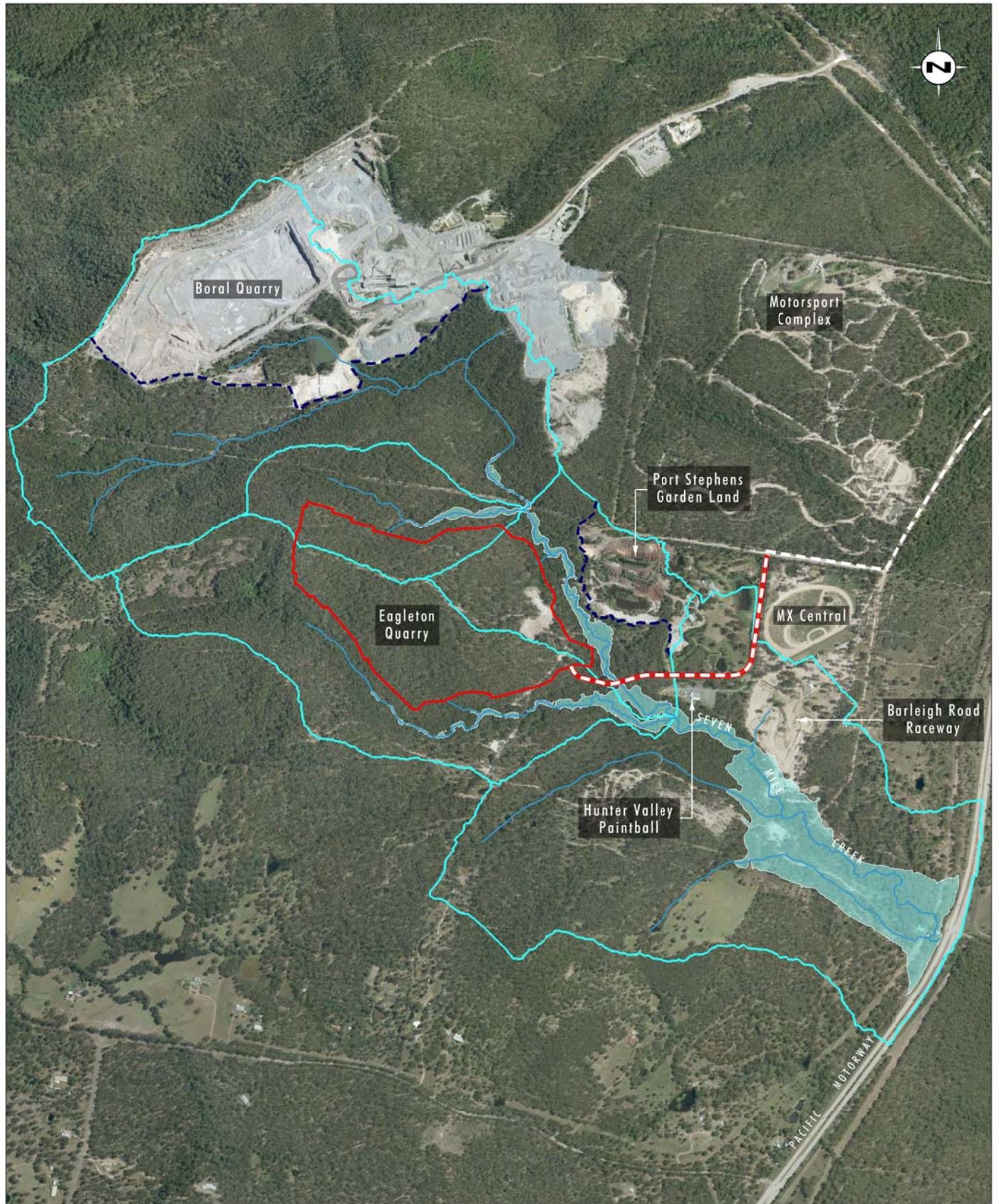


Image Source: Google Earth (2009)

0 250 500 750m
1:15 000

Legend

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

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

FIGURE 2.6

100 Year Flood Extents
Seven Mile Creek

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 <i>Managing Urban Stormwater; Soils and Construction (Department of Environment and Climate Change NSW), Volume E – Mines and Quarries – Blue Book</i> .
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
 - o operational water requirements, that is, ensuring there is adequate water from the wet months to sustain the required usage in the dry months
 - o retention of 10 ML of water as a contingency for drier than average years
 - o 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.

