Peppertree Quarry Water Management Plan

for Boral Resources (NSW) Pty Ltd

20 January 2011

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Peppertree Quarry
Water Management Plan

Approved by:	*Karl Rosen*
Position:	Project Manager
Signed:	
Date:	*20 January 2011*
Approved by:	*Mike Shelly*
Position:	Partner Director
Signed:	
Date:	*20 January 2011*

Environmental Resources Management Australia Pty Ltd Quality System

Boral Resources (NSW) Pty Ltd

20 January 2011

Quality
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0118026RP05

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FINAL REPORT

Boral Quarries and Recycling NSW

Peppertree Quarry
Water Management Plan

20 January 2011

Reference: 0118026RP05

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1 INTRODUCTION

1.1 BACKGROUND

Peppertree Quarry is located at Marulan South, 10 kilometres (km) southeast of Marulan in the Southern Tablelands of New South Wales, approximately 175 km southwest of Sydney. The Boral Cement limestone quarry is located immediately south of the proposed quarry. The site is bordered by a steep gorge to the east that extends towards Morton National Park and is located within the Shoalhaven River catchment area. The location of the proposed quarry with respect to the local setting is shown in *Figure 1.1*.

Project Approval under Part 3A of the *Environmental Planning and Assessment Act*, *1979* (EP&A Act) was issued by the Minister for Planning on 28th of February, 2007.

Schedule 3, Condition 26 of the Project Approval details the project requirements relating to Water Management and Monitoring. Schedule 3 (26) states:

"The Proponent shall prepare and implement a Water Management Plan for the Project to the Satisfaction of the Director-General. This plan must:

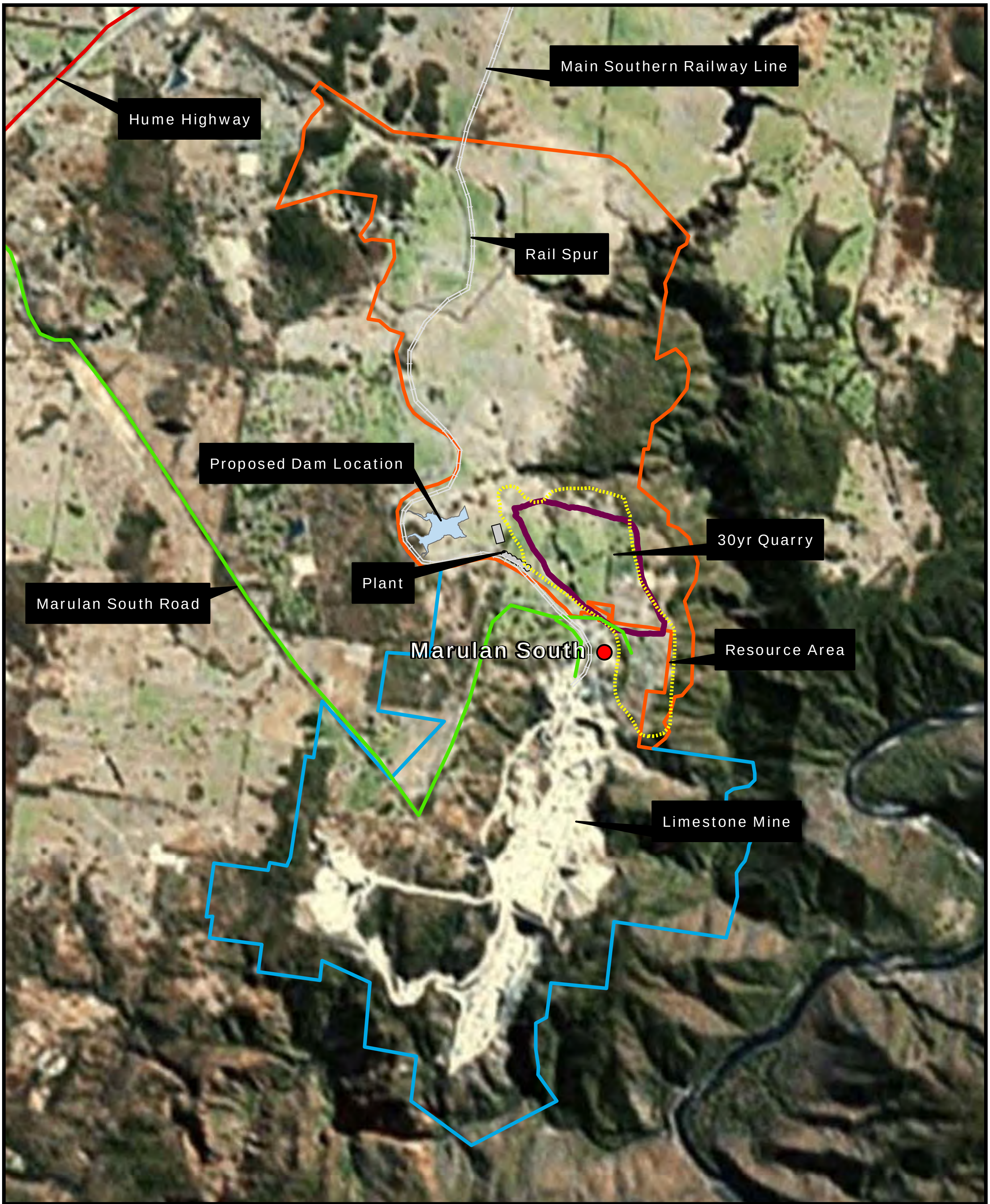
a) be submitted to the Director General (DG) for approval prior to the commencement of construction;

b) be prepared in consultation with the Department of Natural Resources (DNR), the Department of Environment Climate Change and Water (DECCW) and the Sydney Catchment Authority (SCA); and

c) include a:

- *Site Water Balance;*
- *Erosion and Sediment Control Plan;*
- *Surface Water Monitoring Program;*
- *Groundwater Monitoring Program; and*
- *Surface and Groundwater Response Plan to address any potential adverse impacts associated with the project."*

ERM has been engaged by Boral to develop a Water Management Plan (WMP) to meet the requirements presented in Schedule 3, Condition 26 of the Project Approval. This document has been prepared to meet the requirements presented in Schedule 3, Condition 22 to 30 of the approval which relate to water resources and will be forwarded to the DG for approval.



Legend

- Proposed Quarry Location
- Boral Cement Property Boundary
- Boral Peppertree Property Boundary

Client:	Boral
Project:	Peppertree Quarry
Drawing	0118026s_RP01LR_G019_R0.mxd
Date:	23/08/2010 Drawing Size: A4
Drawn By:	SW Reviewed By: RS
Projection:	UTM Zone 56, Southern Hemisphere
Scale:	Refer to scale bar

N

0 300 600 900m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

Figure 1.1

Site Location

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1.2 *PROJECT DESCRIPTION*

The Peppertree Quarry incorporates a 30 year operations area of approximately 170 ha commencing in the northern portion of total resource area. This includes the quarry pit, all bunding and sediment control features surrounding the site operations, a water supply dam and lake, a tertiary processing plant and a rail loading area, which will be built adjacent to the private rail line that currently services the Boral Cement limestone mine. The main water supply dam for the quarry is proposed to be constructed within the headwaters of Tangarang Creek immediately east of the existing rail loop and a provisional second water supply dam may be constructed on a first order tributary to the north of the proposed quarry footprint.

The 30 year quarry area, tertiary processing / rail loading facility and dams together make up the Peppertree Quarry site. Construction at the site is anticipated to start in late 2010 with initial operation expected to commence in 2012. Initial production rates at the quarry are likely to approximate 1-2 million tonnes per annum (mtpa) and grow to 3.5 mtpa at full production.

1.3 *OBJECTIVES OF THE WATER MANAGEMENT PLAN*

The Water Management Plan has the following key objectives:

- detail the water balance for the site. In particular, the water balance will:
    - describe the water management process that will be adopted at the site;
    - describe the water savings measures that have been incorporated into the detailed design of the site; and
    - outline the potential impacts the water management system will have on the surrounding environment;
- provide details of the erosion and sediment control practices that will be adopted at the site. In particular, the erosion and sediment control measures will:
    - implement the requirements of Managing Urban Stormwater: Soils and Construction Volume 1, 4th Edition, 2004 (Landcom, 2004), herein referred to as the *'Blue Book'* and Volume 2E Mines and Quarries (DECC, 2008);
    - detail practices that have potential to cause erosion and generate sediment and what control measures will be adopted to minimise the impact of these practices; and
    - detail the location function and capacity of erosion and sediment control structures and how they will be maintained;

- develop a surface monitoring program. In particular, the surface water monitoring program will aim to:
  - detail the method to be used to monitor surface water flows and quality to assess impacts to Tangarang and Barbers Creeks and to assess the effectiveness of the erosion and sediment control system;
  - establish surface water impact assessment criteria; and
  - develop a protocol for the investigation of identified exceedences of the surface water impact assessment criteria;
- develop a groundwater monitoring program. In particular, the groundwater monitoring program will aim to;
  - detail the method to be used to monitor groundwater levels, flows and quality;
  - establish impact assessment criteria for monitoring bores; and
  - develop a protocol for the investigation of identified exceedences of the groundwater impact assessment criteria; and
- develop a surface water and groundwater response plan to address potential incidents or adverse impacts associated with the project.

1.4 ROLES AND RESPONSIBILITIES

Boral will be responsible for ensuring that all soil and water management works are undertaken in accordance with this WMP.

The Boral Site Manager carries ultimate responsibility for the implementation of this WMP and providing the necessary resources as required. The site Environmental Officer will be responsible for carrying out and/or coordinating the monitoring and reporting requirements of this plan. Operations personnel (Site Supervisors) will be responsible for responding to any water management incidents and adjusting quarry operations as appropriate to minimise impacts to receiving waters. Other site personnel will be responsible for reporting any potential environmental incidents to the shift Supervisor.

1.5 *DOCUMENT STRUCTURE*

The remainder of this document presents the methods adopted on site to meet the above objectives. To meet the above objectives, the report includes the following sections:

Section 1 – Introduction and Description of the Project

Section 2 – Description of the surrounding catchment

Section 3 – Water Management Approach and Site Water Balance

Section 4 – Erosion and Sediment Control Plan

Section 5 – Groundwater and Surface Water Monitoring Plan

Section 6 – Surface Water and Groundwater Response Plan

2 CATCHMENT DESCRIPTION

2.1 OVERVIEW OF CATCHMENT

The Peppertree Quarry site, encompassing the 30 year quarry footprint, proposed processing plant area, bunding and sediment control features surrounding site operations and the water supply dam, occupies approximately 170 hectares (ha), with a potential future expansion to the southern section of the resource area covering an additional 30 ha.

The overall resource area intersects three small catchments, two of which drain northwards to Tangarang Creek. Tangarang Creek is an ephemeral creek which has a catchment area of approximately 753 ha above the north-western corner of the site and flows along the northern edge of the proposed quarry footprint to join with Barbers Creek, approximately 500 m from the quarry site. Barbers Creek has a total catchment area of approximately 9 000 ha with the Tangarang Creek catchment comprising less than 10% of the overall catchment area.

Boral Resources has also acquired a number of properties to the north of the Peppertree Quarry, with an overall property area of approximately 650 ha. Marulan Creek traverses the northern portion of Boral's land, flowing east and also entering Barbers Creek upstream from Tangarang Creek.

Barbers Creek subsequently flows southward to meet the Shoalhaven River. Most of the catchments are gently undulating and have been substantially cleared for agricultural uses, predominantly grazing.

Barbers Creek and the lower section of Tangarang Creek have cut deep gorges with steep heavily vegetated sides. Some channel erosion has occurred in sections of Tangarang Creek and minor tributaries.

2.2 SURFACE DRAINAGE

The resource area is located on a ridge so that surface water generally drains away from the centre of the site. A number of small farm dams currently exist on the site on ephemeral creeks and appear to retain water with little seepage. The majority of creek lines within the site are slightly eroded or are lined with grass.

2.3 GEOLOGY

The local geology consists of a granodiorite igneous intrusion surrounded by host rock. Generally this type of lithology is likely to contain high quartz and mafic quarry contents and it commonly has a high Na-plagioclase and low orthoclase content.

A thin Pegmatite unit is located in the south of the granodiorite. The granodiorite intrusion is bounded to the southwest by a limestone unit, with a zone of contact metamorphism likely to be present immediately adjacent to the intrusion.

2.4 HYDROGEOLOGY

A conceptual site model was developed in the Environmental Assessment (EA) prepared for the project approval in 2006, addressing the hydrogeology of the proposed quarry. The model was based on desktop review of available site data and a field program to establish basic hydrogeological properties of the fractured aquifer. The model indicates that groundwater in the study area occurs in discrete fracture zones, the most significant of which is the interface between the overburden regolith and more competent underlying granodiorite. The hydrogeological and hydrochemical assessment indicates that there is limited hydraulic connection between fracture zones, both vertically and laterally across the site, suggesting that groundwater occurs in localised and potentially discontinuous fracture horizons.

The water table is typically located approximately 15 to 30 m below ground surface indicating there is no direct evidence for groundwater-surface water interaction. However, regionally groundwater discharge is likely to occur into the gorges that surround the granodiorite unit, where fracture zones intersect the gorge walls.

2.5 ENVIRONMENTAL VALUE OF RECEIVING WATERS

Barbers Creek is the primary receiving watercourse for any discharges or runoff from the site. This waterway was considered by the Healthy Rivers Commission (HRC), (1999) to have high ecological value despite being in poor condition relative to the rest of the Shoalhaven catchment due to the effects of variable quality runoff from agricultural sub-catchments. Barbers Creek flows into the Shoalhaven River approximately 30km upstream of Tallowa Dam, which supplies raw water to the Sydney and Illawarra drinking water systems.

Environmental values for the Shoalhaven River and its tributaries, as endorsed by the HRC (1999) are:

- healthy waters – protection of aquatic ecosystems;
- recreation – protection of primary and secondary recreation and visual amenity;
- water supplies – livestock, irrigation and farmstead water; and
- protection of drinking water, within defined areas of the catchment.

Water quality objectives to achieve these environmental values are provided in terms of numerical guidelines in *Australian and New Zealand Guidelines for Fresh and Marine Waters Quality* (ANZECC & ARMCANZ, 2000) – referred to as "ANZECC 2000 Guidelines".

2.6 CATCHMENT WATER QUALITY

The Healthy Rivers Commission Independent Inquiry into the Shoalhaven River System reported that the Middle Western division of the catchment (in which Marulan lies) has moderate water quality (HRC, 1999). Generally, dissolved oxygen is low and there is high turbidity and high salinity in some locations. Bacteria, nutrients and metals were found to be at levels that were acceptable in comparison to ANZECC Water Quality Guidelines for Fresh and Marine Waters. The HRC report also indicates that flows in this part of the Shoalhaven catchment are low, but that levels of extraction in this area are also low.

There was no previously available water quality information available at the site of the proposed quarry. A "snapshot" water sample was collected by ERM during February 2006 from Tangarang Creek to gain a general picture of water quality in the creek. The sample was obtained from ponded water as the creek was not flowing at the time of sampling. This sample showed that water quality in the creek has elevated levels of nutrients (total nitrogen and total phosphorous), which is typical of agricultural catchments. Electrical conductivity (EC) was also found to be slightly elevated, suggesting that saline groundwater may be discharging to this creek.

2.7 *RAINFALL AND EVAPORATION*

Rainfall has also been recorded almost continuously since 1894 at Marulan. The nearest rainfall gauging stations to the site are:

- Station 070063 – Marulan (George St) (Period of record: 1 June 1894 to present), approximately 5.8km from the site;
- Station 070269 – Marulan (Johnniefields) (Period of record: 1 October 1972 to present), approximately 11.2km from the site.

