Water Management Plan

Albion Park Quarry

8201718302

Prepared for
Cleary Bros (Bombo) Pty Ltd

26 February 2021

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Document Information

Prepared for	Cleary Bros (Bombo) Pty Ltd
Project Name	Albion Park Quarry
File Reference	APQ Water Management Plan V7.docx
Job Reference	8201718302
Date	26 February 2021
Version Number	7
Effective Date	26/02/2021
Date Approved	26/02/2021

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
1	22/8/2017	Draft	Jon Bartley	-
2	24/8/2017	Draft for Consultation	Jon Bartley	Alan Bull
3	5/9/2017	Revised Draft	Jon Bartley	-
4	6/9/2017	Final	Jon Bartley	Alan Bull
5	8/5/2018	Revised following DPE comment	Jon Bartley	Garry Masur
6	20/8/2020	Updated Stormwater Plan	Mike Jorgensen	Cassy Baxter
7	26/02/2021	Revised following Audit	Hamish Moses	Mike Jorgensen, Cassy Baxter

Table of Contents

Appendices

Tables

Figures

List of Abbreviations

AHD - Australian Height Datum

AMG - Australian Map Grid

ANZECC - Australian and New Zealand Environment and Conservation Council

BDL - Below Detection Limit

CB - Cleary Bros (Bombo) Pty Ltd

COC - Chain of Custody

CoPC - Chemicals of Potential Concern

DO - Dissolved Oxygen

DC - Development Consent

DPI - Department of Primary Industries

DPE - Department of Planning and Environment

EC - Electrical Conductivity

EPA - Environment Protection Authority

EPL - Environment Protection Licence

GME - Groundwater Monitoring Event

LOR - Limit of Reporting

N/A - Not Applicable

QA - Quality Assurance

QC - Quality Control

QEMP - Quarry Environmental Management Plan

RL - Reduced Level

SCADA - Supervisory Control and Data Acquisition

TDS - Total Dissolved Solids (salinity of water)

WMP - Water Management Plan

1 Introduction

1.1 Background

Cleary Bros (Bombo) Pty Ltd (CB) has extracted and processed hard rock from quarries in the Albion Park area since the middle of last century. On 21 February 2006 the Land and Environment Court (LEC) granted Development Consent (DC) 10639/2005 for quarrying a new area approximately 400 m from the then operating quarry.

The DC was modified in 2009, and in 2015 for an increase in annual production. On 7 June 2017, a modification was granted to permit extraction from quarry Stages 5 and 6. This document is prepared to meet requirements of the 2017 modification of the DC.

Operation of the quarry is licensed by the Environment Protection Authority (EPA), under Environmental Protection Licence 299. The EPA licence covers three premises, including the Quarry Extension area on Lot 1 DP 858245. Licence conditions that are relevant to this Water Management Plan (WMP) are described below.

The location of the site covered by this WMP (labelled “Quarry Extension”) is shown on Figure 1-1.

Figure 1-1 Site Location and adjoining Properties (from CB, 2017b)

1.2 Plan Scope and Responsibilities

Cardno was engaged by CB to prepare a WMP, as required under DC condition 27, focussed on the Quarry Extension. As required by DC Condition 27, the WMP is prepared by a qualified hydrogeologist. To prepare the WMP, a Cardno hydrogeologist visited the site on 2 August 2017 and Cardno has relied on information and reports provided by CB. CB is responsible for the WMP implementation and for consultation with relevant Agencies.

1.3 Consultation

CB provided the draft WMP (ref: 8201718302Report01.2) to the Department of Primary Industries - Water (DPI-W) on 28th August 2017. CB subsequently requested feedback from DPI-W on the 17th October 2017 and 11th April 2018. DPI-W has not provided direct feedback to CB on the WMP in response.

This WMP addresses DPE comments on the previous version of this document.

1.4 Site Overview

The approved Quarry Extension is located on Lot 1 DP 858245. The Environmental Impact Statement (EIS) (Perram & Partners, 2003) and Golder (2005) contain descriptions of the site topography, climate, geology and hydrogeology, and historic water management. In summary:

- The site is approximately 22 km south of Wollongong, and 3.6 km south of Illawarra Regional Airport;
- Surrounding land uses are quarrying, pasture, and remnant vegetation along drainage lines;
- The site is steeply sloping from north to south, from approximately 140 mAHD to 70 mAHD;
- A south flowing ephemeral creek on the eastern side of the site discharges to an unnamed creek south of the site that flows to the east and south east and ultimately discharges to the Minnamurra River via Rocklow Creek. Runoff from the site that previously entered these creeks will be collected in the pit as the pit expands. The original WMP included the collection of water in a sump on the quarry pit floor shown in Figure 1-2, diversion of clean runoff around the quarry, treatment of sediment in collected water and if required, reinjection of water into the aquifer.
- The site comprises red sandy clay and residual soil, Bumbo Latite (volcanic rock) occurring as two distinct flows separated by tuffaceous agglomerate, and the Budgong Sandstone. Quarrying occurs through the full thickness of latite, down to the underlying sandstone.
- Golder (2005) reports groundwater occurs in a shallow perched aquifer (residual soil) and a regional aquifer that encompasses the latite, agglomerate and sandstone bedrock, with groundwater flow mostly through fractures and joints.
- Revegetation at the site under the approved Vegetation Management Plan includes revegetation in an area up to 100m wide along the southern site boundary.
- A sump constructed in the south eastern part of the pit diverts accumulated water away from active operations.

Figure 1-2 shows the Quarry Extension (at 29 July 2017).

The current phase involves continuing the current pit to the north, and then quarrying east into the Stage 5 & 6 area.

Figure 1-2 Quarry Extension Site 29 July 2017 (Source: Nearmap)

2 Statutory Requirements

This document is prepared to meet the Conditions of Consent (Development Application 10639 of 2005), modified 2017, Schedule 4 Specific Environmental Conditions, as described in Table 2-1 below.

The scope is to meet DC condition 27 as relevant to the currently approved extraction of materials in the Quarry Extension (Lot 1 DP 858245). This document supersedes the 2012 revision of the WMP (Golder, 2013).

Table 2-1 Development Consent Condition 27 – Annexure A

Condition	Requirement	Where Addressed
Schedule 4 Condition 27	Within 12 months of the date of this consent, the Applicant must prepare a Water Management Plan for the development, in consultation with DPI Water and to the satisfaction of the Secretary.	This Document
	This plan must be prepared by a qualified hydrogeologist and include:	
	(a) a Water Balance	Appendix B
	(b) an Erosion and Sediment Control Plan;	Section 4
	(c) a Surface Water Monitoring Program;	Section 7.2
	(d) a Ground Water Monitoring Program; and	Section 7.3
	(e) an Integrated Water Management Strategy, if the water balance shows a potential demand for water above that which can be collected from rainfall.	Not required(see Section 3 and Appendix B)
	Prior to the commencement of quarrying activities in Stages 5 and 6, the Water Management Plan must be revised, in consultation with DPI Water and to the satisfaction of the Secretary.	Section 1.3
	The revised Water Management Plan must include a detailed description of the surface water management system on site, including the area, depth and capacity of any in-pit sumps. The Applicant must implement the approved plan as approved from time to time by the Secretary.	Section 5

DC Schedule 4 Conditions 28 to 31 describe the content of the above WMP elements.

Environment Protection Licence 299 covers three premises, including the Quarry Extension area on Lot 1 DP 858245. Conditions relevant to monitoring presented in this WMP are:

- Discharges to water (Condition 2),
- Limit Conditions (Condition 3),
- Monitoring (Condition 5)

Licensing of extraction of water is under the Water Act, 1912.

Further details of statutory requirements are provided in the Quarry Environmental Management Plan (QEMP) (CB, 2017a).

3 Water Balance

DC Condition 27 requires the preparation of a Water Balance for the Quarry Extension.

The Water Balance for the main dam is included in this WMP as Appendix B.

The Water Balance shows there is a surplus of water under a range of climatic conditions, and therefore an Integrated Water Management Strategy (DC condition 27e) is not required.

Measures to monitor and estimate groundwater inflows are described in section 6.

4 Erosion and Sediment Control

4.1 Requirement

DC: Schedule 4, Condition 29.