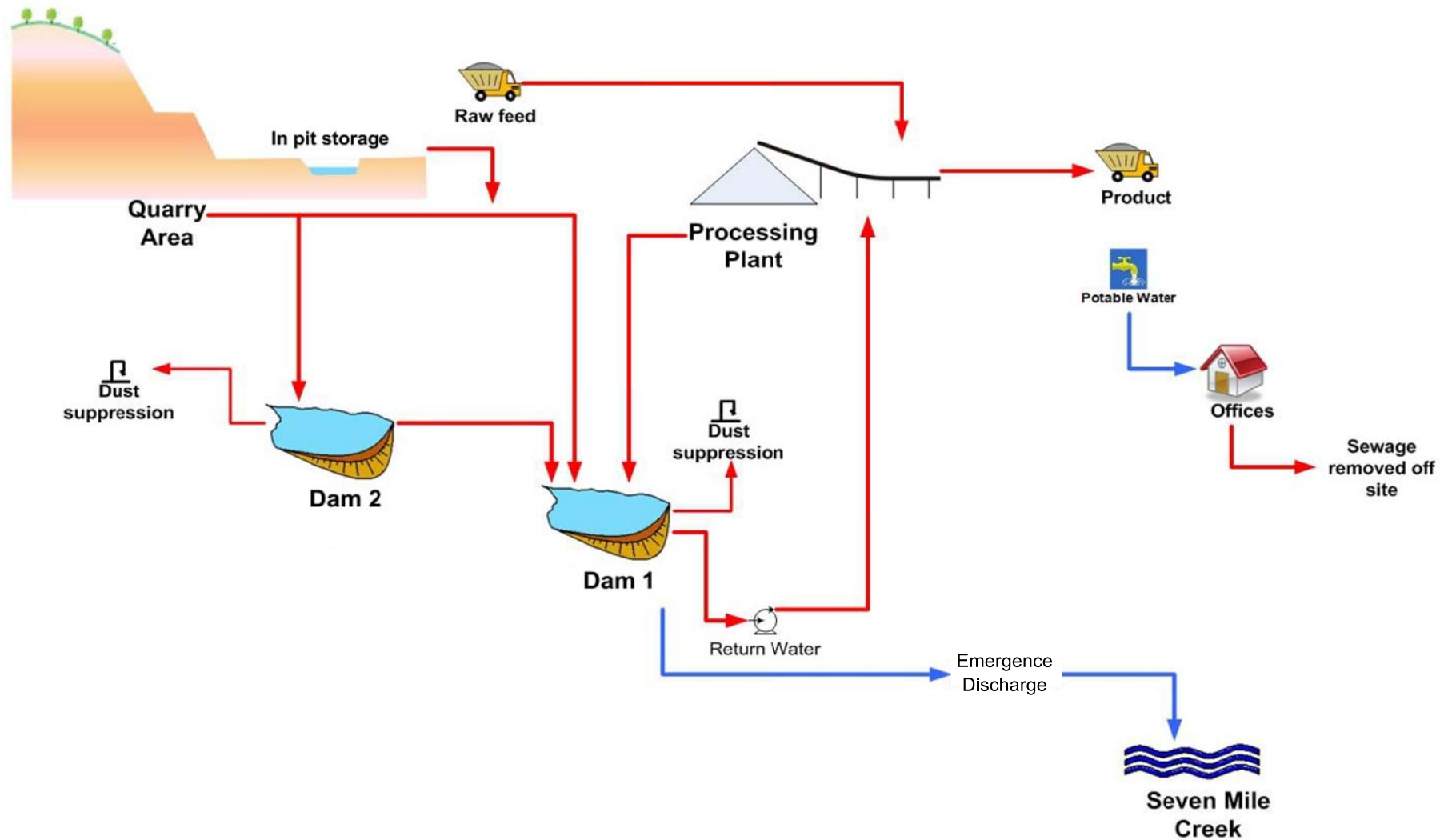
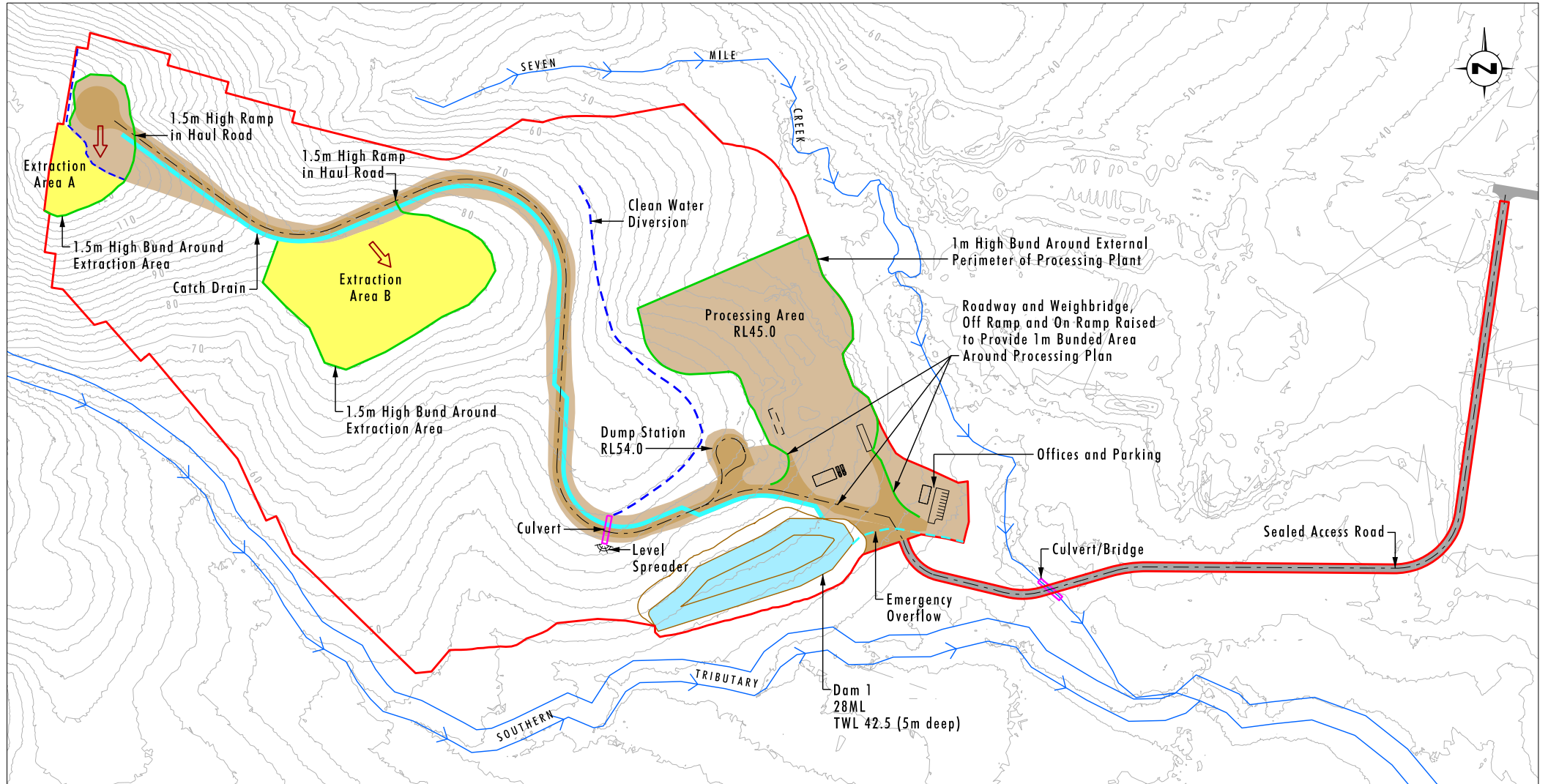