The nearest station with evaporation data to the site is:

- Station 070263 – Goulburn (Progress St) (Period of record: 14 September 1971 to present), approximately 27.2km from the site

Average monthly rainfall and evaporation for the site are given in *Table 2.1* and shown in *Figure 2.1.*

Table 2.1 Average Monthly Rainfall and Evaporation at Site

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean monthly rainfall (mm)	68.8	74.6	51.9	41.6	58.8	67.6	66.3	56.6	50.6	45.7	54.6	54.3	691.3
Mean monthly evaporation (mm)	195.9	153.0	127.7	79.3	51.2	33.9	40.1	59.0	83.4	119.6	147.0	195.1	1285

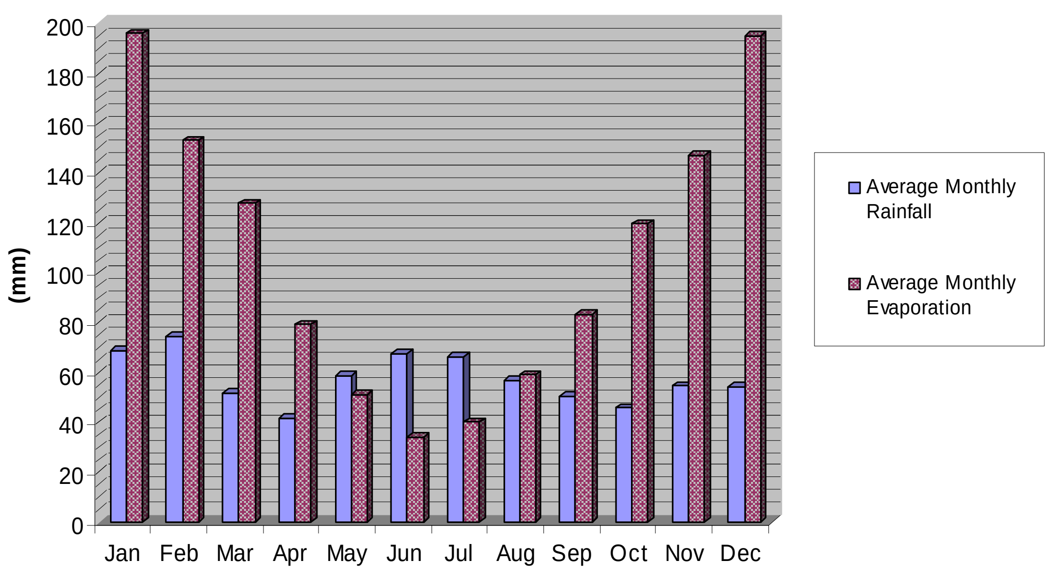

Figure 2.1 Average Monthly Rainfall and Evaporation at Site

3 *WATER MANAGEMENT APPROACH AND WATER BALANCE*

3.1 *INTRODUCTION*

Schedule 3, Condition 27 of the Project Approval details the requirements for the Water Balance. This condition states that:

"The Site Water Balance Shall:

a) Include details of all water extracted (including make-up of water), dewatered transferred, used and/or discharged by the project; and

b) Describe measures to minimise water use by the project."

Based on the above requirements, this chapter details:

- the water management approach that will be adopted at the site;
- the water demand volumes required by the site and how this has been rationalised to save water;
- the capacities and volumes of the infrastructure that will be used to obtain the required water volumes; and
- the impact that the water management approach will have on the surrounding environment.

Further to the requirements of the water balance the, Schedule 3, Condition 24 of the Project Approval States that:

"The proponent shall provide an environmental flow to Tangarang Creek equivalent to 10% of average daily inflows. Details of the management of these environmental flows shall be included in the Site Water Balance for the project."

The Project Approval also states in Schedule 3 (23) that:

"Except as may be expressly provided for by an EPL, the Proponent shall not discharge any dirty water from the quarry or ancillary operational areas."

For the purposes of this assessment "dirty water" is considered to represent water that has not been treated in accordance with the requirements of Schedule 3, Condition 25, which states that:

"The proponent shall ensure that:

a) Critical structures such as "dirty water" dams are designed, constructed and maintained to accommodate a 1 in 100 year ARI 24 hour event; and

b) Other dams and water management structures are designed, constructed and maintained to accommodate a 1 in 20 year ARI 24 hour event."

These factors have also been consider in the site water balance and are detailed in the remainder of this document.

3.2 *WATER MANAGEMENT APPROACH*

A key driver in the development of the Peppertree Quarry is a sustainable water management system, which aims for the proposed operations to be 100% self sufficient in water. A sustainable water management system has been developed based upon capturing stormwater run-off for use in the quarry processes, dust suppression and environmental controls.

The system has been based around obtaining the sites water supply from the construction of the Dam No. 1 located on Tangarang Creek. The water supply dam will capture water prior to being re-used on the site or released to Tangarang Creek catchment as environmental flows.

Runoff from undisturbed areas will be diverted around operational areas wherever practical. This will reduce the risk of flooding in the pit as well as reduce the potential for clean runoff to be polluted by quarry activities. Diversion of clean water will be effected by diversion drains, contour drains and, where necessary, bunds, levees, weirs and pipe culverts and be diverted to the main water storage dam wherever possible.

During construction and operation of the quarry, drainage will convey water from areas of disturbed ground to sediment dams located within the pit and around the site to prevent sediment laden or contaminated runoff leaving the site. Sediment traps and settling ponds form part of the site water management system and improve water quality at various points along both clean and dirty water drainage networks.

Treated water from site sediment dams will primarily be used directly onsite. Excess water will be drained or pumped to a pre-treatment bio-retention swale system located near the upper reaches of the water supply dam prior to being discharged back into Dam No. 1.

Potable water supply and sewage treatment for the offices and amenities will comprise package treatment units with minimal demand for top-up water. The treated effluent will be irrigated onto the landscaping surrounding the offices and amenities buildings.

A schematic overview of the proposed drainage and water management network is shown in *Figure 3.1.*

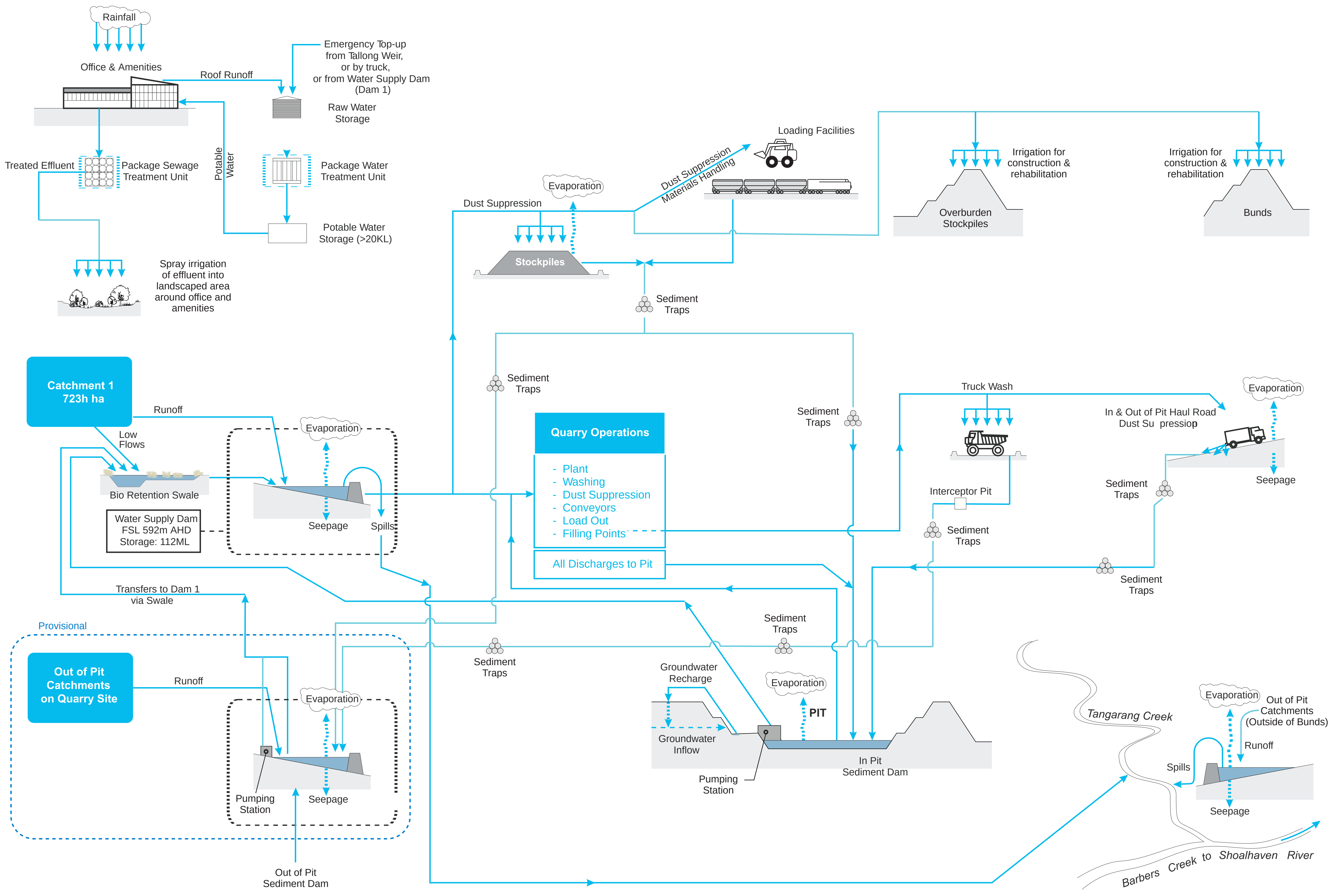

Figure 3.1

Water Management System

Client:	Boral		
Project:	Peppertree Quarry		
Drawing No:	0118026s_WMP_C002_R1.cdr		
Date:	23/08/2010	Drawing size:	A3
Drawn by:	GC	Reviewed by:	SAC
Scale:	Not to Scale		

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3.3 *DRAINAGE PLAN*

Figures 3.2a and *3.2b* present the layout of the water management facilities under construction and operational phase at the quarry. The information presented in the figures is summarised below.

The catchments presented in the figures have been designed to capture surface water flow from the entire operational area of the quarry during both construction and operation phases. The total estimated area likely to be impacted by the 30 year quarry operation approximates 170 ha. The total area of the quarry which is estimated to be draining directly to the sediment dam in the pit prior to discharging to the pre-treatment system at the headwaters of the water supply dam is estimated to be 106 ha.

The aim of the system will be to facilitate the capture of dirty water run-off from the site within the pit and dams on site, appropriately treat this water then pump it to a pre-treatment bio-retention swale at the head waters of the water supply dam before discharging into the water supply dam.

Run-off from Catchments A to G (excluding Catchment D), M, N and O will flow directly into the sediment dam located in the pit. All of these catchments generally form part of two natural catchments that the pit will intersect. During construction and for initial stages of operation two dams will be required to effectively capture water draining these catchments. These dams are presented on *Figure 3.2a*.

Run-off from Catchments D, I, J, K and L do not discharge directly into the pit.

Run-off from catchments I and J will be treated within a sediment dam located within each of these catchments and then subsequently discharged directly to the pre-treatment bio-retention swale system in the head waters of the water supply dam.

Catchments K and L will require pumping from the dam into the pre-treatment bio-retention swale system in the head waters of the water supply dam.

Catchment D will require pumping back into the pit for pre-treatment prior to being discharged to the pre-treatment bio-retention swale in the head waters of the water supply dam.

Catchment O will require draining beneath berming back into the pit for pre-treatment prior to being discharged to the pre-treatment bio-retention swale in the head waters of the water supply dam.

The starter pit will be located in the north western corner of the pit and extend to the eastern and southern areas As such, during early stages of quarrying the pit will be primarily within Catchment A. Eastern areas (including catchments B, C and D will be undisturbed, as such, a secondary pit sump will be developed within Catchment B to facilitate the separation of clean and dirty water (*Figure 3.2b*). There will be no requirement to treat this water prior to discharge back to the catchment as it will be from undisturbed areas. However, bunding emplacements around the pit will prevent outflow to the catchment, as such, this water will be captured and treated within a sediment dam and pumped back into the treatment system at the head waters of the water supply dam.

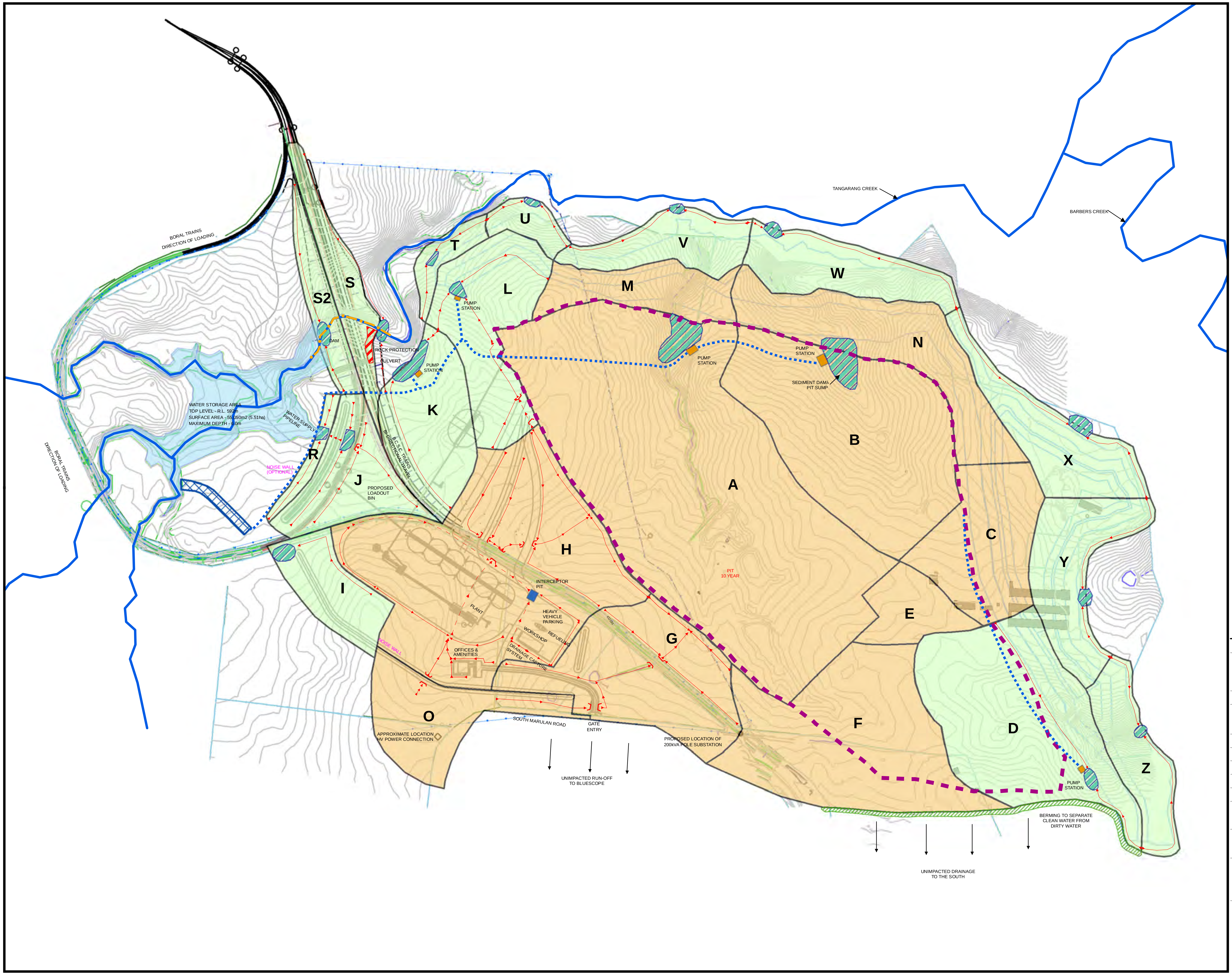
Due to the lie of the land at the site, during early stages of pit development runoff from Catchments E and F will flow into the sediment dam located within Catchment A as well as run-off from Catchments G, H and O.

A small diversion bund will be placed on the southern boundary of the operational area of the 30 year quarry zone to facilitate the separation and migration of clean surface water to the south and away from operational areas.

Temporary catchments have been developed to capture and treat run-off from the bunds and overburden stockpiles during the construction phase of works and include Catchments R to Z. After treatment, these catchments will discharge directly back to Tangarang Creek or Barbers Creek catchments. As the bunds and stockpiles are rehabilitated/re-vegetated, the sediment dams and drainage networks within these catchments will be decommissioned.

Catchment H includes the workshop area, the heavy vehicle parking area and the refuelling area. These areas will be sealed and appropriately bunded where required. The primary contaminants of concern are anticipated to be the petroleum based products. As such, run-off from these will be via an appropriately designed interceptor for capturing petroleum based products before discharging to the sediment dam.

Potable water supply and sewage treatment for the offices and amenities located within Catchment O will comprise package treatment units with minimal demand for top-up water. Treated effluent will be irrigated onto landscaped areas surrounding the offices and amenities buildings.



Legend

- Drainage Lines
- Pumping Pipe Line
- Proposed Location of Culvert
- 30 Year Pit
- Berming
- Sediment Dam
- Water Supply Dam (pre-treatment system/ bio-retention swale)
- Interceptor Pit
- Pump Station
- In Pit Capture and Treatment
- Out of Pit Capture and Treatment
- Dam Location

Notes:
1. There are no catchments P & Q.