29. *The Erosion and Sediment Control Plan must:*

    a) *Be consistent with the requirements of the Department of Housing's Managing Urban Stormwater: Soils and Construction manual;*

    b) *identify activities that could cause soil erosion and generate sediment;*

    c) *describe measures to minimise soil erosion and the potential for the transport of sediment to downstream waters;*

    d) *describe the location, function, and capacity of erosion and sediment control structures; and describe what measures would be implemented to maintain the structures over time.*

4.2 Overview

The following site activities associated with the quarry have been identified as having the potential to cause soil erosion and increase sedimentation of waterways:

- Haul road construction and maintenance
- Topsoil and overburden removal and stockpiling
- Vehicle movement

The erosion and sediment controls for the site are designed to be generally consistent with the requirements of Managing Urban Stormwater: Soils and Construction manual. The Quarry Extension involved construction of an access road, with erosion and sediment controls installed along the access road and on the Quarry Extension.

4.3 Measures to Mitigate Potential Impact

4.3.1 Design and Control Measures

The Quarry Extension Area now forms a constructed sump, which collects runoff from all disturbed areas. All activities with the potential to generate sediment are contained within the excavated pit, ensuring no surface runoff from disturbed areas directly to any watercourse.

The Noise/Visual Bund along the north-eastern boundary of the Quarry Extension Area diverts surface runoff from the undisturbed ridgeline area away from the development. It is not practicable to divert runoff from a small vegetated catchment to the north of the Extension Area around the site, and as such this area is captured and managed within the quarry pit sump. Due to the local topography, all other undisturbed areas surrounding the Quarry Extension Area naturally fall away from the Quarry Pit, and flow to the receiving waters.

The existing quarry pit sump forms a sediment basin in the lowest part of the quarry pit. The sump contains sufficient capacity to contain all runoff generated in a one-in-ten year average recurrence interval with a duration of 24 hours (equating to 225mm of rainfall). The quarry wall height means that the quarry void would need to be inundated to a depth of over approximately 10 m before overflow would occur. In extreme events, assuming the whole current quarry floor is inundated (approximately 200 m x 175 m) to a depth of 10 m, the storage capacity is approximately 350 ML. A one-in-100 year average recurrence interval of the same 24-hour duration would produce approximately 360mm of rainfall. Assuming a catchment area of approximately 21 ha (small vegetated catchment north of quarry and quarry footprint Dec 2020), this would result in up to 76 ML of water, less than a quarter of the volume required to overtop the quarry pit. As such, it is unlikely runoff into the quarry pit from any storm event would lead to an overflow.

The erosion and sediment control measures are shown on the plan in Appendix C.

4.3.2 Operational Measures

The following operational measures form part of the initial approved erosion and sediment control plan and will continue to be implemented by CB where applicable:

- Water spray haul roads and vehicle paths within the quarry;
- Vehicle movements will be restricted where possible to dedicated access paths through the quarry;
- A shaker pad is located at the exit to unsealed areas of the quarry site and is used by all trucks leaving the Sales area.;
- Manage quarry activities to limit potential for dust generation during adverse weather in accordance with the Air Quality Management Plan;
- Stabilise topsoil stockpiles once established;
- Progressively stabilise final surfaces in accordance with the Rehabilitation Management Plan.
- Runoff collected in the quarry pit sump will be dewatered as required as described in Section 5.

4.3.3 Excessive rainfall

Excessive rainfall means rainfall that causes runoff that floods part of the site or exceeds the design capacity of the drainage and sediment control system, and creates a potential for severe erosion and for sediment-laden water to be released into the environment.

The quarry excavation is expected to be capable of retaining runoff from all rainfall within its catchment. In the event heavy rainfall produces runoff in excess of the basin design volume (one-in-ten year average recurrence interval with a duration of 24 hours), excess water may flood the workings and be a hindrance to operations, however, will not be an emergency. The excess water will be released as soon as sampling demonstrates compliance with the discharge criteria of EPL299. If necessary, the water will be flocculated with gypsum to reduce the sediment load prior to discharge to meet EPL criteria. If flocculation is necessary, the pH and turbidity of the water will be measured prior to discharge to assess compliance with the discharge criteria. During and following an excessive rainfall event, the drainage and sediment control system will be monitored and inspected, and any necessary repairs or maintenance undertaken as soon as practicable.

4.4 Maintenance

Routine maintenance and works comprise:

- Install and maintain erosion and sediment controls in accordance with the approved plans.
- Inspect erosion and sediment controls after each major rain event, repair any damage and ensure correct functioning.
- Remove accumulated silt from the sediment basin if required to restore design capacity.

4.5 Assessment of Plan

The effectiveness of the Erosion and Sediment Control plan is assessed by:

- Consideration of frequency and significance of exceedances of the discharge limits.
- Assessment of the condition of the site and surrounds as part of the annual ecological and rehabilitation survey, including changes from the previous survey.

The assessment of the effectiveness of the measures is reported in the Annual Review, and is subject to three-yearly Independent Audit as described in section 9 of this WMP.

5 Surface Water

5.1 Consent and EPL Requirements

DC Schedule 4, Condition 27c, 30.

The Surface Water Monitoring Program must include:

a) detailed baseline data on surface water flows and quality;

b) surface water impact assessment criteria;

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

d) a program to manage water releases from the site, including consideration of water treatment measures, such as vegetated swales;

e) a program to monitor bank and bed stability;

f) a protocol for the investigation, notification and mitigation of identified exceedances of the surface water impact assessment criteria; and

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

5.2 Overview

Rainfall runoff is collected in the storage dam adjacent to the processing area and water from the storage dam is used at the processing plant and for dust suppression. Rainfall runoff in the quarry pit is collected in a sump located in the south east part of the pit.

Water from the pit sump is mainly used for irrigation of vegetation, and excess water is discharged off-site. The volume of water in the sump varies with rainfall and the volume of water discharged off-site. CB on 2 August 2017 estimated the average water depth at the quarry pit sump of approximately one metre, and for the surface area of approximately 2,000 m^2 (40 m x 50 m in August 2017), the volume was approximately 2,000 m^3 (2 ML). In extreme events, assuming the whole current quarry floor is inundated (approximately 200 m x 175 m) to a depth of 1 m, the storage capacity is approximately 35 ML. The quarry wall height means that the quarry void would need to be inundated to a depth of over approximately 10 m before overflow would occur.

The quarry floor sump is protected by large rocks used as bollards, and maintained by removal of fines from the sump by excavator. The pump and discharge line are maintained by quarry personnel, and the discharge point stabilised to limit the potential for erosion at the point of discharge.

Off-site discharge is monitored and CB endeavours to undertake releases from the pit sump during or immediately following wet periods to attempt to mirror the natural behaviour of the receiving creek as far as practicable. The stormwater system is designed to capture runoff from a 10 year Average Recurrence Interval (ARI) 24 hour duration storm (225 mm in 24 hours). To maintain sufficient settling capacity, the stormwater basins will be treated with gypsum (if required) and floodwater removed.

If the water is over the criterion for turbidity, discharge is delayed to allow time for the solids to settle further. If discharge cannot be delayed, then gypsum will be added, and pH checked prior to discharge.

The historic surface water chemistry and flow data obtained from the monitoring program are described in detail in CB (2017b), and summarised in Appendix A of this WMP.

In accordance with DC Condition 30c Watercourse 1 (WC1) and Watercourse 2 (WC2) are monitored for the parameters and at the frequency shown in Table 5-1 below. There are no criteria in the EPL establishing limits relating to monitoring points WC1 and WC2. The monitoring is described in more detail in section 7.2 of this WMP. The catchment of WC1 will be progressively reduced and eventually removed completely as quarrying progresses towards the east.

Table 5-1 Surface Water Monitoring – Water Courses

ID	Location	Parameter	Units	EPL Limit	Frequency
WC1	Water course 1 100 m upstream of unnamed creek	Discharge	L/s		
		Electrical conductivity	µS/cm		
		pH	pH units		
		Temperature	o C		
		Turbidity	NTU		
		Oil & grease	mg/L	n/a	Quarterly
WC2	270 m upstream of confluence of water course 1 and Unnamed Creek	Total Suspended Solids	mg/L		
		Total Dissolved Solids	mg/L		
		Major Cations (Na, K, Ca)	mg/L		
		Major Anions (SO 4 , Cl)	mg/L		
		Alkalinity	mg/L		
		Dissolved metals (Cu, Fe)	mg/L		

Environment Protection Licence 299

The water-related monitoring requirements under EPL 299 are summarised in Table 5-2 below. The site with EPA ID 6 is the point of discharge from the Quarry Extension and the sites with EPA ID 4, 5, and 7 are near the processing plant.