FIGURE 3.1

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



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

0 50 100 200m
1:5 000

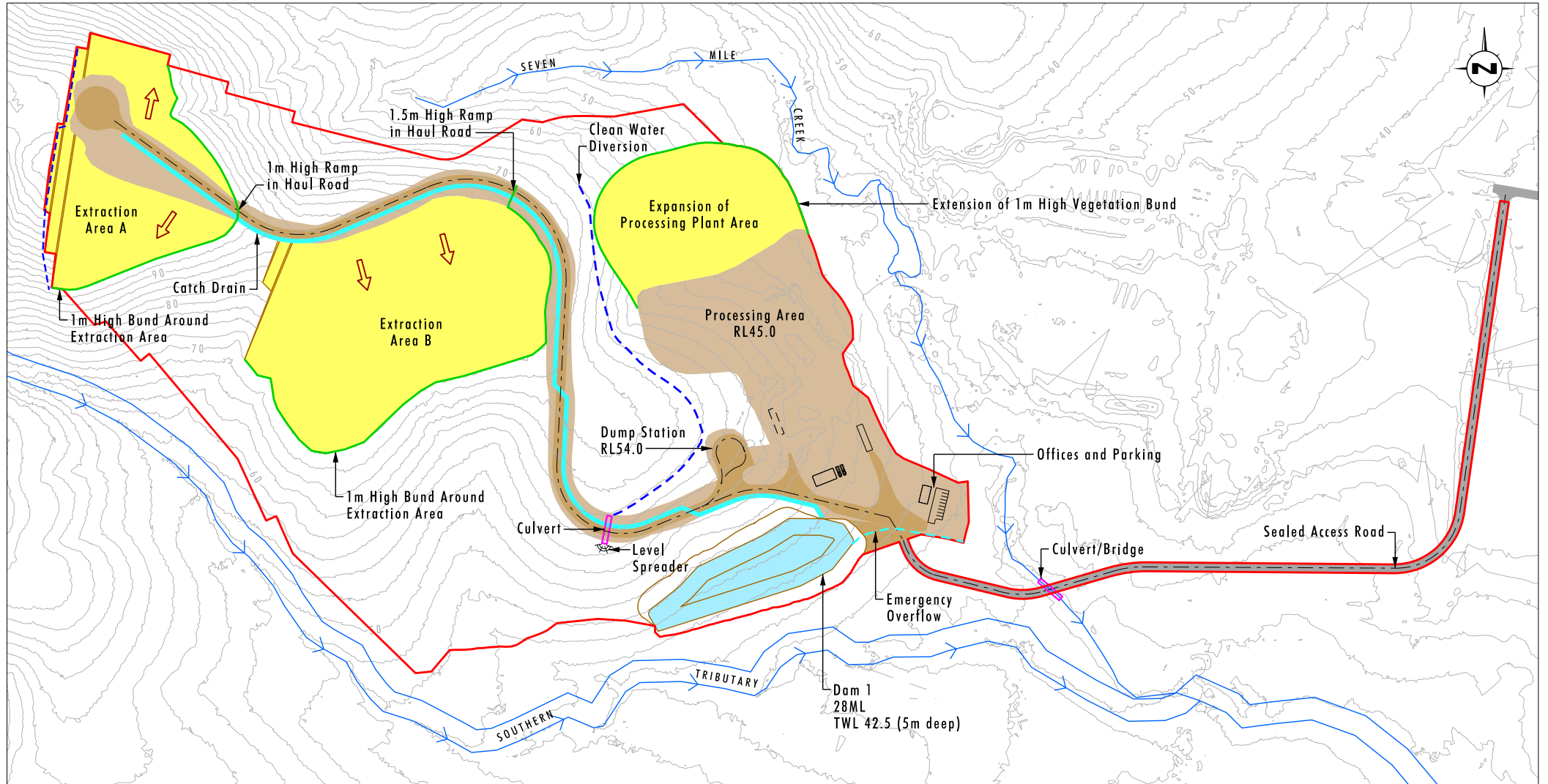
Legend

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

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FIGURE 3.2

Construction to Water Management
Year 1



Data Source: Eagleton Rock Synd (2016)