Figure 3.2a
Construction Drainage Plan

Client:	Boral
Project:	Peppertree Quarry
Drawing No:	0118026_RP01LR_G008_R0
Date:	09/08/2010 — Drawing size: A3
Drawn by:	SW — Reviewed by: SC
Projection:	Not Defined
Scale:	Refer to Scale Bar

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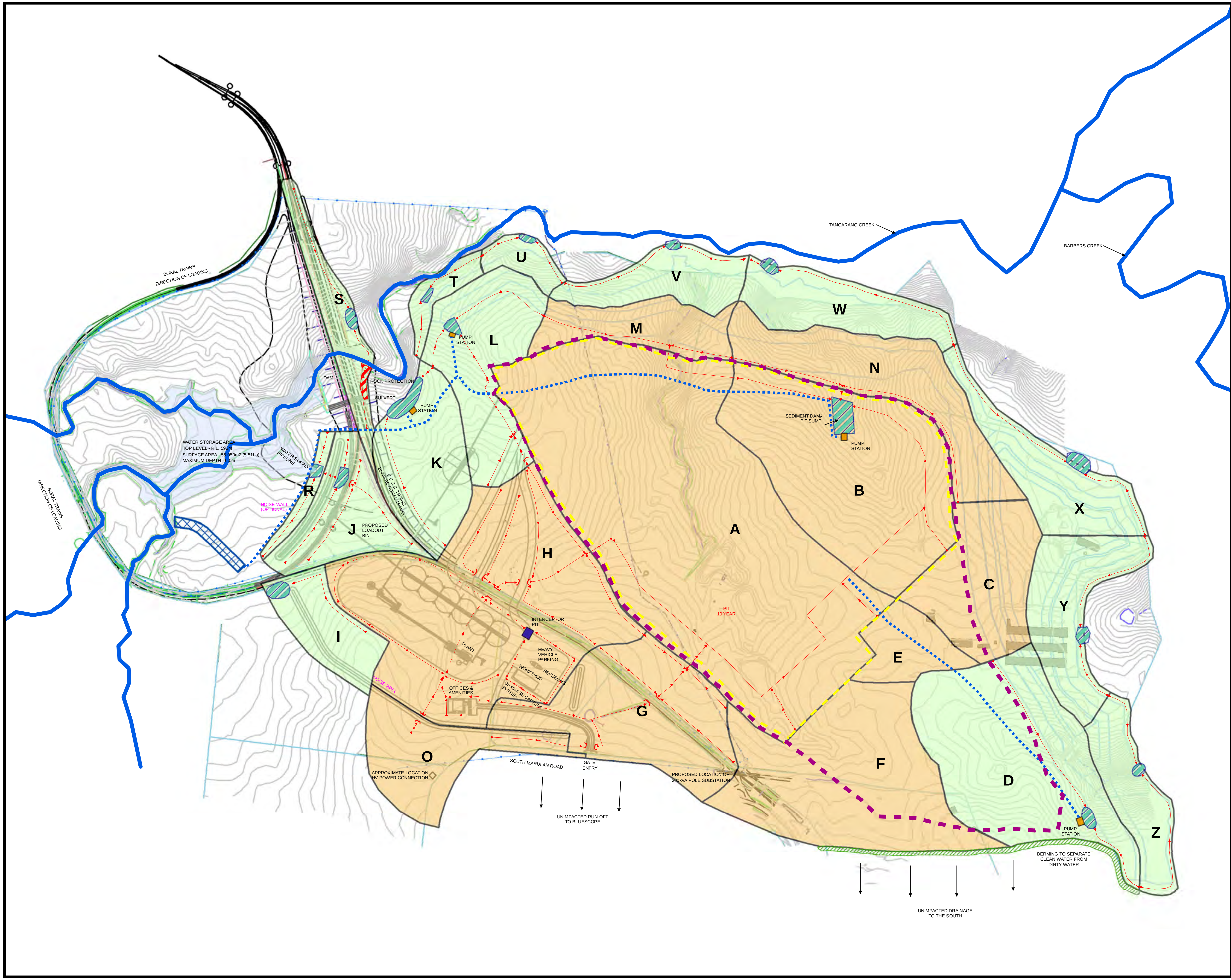

Legend

- 10 Year Pit
- 30 Year Pit
- Pumping Pipe Line
- Drainage Lines
- Interceptor Pit
- Pump Station
- Burming
- Sediment Dam
- Water Supply Dam (pre-treatment system/ bio-retention swale)
- In Pit Capture and Treatment
- Out of Pit Capture and Treatment
- Dam Location

Notes:
1. There are no catchments P & Q.

Figure 3.2b
Operation Drainage Plan

Client:	Boral
Project:	Peppertree Quarry
Drawing No:	0118026_RP01LR_G003_R0
Date:	09/08/2010 — Drawing size: A3
Drawn by:	SW — Reviewed by: SC
Projection:	Not Defined
Scale:	Refer to Scale Bar

N

0 50 100 150m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

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3.4 *WATER SUPPLY REQUIREMENTS*

3.4.1 *Demand Management*

Calculation of raw water demand for the quarry operations over various stages in a proposed 30-year operational period were initially presented in the EA in 2006 with a peak demand of 255 ML per annum. Because the peak demand is expected after approximately 11 years of operation, any potential future extension of the 30-year plan will not increase total demand above 255ML per annum unless production rates are increased above 3.5 mtpa.

The water management system presented in the EA was developed around a range of conservative demand assumptions to ensure both environmental sustainability and to allow for flexibility in detailed design. Where there was any uncertainty in water use across the site, maximum demand assumptions were assumed to ensure an adequate water supply was developed.

A number of demand management investigations have been incorporated into the detailed design of the quarry to minimise the raw water demands. The quarry has been designed to optimise recycling within operations, with water used in all processes including washing, dust suppression for stockpiles and materials handling, will be collected, filtered if necessary, and recycled to minimise demand for top-up water from the clean water catchment storages. Water for site use will be obtained from the site sediment dams with the most suitable water quality using portable pumping equipment.

The demand management investigations and detailed design considerations have resulted in a revised maximum water demand of 145 ML/year, which represents a 43% reduction in site water demand from the initial calculations presented in the EA.

Details of the revised site water demand are presented in *Table 3.1*.

Table 3.1 Details of the Revised Water Demand

Activity	Details of Quarrying Activity							
	Years - 1 to 0	Year 1	Years 2 - 5	Years 6 - 8	Years 9 - 10	Years 11 - 13	Years 14 - 30	Years > 30
Days of operation per year	250	250	250	250	250	250	250	250
Production (Mtpa)	0.00	1.00	1.80	1.80	1.80	3.20	3.20	0.00
Overburden & Weathered Material (Mtpa)	1.75	1.20	1.20	2.00	2.00	1.70	0.00	0.00
Bund Wall Construction / Overburden Placement (Mtpa)	1.45	0.90	0.77	2.00	2.00	1.49	0.00	0.00
Total In Pit Haul Road Length (m)	0	1,500	1,700	1,800	2,000	1,700	2,400	0
Total Out of Pit Haul & Access Road Length (m)	2,600	2,600	2,600	2,600	2,600	2,600	2,600	0
Total Stockpile Area (m^2)/10	2,000	2,000	3,000	5,000	5,000	6,000	6,000	0
Other Unsealed Areas (m^2)	1,000	1,000	8,000	10,000	10,000	14,000	14,000	4,000
Irrigation Area (ha)	20	20	20	5	5	5	5	50

Activity	Average Annual Usage (ML/year)							
In Pit Haul Road Dust Suppression (average 15kL/day per km)	0.00	5.63	6.38	6.75	7.50	6.38	9.00	0.00
Out of Pit Haul Road Dust Suppression (average 15kL/day per km)	9.75	9.75	9.75	9.75	9.75	9.75	9.75	0.00
Stockpile Dust Suppression (average 3L/day per m2)	1.50	1.50	2.25	3.75	3.75	4.50	4.50	0.00
Other Unsealed Areas Dust Suppression (average 3L/day per m2)	0.75	0.75	6.00	7.50	7.50	10.50	10.50	4.40
Overburden & Spoil Water (average 15L/tonne)	26.25	18.00	18.00	30.00	30.00	25.50	0.00	0.00
Bund Wall Construction & Maintenance (average 15L/tonne)	21.75	13.50	11.55	30.00	30.00	22.35	0.00	0.00
Washdown/Irrigation (Ave 200mmpa)	5.7	5.7	5.7	1.4	1.4	1.4	1.4	100
Manufactured Sand Moisture (based on 40ML for 2Mtpa production)	0	20	36	36	36	64	64	0
Amenities Water (Potable) (170L/day per person x 20 people)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0
TOTAL	***66.6***	***75.7***	***96.5***	***126.0***	***126.8***	***145.2***	***100.0***	***104.4***

1. Years -1 to 0 refer to the quarry construction phase.

3.5 *WATER BALANCE METRICS*

3.5.1 *Water Supply Dam Capacity*

ERM undertook surface water modelling to assess the potential water supply dam size that would be required within the Tangarang Creek Catchment to capture suitable volumes of water over the life of the quarry. The minimum water use requirements for the site were to have:

- water use shortages no more than 0.3% of the time; and
- water shortage periods of no more than 3 weeks.

A spreadsheet based model was developed using catchment inflow data from a MUSIC model developed by ERM (ERM, 2006b) to represent the water supply dam catchment. The spreadsheet model included the following parameters:

- 112 years of rainfall data for Marulan (070063) was used with missing records estimated from other stations or from similar years of record at Marulan. Evaporation data was generated by repeating the 27 years of Goulburn (Progress St) data over the same period.
- assessment of the quarry lifetime water use requirements over an extended historical record (1902 to 2002). This included running the quarry lifetime over four different 72 year periods, including 1900 to 1972, 1910 to 1982, 1920 – 1992 and 1930 to 2002. This provided a greater understanding of the potential impacts of the proposed site water use under a range of climatic records. While the initial quarry approval is for 30 years, an extended period of 72 years was used in the model to represent potential future extensions to the quarry. This resulted in the simulation of an extended period of maximum usage, which is considered to be conservative from a demand perspective;
- the release of at least 10% of the daily catchment inflows back to Tangarang Creek catchment. This is in accordance with Schedule 3, Condition 24 of the Project Approval;
- the specification of 50% reduced quarry water usage days when dam water depth falls below 2 m and no quarry water usage when the dam water depth falls below 1 m;
- direct spilling of surface water flows in excess of the dam capacity (and in addition to 10% environmental flows) back to Tangarang Creek; and
- the incorporation of evaporation from the dam surface.

The modelling results suggest that a dam capacity of a 112 ML would be required to meet the site water demands given the current requirements. The modelling results suggest that, with a dam capacity of this size, on average reduced water usage days are likely to be experienced 0.17 % of the time with potential worst case reduced water usage days of 0.4 %. The maximum length of water use shortages days using a dam capacity of this size was simulated to be 12 days.

The proposed water supply dam within Tangarang Creek has a dam wall height of 7 m and a capacity of 112 ML and will therefore provide enough capacity to meet the required water supply volumes and criteria.

3.5.2 Water Supply Dam Environmental Release System Capacity

In order to release 10% of the environmental flows back to the catchment the environmental release system will be required to release a maximum volume of 63,761 KL/day. The 99.5 percentile flow is estimated to be 4,776 kL/day, which could reasonably be handled using pumps installed within the dam face. Based on this a release drain system will be developed to release 10% of daily flows to the down gradient catchment 99.5 % of the time. This will be backed up by a pumping system with a flow meter will be used as required. Inflows greater than the 99.5 percentile flow will not be immediately pumped to the down gradient catchment providing that the inflows contribute entirely to dam storage capacity increases and not dam overflow. This volume will be gradually released in the days after the inflow event.

It is estimated that under the worst case conditions, it will take up to 13 days to release the required flow volumes after a >99.5 percentile peak daily flow event. When overflow from the dam occurs via the spillway, the volumes estimated to be spilling will be subtracted from the volumes required for pumping. Therefore, the requirement to pump water to the down gradient catchment will be reduced or not required during times of spilling.

3.5.3 Sediment Dam Capacities

Sediment dam capacities have been determined using the rational method, which is detailed in Australian Rainfall Run-off, Volume 1 (IEA, 1998).

The dam capacities have been based on the requirement in the Project Approval to capture a 1 in 100 year annual recurrence interval (ARI) 24 hour storm event. This is larger than the capacities estimated using the method outlined in the Blue Book.

Table 3.2 presents the dam capacity requirements for each catchment listed within *Figure 3.2*.

Table 3.2 Dam Capacities

Location	Catchment area (km^2)	ARI (mm/hr) (I tc,100 year)	ARI (mm/hr) (I tc,20 year)	Dirty Water Dams	Run-off coefficient (Cy)	Peak flow rate (m3/s)	Volume per 24 hour storm (m3)	Average Depth of Dam at Capacity (m)	Dam Area (m2)
Quarry Operation Dams									
A	3.3E-01	8.20	6.1	Y	0.8	6.0E-01	51,777	10	5,178
B	1.3E-01	8.20	6.1	Y	0.8	2.5E-01	21,253	10	2,125
C	5.9E-02	8.20	6.1	Y	0.8	1.1E-01	9,365	3	3,122
D	1.2E-01	8.20	6.1	N	0.8	1.6E-01	13,602	3	4,534
E	2.4E-02	8.20	6.1	Y	0.8	4.4E-02	3,826	3	1,275
F	1.2E-01	8.20	6.1	Y	0.8	2.1E-01	18,290	3	6,097
G	7.5E-02	8.20	6.1	Y	0.8	1.4E-01	11,822	3	3,941
H	1.4E-01	8.20	6.1	Y	0.8	2.6E-01	22,773	3	7,591
I	6.8E-02	8.20	6.1	Y	0.8	1.2E-01	10,741	3	3,580
J	4.0E-02	8.20	6.1	Y	0.8	7.3E-02	6,307	3	2,102
K	5.2E-02	8.20	6.1	Y	0.8	9.5E-02	8,198	3	2,733
L	6.0E-02	8.20	6.1	Y	0.8	1.1E-01	9,472	3	3,157
M	3.1E-02	8.20	6.1	Y	0.8	5.6E-02	4,849	3	1,616
N	7.4E-02	8.20	6.1	Y	0.8	1.3E-01	11,604	3	3,868
O	7.2E-02	8.20	6.1	Y	0.8	1.3E-01	11,270	3	3,757
Construction and Rehabilitation Dams									
R	7.8E-03	8.20	6.1	N	0.8	1.1E-02	920	3	307
S	2.7E-02	8.20	6.1	N	0.8	3.7E-02	3,165	3	1,055
T	1.1E-02	8.20	6.1	N	0.8	1.5E-02	1,312	3	437
U	1.1E-02	8.20	6.1	N	0.8	1.5E-02	1,312	3	437
V	3.1E-02	8.20	6.1	N	0.8	4.2E-02	3,650	3	1,217
W	4.4E-02	8.20	6.1	N	0.8	5.9E-02	5,123	3	1,708
Y	4.7E-02	8.20	6.1	N	0.8	6.4E-02	5,499	3	1,833
X	4.9E-02	8.20	6.1	N	0.8	6.6E-02	5,739	3	1,913
Z	1.9E-02	8.20	6.1	N	0.8	2.6E-02	2,241	3	747

The information presented in the table is summarised as below:

- the required capacity of the sediment dam within the pit will be 167 ML with an estimated surface area of 1.67 ha, assuming an average depth of 10 m. The excavated base of the pit is likely to be able to provide containment for this volume of water. If the sediment dam was to be shallower in depth, i.e. 5 m on average, then the sediment dam would be required to be 3.3 ha;

- the required capacity of the sediment dam within Catchment D will be 13.6 ML with an estimated surface area of 0.45 ha assuming an average depth of 3 m. As the quarry pit progresses into this area run-off will be redirected into the pit void sediment dam;

- the required capacity of the sediment dam within Catchment I will be 10.7 ML with an estimated surface area of 0.36 ha assuming an average depth of 3 m;

- the required capacity of the sediment dam within Catchment J will be 6.3 ML with an estimated surface area of 0.21 ha assuming an average depth of 3m;

- the required capacity of the sediment dam within Catchment K will be 8.2 ML with an estimated surface area of 0.28 ha assuming an average depth of 3m; and

- the required capacity of the sediment dam within Catchment L will be 9.5 ML with an estimated surface area of 0.32 ha assuming an average depth of 3m.

As mentioned earlier, the pit intersects two main catchments [Catchments A (inclusive of catchments A, E, F, H and M) and B (inclusive of catchments B, C and N) in *Figures 3.2a and 3.2b*]. This catchment shape when overlapped with the quarry pit shape could require the incorporation of a second sediment dam to effectively capture and treat the run-off at early stages of quarry development. If this occurs, the capacity of the sediment dam in Catchment A will be required to be 126 ML. Assuming an average sediment dam depth of 10 m the dam would have a surface area of 1.2 ha. The capacity of the sediment dam in Catchment B will be required to be 42 ML. Assuming a depth of 10 m the dam would have a surface area of 0.42 ha.

3.5.4 *Sediment Dam Pumping Capacities*

The dams have been sized to capture flow from a 1 in 100 ARI 24 hour rainfall event. When flows occur in excess of this volume, the sediment dams will over flow. This could result in the development of a significant surface water feature within the pit at times of high rainfall and /or unwanted flooding within the plant facility catchments.

The water balance model used for sizing the water supply dam was adapted to assess the likely inflows into a single sediment dam located within the pit and the pumping rates that would be required to minimise the breach of the sediment dam and hence the potential for flooding in the pit to prevent quarrying operations.