Table 5-2 Surface Water Monitoring – Discharge (EPL No.299)

	Location	Analyte	Units	EPL Limit	Frequency
4	Main Sedimentation Pond (DP1)	pH	pH units	6.5 8.5	Daily during overflow
		Total Suspended Solids	mg/L	50	
5	Sewage Treatment Plant	BOD	mg/L	150	Quarterly
		Oil & grease	mg/L	30	
		Total Suspended Solids	mg/L	50	
6	Quarry Extension Discharge (DP2)	pH	pH units	6.5 8.5	Daily during discharge
		Turbidity	NTU	32.2	
7	Watercourse West of Quarry Managers Office	pH	pH units		Daily during overflow
		Total Suspended Solids	mg/L		

DC Condition 21 requires discharge from any licensed discharge point/s to comply with the limits in DC Table 6, unless otherwise agreed by the EPA. Those limits are for TSS and pH and are the same as the EPL limits listed in Table 5-2 above.

6 Groundwater

6.1 Consent and EPL Requirements

DC: Schedule 4, Conditions 27 and 31.

31 The Ground Water Monitoring Program must include:

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

b) groundwater impact assessment criteria;

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

d) a program to monitor groundwater level effects on vegetation, and on groundwater supply to adjoining properties;

(dd) a program for monitoring groundwater inflows into the quarry from the quarry face or floor, or into any in-pit sumps;

e) a protocol for the investigation, notification and mitigation of identified exceedances of the groundwater impact assessment criteria; and

f) a protocol to consult with DPI Water prior to any re-injection of groundwater.

There is no requirement for monitoring of groundwater under EPA Licence 299. Licence Condition L1.1 states, Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997

CB monitoring of groundwater is described in section 7.3 of this WMP. The monitoring objective is to collect sufficient data to enable assessment of the groundwater condition, and possible relationship between surface water flow and quality, and groundwater level and quality.

6.2 Overview

Groundwater at the site occurs primarily within the underlying sandstone aquifer. Groundwater in that aquifer is likely connected with surface water features and vegetation downhill from the site. Groundwater could also occur in the surficial sediments as a perched layer, in the latite in fractures, and more likely in an agglomerate layer between the upper and lower latite.

A pit floor sump has been excavated near the southeast corner of Stage 2, and if there were groundwater seepage from the base of the highwall and upward through the floor of the pit, this would collect in the pit floor sump. Discharge from the pit floor sump is by pumping via pipeline and discharge to the rehabilitation areas and the watercourse immediately south of the quarry.

The historic groundwater chemistry and groundwater levels are described in CB (2017b) and summarised in Appendix A of this WMP.

6.3 Groundwater Impact Assessment Criteria

The possible impacts of quarrying activities on groundwater are:

- Contamination of groundwater from quarrying operations (storage and use of chemicals)
- Decline in groundwater level leading to:
  - reduction in groundwater throughflow and baseflow discharge in nearby surface water bodies
  - adverse impact on groundwater dependant vegetation
  - reduction in available groundwater for extractive users

The purpose of the groundwater monitoring has been to establish the normal range of variability of the groundwater chemistry and groundwater level immediately down gradient of the quarry, to assist with assessment of the effects of changed groundwater level on vegetation, and on groundwater supply to adjoining properties.

The triggers for further investigation (see section 8) are:

- any unusual variation in monitored parameters (see Section 7.3.1);
- establishment of a statistically significant trend of change in concentration of analytes;
- decline in groundwater level to below the level historically recorded.

In addition, where the groundwater electrical conductivity is above a bore-specific trigger (Table 6-1), an extended dissolved metals sampling suite is to be undertaken, as described in section 7.3.

Table 6-1 Trigger for Additional Metals Analysis

Monitoring Bore ID	Trigger for Additional Metals EC (µS/cm)
MW1s	1,600
MW1d	1,300
MW2s	1,300
MW2d	1,800

The monitoring data is assessed and reported in the Annual Review (reporting is described in section 9 of this WMP).

Ecological monitoring is undertaken as described in the Quarry Vegetation Management Plan. The riparian strip of bushland immediately downhill from the quarry that could potentially be impacted by changes to surface water and / or groundwater patterns is to be inspected annually by a qualified ecologist. The findings are to be discussed with the Quarry Production Manager and reviewed in light of water management practices during the past year. The ecologists report would be an input to an assessment (if required) under the Hydrogeological Investigation and Assessment (section 8.3 of this WMP), specifically with regard to the impact of changes to surface water release or implementation of groundwater injection.

7 Monitoring Program

7.1 Overview

Figure 7-1 shows the surface water and groundwater monitoring locations at the Quarry Extension, as discussed in this section of the WMP.

Figure 7-1 Monitoring Locations - Quarry Extension (image Nearmap 29 July 2017)

7.2 Surface Water

7.2.1 EPL Licence 299

The monitoring to meet the EPL requirement (see section 5.1) is listed in Table 7-1. Site EPA ID 6 (i.e. DP2) is located at the Quarry Extension and the other sites are located near the processing plant.

Table 7-1 Surface Water Monitoring (EPL No. 299)

EPA ID	Location	Analyte	Method	Testing	Frequency
4	Main Sedimentation Pond (DP1)	pH Total Suspended Solids	Grab	Field Measured	Daily during overflow
5	Sewage Treatment Plant	BOD Oil & grease Total Suspended Solids	Grab	Laboratory	Quarterly
6	Quarry Extension Discharge (DP2)	pH Turbidity	Grab	Field Measured	Daily during discharge
7	Watercourse West of Quarry Managers Office	pH Total Suspended Solids	Grab	Field Measured	Daily during overflow

7.2.2 Quarry Extension: Watercourse 1 and Watercourse 2

Monitoring (summarised in Table 7-2) occurs at sites in the natural watercourses south of the extraction area. One site is located in the watercourse that currently drains the area east of the current pit (WC1) 100m upstream of the confluence with the unnamed watercourse 2. The other site is on the main watercourse entering the property from the west (WC2), 270m upstream of the confluence with the unnamed watercourse 1. It is understood that, at times, WC2 also receives discharges from quarry sedimentation dams on a neighbouring site.

Table 7-2 Monitoring at WC1 and WC2

ID	Parameter	Method	Testing	Frequency
WC1 WC2	Discharge (flow)	Flow meter or calibrated bucket	Field Measured	Monthly
WC1 WC2	Electrical conductivity pH Temperature Turbidity	Grab Sample	Field Measured	Quarterly
WC1 WC2	Oil & grease Total Suspended Solids Total Dissolved Solids Major Cations (Na, K, Ca) Major Anions (SO 4 , Cl) Alkalinity	Grab Sample	Laboratory	

	Dissolved metals (Cu, Fe)
	Additional metals [1] (As, Cd, Cr, Cu, Fe, Hg, Pb, Ni, Zn)

[1]Additional metals are added to the laboratory analytical suite if the electrical conductivity at WC 1 exceeds 1,000 µS/cm or at WC2 exceeds 1,700 µS/cm

7.2.3 Bank and Bed Stability

The condition of bank and bed at WC1 and WC2 is observed at each monitoring event for signs of degradation or scouring.

7.3 Groundwater

7.3.1 Groundwater Level and Quality

Groundwater monitoring is undertaken at four monitoring wells (at two locations) installed in September 2004. At each location there is a shallow well approximately 11 m deep, and a deep well approximately 25 m deep (Golder, 2013). Golder (2005) reports the deeper wells monitor the regional aquifer and the shallow wells a perched aquifer.

The wells are MW1S, MW1D and MW2S, MW2D. The monitoring is summarised in Table 7-3 below.

Golder (2005) reports the wells were constructed with slotted 50 mm diameter PVC casing, 6 m PVC screen 0.5 mm slot width, PVC end cap. The casing is flush jointed, threaded with O-ring seal and annulus is filled with 8/16 mm river gravel to approx. 0.5m above screen, 0.5m bentonite seal, clay and gravel backfill. The casing is protected by a steel riser cap set in concrete at ground surface.

The NSW Water Register shows 95 current licences for the extraction of groundwater from the Sydney Basin South Groundwater Source, which includes the Albion Park Quarry. Most licences permit the extraction of groundwater from aquifers in the Southern Highlands southwest of the quarry, and some permit extraction from the alluvial aquifers near Jamberoo, Gerringong, and Berry.

As all these registered extractions are distant from the quarry, they are unlikely to be affected by operations at the quarry.