Note: Contour Interval 2.5m

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1:5 000

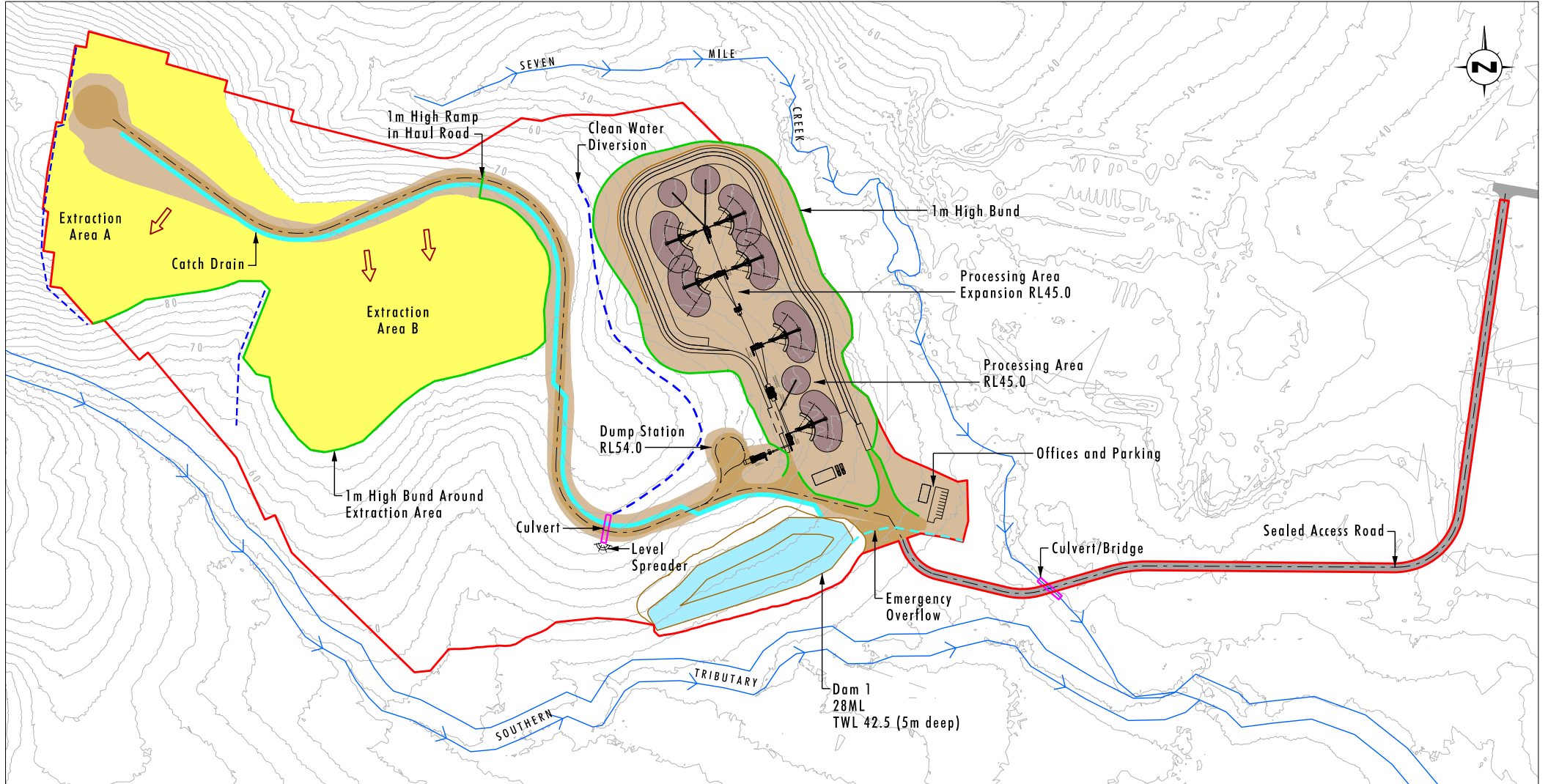
Legend

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

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

FIGURE 3.3

Water Management
Year 1 - Year 3



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

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1:5 000

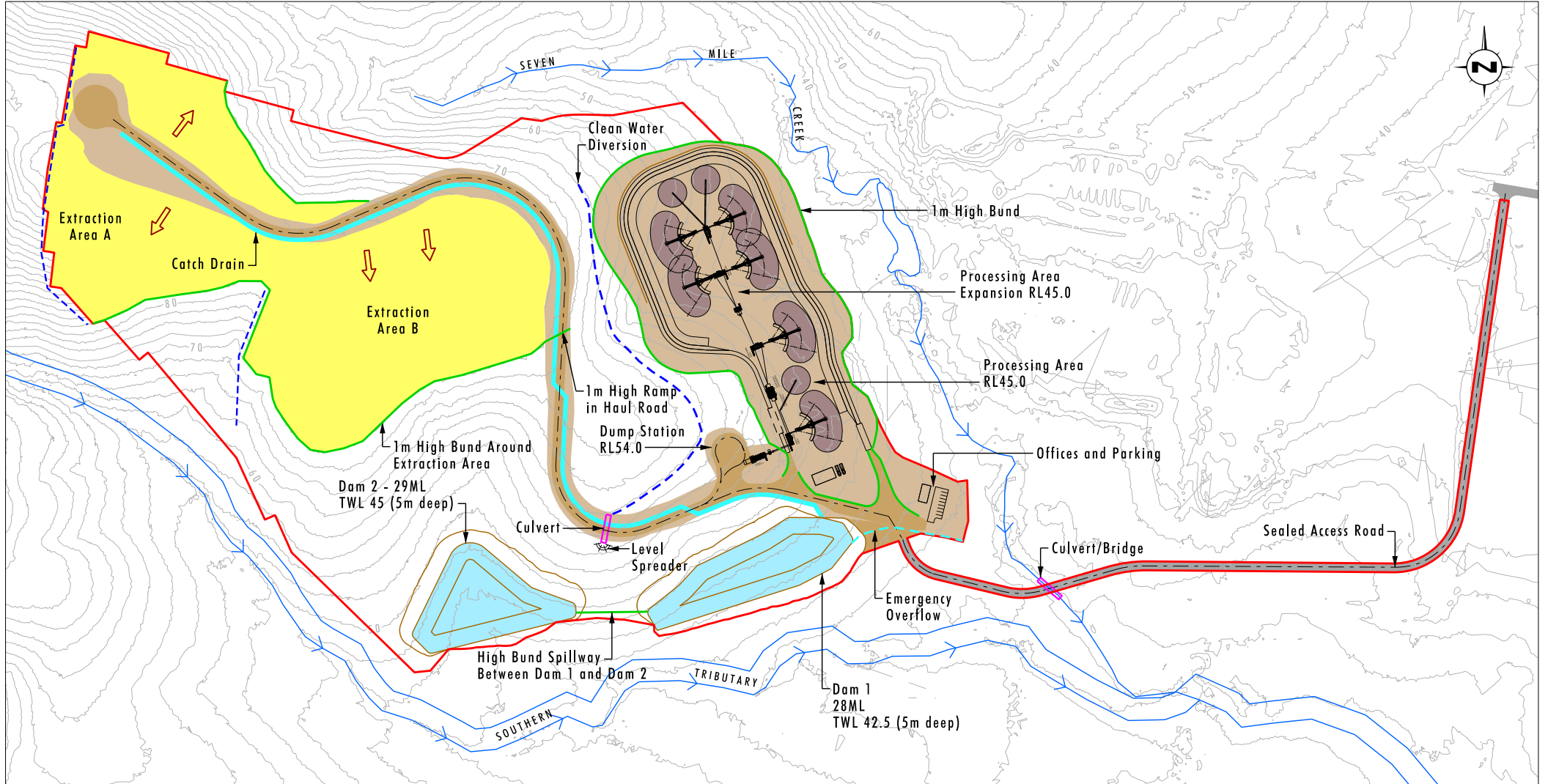
Legend

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

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

FIGURE 3.4

Water Management
Year 5



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

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1:5 000

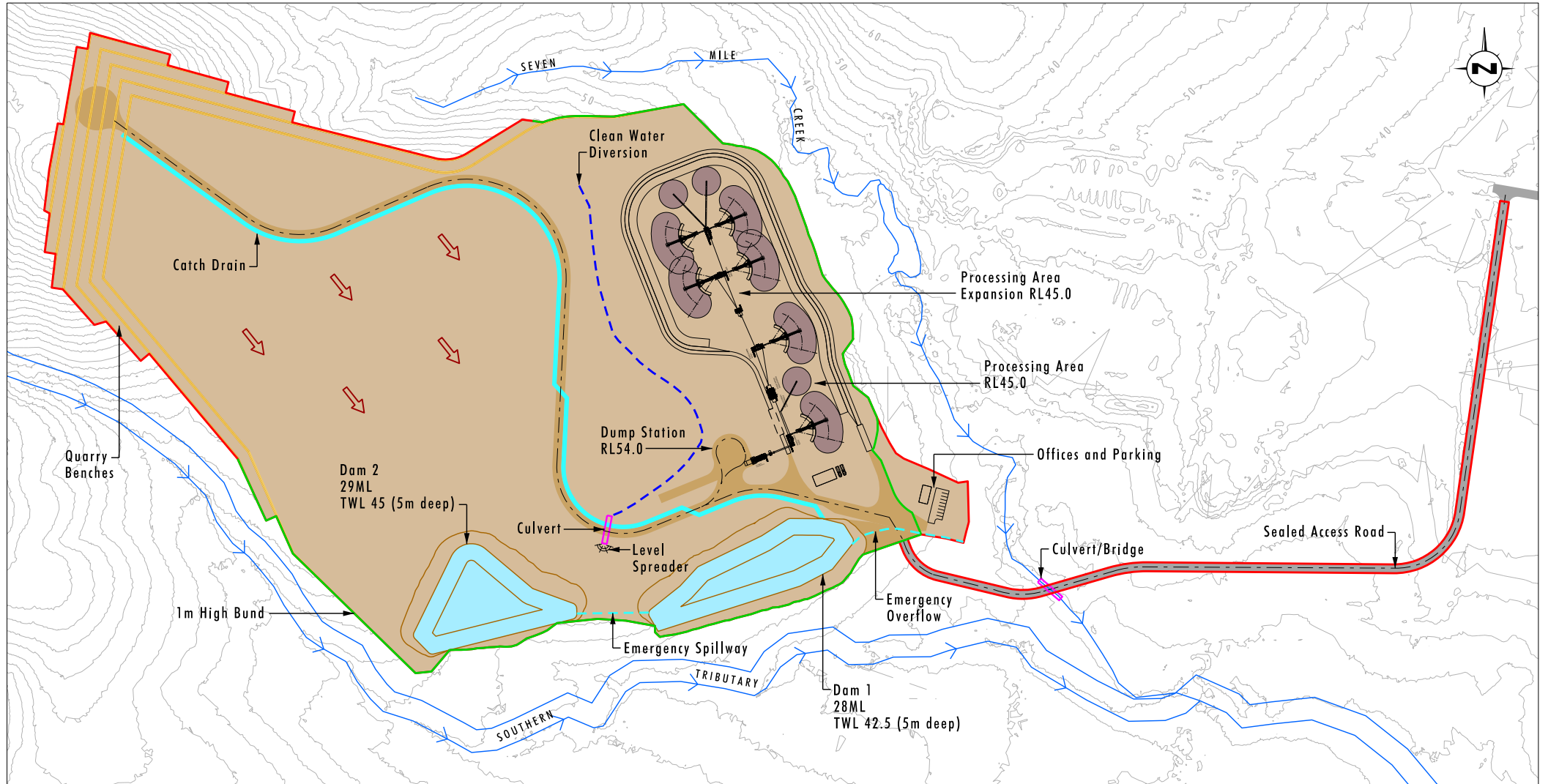
Legend

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

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

FIGURE 3.5

Water Management
Year 6



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

0 50 100 200m
1:5 000

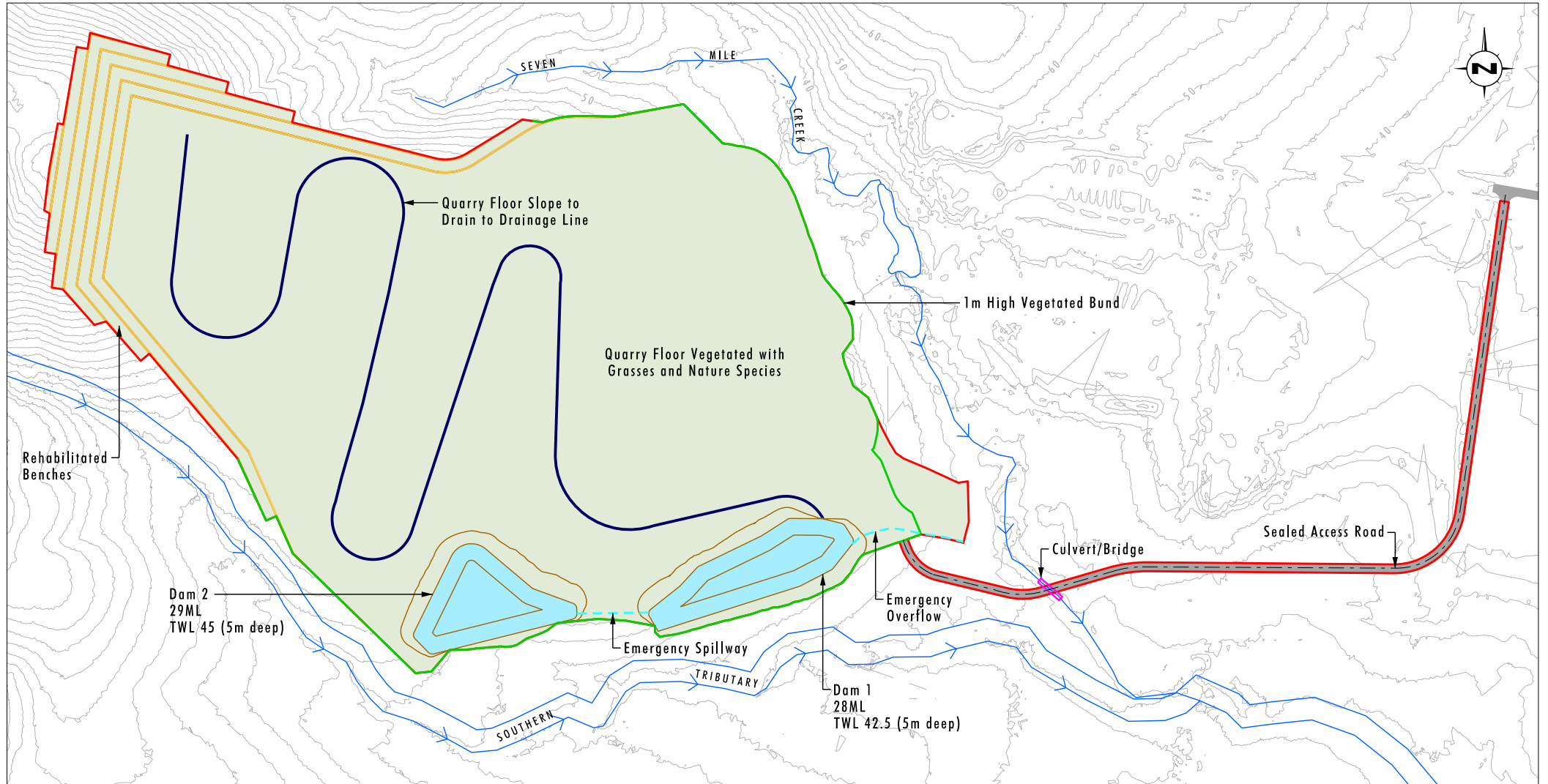
Legend

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

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

FIGURE 3.6

**Water Management
Ultimate Development Footprint**



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

0 50 100 200m
1:5 000

Legend

- Project Area
- Bund
- Rehabilitated Area
- Road Centreline
- Sealed Road
- Drainage Line
- Dam 1
- Culvert

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

FIGURE 3.7

Water Management
Conceptual Final Landform

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 m³/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. <i>These are specific purpose access licences in clause 19 of the Water Management (General) Regulation 2004.</i> - 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. <i>The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</i>	• 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 bores 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. <i>The plan lists circumstances in which these distance conditions may be varied.</i>	• 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. <i>The plan lists circumstances in which these distance conditions may be varied.</i>	• 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
 - $\text{Evaporation volume} = (\text{Evaporation} - \text{Rainfall}) \times \text{Watering Factor (WF)}$ where
 - $\text{Evaporation} = \text{Pan evaporation} \times 0.8$
 - 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
 - o dust suppression demand for crushing and screening has been assumed to be 0.03 kL/tonne of production
- Extraction Area and Processing Area
 - o watering is applied to the exposed sections of the Extraction Area and Processing Area whenever pan evaporation exceeds rainfall
 - o 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 m² increasing to approximately 46,500 m² 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 m²

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.