The following key changes were made to the water balance spreadsheet:

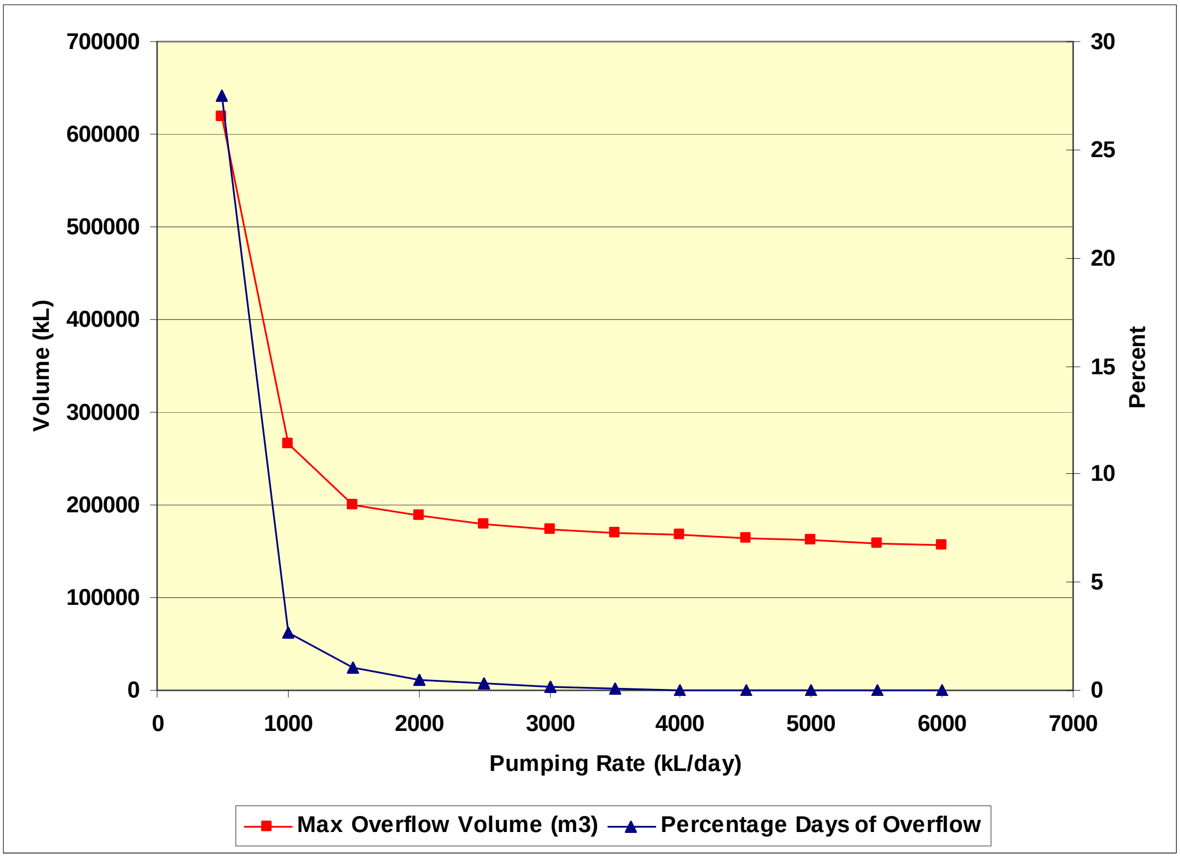
- no environmental flows are released to down gradient catchments and all inflow is captured within the pit;

- it is assumed that all site usage is obtained from the water supply dam and not from within the pit;

- pumping rates are variable depending on the depth of water within the pit sump. When the water elevation in the pit sump is greater than 2 m the dewatering pumping rates are at full capacity, when the water elevation in the pit sump is between 1 and 2 metres the dewatering pumping rates are at half capacity and when water elevation in the pit sump is below 1 m there is no dewatering;
- flooding within the pit is assumed to occur when water storage within the pit is above the design capacity of the sump; and
- groundwater seepage and/or sump leakage is considered to be negligible. This is considered to be an acceptable assumption given the hydrogeological conditions of the granodiorite deposit (ERM, 2006).

Figure 3.3 presents that the pumping rates versus percentage days of flooding and maximum flooding volume.

Figure 3.3 Percent Days of Flooding and Maximum Flood Volumes associated with Pit Sump Pumping Rates.



The information presented in the figure is summarised below:

- pumping rates of 500 kL/day will result in flooding within the pit 27 % of the time;
- if pumping rates are increased to a maximum capacity of approximately 4,300 kL/day there is unlikely to be any over flow from the pit sump over the quarry lifetime; and
- at a maximum pumping rate of 4,300 kL/day the minimum residence time of run-off entering the pit is estimated to approximate 6.5 days, which is based on the assumption that the pit sump will have a storage capacity of 15,000 kL below an elevation of 1 m. A residence time of 6.5 days is considered to be acceptable to allow settling of sediment within the pit sump prior to discharge of the water to the water supply pre-treatment system.

As such a pumping system with a capacity to pump 4,300 kL/day to the water supply dam is required for installation within the pit sump.

Given that the shape and slope of the quarry pit base is unknown at this time, it cannot be ascertained using the model as to the areal extent of the flooding once it occurs. Consequently an assessment of the extent of the area flooded in the pit has not been undertaken.

A pump will not be required within Catchment I as this catchment will discharge directly into the water supply dam pre-treatment system.

The pumping rates to the water supply dam pre-treatment system required to prevent overtopping of the remaining on site sediment dams is estimated to be:

- 1,400 kL/day Catchment D. This catchment's water will be pumped directly into the pit sump and is included within the pumping rates to be pumped from the pit sump to the water supply dam pre-treatment bio-retention swale;
- 298 kL/day from Catchment O. This catchments water will be drained back into the primary pit sump and is included in the pumping rates to be pumped directly from the pit sump to the water supply dam pre-treatment bio-retention swale;
- no pumping will be required from Catchment I as this will discharge directly to the pre-treatment bio-retention swale;
- 141 kL/day for Catchment J with a minimum residence time of 3.7 days;
- 195 kL/day for Catchment K with a minimum residence time of 3.5 days; and
- 224 kL/day for Catchment L with a minimum residence time of 3.5 days.

3.5.5 *Water Supply Dam Pre-Treatment Bio-retention Swale Capacity*

This pre-treatment facility will comprise a bio-retention swale system that will be designed to handle a capacity flow of approximately 4,860 kL/day, which approximates the rate of all onsite pumps (excluding Catchment D, which has been included in the pit sump pumping rate) pumping at maximum capacity.

3.6 RECEIVING WATERS

Surface Water Flow Volumes

The Tangarang Creek Water Supply Dam catchment is approximately 730 ha, and flows to Barbers Creek, which has a catchment of approximately 9,000 ha. Modelling undertaken indicates that 79% of the flows into the water supply dam will be returned to the catchment, and it is likely that the overall reduction in the Barbers Creek catchment flow due to quarry consumption will be around 1.6%.

Releases from the water supply dam will include an allowance for 86% of surface water run-off captured within the operational quarry. In practice, in-pit water will be used within quarry operations in preference to returning it to the water supply dam. Water captured within the active quarry area is for the purposes of pollution control. As such it is not subject to harvestable rights requirements.

Taking into account losses and use from the dam, the average yearly water losses from the water supply dam catchment and the quarry site will approximate 234.2 ML/yr incorporating evaporative losses from all dams. This equates to less than 0.1% of the total yearly flow within the Shoalhaven River and is insignificant in terms of total flows in the Shoalhaven River, which averaged approximately 250,000 ML per annum at Tallowa Dam between 2001 and 2005.

Schedule 3, Condition 24 of the Project Approval stipulates that 10% of the daily flows into the dam are returned to Tangarang Creek. The modelling undertaken by ERM incorporated a daily return of 10% of dam flows to the catchment while allowing the required site water use to be obtained. As such, the water supply assessment has allowed for release of the required environmental flows.

Surface Water Flow Regimes

The dam design will include a pumping station/release pipeline which will return 10% of the daily inflows into the dam back into the catchment down gradient of the dam. The daily inflows will be determined using a level meter near the dam wall embankment, which will be linked to overall catchment inflow.

The dam will also include a spill way that will allow spills under high inflow conditions. These factors will result in a flow regime down gradient of the dam that will mimic the natural flow frequencies and variations to the extent that they meet the requirements of the Project Approval.

Water Quality

Storage dams have the potential for negative impacts on water quality by depleting dissolved oxygen and providing a potential source of algal blooms and undesirable habitat.

Appropriate management of the dam will prevent any potential detrimental impacts upon water quality.

Water from the water supply dam used for site water will be obtained from lower layers of the water column to ensure usage of any potential oxygen depleted water and to facilitate circulation within the dam.

Water returned to the down gradient catchment will primarily be sourced from the shallower water column layers in the dam that have had the least residency time within the dam.

If algal blooms occur within the dam that are considered to be inconsistent with natural conditions, water from these areas will not be dispensed to down gradient catchment areas unless they can be successfully filtered from discharge or until further work by an appropriately qualified consultancy has been undertaken to determine potential impacts and/or appropriate mitigation measures.

Surface water run-off from within the pit will also be collected and incorporated into the water management system to maximise recycling and minimise the potential for off-site transport.

All discharge from the sediment dams to the water supply dam will be pre-treated in a bio-retention swale before discharge into the dam. This will result in water quality meeting expected criteria.

MUSIC modelling undertaken by ERM (2006) suggests that there will be a net benefit to the water quality from redirecting surface run-off from the catchment and disturbed areas through the water supply dam. The model indicated that the dam will potentially result in an 89% reduction in suspended solids, 75.5% reduction in total phosphorus load and a 68 % reduction in the total nitrogen load in background concentrations discharged from the dam back to the catchment.

4 *EROSION AND SEDIMENT CONTROL*

4.1 *INTRODUCTION*

Erosion and sediment control requirements for the quarry are presented in Schedule 3, Conditions 26 and 28 of the Project Approval. These requirements are presented below.

Condition 28 – Erosion and Sediment Control

"The erosion and sediment control plan shall:

1. *Be consistent with the requirements of Managing Urban Stormwater: Soils and Construction Volume 1, 4th Edition, 2004 (Landcom);*
2. *Identify activities that could cause soil erosion and generate sediment;*
3. *Describe measures to minimise soil erosion and the potential for the transport of sediment to downstream waters;*
4. *Describe the location, function and capacity of erosion and sediment control structures; and*
5. *Describe what measures would be implemented to maintain (and if necessary decommission) the structures over time."*

Condition 25 – Sediment Dams

"The proponent shall ensure that:

c) *Critical structures such as "dirty water" dams are designed, constructed and maintained to accommodate a 1 in 100 year ARI 24 hour event; and*

d) *Other dams and water management structures are designed, constructed and maintained to accommodate a 1 in 20 year ARI 24 hour event."*

6. The objective of this chapter is to describe the mechanisms that will be adopted at the site to meet the erosion and sediment control requirements presented above, such that contractors can use this document as a basis for implementing on site sediment and control systems.
7. As stated in the previous chapter, the main mechanism for managing the discharge of sediment from the site will be to capture run-off within sediment basins. Details of the location and capacities of these structures is presented in Section 3 of this WMP. The sizing of the sediment dams to meet Schedule 3, Condition 25 of the project approval are also presented in Section 3 of the WMP.

4.2 ACTIVITIES REQUIRING EROSION AND SEDIMENT CONTROL MEASURES

During construction there will be significant earth works to develop site structures. This will include:

- development of bunds;
- development of the plant and site facilities, include road and rail line development;
- development of sediment dams and drainage infrastructure;
- development of overburden stockpiles; and
- development of the water supply dam.

The main issues associated with developing these structures will include stripping back of land surfaces, which will result in exposed soil surfaces and loose stockpiled material. This material will be prone to erosion from rainfall impact and surface run-off.

The erosion and sediment control measures that will be adopted to protect these systems are detailed in the following sections.

During operation of the quarry there will be ongoing stripping and stockpiling of overburden and exposed surfaces that will require erosion and sediment control measures.

4.3 EROSION AND SEDIMENT CONTROLS

Erosion control is considered to be the first line of defence in managing surface water run-off quality and alleviating pressure on site sediment dams.

Land disturbance will be minimised by clearing the smallest practical area required for ongoing quarry operations and rehabilitating non-active operational areas as quickly as possible (eg outer bund walls and overburden dumps).

An erosion control measure selection process will be adopted in any area where land is being disturbed as described below. Following the implementation of all practical erosion control measures, the general approach to managing site water will be to capture and treat the water in sediment dams that have been designed in accordance with the requirements of the Project Approval and that meet the requirements of *Managing Urban Stormwater: Soils and Construction Volume 1, 4th Edition, March 2004 (Landcom, 2004)* herein referred to as the "Blue Book".

Design details for stormwater and sediment control structures for mine and quarry sites are detailed in the Sections 5 and 6 of Volume 1 of the Blue Book. Additional measures are outlined within *Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries (DECC, 2008).* The design requirements presented in these documents that will be adopted for site sediment control structures is detailed below.

Appendix F of *Volume 2E Mines and Quarries (DECC, 2008)* details a procedure for selecting erosion and sediment control measures. This is provided in *Annex B* and will be adopted onsite, where possible, for the selection of the techniques to be used during construction and operation of the quarry. Particular approaches that will be adopted for the site are discussed further below.

Figures 3.2a and Figure 3.2b present the layout of the sediment dams during construction and operational stages of the quarry.

The main approach that will be adopted on site to prevent ongoing erosion will be to re-consolidate exposed surfaces by re-vegetation. Prior to that temporary systems will be put in place to reduce erosion from exposed surfaces.

A small diversion bund will be placed on the southern boundary of the operational area of the 30 year quarry zone to facilitate the separation and migration of clean surface water to the south and away from operational areas.

Specific sediment and control measures that will be adopted at the site are presented below.

4.3.1 Land Disturbance

All erosion and sediment control measures will be implemented prior to the disturbance of any land. This will include development of all of the sediment dams presented in *Figures 3.2a* and *b* prior to construction and during operation of the quarry.

Sediment fencing will be installed down slope of any disturbed areas to minimise off site migration of contamination. Sediment fencing will be installed in accordance with the Blue Book sediment fence guidance (SD 6-8).

Prior to any area of land being disturbed, the area will be marked out and contractors informed that works cannot extend outside the boundary of this area. This will ensure that the erosion and sediment control measures set up are able to capture the area of land being disturbed.

Land disturbance will be minimised by clearing the smallest practical area possible and rehabilitating non-active operational areas as quickly as possible (eg outer bund walls and overburden dumps).

An erosion control measure selection process will be adopted in any area where land is being disturbed. This assessment process will include adopting the erosion and sediment control decision tree presented in Annex A, which has been adapted from Annex F of *Volume 2E Mines and Quarries (DECC, 2008)*. This selection process is based on the following key steps:

- identifying the problem – erosion or sedimentation – to be managed;
- where the problem is erosion, identifying whether it is caused by rainfall impact or concentrated flow;
- where the problem is sedimentation, identifying if sediment is conveyed by sheet or concentrated flow; and
- selecting the appropriate techniques presented in Annex A depending on the identified specific nature of the problem.

This process will be implemented prior to land disturbance being undertaken as the quarry proceeds over the 30 year operations. The methods adopted will be implemented as soon as practicably possible after the land is disturbed. This will include staged implementation of the erosion and sediment controls/measures, i.e., site stabilisation works prior to land disturbance works finishing.

The measures adopted will be merged with the long-term management objective to permanently re-vegetate disturbed areas with native vegetation species as appropriate, which is discussed further in subsequent sections.

4.3.2 *Top Soil Management*

Top soil stripping will be completed when the soil is moist to prevent disaggregation of soil structure where possible.

A philosophy of handling soil only once will be adopted where possible at the site to minimise the time at which soil may be vulnerable to erosion. This will be achieved by careful scheduling of quarrying activities and having designated permanent areas for top soil stockpiling. It will also include appropriate scheduling of stripping to develop the bunding around the site without stockpiling the material first.

Stockpiles and bunds will be managed in accordance with the SD 4-1 stockpiles present within the Blue Book.

Drainage will be developed around stockpiles to prevent ponding on or around the base of the stockpiles.

Erosion control systems on overburden stockpiles and bunding will include surface roughening, soil surface mulching and mid slope diversions where possible.

4.3.3 *Sediment Dams*

The capacities of sediment dams onsite have been designed in accordance with the Schedule 3, Condition 25 of the Project Approval. Details of this are provided in the previous chapter. The locations of sediment dams around the site are presented in *Figures 3.2a* and *Figure 3.2b.*

In accordance with the requirements of the Blue Book, all sediment dams will be design with a length to width ratio of 3 to 1 such that the residence time within the dams will be suitable for settling sediment prior discharge to the water supply dam pre-treatment system. If this ratio cannot be achieved, baffles will be installed within the dams to artificially create a 3 to 1 ratio.

The required sediment dam capacities within the pit are large. In order ensure that the sump pits achieve the desired purpose of capturing all surface run-off from disturbed areas while preventing the sump from impacting site works a staged approach to pit sump migration and development is recommended. An idealised approach is presented in *Figure 4.1*. This includes the following key factors:

- alternating the location of the pit sump from one side of the pit to the other;
- developing the pit sump prior to commencing any quarrying of the remainder of the pit;
- the pit sump will be excavated to a depth equal to the depth required to reach recommended dam capacity plus the quarry bench height;
- quarrying will move progressively across the base of the pit from one side to the other;
- Once quarrying has reached the other side of the pit a new pit sump will be developed to a depth required to reach recommended pit sump capacities plus the quarry bench height; and
- Quarrying will move progressively back across the pit again. This will be an ongoing process until the maximum depth of the pit is reached.