The closest access licence is southeast of the quarry, at Dunmore Sand and Soil (DSS) sand dredging site. Although there could be groundwater discharge to the shallow sediments from the deeper aquifer, the operations at the quarry are unlikely to adversely affect the groundwater levels at DSS, as the DSS site is in a different (alluvial) hydrogeological setting.

Nevertheless, as the deeper bores in the groundwater monitoring network are located down-gradient of the quarry, these bores provide data on changes in groundwater level and chemistry, and monitor the potential for impacts to groundwater at nearby properties.

Table 7-3 Groundwater monitoring

Bore ID	Parameter	Units	Testing	Frequency
MW1S MW1D MW2S MW2D	Groundwater level	mbgl[2]	Field measured	Biannual
	Electrical conductivity	µS/cm	Field measured	
	pH	pH units		
	Temperature	^{0}C		
	Electrical conductivity	µS/cm	Laboratory	
	pH	pH units		
	Total Suspended Solids	mg/L		
	Total Dissolved Solids	mg/L		

Major Cations (Na, K, Ca)	mg/L
Major Anions (SO 4 , Cl)	mg/L
Alkalinity	mg/L
Nitrogen species (NO3, NH3, TKN)	mg/L
Dissolved metals (Cu, Fe, Ni, Zn)	mg/L
Additional metals 1 (As, Cd, Cr, Hg, Pb)	mg/L

[1]Additional metals are added to the laboratory analytical suite if the EC trigger (section 6.3, Table 6-1) is exceeded.

[2]mbgl metres below ground level

7.3.2 Groundwater Inflows to Quarry

DC Condition 31(dd) requires

> *a program for monitoring groundwater inflows into the quarry from the quarry face or floor, or into any in-pit sumps*

Historically, general observations of the quarry walls have not identified groundwater seepages. Nevertheless, a formal monitoring program for groundwater inflows through the quarry walls will be established, comprising a weekly inspection by the Quarry Production Manager.

The inspection observations, including rainfall occurrence in the preceding week, will be recorded on the inspection checklist. The inspection will be undertaken during dry periods only, so that groundwater can be distinguished from rainfall runoff.

If groundwater is observed seeping from the quarry walls, the Quarry Production Manager will notify the CB Environmental Officer (EO). The CB EO will inspect the quarry wall and calculate the flow rate either by estimation where flows are minimal, or using a measuring device for larger flows, and determine whether further assessment is required.

The results of the visual inspection and any flow data are to be recorded and will be assessed as part of the Annual Review.

The aim of this inspection is to determine the volume of groundwater (if any) that is intersected as a result of quarrying activities and runs off as surface flow to the site sump. Groundwater may also seep into the base of the quarry sump, however as it is impractical to directly measure the actual flow, following survey of the quarry floor to develop a volume / depth table for the sump, and establishment of a gauge point, CB will:

- Measure monthly the water level at the sump
- Compile the level data, change in water level, estimated inflow from seepage from walls, and rainfall / evaporation
- Calculate the water balance at the sump to assess if there appears to be a groundwater component from beneath the pit floor into the sump.
- Report the data reconciliation and findings as part of the Annual Review.

If a significant amount of groundwater is identified to be entering the quarry sump, CB will approach the DPI-W with a strategy for returning these flows to the environment. This may take the form of a process for direct pumping of accumulated water to the adjacent watercourse (in a similar manner to rainfall-related releases) or a process for groundwater injection using an infiltration trench or bore. CB will seek feedback from the DPI-W regarding this strategy prior to its implementation.

An assessment of the observations with recommendations as to whether the approach should be continued, or a modified program trialled, to achieve the DC requirements will be reported in the Annual Review.

8 Response to Issues

8.1 Approach

Incident investigation and corrective actions are documented in the HSEQ Procedure, which includes the purpose, scope, definitions and process.

This section of the WMP presents the approach to investigate, notify and if necessary undertake mitigation measures if there are exceedances of criteria.

8.2 Potential Issues and Response

- The approach if there is an exceedance of criteria or an Issue as listed in Table 8-1 is:
- Advise EPA if EPL exceedance or DPE if a non-EPL exceedance or trigger;
- Obtain a follow up measurement or sample to verify the initial measurement; and
- If verified, implement the response as listed in Table 8-1.

Table 8-1 Summary of Potential Issues and Proposed Response

Issue	Response
Interception of groundwater through quarry walls (DC Condition 22)	Increase groundwater level monitoring frequency to monthly Undertake hydrogeological investigation and assessment as in section 8.3 If necessary, implement measures to minimise impact
Groundwater level decline below historic levels	Increase groundwater level monitoring frequency to monthly Review data, assess rainfall, and evaluate if the decline is a regional effect or potentially a local impact. If local impact is the likely cause, undertake hydrogeological investigation and assessment as outlined in section 8.3 If necessary, implement measures to minimise impact
Increasing concentration of a chemistry parameter or analyte that is potentially a result of quarry activities	Assess trend through data review, and statistical analysis if there are sufficient data points If trend is confirmed, undertake hydrogeological investigation and assessment as outlined in section 8.3 If necessary, implement measures to minimise impact
Exceedance of EPL surface water impact assessment criteria	Assess if the impact is potentially due to groundwater, surface water, or discharges from on-site or by activities elsewhere in the catchment, and assess risk of immediate harm If exceedance of the criteria (TSS, pH) in DC Table 6, notify DPE in accordance with Condition 5 of Schedule 6 of the DC If an on-site non-groundwater source, immediately implement measures to prevent the on-going discharge If a groundwater source, undertake a hydrogeological investigation and assessment as outlined in section 8.3 If necessary, implement measures to minimise impact

8.3 Hydrogeological Investigation and Assessment

The following general approach will be adopted if a hydrogeological investigation is required.

Notification

CB will advise DPI-W that a hydrogeological investigation is being undertaken in accordance with Condition 22 of the DC.

Review and Investigation

CB will engage an appropriately qualified person to:

- Review the data collected under the WMP
- Document the hydrogeological model including groundwater occurrence, level, flow direction, quality and linkages with surface system
- Assess the risk of impact on beneficial uses of groundwater:
  - Baseflow of surface water bodies
  - Water quality in surface water bodies
  - Impact on vegetation and groundwater dependant ecosystems
  - Groundwater users

Subject to the nature of the issue and the assessment of risk, it may be necessary to:

- Collect additional data from existing monitoring points
- Install additional groundwater monitoring bores and monitor groundwater (for parameters in Table 7-3)
- Undertake hydraulic testing of aquifer(s)
- Undertake numerical modelling to assess short and long term impact on groundwater levels, flow to GDE, and movement of contaminants

Outcome

Recommend an appropriate course of action that may include a detailed assessment of risk and/or activate remediation measures, further or additional monitoring including adjustments to the monitoring frequency or parameters measured and reassessment and revision of triggers and criteria.

8.4 Potential Mitigation Measures

There are a range of measures and alternative approaches to minimise impact that could be considered if deemed necessary, after the hydrogeological investigation and assessment. These may include:

- Hydraulic control by pumping of groundwater or installation of barriers to groundwater
- Modification to quarry staging
- Enhanced recharge of groundwater through an infiltration trench.

The previous version of the WMP included an infiltration trench immediately downhill of the extraction area to allow water to be injected into the aquifer, if necessary. The trigger for action was groundwater level decline as a result of quarrying, and if the vegetation immediately downhill of the quarry and above the creek line was impacted.

If following a hydrogeological investigation and assessment it is considered recharge of groundwater via a trench is the appropriate response, the design of the trench would be confirmed. The previous WMP described a trench within 10 metres of the quarry edge following the contour, and 1.5 to 2 metres deep with a slotted pipe at the base, and backfilled with washed gravel.

If recharge of groundwater is considered a feasible mitigation measure, DPI-W will be consulted prior to undertaking further planning, investigation or testing.

9 Reporting and Review

9.1 Reporting

The review and reporting processes to meet DC Condition 33 are described in the QEMP.

The Annual Review is prepared by CB and submitted to DPE and contains the monitoring data collected under the WMP, and assessment of the data against historical data.

As part of the Annual Review, the data will also be assessed and reported with regard to:

- The relevant statutory requirements, limits or performance measures/criteria
- The monitoring results of previous years
- The relevant predictions in the documents referred to in Condition 2 of Schedule 3 of the Development Consent
- Any trends in the monitoring data over the life of the development
- Any discrepancies between the predicted and actual impacts of the development, and an analysis of the potential cause of any significant discrepancies
- Details of the measures undertaken/proposed to address any identified issues.

