WATER MANAGEMENT PLAN

Hy-Tec Industries Pty Limited

ABN: 90 070 100 702

Austen Quarry

Water Management Plan

August 2019

Prepared by:

GROUNDWORK plus


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TABLES

FIGURES

ATTACHMENTS

LIST OF ACRONYMS

As	Arsenic
BOD	Biological Oxygen Demands
Cd	Cadmium
Cr	Chromium
Cu	Copper
DPE	NSW Department of Planning and Environment
DPI	Department of Primary Industries
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EMSP	Environmental Management Strategy and Plan
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence
EV	Environmental Value
Fe	Iron
GDE	Groundwater Dependent Ecosystems
HPC	Hartley Pastoral Corporation Pty Ltd
m AHD	Australian Height Datum
Mn	Magnesium
NH4	Ammonia
Ni	Nickel
Pb	Lead
PIRMP	Pollution Incident Response and Management Plan
POEO Act	Protection of the Environment Operations Act 1997
SSD	State Significant Development
SWMDA	Surface Water Management and Discharge Assessment
TP	Total Phosphorus
TSS	Total Suspended Solids
WMIP	Water Management Improvement Program
WMP	Water Management Plan
Zn	Zinc

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1. INTRODUCTION

This Austen Quarry - Water Management Plan (WMP) has been prepared to satisfy *Condition 20* of Schedule 3 of Development Consent SSD 6084 (the Consent) and as an operational tool to assist in the management of water during the operation of the Austen Quarry ("the Quarry"). It will be used by Hy-Tec Industries Pty Limited (Hy-Tec) personnel as the first point of reference for water management.

This WMP synthesises the recommendations made during the preparation of an *Environmental Impact Statement* (EIS) for the Stage 2 development of the Quarry (RWC, 2014), and a subsequent modification to SSD 6084 approved in August 2018. It is a practical guide for management of water on site. A *Surface Water Management and Discharge Assessment* (SWMDA) was prepared as Part 9 of a Specialist Consultant Studies Compendium to accompany an EIS for the Stage 2 Extension of the Austen Quarry ("the Stage 2 Extension"), located on Jenolan Caves Road, Hartley, NSW to detail management strategies designed to minimise water pollution.

SSD 6084 was modified in August 2018 and in July 2019. The outcomes of these modifications to SSD 6084 did not change the implementation of water management at the Quarry.

The construction and development of Stage 2 of the Quarry will involve an increase in depth and lateral extension of the Stage 1 extraction area along an adjacent southwest-northeast trending ridge and a lateral extension and elevation of the existing overburden emplacement. The approved layout is displayed in **Figure 1 Approved Stage 2 Site Layout**. The land within the approved site boundary is referred to as the Quarry Site.