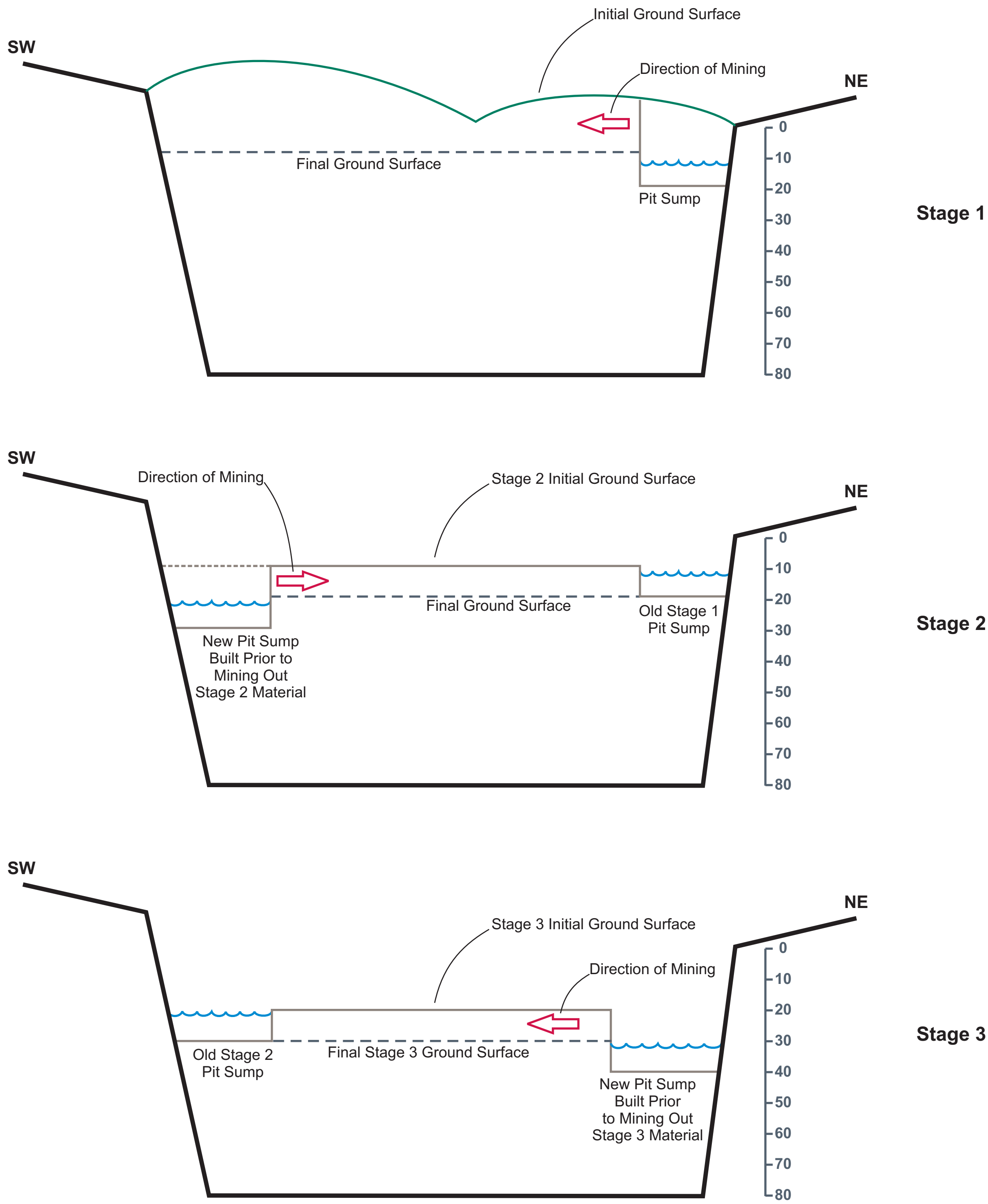


Figure 4.1

Idealised Quarrying Procedure

Client:	Boral		
Project:	Peppertree Quarry		
Drawing No:	0118026s_WMP_C001_R0.cdr		
Date:	09/08/2010	Drawing size:	A4
Drawn by:	ML	Reviewed by:	SAC
Scale:	Not to Scale		

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This approach represents an idealised procedure to guide pit sump development. Other approaches may be adopted within the pit to account for effective capture of surface run-off in the pit sump and to meet on going operation requirements. However, the approaches adopted will ensure that the pit sump capacity meets the required design capacity and is performing the required function detailed in the Project Approval.

The bunding around the northern and eastern boundaries of the resource area has an elevation of approximately 10 m and will form barriers to natural drainage from sediment dams back to the Tangarang Creek and/or Barbers Creek catchments. The bunding will act as a secondary containment mechanism in addition to sediment dams located within the pit for impacted surface water. However, once the pit extends below the base of the natural catchment area draining to the north, the pit itself will act as a secondary water containment mechanism for water from disturbed areas flowing into the pit. This will prevent any untreated surface water from disturbed areas from flowing directly into Tangarang Creek.

The pit sump is unlikely to be subject to significant leakage mainly due to the very low permeability of the granodiorite and a groundwater gradient that will be directed into the pit. As such no liner will be placed within the pit sump.

Out of pit sediment dams will be designed in accordance with earth dam requirements presented in *Section 6 (SD 6-4)* of *Volume 1* of the *Blue Book*. In pit, sediment dams will not spill water and will not be designed to strictly meet these criteria.

The sediment dams external to the pit will be constructed within the natural low permeability silt and clay sediments within the study site. If permeable material below the silts and clays are penetrated, exhumed silts and clays will be used to line the dams. A silt/clay layer of approximately 1 m thickness will be used to line all sediment dams outside of the quarry pit.

All sediment dams and associated drainage will be constructed prior to any works commencing upgradient of the dams. The dams will be constructed in dry conditions only to prevent sediment laden water discharging from the site due to run-off occurring during their construction.

4.3.4 Pre-Treatment System for the Water Supply Dam

A pre-treatment facility will be located in the headwaters of the water supply dam that will receive water from sediment dams on site and within the pit.

The bio-retention system will include a sloped vegetated drainage channel underlain by filter media, comprising of a layer of sand.

A perforated drainage pipe embedded in course aggregate will underlie the filter media. The bio-retention swale will act as an additional filter to water being discharged into the water supply dam.

The required capacity of this system is detailed in the previous chapter.

4.3.5 Drainage Systems

The drainage network will be designed to pre-treat run-off prior to discharging to sediment dams. This will be accomplished by installing rock check dams along the drainage pathways to reduce flow energy and promote capture and settling of fines.

The permanent areas of the drainage network will be designed to minimise in drain erosion and will include:

- installing appropriate liners, which could include prefabricated liners consisting of concrete, polyethylene, other forms of erosion control blankets or hard armour channels;
- rock check dams at regular[1] intervals along drainage lines to reduce flow energy; and
- design of drains that have grades of less than 1 % where possible. Where grades are greater than 1 % suitable systems will be developed to prevent erosion of the drainage channels in accordance with the Blue Book. This may include the use of liner blankets.

Upslope drainage systems will be placed around the permanent edges of the pit to prevent erosional surfaces developing around the edge of the pit and to prevent instability. This drainage system will then direct water within localised structures into the pit base.

Areas of the quarry footprint which are yet to be disturbed (eg.. to the south of the pit) surface run-off will be uncontrolled and will flow directly into the pit. Due to the nature of the topography in these areas, the majority of surface run-off will naturally channel into localised discharge zones into the pit. If required, temporary permeable rock walls/dams will be used to dissipate flow and reduce erosion at the quarry pit edge and at the pit base where these flows occur.

[1] The 'Blue Book' recommends that rock check dams should be spaced so that the toe of the upstream dam is level with the spillway of the downstream dam.

4.3.6 *Road Systems*

Roads will be constructed to ensure surface drainage is optimised and stabilised so that erosion of roads is reduced and so that sedimentation along roadside drains is minimised.

Roads will be sloped such that run-off will flow by the shortest routes to roadside drainage systems that will redirect run-off to catchment drainage networks and sediment dams.

Roadways on stockpiles and bunded areas will be designed to slope inwards so that run-off will be directed back into the pit and trapped within the site erosion and sediment control network.

4.3.7 *Long Term Management*

As explained earlier, the long term management procedure will be to revegetate disturbed areas or implement suitable drainage facilities around built structures.

The re-vegetation plan will be design to use native flora that will result in rapid stabilisation of disturbed areas. Key areas that will be re-vegetated will include bund walls and overburden stockpiles.

4.3.8 *Water Supply Dam Construction*

In order to prevent sedimentation and water quality reduction within Tangarang Creek during construction of the water supply dam wall, the following methods will be adopted at the site. Construction of the dam is anticipated to take less than two weeks, with construction planned to be undertaken during low flows in Tangarang Creek. These methods are summarised on *Figure 3.2a*.

1. A temporary weir will be developed at the up-gradient side of the dam footprint. This weir will be developed during a period when there is limited flow within the creek.

2. Drainage lines will then be developed around the periphery of the water supply dam construction site.

3. The drainage lines will drain directly into sediment dams of Catchment S capacity located within Catchment S and S2 in *Figure 3.2a*. The sediment dam in the Catchment S2 will drain back into the temporary weir created to capture and divert Tangarang Creek flows to down gradient areas. The sediment dam in Catchment S will drain directly back into Tangarang Creek.

4. Pumps will be installed within the temporary weir to pump inflow to the down gradient catchment.

5. The construction area will be stabilised using the process outlined for erosion and sediment control measure implementation detailed in 4.3.1 above. This will be followed by long term stabilisation using native vegetation species.

6. After construction and stabilisation works are complete, the temporary diversion weir and the sediment dam within Catchment S will be decommissioned or left to form part of the base of the water supply dam. The sediment dam within Catchment S will remain to capture and effectively treat run off from the dam wall . This sediment dam will discharge directly back to Tangarang Creek catchment down gradient of the water supply dam.

4.4 MAINTENANCE

The site environmental officer or delegated individual will undertake regular inspections to assess the integrity of the sediment and erosion control systems on site. This will include assessing permanent structures and those temporarily installed by contractors working in specific areas.

Inspections of permanent structures will be undertaken after rainfall events greater than 15 mm in 24 hours). The aim of this will be to see how the system is performing under low flow events so that system weaknesses can be improved in preparation for larger rainfall events and to ensure that the system is unobstructed ahead of larger rainfall events. The 15 mm rainfall event used for initiating checks maybe revised if the system is seen to be performing effectively under this amount of rainfall.

Inspection of temporary structures around construction areas, overburden stripping areas and unconsolidated stockpiles will be undertaken prior to the commencement of works and on a rainfall event and weekly basis thereafter.

Inspections will include visual observations to check for erosion of surfaces on site and sedimentation within the water management network. An erosion and sediment control checklist is provided in Annex C.

Where systems have been viewed not to be functioning correctly the system will be restored to meet the requirements presented within this document and the standards presented in the "Blue Book". In areas, where erosion is occurring regularly, additional erosion control measures will be put in place in accordance with the "Blue Book".

The structures/activities requiring inspection include:

- road and associated drainage systems;
- drainage networks;
- sediment dams;
- bunding and overburden stockpiles;
- temporary stockpiles; and
- overburden stripping areas.

The specific inspection requirements for these structures are presented below.

4.4.1 Roads

Roads will be visually inspected for the presence of erosion of the road systems and sedimentation within roadside drainage networks. Where erosion and sedimentation is observed, this will be rectified immediately by regrading the road and by clearing sediment accumulation within the drainage network. An assessment will then be made of the potential cause of the erosion and sediment control issues and additional measures will be put in place to reduce erosion. The measures that could be considered include:

- installation of mitre drains;
- scour protection of road drainage; and
- re-grading of the road surface to reduce gradient.

4.4.2 Drainage Networks

Drainage networks will be visually inspected for the presence of erosion of drainage channels and accumulation of sediment in drainage channels. Where erosion and sedimentation has occurred, immediate action will be taken to repair the damage. Rock check dams will also be inspected for sedimentation and will be clean out as required.

Where regular erosion and sedimentation is occurring, an assessment will be made of the likely cause of the issue and further protection measures will be put in place to mitigate the erosion and sedimentation. This may include, but is not limited to:

- installing additional up gradient sediment fences;
- emplacement of more robust drain liners in accordance with the "Blue Book";
- installing additional energy dissipation structures in accordance with the "Blue Book";
- reducing the grade of the drainage network.

4.4.3 Sediment Dams

The sediment dam within the pit (the pit sump) will be regularly moved and will therefore not require regular visual inspection for sedimentation. Other dams will require visual inspection on a regular basis to ensure that sedimentation of the dams is not resulting in a capacity less than the design requirements. As such these dams will require emptying on a regular basis for inspection. It is recommended that measuring stakes are placed in the dams to monitor the depth of sediment. Subject to required capacities being reduced by sediment accumulation, the dams will be re-excavated/re-graded.

Visual inspections should also be completed to assess the clarity of water within the dams prior to discharge and the integrity of the dams structures. This will include checking for cracking within, leakage of the dam walls. Where the integrity of the dam walls appears to compromised, immediate works will be undertaken to stabilise the structure.

4.4.4 Bunding and Overburden Stockpiles

The sides of overburden stockpiles and bunding will be visually inspected to check the condition of existing erosion control structures and for the development of erosion features such as scouring. Where identified, additional measures will be put in place to reduce erosion. This may include the installation of upgradient surface water flow capture systems, the installation of erosion control blankets, development of mid-slope terraces or the re-grading of the slopes to reduce gradients.

4.4.5 *Temporary Stockpiles And Overburden Stripping Areas*

Regular visual inspections of these areas will be undertaken to ensure that works are being undertaken within the area that erosion and sediment controls are protecting. Visual inspections will also be undertaken of the features that have been installed such as sediment control fencing and hay bailing to prevent soil erosion and sedimentation.

4.4.6 *Remaining Areas*

A broad inspection of all other areas onsite will be undertaken for the signs of erosion and sedimentation. Where identified, an assessment will be made of the likely cause of the erosion/sedimentation and appropriate control measures will be installed.

5 MONITORING PROGRAM

5.1 INTRODUCTION

Schedule 3, Condition 29 of the Project Approval details the requirements for a Surface Water Monitoring Program. It states that:

"The Surface Water Monitoring Control Program shall include:

a) detailed baseline data on surface water flows and quality in Tangarang Creek and Barbers Creek;

b) surface water impact assessment criteria;

c) a program to monitor surface water flows and quality;

d) a protocol for the investigation of identified exceedences of the surface water impact assessment criteria; and

e) a program to monitor the effectiveness of the Erosion and Sediment Control Plan."

Schedule 3, Condition 30 of the Project Approval details the requirements for a Groundwater Monitoring Program. It states that:

"The Groundwater Monitoring Control Program shall include:

a) detailed baseline data on groundwater levels, flows and quality based on statistical analysis;

b) groundwater impact assessment criteria for monitoring bores;

c) a program to monitor regional groundwater levels and quality; and

d) a protocol for the investigation of identified exceedences of the groundwater impact assessment criteria;

The overall objective of the monitoring plan is to meet the requirements of the project approval presented above. To meet this objective the monitoring plan has been designed to:

- characterise baseline surface and groundwater conditions to set a benchmark for water quality conditions against which the any potential impacts of the quarry can be compared;

- provide water quality data, such as pit water chemistry groundwater and surface water chemistry, to establish chemical relationships between the quarry operations, groundwater and surface water features, which will allow potential impacts to be better delineated;

- assess the suitability of water stored in the water supply dams for use in quarry operations and for environmental releases;

- assess the quality of water being discharged from sediment dams to the water supply dam;

- collectively assess the effectiveness of the water management system;

- assess the quality of water being discharged from sediment dams located outside the pit catchment (i.e. around site bunding) to ensure discharge water quality meets required standards;

- assess the quality of water being discharged from the water supply dam back to Tangarang Creek to ensure discharge water quality meets required standards;

- characterise the groundwater elevations in both the shallow aquifer system located at the interface between overburden and granodiorite bedrock (located at depths of between 15 m and 30 m below ground surface (m bgs) and the deeper fractured bedrock system to the estimated maximum depth the quarry pit (approx. 80 mbgs);

- provide a sentinel well between the pit void and any abstraction wells, which can be used as a trigger for potential impacts and therefore for implementing potential mitigation measures;

- tie the monitoring network into previous surface and groundwater assessments to maintain consistency and to allow for extended baseline conditions data. This therefore excludes those wells currently located within the quarry pit footprint; and

- provide additional data such as pit void base elevations/water elevations and surface water elevations to establish groundwater flow directions between the quarry pit and surface water features such that potential seepage impacts can be estimated.

5.2 *MONITORING PROGRAM*

5.2.1 *Surface Water Quality Monitoring*

To achieve the surface water objectives the monitoring site presented in *Figure 5.1* have been established. The monitoring sites presented are summarised below.