9.2 Incident / Exception Reports

Incident / Exception Reports are submitted by CB as per section 6.7 of the QEMP and details included in the Annual Review report.

9.3 WMP Review and Continuous Improvement

An independent environmental audit (QEMP section 8) is commissioned by CB every three years. The nominated auditor details are submitted to the DPE for approval prior to an audit commencing.

The WMP should be reviewed as part of the Audit and recommendations made to achieve continuous improvement of the WMP.

The WMP may also be reviewed and modified if necessary:

- To reflect significant changes to operations at the site, and / or
- Following modification of consent conditions; and/or
- As part of a hydrogeological investigation and assessment, as described in section 8.3 of this WMP.

10 Reference Documents

The following documents are referenced in this WMP.

CB, 2017a. Albion Park Quarry Environmental Management Plan 10 January 2017. Cleary Bros (Bombo) Pty Ltd.

CB, 2017b. Albion Park Quarry Annual Review Period 01 July 2016 30 June 2017. Cleary Bros (Bombo) Pty Ltd.

DC (Development Consent), 2017. Land and Environment Court Proceedings No. 10639 of 2005. Modified 2017.

EPA, 2015. Environment Protection Licence No. 299, version 16 April 2015. Environment Protection Authority NSW.

Golder, 2005. Report on Cleary Bros Quarry, Albion Park Surface Water and Groundwater management Plan and Water Quality Monitoring Albion Park, New South Wales. Golder Associates Ref: 04623089/007. October 2005.

Golder, 2013. Cleary Bros Albion Park Quarry Water Management Plan Review. Golder Associates Ref:1276260002-001-R-Rev0. 18 January 2013.

KFWA, 2006. Soil and Erosion Control Plan issued for C.C. Approval. K.F. Williams & Associates, December 2006 (Ref 0106208 Dwg C6 - C15).

MMJ, 2016. Environmental Assessment. Cleary Bros (Bombo) Pty Ltd Modification of Development consent 10639 of 2005 (LEC). Activation of Approved Stages 5 & 6 Albion Park quarry. MMJ Wollongong, August 2016.

Perram & Partners, 2003. Proposed Quarry Extension, Albion Park, Environmental impact statement, Prepared by Perram and Partners Pty Ltd, October 2003.

Appendix A

9 Pages

Baseline Surface Water and Groundwater Data

Surface Water – Summary of Historic and 2016/17 Data (from CB)

Sewage Treatment Plant

Analyte	Unit	2016/17 Reporting Period			Historical Results			DC limit	EPL trigger
		Min	Ave	Max	Min	Ave	Max		
Oil and Grease	mg/L	<5	16	55	<5	9	44	N/A	30
TSS	mg/L	<5	14	30	<5	40	107	N/A	50
BOD	mg/L	5	15	23	3	56	387	N/A	150

Quarry Extension Discharge

Analyte	Unit	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
		Min	Ave	Max	Min	Ave	Max		
pH	pH units	6.6	7.1	7.9	6.2	7.7	8.5	6.5 – 8.5	6.5 – 8.5
Turbidity	NTU	3.8	17.4	27.6	9.7	20.8	29.8	32.2	32.2

Watercourse West of Quarry Manager's Office

Analyte	Unit	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
		Min	Ave	Max	Min	Ave	Max		
pH	pH units	7.7	8.0	8.4	7.1	7.8	8.3	N/A*	N/A*
Oil & Grease	mg/L	<5	<5	<5	<0.1	<5	11	N/A	N/A*
TSS	mg/L	<5	13	45	<1	14	190	N/A*	N/A*

* Not Applicable as there were no discharges of water from the Main Sedimentation Pond during the reporting period. Results reflect natural flow in watercourse.

Watercourse 1 and Watercourse 2 (Field Measurements)

pH	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
pH units	Min	Ave	Max	Min	Ave	Max		
WC1	6.8	7.1	7.2	6.1	7.4	8.3	N/A	N/A
WC2	7.5	7.5	7.5	6.9	7.7	8.7	N/A	N/A
Temperature	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
°C	Min	Ave	Max	Min	Ave	Max		
WC1	11	17	24	9	17	29	N/A	N/A
WC2	24	24	24	9	18	29	N/A	N/A
EC	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
µS/cm	Min	Ave	Max	Min	Ave	Max		
WC1	191	261	320	160	460	910	N/A	N/A
WC2	698	698	698	443	1109	2100	N/A	N/A
Turbidity	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
NTU	Min	Ave	Max	Min	Ave	Max		
WC1	7	119	313	2	73	5890	N/A	N/A
WC2	241	241	241	1	83	5040	N/A	N/A

	Flow (L/sec)	
Month	WC1	WC2
Jul-16	dry	49
Aug-16	dry	dry
Sep-16	dry	dry
Oct-16	dry	dry
Nov-16	dry	dry
Dec-16	dry	dry
Jan-17	dry	dry
Feb-17	0.333	dry
Mar-17	1.08	44.5
Apr-17	0.1	dry
May-17	0.02	dry
Jun-17	0.01	dry

Watercourse 1 and Watercourse 2 (Laboratory Measurements)

TDS	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	202	246	332	135	260	510	N/A	N/A
WC2	514	514	514	320	679	1500	N/A	N/A
TSS	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	11	28	51	3	12	44	N/A	N/A
WC2	105	105	105	2	124	2600	N/A	N/A

Sodium	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	24	31	37	7	46	92	N/A	N/A
WC2	72	72	72	69	132	207	N/A	N/A
Potassium	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	<1	2	3	<1	1	5	N/A	N/A
WC2	2	2	2	<1	1	5	N/A	N/A
Calcium	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	5	10	14	6	19	46	N/A	N/A
WC2	42	42	42	28	63	170	N/A	N/A

Sulphate	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	9	13	16	<1	20	110	N/A	N/A
WC2	176	176	176	90	252	690	N/A	N/A
Chloride	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	30	31	33	20	47	100	N/A	N/A
WC2	22	22	22	14	39	116	N/A	N/A

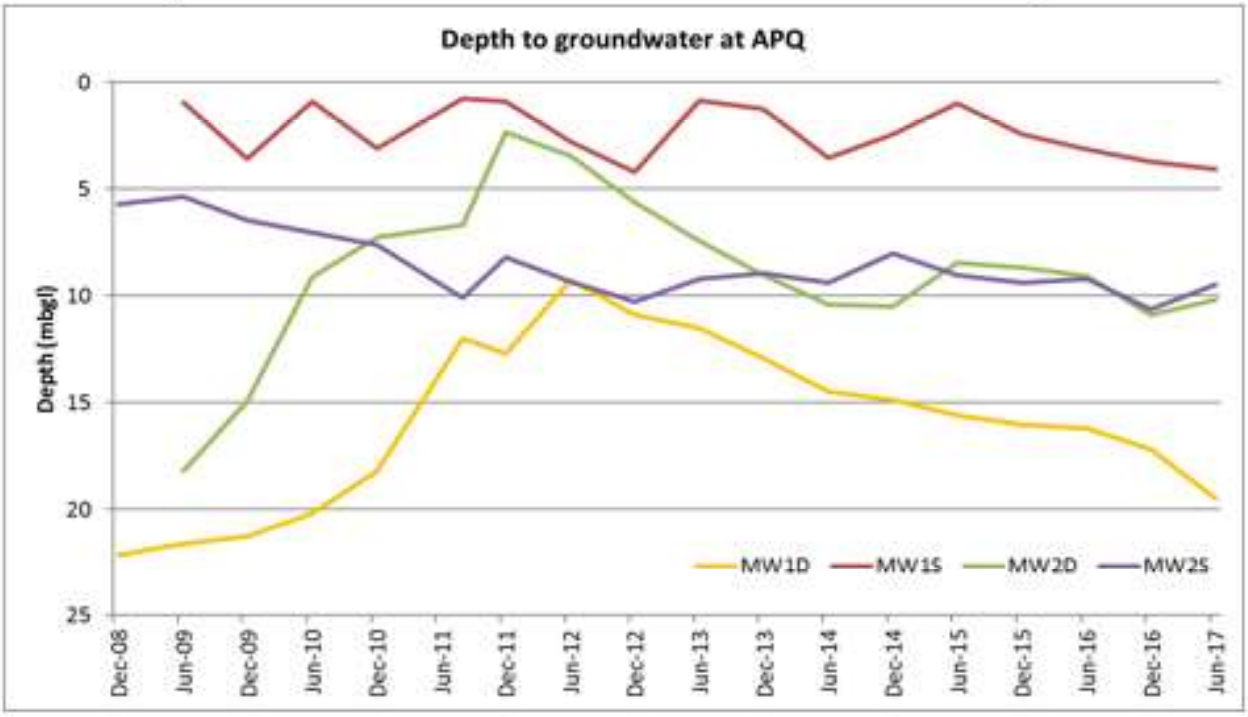
Alkalinity	2015/16 Reporting Period			Historical Results			DC limit	EPL limit
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	39	86	176	42	118	220	N/A	N/A
WC2	121	178	235	144	208	406	N/A	N/A