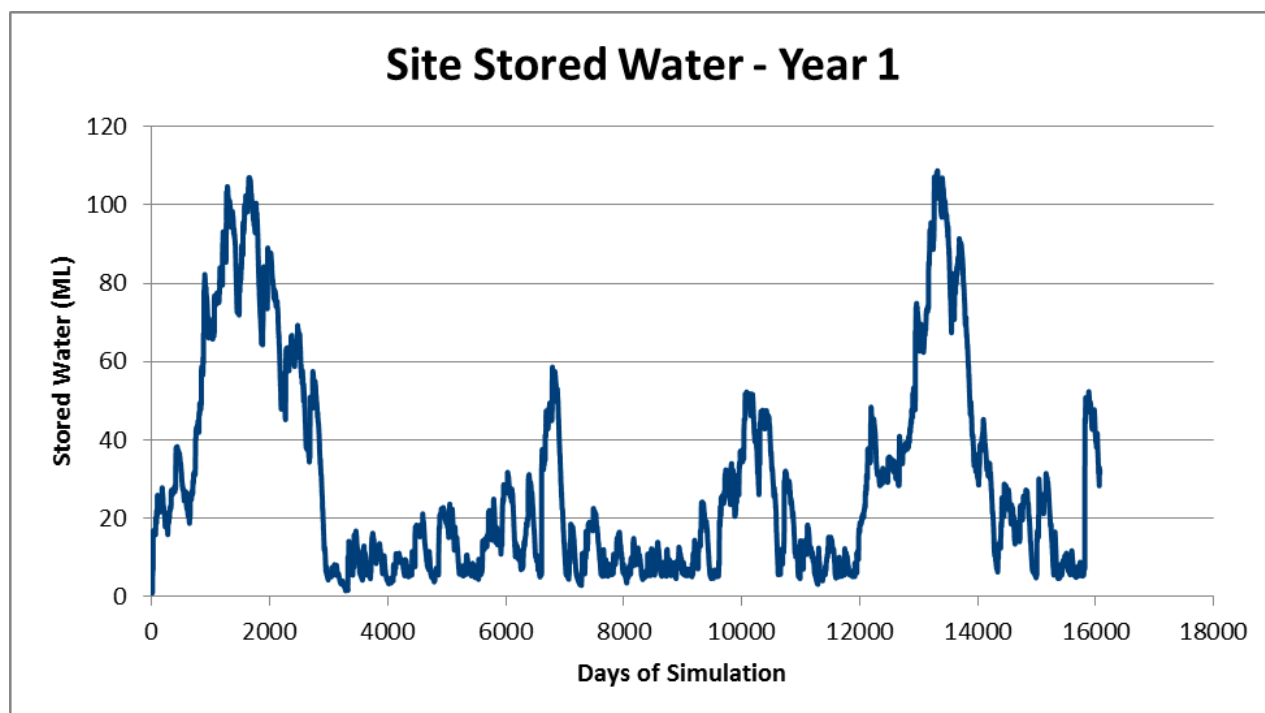


Plate 5.1

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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.

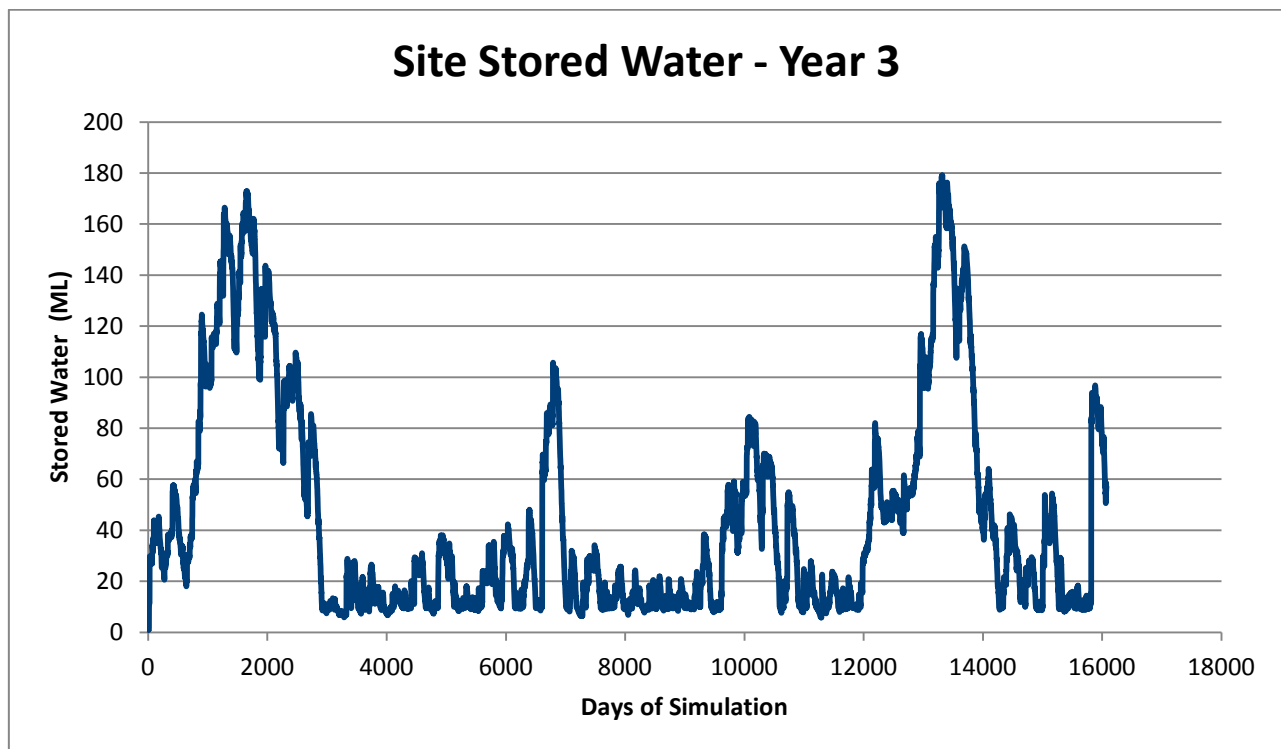


Plate 5.2

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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.