Upstream (monitoring site U1) – water quality will be monitored upstream from the main water supply dams to assess the water quality from upstream catchment areas. Catchment run-off has the potential for elevated nutrient levels associated with agricultural practises in the predominantly rural catchment. The samples will be scheduled for the complete laboratory analytical suite presented in following sections of this chapter.

Dams (monitoring sites WD1) – water quality will be monitored at the outflow point in the main water supply dams following establishment to ensure that water is of suitable quality for its intended use in quarry operations and for releases to Tangarang Creek. The samples will be scheduled for the complete laboratory analytical suite.

Tangarang Creek (monitoring site T1) – water quality will be monitored in Tangarang Creek downstream of the supply dam to confirm that site operations are not impacting receiving waters. Water samples will be scheduled for the complete laboratory analytical suite.

Out of Pit Sediment Dams (monitoring sites OSD 1 to OSD 14) – field based water quality monitoring will be undertaken at all sediment dams located outside the bund that discharge offsite during construction and rehabilitation of the bunds. This will be undertaken prior to discharge of water from the site. Sampling will include visual inspections of the water quality and collection of water clarity data using a water quality meter.. Further to this, field monitoring of the water quality in the 'out of pit' site sediment dams located within the operational area will be undertaken to assess the effectiveness of the dams. If adverse water quality is identified an assessment will be undertaken to identify and mitigate any potentially adverse impacts. Samples will be obtained from the discharge point of the dams. As sampling will be undertaken within these dams, it is not considered necessary to monitor flow quality in Barbers Creek. This is considered to be a suitable approach given that accessibility to Barbers Creek is severely limited and accessing the Creek for sampling is likely to represent a significant health and safety issue.

In Pit Sediment Dams (monitoring site ISD1) – in pit water quality will be sampled prior to discharge to the pre-treatment bio-retention swale located at the head waters of the water supply dam. The samples will be scheduled for the complete laboratory analytical suite.

Bio-retention Swale Discharge (monitoring site BRS1) – discharge from the pre-treatment bio-retention swale to the water supply dam will also be monitored. This will holistically assess the discharge water quality from other sediment dams located on site. The samples will be scheduled for the complete laboratory analytical suite. Samples will be obtained from the discharge point of the dams.

Usage - rainfall, flow and usage data will also be recorded during the operation of the quarry. A gauge will be located at the site to gain daily rainfall and evaporation data to predict water supply balances and to manage dust suppression. Water levels in each of the storages will be monitored at least weekly to confirm available supply and to alert operations to impending water restrictions. Flow meters will be installed to monitor the quantity of water being used on-site and to quantify environmental release requirements.

5.2.2 *Surface Water Flow Monitoring*

To ensure that at least 10 % of the daily flows in Tangarang Creek are being released back to the catchment, a flow monitoring system will be implemented within the water supply dam. . Changes in the level of the lake at the water supply dam face will be calibrated with dam volume and used to determine daily inflow and outflow volumes.

Environmental releases will occur continuously in accordance with in-flows, and will be supplemented by spills during high flow conditions.

Spills from the overflow point in the water supply dam will be monitored daily using a level stage system that relates stage height to total flows. When flows occur the stage will be monitored on a twice daily basis by the environmental officer for the site or by an automated flow gauging system.

5.2.3 *Groundwater Elevation Monitoring*

North of Quarry: Two wells will be monitored on the northern side of the pit, this will include on going monitoring of P04, which is screened within the shallow aquifer system and an additional well (MW42) will be installed within the fractured bedrock aquifer to depths (80 m) that will allow characterisation of groundwater elevations over the entire lifetime of the quarry.

East of the Quarry - Two wells will be monitored on the eastern side of the pit. Well (MW43) will be installed within the fractured bedrock aquifer to depths (80 m) to allow characterisation of groundwater elevations over the entire quarry life. Well (MW44) will be installed within the shallow aquifer system to monitor shallow groundwater elevations over the life of the quarry.

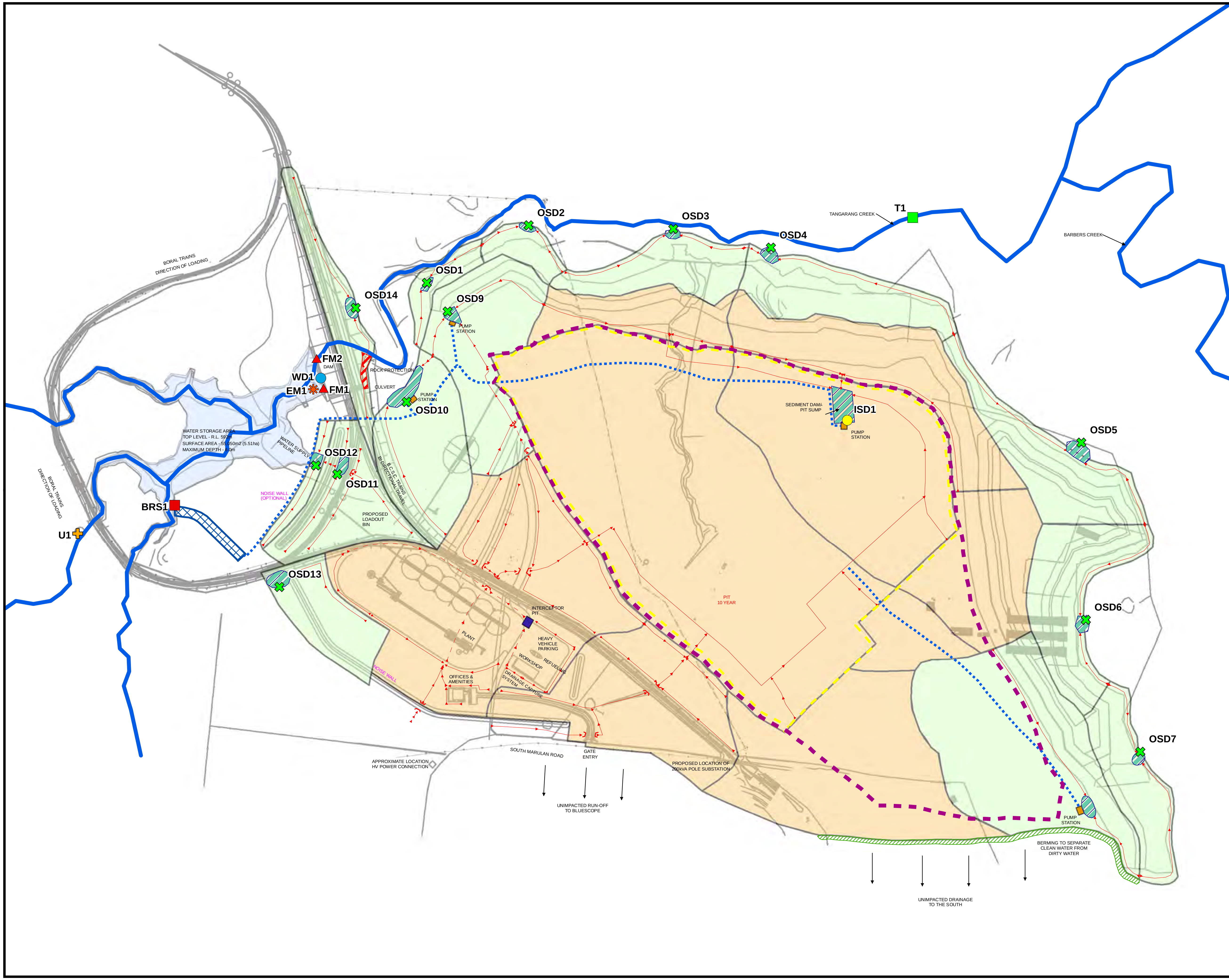
South of the Quarry: The existing monitoring network to the south of the quarry pit will be used to monitor groundwater elevations. P35 and P41 will be used to monitor shallow and deep groundwater elevations and chemistry on the south side of the quarry pit. These wells will need to have casings installed through the overburden and well monuments emplaced at the surface (they will remain as open hole installations).

West of the Quarry: Two wells will be monitored on the western side of the pit. (MW45) will be installed within the fractured bedrock aquifer to depths (80 m) that will allow characterisation of groundwater elevations over the entire quarry lifetime. A further well (MW46) will be installed within the shallow aquifer system to monitor shallow groundwater elevations over the quarry lifetime.

Sentinel Well: - An additional sentinel well (MW47) will be installed within the overburden/bedrock interface aquifer approximately 500 m to the west of the pit void to monitor potential impacts between the site and the nearest abstraction bores. Groundwater elevation changes in this will then be tied to mitigation measures to prevent adverse impacts to the nearest abstraction bores.

Pit Void: - The base of the pit void and/or the pit sump water elevations will be recorded and related to groundwater elevations and surrounding surface water features to provide essential data for determining potential seepage impacts.

All groundwater sampling locations will be surveyed relative to Australian Height Datum.



Legend

- Flow Monitoring Site
- Bio-Retention Swale Discharge Water Quality Monitoring Location
- Tangarang Creek Water Quality Monitoring Location
- Upstream Inflow
- Water Supply Dam Discharge Water Quality Monitoring Location
- In Pit Sediment Dam Water Quality Monitoring Location
- Out of Pit Sediment Dam Water Quality Monitoring Location
- Elevation Monitoring Point
- 10 Year Pit
- 30 Year Pit
- Pumping Pipe Line
- Drainage Lines
- Interceptor Pit
- Pump Station
- Burming
- Sediment Dam
- Water Supply Dam (pre-treatment system/ bio-retention swale)
- In Pit Capture and Treatment
- Out of Pit Capture and Treatment
- Dam Location

Notes:

1. There are no catchments P & Q.
2. There is no sampling point OSD8.

Figure 5.1
Surface Water Monitoring Sites

Client: Boral
Project: Peppertree Quarry

Drawing No: 0118026_RP01LR_G016_R0
Date: 09/08/2010 Drawing size: A3
Drawn by: SW Reviewed by: SC
Projection: Not Defined
Scale: Refer to Scale Bar

N 0 50 100 150m

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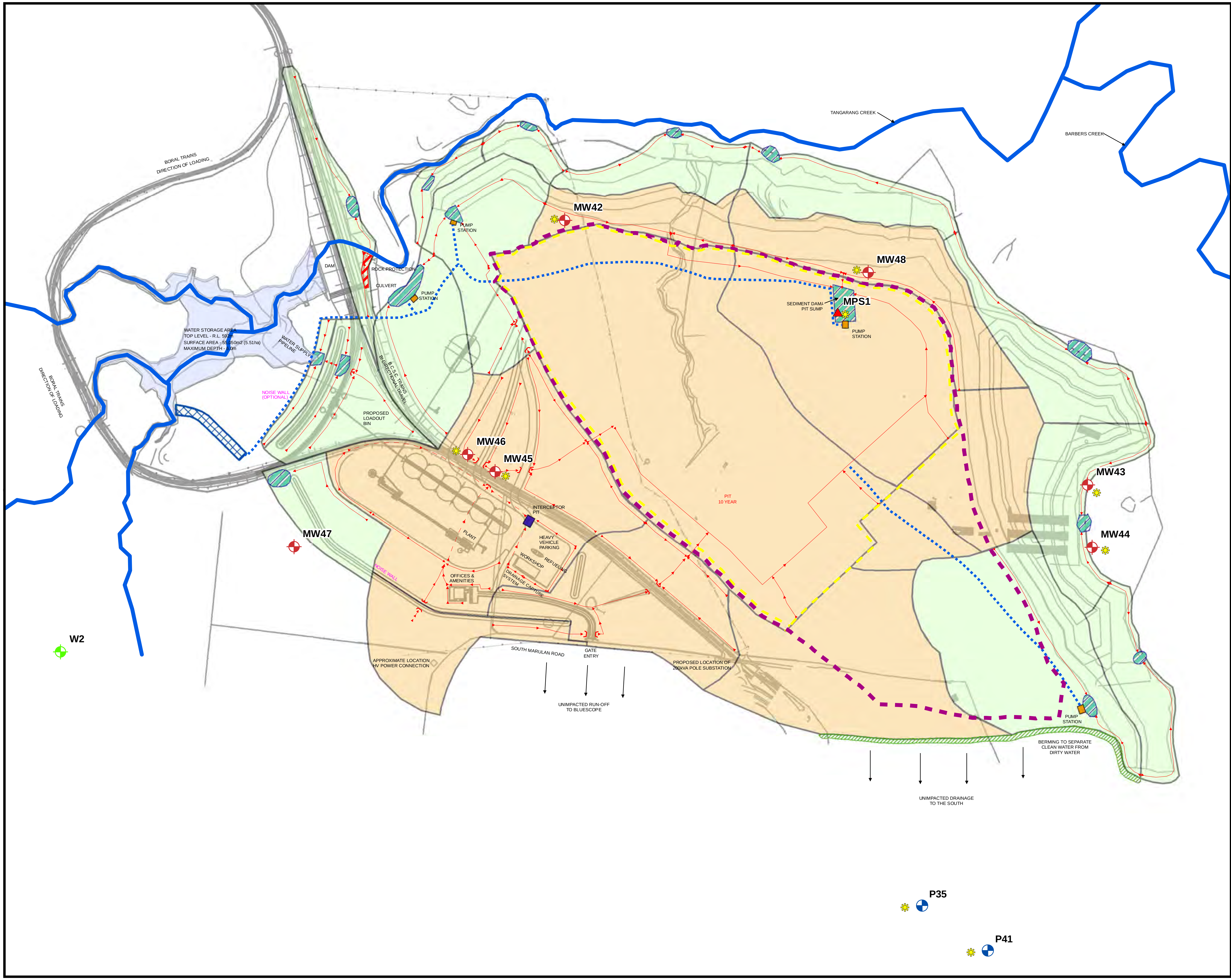
5.2.4 *Groundwater Quality Monitoring*

Eight monitoring wells used for monitoring elevation and the pit sump will be sampled for groundwater quality. This includes a shallow and deeper aquifer system well on each side of the quarry pit including:

- wells MW42 and MW48 on the north side of the pit,
- wells MW43 and MW44 on the east side of the pit;
- wells P35 and P41 on the south side of the pit;
- wells MW45 and MW46 on the west side of the pit; and
- pit sump water will be sampled at times when water is present during groundwater sampling events.

The Sentinel Well will be installed further west of the site as a trigger for potential drawdown effects at the nearest abstraction bore and therefore is not required to be included in the groundwater chemistry regime.

Groundwater monitoring sites are shown graphically on *Figure 5.2*.



Legend

- Abstraction Well Locations
- Existing Monitoring Well Locations
- Proposed New Monitoring Well Locations
- Mine Pit Sump
- Groundwater Sampling Sites
- 10 Year Pit
- 30 Year Pit
- Pumping Pipe Line
- Drainage Lines
- Dam Location
- Interceptor Pit
- Pump Station
- Burming
- Sediment Dam
- Water Supply Dam (pre-treatment system/ bio-retention swale)
- In Pit Capture and Treatment
- Out of Pit Capture and Treatment

Notes:
1. There are no catchments P & Q.

Figure 5.2
Groundwater Monitoring Sites

Client:	Boral
Project:	Peppertree Quarry
Drawing No:	0118026_RP01LR_G017_R0
Date:	09/08/2010
Drawing size:	A3
Drawn by:	SW
Reviewed by:	SC
Projection:	Not Defined
Scale:	Refer to Scale Bar

N 0 50 100 150m

Maps and figures contained within this document may be based on third party data, may not be to scale and is intended for use as a guide only. ERM does not warrant the accuracy of any such maps or figures.

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5.2.5 *Analytical Schedule*

The following analytical schedule will be completed for surface and groundwater samples obtained from the site and the surrounding area, except for the out of pit sediment dams. The out of pit sediment dams will be monitored for field chemical and visual parameters only.

- field chemical parameters including dissolved oxygen (DO), turbidity (surface water only), electrical conductivity (EC), pH, oil and grease and temperature;
- visual monitoring of algal blooms within the water supply dam;
- total dissolved solids (TDS);
- total suspended solids (TSS);
- turbidity (NTU);
- TPH,
- PAH,
- major cations and anions including calcium (Ca^{2+}), potassium (K^{+}), magnesium (Mg^{2+}), sodium (Na^{+}), ammonia (NH_4^{+}) chloride (Cl^{-}), sulphate (SO_4^{2-}), bicarbonate (HCO_3^{-}), nitrate (NO_3^{-}) and nitrite (NO_2^{-}).
- total nitrogen (TN) and total phosphorus (TP); and
- faecal coliforms including enterococci (surface water samples only);

Given that industrial facilities and machinery will be onsite there may be potential for petroleum based contaminants. Indicator analyses for these type of contaminants include total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH).

Nitrogen based compounds often occur within mines and quarries due to the use of explosives and it is proposed that speciated nitrogen including, ammonia, nitrate and nitrite are added to the analytical schedule.

Total nutrient concentrations have been included in the list of parameters as elevated nutrient levels have been identified within existing water quality data for Tangarang Creek, which is typical of agricultural catchments. The operation of the quarry has potential to contribute to nutrient levels and faecal coliforms through the operation of the package sewage treatment plant for offices and amenities. The snapshot water sample from Tangarang Creek indicated that baseline water quality has elevated levels of nutrients (total nitrogen and total phosphorous), which is typical of agricultural catchments.