Copper	2016/17 Reporting Period			Historical Results			DC limit	EPL limit
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	0.004	0.009	0.016	0.002	0.008	0.020	N/A	N/A
WC2	0.009	0.009	0.009	0.002	0.004	0.005	N/A	N/A
Iron	**2016/17 Reporting Period**			**Historical Results**			**DC limit**	**EPL limit**
mg/L	Min	Ave	Max	Min	Ave	Max		
WC1	0.02	0.24	0.49	0.12	0.34	1.60	N/A	N/A
WC2	<0.05	<0.05	<0.05	<0.01	0.05	0.32	N/A	N/A

Groundwater – Summary of Historic and 2016/17 Data (from CB)

Depth to Groundwater (m)

BORE HOLE	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	17.16	18.33	19.5	9.26	15.62	22.13
MW1S	3.72	3.91	4.1	0.75	2.13	4.24
MW2D	10.2	10.55	10.9	2.34	8.75	18.22
MW2S	9.48	10.06	10.64	5.35	8.33	10.3



Electrical Conductivity (µS/cm) and TDS (mg/L)

EC µS/cm	2016/17 Reporting Period			Historical Results			Pre-quarrying maximum
	Min	Ave	Max	Min	Ave	Max	
MW1D	948	1014	1080	110	537	1300	2700
MW1S	1610	1635	1660	211	875	1560	1236
MW2D	1880	1945	2010	140	715	1800	2000
MW2S	1130	1160	1190	627	992	1250	1305
TDS mg/L	**2016/17 Reporting Period**			**Historical Results**			
	Min	Ave	Max	Min	Ave	Max	
MW1D	602	652	702	84	308	710	
MW1S	1100	1150	1200	131	559	1060	
MW2D	1040	1140	1240	85	458	1110	
MW2S	942	1036	1130	397	706	1230	

pH and Alkalinity

pH pH units	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	7.5	7.6	7.6	6.5	7.1	7.7
MW1S	6.6	6.7	6.7	5.9	6.5	7
MW2D	7.4	7.5	7.5	6.5	7.1	7.7
MW2S	7	7.1	7.1	6	6.8	7.2
Alkalinity mg/L as $CaCO_3$	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	153	170	186	28	106	310
MW1S	209	211	213	16	176	444
MW2D	254	268	281	33	137	250
MW2S	319	338	356	50	242	404

Temperature °C

Temperature °C	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	17.3	18.1	18.8	13.5	18.2	27.3
MW1S	17.9	18.4	18.9	14.9	17.6	19.4
MW2D	16.4	17.6	18.7	15	17.6	19.8
MW2S	16.1	17.8	19.5	14.7	18.3	22.8

Total Suspended Solids (mg/L)

TSS mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	39	109	178	2.5	82	640
MW1S	34	65	96	5	40	201
MW2D	38	97	156	2.5	251	3200
MW2S	765	9283	17800	27	891	9960

Major Cations (mg/L)

Sodium mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	145	181	216	7	71	220
MW1S	112	130	148	22	68	121
MW2D	205	239	272	5.7	63	210
MW2S	121	141	160	21	105	152
Potassium mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	2	3	4	<1	4	14
MW1S	1	1	1	<1	1	4
MW2D	5	5	5	1	5	13
MW2S	<1	<1	<1	<1	1	6
Calcium mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	51	61	71	7	32	100
MW1S	116	128	140	7	62	130
MW2D	108	120	132	9	52	100
MW2S	78	80	81	26	71	130

Major Anions (mg/L)

Sulphate mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	196	208	219	3	86	320
MW1S	177	191	204	23	57	114
MW2D	165	186	206	3.3	131	270
MW2S	162	178	194	81	191	350
Chloride mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	88	98	108	8	46	210
MW1S	314	325	335	22	142	332
MW2D	372	394	416	8	53	320
MW2S	66	66	66	30	64	170

Nitrogen Species (mg/L)

Nitrate as N mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.06	0.74	1.41	0.03	0.50	1.84
MW1S	0.06	0.09	0.11	<0.01	0.12	0.69
MW2D	0.24	0.34	0.44	0.11	2.21	4.77
MW2S	1.03	1.47	1.9	0.04	1.26	4.57
Ammonia as N mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.1	0.24	0.37	<0.01	0.19	1.78
MW1S	0.04	0.06	0.08	<0.01	0.15	0.98
MW2D	0.03	0.05	0.07	<0.01	0.06	0.52
MW2S	0.14	0.17	0.2	<0.01	0.02	0.08
TKN as N mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	2.1	2.4	2.7	0.1	0.9	4.6
MW1S	1	1.5	1.9	0.3	1.1	2.9
MW2D	0.7	1.7	2.7	0.1	0.8	2
MW2S	2.2	17.1	31.9	0.2	0.6	1.5

Total Phosphorous (mg/L)

Phosphorus mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.36	0.60	0.83	0.01	0.31	3.25
MW1S	0.08	0.19	0.3	0.01	0.15	0.42
MW2D	0.07	0.22	0.37	0.02	0.17	0.6
MW2S	1.25	13.73	26.2	0.03	0.41	2.09

Oil & grease (mg/L)

Oil and Grease mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	<5	<5	<5	<5	<5	8
MW1S	<5	<5	<5	<5	<5	13
MW2D	<5	<5	<5	<5	<5	6
MW2S	<5	<5	<5	<5	<5	8

BOD (mg/L)

BOD mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	3	4	5	<2	3	11
MW1S	2	4	5	<2	12	150
MW2D	4	8	12	<2	3	14
MW2S	1	3	5	<2	2	8

TOC (mg/L)

TOC mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	10	13	16	<1	6	16
MW1S	14	15	16	8	18	88
MW2D	5	12	19	2	9	38
MW2S	3	9	14	2	4	7

Total dissolved metals (mg/L)

Dissolved Copper mg/L	2016/17 Reporting Period			Historical Results		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.005	0.012	0.019	<0.01	0.010	0.027
MW1S	0.005	0.007	0.009	<0.01	0.021	0.078
MW2D	0.019	0.020	0.021	<0.001	0.022	0.072
MW2S	0.006	0.013	0.02	<0.01	0.014	0.088
Dissolved Iron mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.3	0.32	0.34	<0.05	0.42	1.14
MW1S	0.11	0.94	1.76	<0.05	1.01	5.54
MW2D	<0.05	0.31	0.59	<0.05	0.25	1
MW2S	0.1	1.38	2.66	<0.05	0.48	5.45
Dissolved Nickel mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.024	0.029	0.033	<0.01	0.008	0.018
MW1S	0.002	0.003	0.003	<0.01	0.003	0.005
MW2D	0.004	0.006	0.007	<0.01	0.006	0.014
MW2S	0.002	0.007	0.012	<0.01	0.004	0.008
Dissolved Zinc mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1D	0.052	0.137	0.222	<0.01	0.052	0.177
MW1S	0.03	0.036	0.042	0.007	0.022	0.055
MW2D	0.053	0.094	0.135	<0.005	0.125	0.373
MW2S	0.167	0.349	0.531	<0.01	0.028	0.107
Dissolved Arsenic mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1S	0.002	0.003	0.004	<0.01	0.004	0.006
MW2D	<0.001	0.001	0.002	<0.001	0.002	0.005
Dissolved Cadmium mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1S	<0.0001	<0.0001	<0.0001	<0.0001	0.001	0.005
MW2D	<0.0001	0.0002	0.0004	<0.0001	0.001	0.005
Dissolved Chromium mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1S	<0.001	<0.001	<0.001	<0.001	0.002	<0.01
MW2D	<0.001	<0.001	<0.001	<0.001	0.002	<0.01
Dissolved Lead mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1S	<0.001	<0.001	<0.001	<0.001	0.003	0.01
MW2D	<0.001	0.001	0.001	<0.001	0.002	<0.01
Dissolved Mercury mg/L	**2016/17 Reporting Period**			**Historical Results**		
	Min	Ave	Max	Min	Ave	Max
MW1S	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.01
MW2D	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.01

Appendix B

3 Pages

Water Balance

Water Balance

1. Introduction

CB operational experience is that water collected at the site and stored in the 18 ML capacity on-site dam, has been sufficient for dust suppression on haul roads and the processing plant, and use in the concrete batching plant.