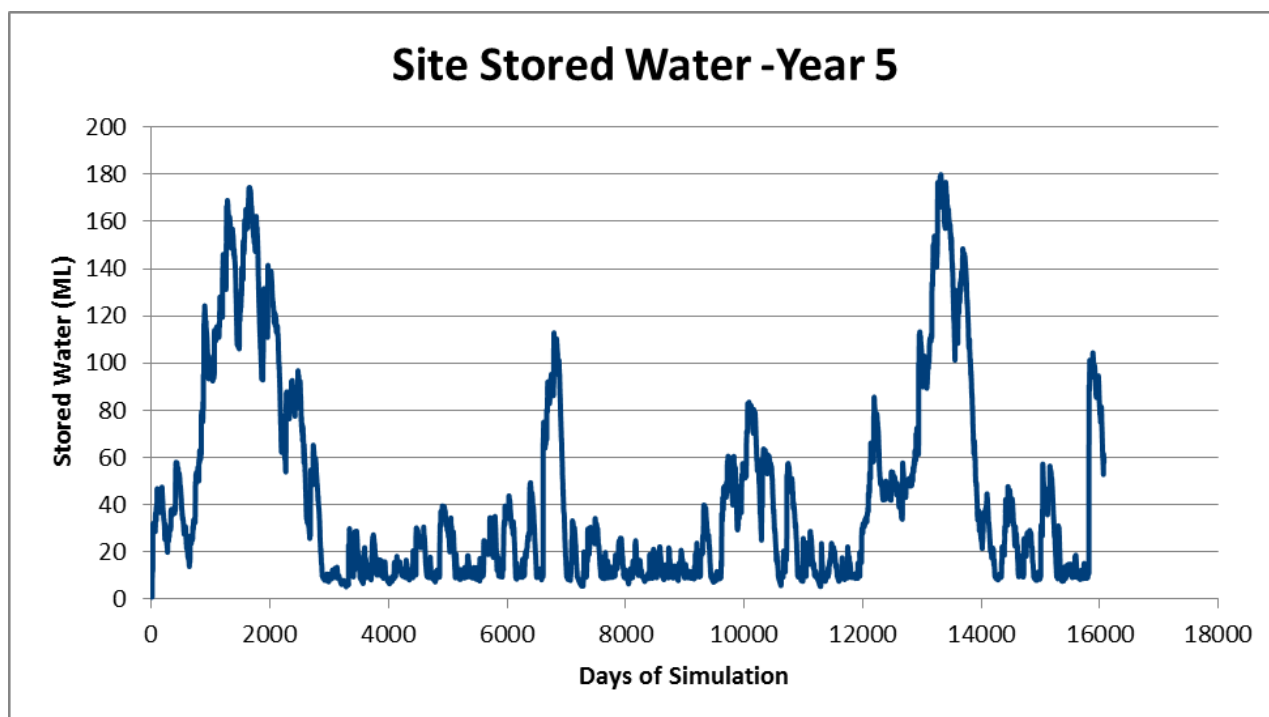


Plate 5.3

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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.

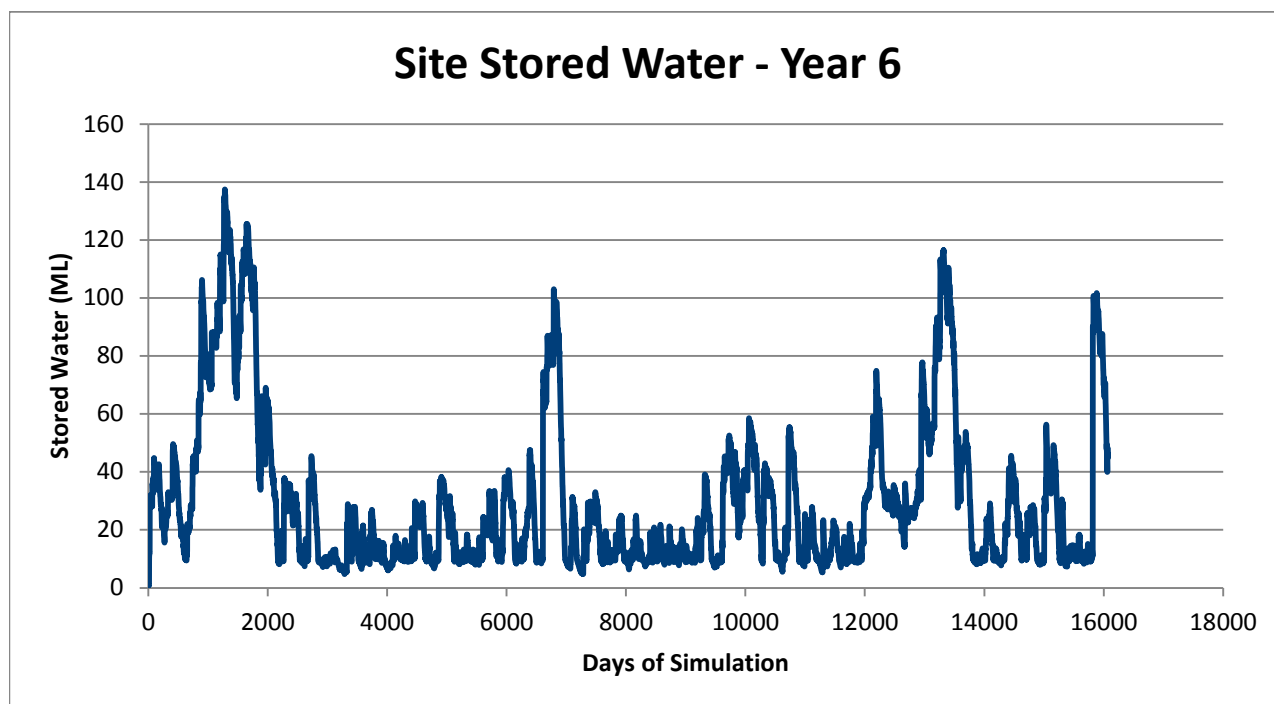


Plate 5.4

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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.