5.2.6 *Monitoring Frequency*

Water quality monitoring will commence prior to site establishment and/or any quarrying activities to develop background information on quality and flows within the existing waterways.

Water quality sampling will initially be quarterly with additional event based sampling following rainfall events of greater than 30 mm (max one per quarter when out flow from the dams is occurring). Sampling of surface water monitoring sites will be restricted to T1 and B1 to establish a baseline prior to the commencement of construction. All groundwater sampling sites will be included in the baseline sampling regime.

Field chemical parameters will be measured from the site's dirty water management system to confirm suitability prior to any releases to the external receiving water environment.

If adverse water quality parameters are identified at any location within the site water management system, increased monitoring will be undertaken to further characterise the issue. The increase in frequency will be subject to the particular condition and may result in daily or weekly monitoring at localised zones within the water management system.

Following the initial year of quarry operations the frequency may be extended to half yearly, provided water quality continues to meet the performance criteria.

Groundwater elevations and the pit void base/sump elevations will be monitored on a quarterly basis to allow seasonal trends in baseline and operational groundwater elevations to be established.

Surface water releases will be monitored at locations FM1 and FM2 whenever flows are occurring using automated flow meters.

5.2.7 *Quality Control*

All samples will be taken in accordance with NSW guidance for surface and groundwater sampling and by a suitably experienced sampler.

All laboratory analysis will be completed by a laboratory that is NATA accredited for the analytes presented above.

A summary of the proposed monitoring program is included in *Table 5.1*.

All flow gauging equipment will be checked and re-calibrated in accordance with suppliers recommendations.

Monitoring will be undertaken by appropriately trained and qualified individuals to ensure quality of monitoring procedures.

5.2.8 *Reporting*

Reporting will be undertaken on a quarterly basis and compared against assessment criteria. Any exceedances of criteria will trigger an immediate investigation to determine the cause of the exceedance and preparation of a corrective action plan to re-establish appropriate controls.

Reporting of all monitoring data will be undertaken in accordance with the requirements of *Schedule 5 - Environmental Management and Monitoring Conditions.* This includes requirements to report incidents that occur on site and to report monitoring data within and annual report. Quarterly monitoring reports will also be posted on the quarry website (www.boral.com.au/peppertreequarry).

Table 5.1 Summary of Monitoring Program

Location	*Location Name*	*Depth (m bgs)*	*Water Body*	*Installation*	*Monitoring Network*	*Analytical Suite*	*Frequency*	*Rationale*
Surface water								
Upstream catchment	*U1*	*Na*	*Tangarang Creek*	*Na*	*Water Chemistry*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions, nutrients and faecal coliforms.*	*Quarterly.*	*Determine the quality of water in the upper catchment for use in quarry operations*
Water Supply Dam	*WD1*	*Na*	*Tangarang Creek*	*Na*	*Water Chemistry*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions, nutrients and faecal coliforms.*	*Quarterly during a flow event. If no flow at least quarterly.*	*Determine suitability for use and environmental releases.*
Tangarang Creek	*T1*	*Na*	*Tangarang Creek*	*Na*	*Water Chemistry*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions, nutrients and faecal coliforms.*	*Quarterly during a flow event. If no flow at least quarterly.*	*Confirm releases from the main water supply dams are not adversely impacting upon downstream water quality.*
Pit Sump/Sediment Dam	*ISD1*	*Na*	*In Pit Sediment Dam*	*Na*	*Water Chemistry*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions, nutrients and faecal coliforms.*	*Quarterly during a flow event. If no flow at least quarterly.*	*Assess the impact that water requiring release from dirty water dams have on water supply dam water quality.*
Water Supply Dam Pre-treatment Bio-Retention Swale	*BRS1*	*Na*	*Bio-retention Swale.*	*Na*	*Water Chemistry*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions, nutrients and faecal coliforms.*	*Quarterly during a flow event. If no flow at least quarterly.*	*Assess the impact water requiring release from dirty water dams will have upon water supply dam and downstream water quality.*
Out of Pit Sediment Dams	*OSD1 to OSD15*	*Na*	*Out of Pit Sediment dams*	*Na*	*Water Chemistry*	*Field chemical parameters including water clarity.*	*Quarterly during a flow event. If no flow at least quarterly.*	*Assess the impact that water running off the bund areas after construction and during rehabilitation will have on downstream water quality.*
Water Supply Dam Environmental Release Point	*FM1*	*Na*	*Water Supply Dam*	*Na*	*Surface Water Flow*	*Flow gauging*	*Automated monitoring when flow occurs (hourly)..*	*To monitor outflow from the water supply dam to meet the 10% environmental flow requirements.*

Location	Location Name	Depth (m bgs)	Water Body	Installation	Monitoring Network	Analytical Suite	Frequency	Rationale
Water Supply Dam Spill Point	*FM2*	*Na*	*Water Supply Dam*	*Na*	*Surface Water Flow*	*Flow gauging*	*Automated monitoring when flow occurs (hourly). or twice daily manual monitoring during spill events.*	*To monitor flows spilling form the spill way to determine total flows back to the catchment.*
Water Supply Dam Water Elevation	*EM1*	*Na*	*Water Supply Dam*	*Na*	*Surface Water Flow*	*Flow gauging*	*Automated monitoring of change in lake levels (hourly)*	*Determining the daily inflows to the dam to aid the determination of 10% environmental release volumes.*
Groundwater								
North of Pit	*MW48*	*22*	*Overburden/ Bedrock Interface Aquifer*	*Proposed*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and chemistry within the shallow aquifer system to the north*
	MW42	*approx. 80*	*Fractured Rock Aquifer*	*Proposed*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and groundwater chemistry within the deeper aquifer system*
East of Pit	*MW43*	*approx. 80*	*Fractured Rock Aquifer*	*Proposed*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and groundwater chemistry within the deeper aquifer system to the east*
	MW44	*approx. 30*	*Overburden/ Bedrock Interface Aquifer*	*Proposed*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and groundwater chemistry within the shallow aquifer system to the east*
South of Pit	*P35*	*18*	*Overburden/ Bedrock Interface Aquifer*	*Existing*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations within the shallow aquifer system to the south*
	P41	*79*	*Fractured Rock Aquifer*	*Existing*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and groundwater chemistry within the deeper aquifer system to the south*

Location	Location Name	Depth (m bgs)	Water Body	Installation	Monitoring Network	Analytical Suite	Frequency	Rationale
West of Pit	*MW45*	*approx. 80*	*Fractured Rock Aquifer*	*Proposed*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and groundwater chemistry within the deeper aquifer system to the west*
	MW46	*approx. 30*	*Overburden/ Bedrock Interface Aquifer*	*Proposed*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising groundwater elevations and groundwater chemistry within the shallow aquifer system to the west*
	MW47	*approx. 30*	*Overburden/ Bedrock Interface Aquifer*	*Proposed*	*Groundwater Elevation*	*na*	*Quarterly*	*Sentinel well to act as an indicator of potential impacts at the nearest abstraction well.*
Quarry Pit	*MPS1*	*Surface*	*NIL*	*NIL*	*Groundwater Quality and Elevation*	*Field chemical parameters, BOD, TSS, TPH, PAH, major cations and anions*	*Quarterly*	*Characterising water elevations and chemistry of the quarry pit surface water.*

5.3 *ASSESSMENT CRITERIA*

5.3.1 *Surface Water and Groundwater Water Quality*

Surface and groundwater quality data will be compared to the baseline data to be established prior to commencement of construction and operation and against ANZECC criteria for the protection of fresh and marine water quality. Groundwater samples will also be compared with the Australian Drinking Water Guideline criteria for potential impacts upon surrounding bores registered for domestic use.

A potentially adverse impact will be considered to exist where identified concentrations are present above ANZCECC or ADWG criteria and are outside the range of background concentrations. When this occurs, further investigation by appropriately qualified person/consultant, will be initiated to characterise the source of the exceedance and to recommend and implement solutions to mitigate any potential impacts. Additional monitoring may be required to identify the source of the impact and monitor the effectiveness of the remedial solution.

The threshold criteria adopted for the analytes being monitored are presented in *Table 5.2*.

Table 5.2 Water Quality Criteria

Analyte	ADWG		ANZECC		Other
	Guideline Values				
	health	aesthetic	Ecosystem Protection	Primary Contact	
Field Parameters					
Dissolved oxygen (mg/L)	not necessary	>8	9-12 [2]	> 6.5	
Turbidity Field (water quality meter)	not necessary		2-25		
Electrical conductivity (mS/cm)	-	1000	30-350		
pH (field)	-	6.5-8.5	6.5-8.0 [2]	5-9.0	
Oil and Grease					None Visible
Solids					
Total Dissolved Solids mg/L		500			
Total Suspended Solids mg/L					
Turbidity – Laboratory (NTU)		5	2_25		
TPH					
TPH C_{10}-C_{36}	-	-	7 [3]		
PAHs					
Benzo[a]pyrene	0.01	-	ID [1]		
Naphthalene	-	-	16 [1]		
Cations and Anions					
Calcium (Ca2+)	-	-	-		
Potassium (K+)	-	-	-		
Magnesium (Mg2+)	-	-	-		
Sodium (Na+)	ID	180 000	-		
Ammonia (NH4+)	ID	500	900 [1]		
Chloride (Cl-)	-	250 000	-		
Sulphate (SO42-)	-	-	-		
Bicarbonate (HCO3-)	-	-	-		
Nitrate (NO3-)	50 000	-	700 [1]		
Nitrite (NO2-)	3000	-	-		
Nutrients					
Total Nitrogen			250		
Total Phosphorous			20		
Bacteria					
Faecal coliforms (cfu/100mL)				150	

All data in µg/L unless otherwise specified
- no criteria
ID insufficient data to set guidelines
1. ANZECC (2000) freshwater trigger value for the protection of 95% of species
2. ANZECC (2000) default trigger values for physical and chemical stressors for South East Australia for slightly disturbed ecosystems - upland river
3. ANZECC (2000) low reliability value for the protection of 95% of species

5.3.2 *Surface Water Flows*

A potential adverse impact will be deemed to occur when the environmental flow releases from the water supply dam are not equivalent to 10% of the daily inflows to the water supply dam catchment. ;

5.3.3 *Groundwater Elevation*

The assessment criteria for groundwater elevations will include potentially adverse drawdown within sentinel well MW47 located 500 m from the western pit edge. Modelling in the previous groundwater investigation suggested a drawdown of greater than 5 m near the pit was required before drawdown impacts would be observed in the nearest abstraction bore (W2). Therefore, when a drawdown of greater than 5 m is observed within this well a potentially adverse impact will be considered to be potentially present at the nearest registered groundwater abstraction well (W2). When this occurs further investigation will be initiated, which is discussed in more detail in the following section.

The assessment criteria for groundwater elevations to the north and east of the quarry pit will include lowering of groundwater elevations below the base of the Barbers Creek Tributary elevations, which has potential to induce seepage from Barbers Creek.

6 SURFACE WATER AND GROUNDWATER RESPONSE PLAN

6.1 INTRODUCTION

The objective of this section is to provide procedures for responding to impacts identified by the monitoring program and by routine monitoring of the erosion and sediment control systems.

It should be noted that previous chapters have described a comprehensive system via which water will be managed in a way that will minimise/mitigate impacts to the flow and quality of surrounding surface water and groundwater systems. This system includes the following mitigation measures:

- diversion of clean water run-off away from site activities;
- containment of potentially contaminating activities within sealed and bunded areas and the inclusion of interceptor systems to contain contamination;
- appropriate storage of potentially contamination substances;
- retention and treatment of "dirty water" to prevent sediment laden or contaminated runoff leaving the site;
- specific erosion and sediment control systems and monitoring to minimise the development of sediment laden rain-off;
- recycling and treatment of all water used in quarrying activities to minimise demand for top-up water from the clean water dams and to minimise the flow of dirty water to the Pit storage;
- construction of a vegetated bio-retention swale upstream of the primary water storage dam is expected to improve the quality of run-off entering the water supply dam and act as a filter for excess flows from the in-pit storages;
- release of environmental flows, equivalent to a minimum of 10% of average daily flows to be released to mimic natural flow patterns; and
- surface water and groundwater quality and quantity monitoring to confirm the efficiency of the proposed water management system and ensure there are no detrimental impacts upon groundwater systems or surface receiving waters.

Based on the above, this chapter is designed to act as a response plan for taking action in the unlikely event that an unforeseen incident occurs at the site.

Responding to identified impacts will be the responsibility of the Site Environmental Officer.

Schedule 5, Condition 3 of the Project Approval details the reporting requirements for identified impacts/incidents and the states that:

"Within 7 days of detecting an exceedance of the goals/limits/performance criteria in this approval or an incident causing (or threatening to cause) material harm to the environment, the Proponent shall report the exceedance/incident to the Department and any relevant agencies. This report must:

a) describe the date, time and nature of the exceedance/incident;

b) identify the cause (or likely cause) of the exceedences/incident;

c) describe what action has been taken to date; and

d) describe the proposed measures to address the exceedences/incident."

The key areas that the monitoring system will identify potential impacts include:

- surface water flows;
- surface water quality;
- groundwater quality; and
- groundwater elevations.

The response plans for identified impact in these key areas is detailed below.

6.2 *SURFACE WATER FLOW IMPACT RESPONSE*

Adverse impacts to flows are likely to be identified as a reduction in flow below the 10% environmental release requirements.

It is most likely that reduced flow releases from the dam back to the catchment will be associated with blocking of dam outlet pipes, the temporary failure of pumping systems due to power and/or mechanical issues, malfunction of the monitoring systems, or routine maintenance work.

If the flow monitoring system identifies an issue associated with the flows being returned back to the catchment the following actions will be taken:

- immediate action will be taken to augment the flows back to the catchment. This will include installing standby pumps within the water supply dam or having an stand by release pipeline within the dam, which will be used to augment flows as required;
- the Department of Planning (DoP) and DECCW will be notified of the incident/impact/potential impact within seven days of its identification;
- an investigation will be undertaken to establish the root cause of the reduced flows. This will include checking for blockages, assessing the design of the system, checking flow gauging systems and checking pump capacities. Investigations will be undertaken by appropriately qualified personnel or consultants;
- subject to the findings of the investigation actions will be taken to repair, replace or change the identified cause of the reduced flows. These actions will be completed by appropriately qualified personnel or consultants; and
- the identified cause of the impact and the selected response will be formally documented in an incident response report. This will be prepared in accordance with Schedule 5, Condition 3 of the Project Approval..

6.3 SURFACE WATER QUALITY IMPACT RESPONSE

Adverse water quality impacts are likely to be associated with malfunction of the site water management system. This would include:

- inappropriate design of the capture and treatment of the surface water run-off from the site during construction and operation;
- isolated spills of contamination substance on the site;
- algal blooms within the water supply dam;

If the water quality monitoring system identifies an issue associated with the discharge water quality being returned back to the catchment, or at any stage at which monitoring is being undertaken along the water management treatment train the following actions will be taken:

- while considered highly unlikely due to the proposed designed of the water management system, if water quality issues associated with discharge from the water supply dam to the down gradient catchment are identified, further treatment trains will be implemented. It is anticipated that this will include:

  - standby treatment systems to remove algae from discharge. These would be developed in response to regular monitoring for algae and be species specific;

  - standby treatment systems (such as flocculation ponds) to reduce sediment loads within the discharge;

- while systems have been put in place to effectively capture spills, spill response kits will be readily available at locations of potential spills and will be deployed immediately after a spill occurs to capture and contain a spill. All staff, handling potentially contaminating substances or using potentially contamination vehicles or undertaking potentially contaminating activities will be appropriately trained in the use of the spill kits.

- the Department of Planning (DoP) and DECCW will be notified of the incident/impact/potential impact within seven days of its identification;

- an investigation will be undertaken to establish the root cause of water quality issues. This will include checking the water treatment train within the water management and drainage system to identify the source of the water quality impacts. Investigations will be undertaken by appropriately qualified personnel or consultants;

- subject to the findings of the investigation actions will be taken to repair, replace or change the identified cause of the water quality impacts. These actions will be completed by appropriately qualified personnel or consultants; and

- the identified cause of the impact and the selected response will be formally documented in an incident response report. This will be prepared in accordance with Schedule 5, Condition 3 of the Project Approval.

6.4 *GROUNDWATER WATER QUALITY IMPACT RESPONSE*

While groundwater and surface water impacts to local water users are unlikely due to the management systems implemented at the site and the nature of the (i.e. not free flowing), if impact was to occur it is likely to be associated with:

- isolated spills seeping directly to underlying groundwater; and/or
- diffuse contamination associated with general quarrying activities, such as chemicals used for rock blasting seeping into underlying groundwater.

Isolated contaminant spills will be dealt with in the same way as described previously, however, additional action will be taken to isolate, remove or remediate contaminated soil that could be acting as a source for contaminating underlying groundwater.