The calculations presented below show the estimated water use and water availability based on operational data provided by CB and climate data from Kiama (BOM 068038). For these calculations, a wet year is considered 90th percentile annual rainfall (1740 mm) and dry year as 10th percentile (835 mm). The median rainfall is 1160 mm.

2. Water Use

Based on information from CB, the main elements of the site water use are discussed below and summarised in Table 1.

Dust Suppression - Haul Roads and Environs

CB has advised that based on records in March 2018, usage on non-rain days is nine (9) water cart loads per day (9 @ 33,000L = 297kL/day), and under average winter conditions this reduces to approximately five (5) water cart loads per day (165 kL/day). These water cart loads include water for dust suppression at the mobile crusher in Pit 2.

Water balance calculation assumptions:

- Quarry operation for 286 days (52 weeks x 5.5 days/week)
- Non-use days (rain > 1mm)
  - 90 days (dry year)
  - 115 days (wet year)
- Average water cart loads across the year:
  - Dry 8/day (75% summer rate, 25% winter rate)
  - Median 7/day (50% summer rate, 50% winter rate)
  - Wet 6/day (25% summer rate and 75% winter rate)

Based on the above assumptions the estimated annual use for dust suppression on haul roads and environs ranges from **39 ML/yr to 57 ML/yr.**

It is noted that in the calculation, preceding days of rainfall (which may reduce demand) are not considered although this is expected to be balanced by the days where some dust suppression is required although there is greater than 1mm rain.

Dust Suppression – Main Processing Plant

The processing plant uses water for spraying on conveyors, stockpiles and the manoeuvring area around the stockpiles and the water use is not significantly affected by climate.

CB advises that water use at the main processing plant is currently unmetered, and is estimated at 50kL/day on operational days. There are approximately 300 operational days per year at the processing plant (assuming no use on Sundays and shutdown periods).

The estimated annual use for dust suppression at the main processing plant is **15 ML/yr**.

Concrete Batching Plant

CB estimates water use in the concrete batching plant at **8 ML/yr** based on 2017 production volumes and mix designs, and expects this rate of water use to continue for the foreseeable future.

Total Estimated Use

Table 1 shows the estimated total water use at the site ranges from approximately 75 ML/yr to 93 ML/yr, with an average of approximately 85 ML/yr. Potable water use on-site is not included above as potable water is from the Sydney Water reticulated supply.

Table 1: Estimated Annual Water Use

Use	Estimated Annual Use (ML) Dry year (10 percentile)	Estimated Annual Use (ML) Median year (50 percentile)	Estimated Annual Use (ML) Wet year (90 percentile)
Dust Suppression			
Haul Roads and Environs	57	49	39
Main Processing Plant	15	15	15
Concrete Batching Plant			
Plant	8	8	8
Other			
Evaporation from Dam[1]	13	13	13
Estimated Total Annual Water Use (ML)	**93**	**85**	**75**

[1]Pond area 10,900 m^2, evaporation 1,200 mm (pan evaporation 1,600 mm x 0.75 pan factor) assumed for all years.

3. Water Source

CB advises that the main storage dam located south of the processing area is the source of water for the site uses described in Table 1. The storage has 18 ML capacity under the current overflow configuration and receives rainfall runoff within its catchment together with any localised groundwater that may discharge to surface in the catchment.

An estimate of water availability for the storage dam based on rainfall, catchment area and assumed runoff coefficient[1] for each land use (provided by CB) is summarised in Table 2. The catchment areas are shown on Figure A (provided by CB). The adopted runoff coefficients reflect the steep slopes and clayey soils in the catchment.

Table 2: Estimated Available Runoff – Storage Dam Catchment

Source	Area (m^2) (from GIS)	Runoff coefficient	Estimated Annual Runoff (ML) Dry year (10 percentile)	Estimated Annual Runoff (ML) Median year (50 percentile)	Estimated Annual Runoff (ML) Wet year (90 percentile)
Dam	10,893	1	9	13	19
Forest	112,372	0.16	15	21	31
Pasture	151,100	0.4	50	70	105
Pit	145,595	0.7	85	118	177
Roads	29,846	0.8	20	28	42
Total runoff (ML/yr)			**180**	**250**	**374**
Note: Assumed annual rainfall: Dry 835 mm, Median 1160 mm, Wet 1740 mm					

The above calculations indicate that average annual water availability, even in a dry year, exceeds the anticipated water use requirements for the site. In average to wet rainfall years the capacity of the main dam is likely to be exceeded and if there is no additional storage area available on-site, discharge off-site would occur.

[1] Runoff coefficient is the proportion of rainfall assumed to become surface water runoff

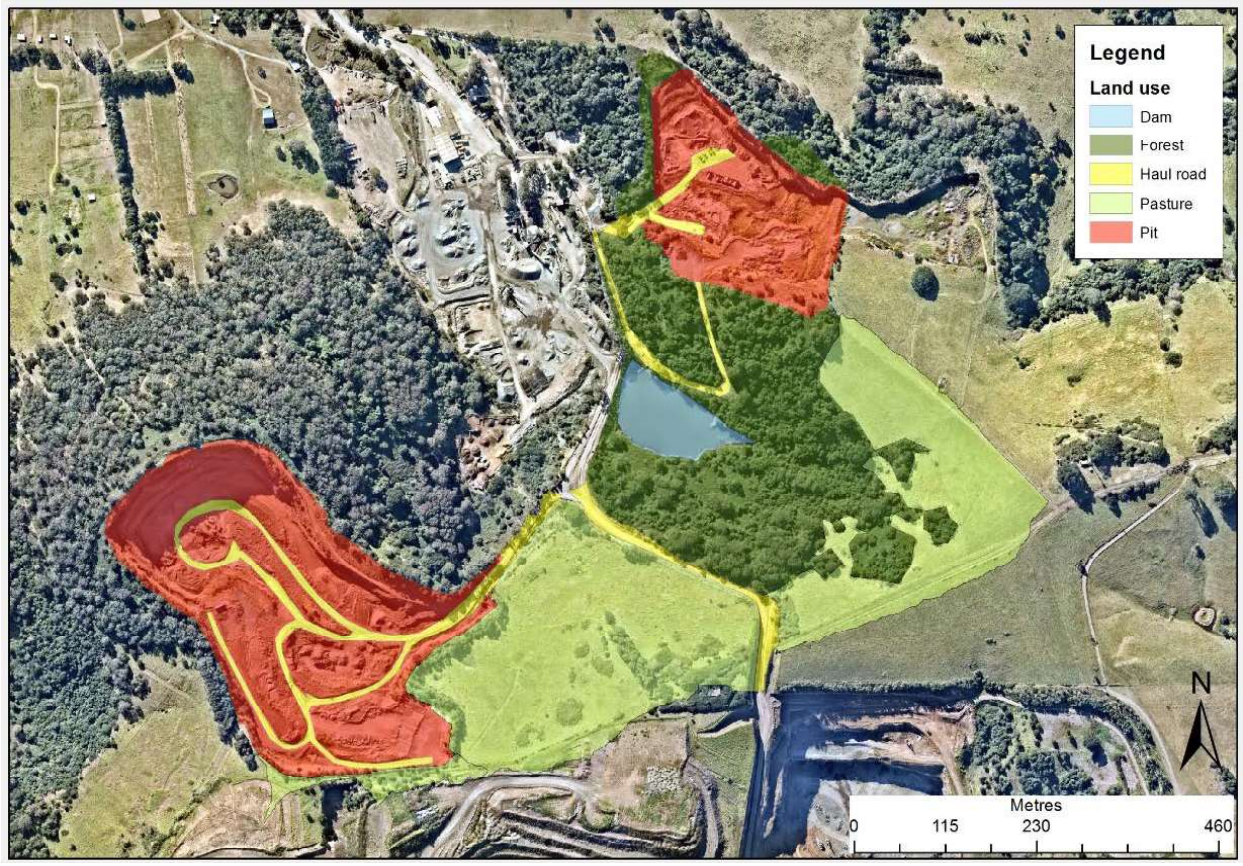


Figure A: Storage Dam Catchment Areas (from CB)

4. Other Site Water Management

a. Groundwater Interactions and Volumes

Although it is possible there is a relatively small contribution from perched groundwater in the dam catchment, CB has not observed significant inflow of groundwater through the walls or floor of the former quarry. Therefore the groundwater contribution to the flow to the dam is expected to be negligible compared with surface water runoff and is not included in the above water balance calculation.