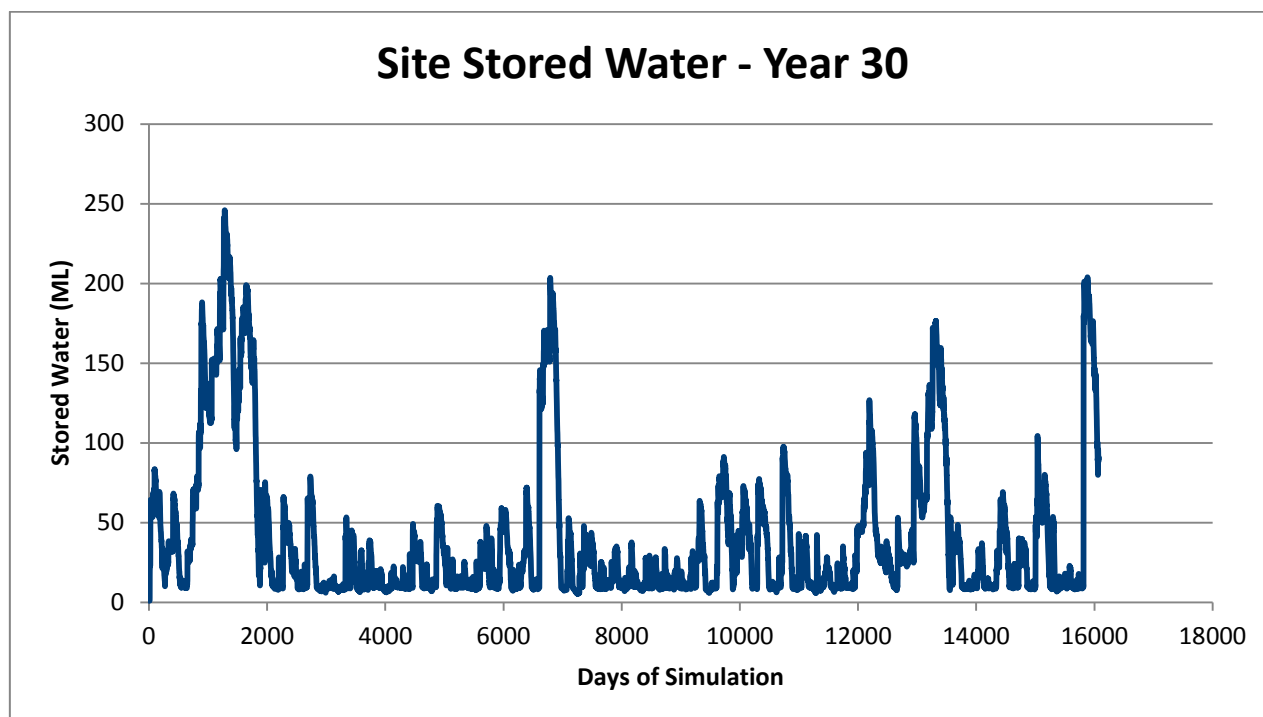


Plate 5.5

Year 30 water balance statistics

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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 m³/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.

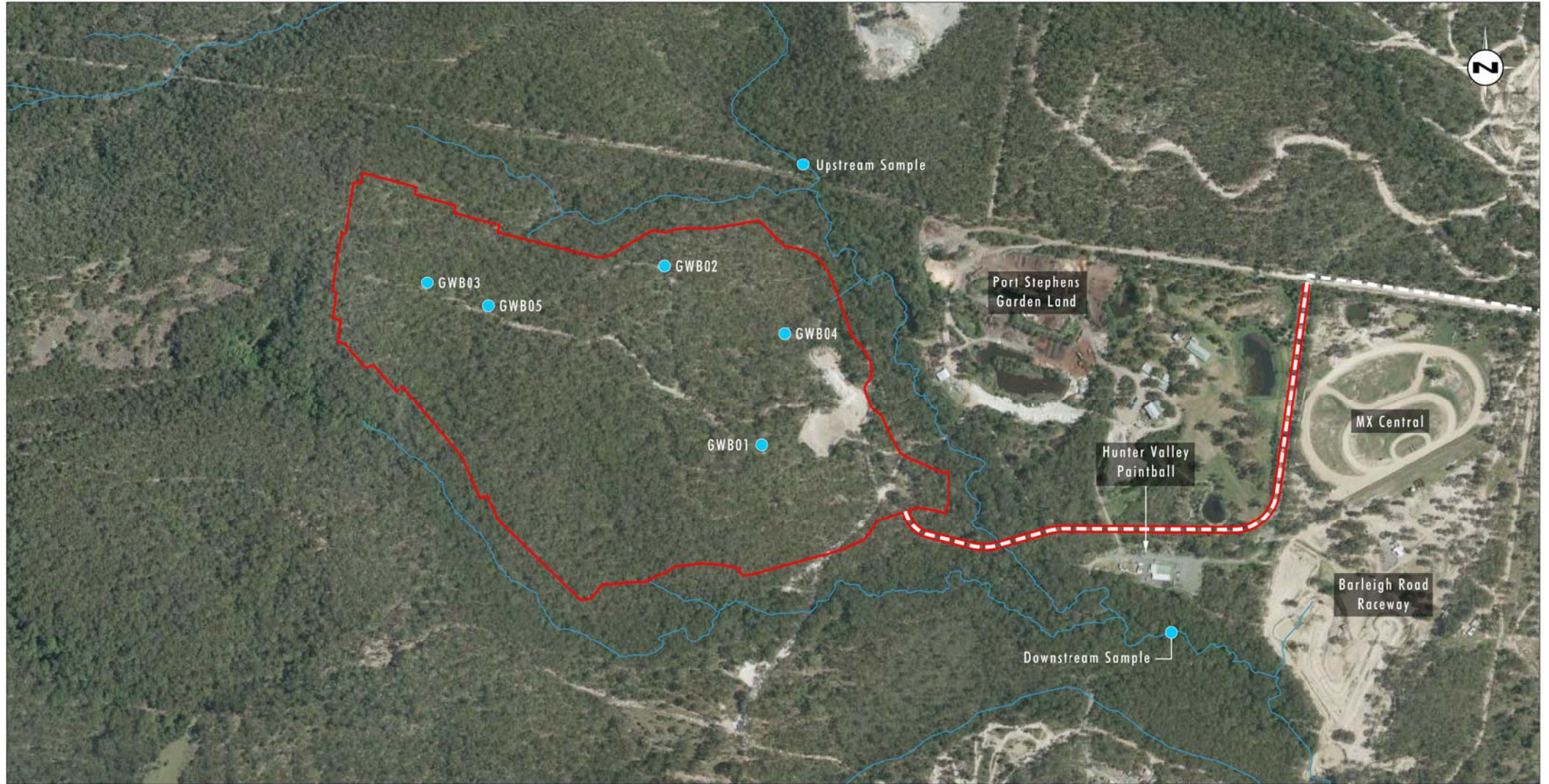


Image Source: Google Earth (2009)

Legend

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

FIGURE 7.1
Water Monitoring Points

8.0 References

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