Diffuse contamination identified in monitoring wells will be handled in the following way:

- as groundwater generally travels slowly, identification of contamination within groundwater wells surrounding the site is likely to act as an early warning sign to promote investigation and remedial action. As such, at the identification of contamination above assessment criteria, an investigation will be undertaken to assess the potential impacts the identified contamination may have on surrounding receptors. This will include undertaking a hydrogeological assessment, fate and transport model and an ecological risk assessment to quantify the potential impacts at identified receptors. The investigation will make recommendations on appropriate actions to take to mitigate any potential adverse impacts identified by the investigation;
- actions will then be taken mitigate any potential impacts that are simulated to occur in the future; and
- similarly to the previous sections, appropriate action will be taken to notify the appropriate regulatory authorities and report the incident in accordance with the requirements of the Project Approval.

6.5 *GROUNDWATER ELEVATION IMPACT RESPONSE*

If drawdown with the sentinel well MW47 associated with the pit exceeds 5 m, further investigation will be initiated. This will include initiation of monitoring of groundwater elevations within the nearest registered abstraction well (if permission is provided). The available water column in this well during abstraction will be compared against the expected drawdown associated with the quarry pit void, as previously modelled, to determine if the water supply is likely to be potentially compromised. If there is potential for this to occur, Boral will further quantify the significance of the impact using more sophisticated hydrogeological techniques. If significant impacts are still identified, then options for supplementing the water supply of surrounding abstraction wells will be considered.

Similarly to the previous sections, appropriate action will be taken to notify the appropriate regulatory authorities and report the incident in accordance with the requirements of the Project Approval.

7 REFERENCES

Department of Environment and Climates Change, NSW, June 2008; *Managing Urban Stormwater – Soils and Construction – Volume 2E Mines and Quarries*; Department of Environment and Climates Change, NSW, Sydney.

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ERM, April 2009; *Marulan South Quarry Alternative Water Management – Discussion Paper*.

ERM, May 2010; *Proposal P17164 – Peppertree Quarry Management Plans*

Landcom, 2004; *Managing Urban Stormwater - Soils and Construction Volume 1, 4th Edition*; New South Wales Government, Parramatta.

Annex A

Modelling Spreadsheet Results

Water Supply Dam Catchment Area

Total Catchment Area =	730.00	***ha***	***Weir Level (FSL) =***		6.50
Catchment Multiplier =	0.77		***Weir Length =***		15.00
Full Supply Vol =	111607	***m^3***	***Weir Coeff =***		1.70
FSL	6.50	***m AHD***	111.6	***ML Storage***	
Rainfall Period ->	***1900-1972***	***1910-1982***	***1920-1992***	***1930-2002***	***Ave***
Period (Days)	26663	26663	26664	26663	26663
Maximum Inflow (ML/d)	637.6	637.6	637.6	637.6	637.6
Average Inflow (ML/d)	2.50	2.64	2.67	2.28	2.52
10 Percentile Daily Inflow (ML/d)	2.66E-05	2.26E-05	4.85E-05	2.19E-05	2.99E-05
90 Percentile Daily Inflow (ML/d)	5.84	6.16	6.24	5.57	5.95
Days of Shortages (no water)	2	2	2	33	9.75
(Percentage)	0.01%	0.01%	0.01%	0.12%	0.04%
Days of Restrictions (50% usage)	59	12	12	98	45.25
(Percentage)	0.2%	0.0%	0.0%	0.4%	0.17%
Max Duration of Shortage (Days)	2	2	2	12	5
Ave. Duration of Shortage (Days)	2.0	2.0	2.0	4.7	2.7
Med. Duration of Shortage (Days)	2	2	2	3	2
10 Percentile of Shortage (Days)	2.0	2.0	2.0	1.6	1.9
90 Percentile of Shortage (Days)	2.0	2.0	2.0	10.8	4.2
Days of Spills	8267	8663	8902	7998	8457.5
(Percentage)	31.0%	32.5%	33.4%	30.0%	31.7%
Max Daily Outflow (ML)	637.14	637.00	637.00	637.00	637.03
Average Daily Outflow (ML)	1.98	2.12	2.15	1.77	2.00
10 Percentile Daily Outflow (ML)	2.66E-06	2.26E-06	4.85E-06	2.19E-06	2.99E-06
90 Percentile Daily Outflow (ML)	4.66	4.97	5.13	4.36	4.78
Flow Returned to Catchment (%)	79	80	80	78	79

Operational Area

Total Catchment Area =	164.00	ha	***Weir Level (FSL) =***	10.49
Catchment Multiplier =	0.17		***Weir Length =***	15.00
Full Supply Vol =	992250	m^3	***Weir Coeff =***	1.70

FSL	10.49	***m AHD;***	992.3	***ML Storage***	
Rainfall Period ->	***1900-1972***	***1910-1982***	***1920-1992***	***1930-2002***	***Ave***
Period (Days)	26663	26663	26664	26663	26663
Maximum Inflow (ML/d)	143.2	143.2	143.2	143.2	143.2
Average Inflow (ML/d)	0.56	0.59	0.60	0.51	0.57
10 Percentile Daily Inflow (ML/d)	5.97E-06	5.07E-06	1.09E-05	4.92E-06	6.71E-06
90 Percentile Daily Inflow (ML/d)	1.31	1.38	1.40	1.25	1.34
Days of Shortages (no water)	23693	23511	23471	23968	23660.75
(Percentage)	88.86%	88.18%	88.03%	89.89%	88.74%
Days of Restrictions (50% usage)	2388	2528	2560	2288	2441
(Percentage)	9.0%	9.5%	9.6%	8.6%	9.15%
Max Duration of Shortage (Days)	299	280	234	234	262
Ave. Duration of Shortage (Days)	16.9	16.2	15.4	17.2	16.4
Med. Duration of Shortage (Days)	5	5	5	6	5
10 Percentile of Shortage (Days)	1.0	1.0	1.0	1.0	1.0
90 Percentile of Shortage (Days)	49.0	43.0	40.0	46.0	44.5
Days of Spills	0	0	0	0	0
(Percentage)	0.0%	0.0%	0.0%	0.0%	0.0%
Maximum Daily Pumping Rate (ML)	4.68	4.68	4.68	4.68	4.68
Average Daily Pumping Rate (ML)	0.52	0.55	0.55	0.47	0.53
10 Percentile Daily Outflow (ML)	0.00E+00	0.00E+00	0.00E+00	4.73E+02	1.18E+02
90 Percentile Daily Outflow (ML)	0.00	0.00	0.00	0.00	0.00
Flow Returned to Catchment (%)	93	93	92	92	93

Annex B

Selection of Control Measures

Appendix F: Selection of control measures

This appendix, based on an approach developed by the Queensland Department of Mains Roads, provides a step-by-step guide to the selection of erosion and sediment control measures.

The steps involve:

- identifying the problem – erosion or sedimentation – to be managed (see figure F.1)
- where the problem is erosion, identifying whether it is caused by raindrop impact or concentrated flow
- where the problem is sedimentation, identifying if sediment is conveyed by sheet or concentrated flow
- selecting the appropriate techniques (see table F.1) depending on the identified specific nature of the problem.

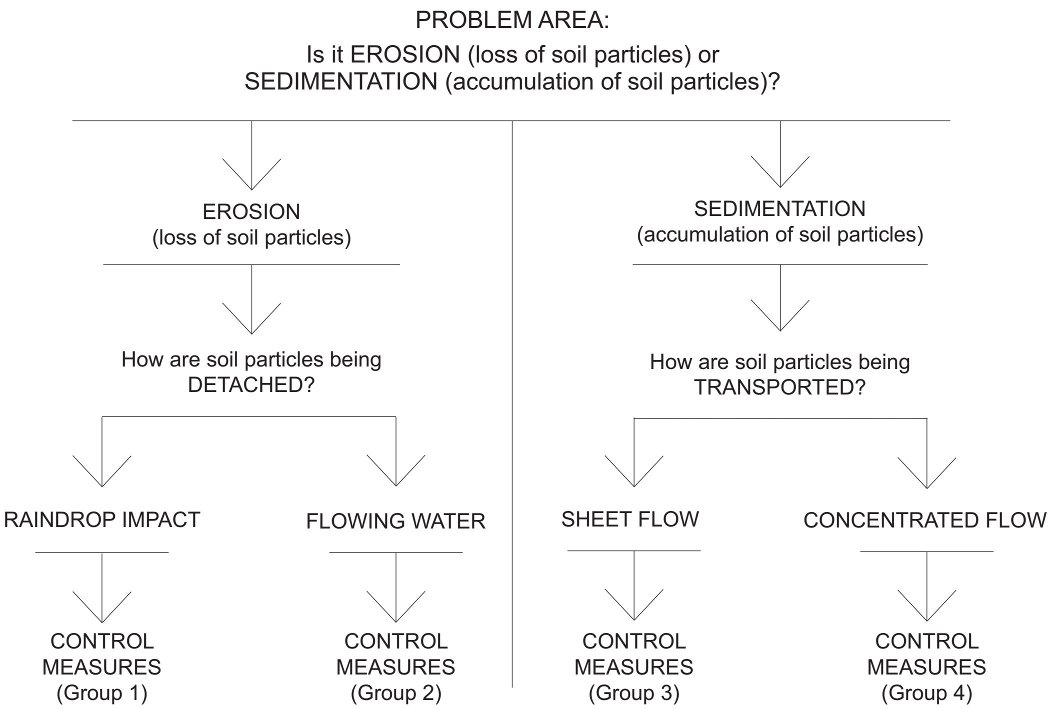

Figure F.1 Step-by-step decision-support flowchart for selection of erosion and sediment control measures

Table F.1 Group 1 – Erosion control RAINDROP IMPACT

Vegetation

- temporary vegetation (cover crop only)
- permanent vegetation – introduced (exotic) pasture species or native (endemic) species
- refer to **vol. 1**: sections 4.3.2, 7.1 and 7.2; appendices A6 and G

Batter blankets

- vegetation promotion blankets
- vegetation suppression blankets
- needle-punched geotextile membrane
- builder's plastic membrane
- refer to **vol. 1**: section 5.4.2; SD5-2; appendices A6 and D

Soil surface mulching

- hydromulch or hydraulic bonded-fibre matrix
- blown straw, hay, crop residue, with bitumen tack
- tub-ground or chipped organic mulch
- brush-matting
- rock or gravel mulch
- refer to **vol. 1**: section 7.4; figure 7.3; appendices A6 and D

Geocellular containment systems

- Non-woven geotextile type material
- Polypropylene material (perforated and non-perforated)
- refer to **vol. 1**: section 5.4.2; SD5-3; appendix D

Surface roughening

- roughening parallel to contour
- contour ripping or scarifying
- 'track walking'
- refer to **vol. 1**: section 4.3.2; figures 4.3(a) and (b)

Geobinders

- organic tackifiers
- co-polymer emulsions
- bitumen emulsion
- cementitious products
- refer to **vol. 1**: section 7.1.2; appendices A6 and D

Table F.1	Group 2 – Erosion control CONCENTRATED WATER FLOW
Up-slope diversions • excavated channel-type bank • backpush-type bank or windrow • catch drains • shoulder dyke • refer to **vol. 1**: section 5.4.4; SD5-5 and SD5-6	 © Tony King
Mid-slope diversions • berms and benches • temporary diversions (at cut/fill line) • cross banks • refer to **vol. 1**: section 4.3.1; figure 4.2; appendix A4	 © Tony King
Soft armour channels • trapezoidal or parabolic shape • consider channel grade and maximum permissible velocity • establish vegetative ground cover • standard (un-reinforced) or re-inforced turf • biodegradable erosion control mat (temporary) or synthetic erosion control mat (permanent) • refer to **vol. 1**: sections 5.4.3, 7.3; SD5-7; appendix D	 © Tony King
Hard armour channels • loose rock • rock-filled wire mattresses • articulating concrete block systems • grouted rock • cast in-situ concrete • builder's plastic lining or geotextile lining • refer to **vol. 1**: section 5.4.4; table 5.2; figure 5.4; appendix D	 © Rick Morse
In-stream diversions • temporary coffer dams • water-filled structures • temporary lined channel (stream diversion) • refer to **vol. 1**: section 5.3.5; appendix I	 © Portadam

Table F.1 Group 2 – Erosion control CONCENTRATED FLOW (cont'd)

Check dams

- stacked rock
- sandbags and geotextile sausages
- straw bales
- logs
- proprietary products
- refer to **vol. 1**: section 5.4.3; SD5-4; figures 5.3(a) and (b)

Batter drains

- concrete (pre-cast or on-site)
- half 'armco' pipe
- sandbags
- rock-filled wire mattresses
- loose-rock rip rap
- builder's plastic or geotextile lined chutes
- refer to **vol. 1**: section 5.4.4; appendix D

Grade control structures and flumes

- gully pits and field inlets
- sandbag drop structures
- rock-filled wire gabions and mattress structures
- driven sheet piling
- concrete chutes
- inclined pipe spillways
- builder's plastic-lined chutes

Outlet dissipation structures

- loose-rock rip-rap aprons
- rock-filled wire mattresses
- roughness elements
- hydraulic jump-type structures
- impact-type structures
- refer to **vol. 1**: section 5.4.5; figures 5.8, 5.9, 5.10, 5.11 and SC5-8

Revetments and retaining walls

- rip rap
- rock-filled wire gabions and mattresses

Table F.1	Group 3 – Sediment control SHEET FLOWS
Vegetative buffers • well established sward with good groundcover • refer to **vol. 1**: section 6.3.8; table 6.4; SD6-13; appendix G	
Sediment barriers/filters • sediment fences • vegetation, brush, rock or gravel windrows • straw bale barriers • refer to **vol. 1**: section 6.3.7; SD6-7 and SD6-8; figure 6.10; appendix D	
Site exit points • shaker ramps • rock aprons • wheel wash systems • refer to **vol. 1**: section 6.3.9; SD6-14	

Table F.1	Group 4 – Sediment control CONCENTRATED FLOWS
Sediment curtains / turbidity barriers • floating geotextile • proprietary polypropylene products • temporary coffer dams • water-filled structures • refer to **vol. 1**: section 6.3.7; SD6-10; appendix D	
Sediment traps • stacked rock/timber with geotextile • excavated sumps • straw bale or sand bag structures • gully pit, field inlet and kerb inlets • refer to **vol. 1**: section 6.3.6, figure 6.11; SD6-11 and SD6-12	
Sediment retention basins • Type C (riser type) basin • Type F (extended settling) basins • Type D (flocculation) basins • refer to **vol. 1**: sections 6.3.3, 6.3.4 and 6.3.5; SD6-3 and SD6-4; appendices E and J	

Annex C

Erosion And Sediment Control Inspection Checklist

EROSION AND SEDIMENT CONTROL INSPECTION CHECKLIST

Date							
Start Time			**Finish Time**				
Conducted By							
Inspections to be Completed	**Compliance with CEMP (tick one box)**			**Comments/ Corrective Action(s) Required?**	**Action by / Date**	**Date Completed**	
	NA	**Yes**	**No**				
Site Erosion							
Are work activities and land disturbance being confined to the minimum area practicable and are sensitive areas being avoided/protected? [*Use barrier fence where required to control access and limit the extent of disturbance*]	☐	☐	☐				
Is site access controlled to limit unnecessary disturbance?	☐	☐	☐				
Is there evidence of problematic site erosion such as gullies, rilling, land slips, subsidence, and stream bank instability associated with project activities?	☐	☐	☐				
Does an erosion hazard exist that requires installation of new erosion and sediment controls? Operational areas, bunding and overburden stockpiles *Implement decision tree for the selection of erosion control devices as outlined in Annex B*	☐	☐	☐				
Is upstream 'run-on' stormwater being successfully diverted around active quarry areas to minimise dirty water run-off? [*stormwater diversions should be in place before land disturbance commences*]	☐	☐	☐				
Are appropriate site erosion control measures (barrier fencing, stormwater diversions, mulch, surface stabilisation) in place where required and are they being properly maintained?	☐	☐	☐				
Is there evidence of erosion on haul roads or road side drainage networks?	☐	☐	☐				

EROSION AND SEDIMENT CONTROL INSPECTION CHECKLIST

Is there an accumulation of sediment in drainage network or check dams?	☐	☐	☐			
Are sediment dams working within design capacity? Does sediment need to be removed from the base of the ponds as indicated by measuring stakes?	☐	☐	☐			
Is there evidence of cracking or leaking from the dam walls?	☐	☐	☐			
Is there evidence of increased turbidity in Tangarang Creek attributable to the project downstream of the construction activities?	☐	☐	☐			
Is uncontaminated, weed free topsoil being stockpiled separately from general excavated material so that it may be used in subsequent rehabilitation	☐	☐	☐			
Are sediment traps filled with so much sediment that their function is reduced? [*Sediment should be removed from traps when it accumulates to 1/3 of the capacity of the device*]	☐	☐	☐			
Are all completed work areas being successfully stabilised (by vegetation or other means)?	☐	☐	☐			
Is the site inspected weekly and after all significant rain events to assess the integrity and performance of the erosion and sediment controls and ensure ongoing maintenance of erosion and sediment controls	☐	☐	☐			
Checked By:						
Authorised By:						

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