In the active quarry, where groundwater seeps can occur at the base of the highwall, CB intends to undertake weekly inspections of the quarry walls and will estimate the seepage rate where flows are minimal, and measure larger flows. The aim of this inspection is to determine the volume of groundwater (if any) that is intersected as a result of quarrying activities and which runs off as surface flow to the pit floor sump.

Also, groundwater could seep into the quarry pit floor sump, or the quarry floor via diffuse discharge, and then flow as runoff to the sump. As it is impractical to directly measure the groundwater inflow into the sump, CB proposes to estimate the groundwater inflow to the quarry pit floor sump adopting the approach described in the WMP. The results of the inspection of the base of the highwall and also the estimated groundwater inflow to the sump will be reported in the Annual Review.

b. Stage 5 Sump Discharge

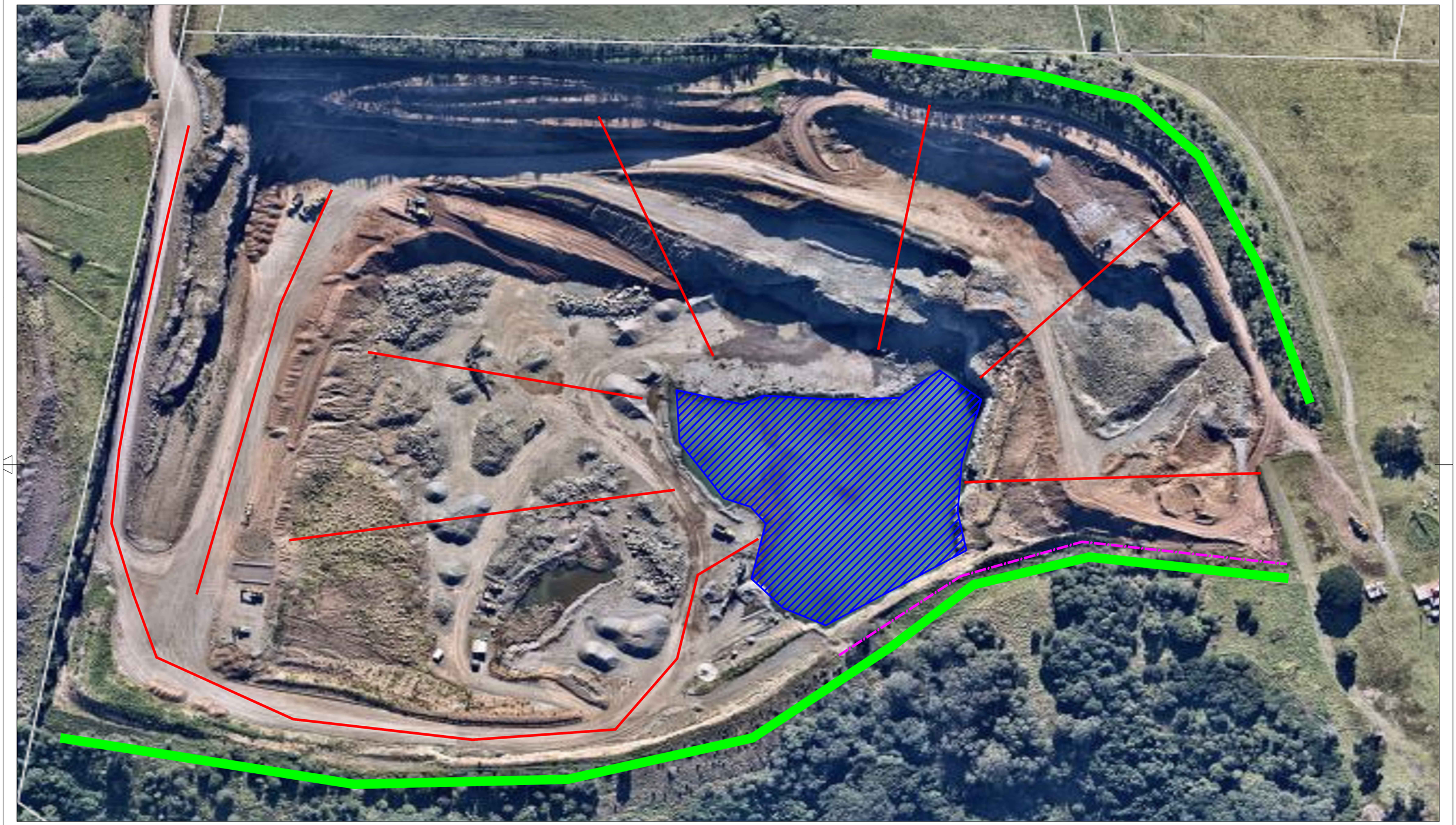
CB has advised Cardno that water in the sump in the active quarry is discharged following heavy rainfall or extended wet weather, and records of these discharges are kept for Environmental Protection Licence reporting. During 2017 discharge was reported on 18 days. Assuming a pumping rate 50L/s for 23 hours on each day, in 2017 the discharge from the active quarry pit sump was approximately 74 ML.

Appendix C

1 Page

Erosion and Sediment Control (CB File: APQ Ed A)

RevNo	Revision note	Date	Signature	Checked



Sediment Pond	
Vegetated Buffer	
Stormwater Flow Paths	
Sediment Fence	

Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by RD		Checked by MH	Approved by - date 14/08/2020	File name APQ	Date 14/08/2020	Scale As Shown

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Sediment and Erosion Control

APQ Level 3

Edition	Sheet
A	1/1

Appendix D

1 Page

Report Limitations

LIMITATIONS OF GEOTECHNICAL & ENVIRONMENTAL REPORTS

The purpose of this report is to provide a geotechnical and contamination assessment of the sites examined. The information provided herein will reduce the exposure to risks, but no assessment can eliminate them. Nonetheless, even a rigorous assessment may fail to detect all of the geotechnical or contamination conditions on a site. Site variations may have occurred in areas not investigated or sampled.

This report should not be used when the nature of the proposed site usage changes, when the size, layout, or location of the development is modified, when the site ownership changes nor should it be applied to a nearby area.

The site geotechnical and contamination assessment identifies actual subsurface conditions where the samples were taken and when they were taken. The contamination tests are carried out by an external NATA accredited chemical laboratory and any liability with regards to the testing is solely this laboratory's responsibility. The laboratory results together with the field, and other data were then interpreted by geotechnical and environmental engineers who rendered an opinion about the overall subsurface conditions, the nature, mobility, type and extent of contamination, its likely impact on the proposed development with a discussion of the remediation measures considered likely.

The actual conditions may differ from the inferred conditions, as no person (no matter how qualified) or even the most detailed subsurface investigation can predict with confidence what may be hidden by soil or water or may have altered with time. Often the interface between contamination zones may be more abrupt or gradual than anticipated. The actual conditions in an area may differ from that predicted. Site assessments are limited by time and may be affected by natural processes such as erosion, mankind altering the ground conditions, or chemical reactions of potential contaminants altering the physical characteristics of the soil or water on the site.

Costly problems can occur if the report is misinterpreted. To avoid these problems, Cardno should be retained to work with the appropriate design professionals and to review the adequacy of their plans and specifications relative to the geotechnical matters. No person other than the client should apply the report without first conferring with Cardno.

This report should only be reproduced in its entirety. Reproduction of borehole or testpit logs alone without the entire report should not be permitted. Redrafting of the borehole or testpits logs for inclusion in drawings or other reports should not be allowed as errors in the drafting can occur. It is recommended that the report be made available in entirety to persons and organisations involved in the project such as contractors. Simply disclaiming responsibility for the accuracy of the subsurface or geotechnical information does not insulate the organisation from liability. The more information a contractor has available to him, the better able he is to avoid costly construction problems and costly adversarial situations.

Finally, geotechnical and environmental reports are based extensively on opinion and judgment and are less exact than other sciences. The report may contain a number of explanatory clauses or limitations on the results to inform the client about the restrictions of the report. These clauses are not meant to be exculpatory clauses to foist liability onto another person, but to identify where Cardno's and the client's responsibilities start and finish. Their use is to clarify where individual responsibilities lie and to allow the individual to take appropriate actions.