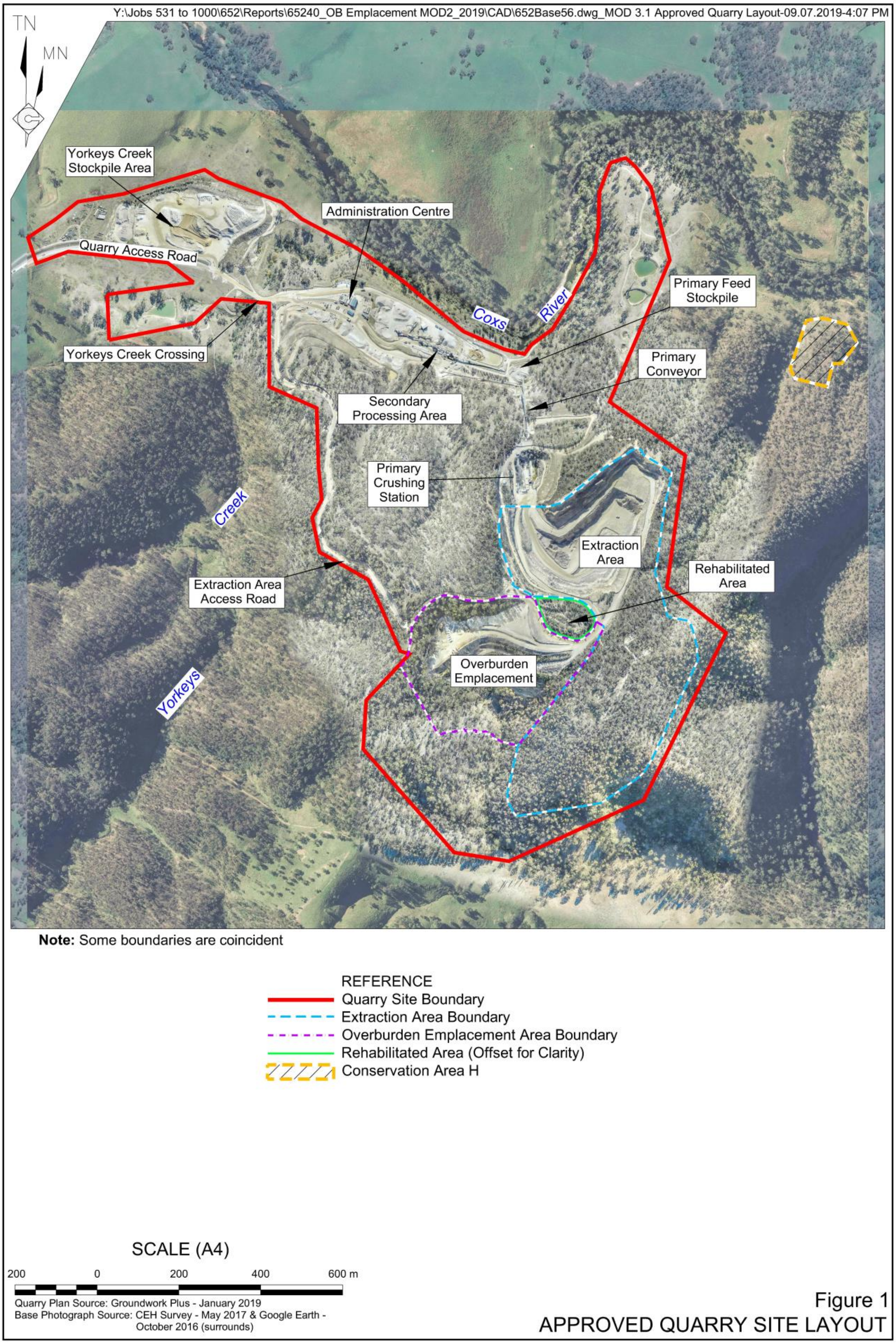

Figure 1
APPROVED QUARRY SITE LAYOUT

Surface Water

Extraction activities on-site have the potential to impact upon overland flow water quality (e.g. elevated suspended solids, turbidity and due to chemical spills such as hydrocarbons). These activities include:

- vegetation clearing
- topsoil and overburden stripping
- quarry pit development
- maintenance of internal roads
- stockpiling of topsoil, overburden, raw source material and product
- spillage during handling of materials
- use of oils, greases, fuels and other chemicals.

Potential water discharged from the Quarry include:

- control discharge of stormwater that collects within the on-site sediment basins.
- overtopping of quarry pit sumps / sediment dam.
- overland flow from disturbed areas including quarry pit and product stockpiling area(s).
- overland flows from handling areas of oils, greases, fuels and other chemicals.

Environmental values of the receiving environment that may be potentially impacted as a result of water discharge are:

Table 1
Environmental Values for the Receiving Environment

Type	Value
Aquatic Ecosystems	Ecosystem protection (aquatic plants, fish and other flora and fauna habitat) for a moderately disturbed level of protection.
Human Uses	Agricultural uses (e.g. Long term irrigation and Livestock water)
	Drinking water for human consumption
	Recreation

The Applicant shall ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of operations under the consent to match its available water supply, to the satisfaction of the Secretary.

The purpose of this WMP is to:

- Carry out on-site activities so as to prevent or minimise as far as practicable, any contamination of waters and any release of contaminated water off-site.
- Ensure compliance with the release water quality limits of the EPL12323, or to comply with Section 120 of the Protection of the Environment Operations Act 1997 (POEO Act).

Groundwater

Ground Doctor Pty Ltd (2014) presented an assessment (Groundwater Assessment for the Austen Quarry Stage 2 Extension Project) of potential groundwater impacts associated with the Stage 2 Quarry extension. This included assessment of:

- potential drawdown impacts to other existing groundwater users
- potential drawdown impacts on the environment
- potential impacts to groundwater quality.

Ground Doctor Pty Ltd (2014) concluded that potential groundwater impacts associated with the Stage 2 extension would be minimal and acceptable.

This WMP, in conjunction with the Austen Quarry Groundwater Management Plan (Appendix V of the Environmental Management Strategy and Plan, hereafter EMSP) outlines measures to:

- Estimate groundwater take associated with operation of the Quarry.
- Monitor potential groundwater impacts associated with the Quarry.
- Address any unforeseen groundwater impacts, if these are identified by the proposed impact monitoring.

2. CONSULTATION

Condition 20(b) of Schedule 3 of the Consent requires that the NSW Environment Protection Authority (EPA), NSW DPI Water (now DoI) and Water NSW be consulted in the preparation of the WMP.

A consultation log outlining correspondence with regulatory agencies is provided at **Attachment 1 – Regulatory Agency Consultation Log**.

3. LEGAL AND OTHER REGULATORY REQUIREMENTS

3.1 DEVELOPMENT CONSENT SSD 6084

The Consent was granted, under delegation, by the NSW Minister for Planning on 15 July 2015 (and subsequently modified in August 2018), with *Condition 20* (of Schedule 3) requiring the preparation of a WMP. *Conditions 15* to *19* of the Consent are also pertinent to the WMP. General requirements for the preparation of management plans are also provided by *Condition 2* of Schedule 5. **Table 2 – Conditional Requirements of the Consent for a Water Management Plan** identifies the water-related conditional requirements and identifies where in the WMP individual requirements have been addressed.

Table 2
Conditional Requirements of the Consent for a Water Management Plan

Condition	Corresponding WMP Section
Schedule 3	
Water Supply Condition 15 – The Applicant must ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of operations under the consent to match its available water supply, to the satisfaction of the Secretary. *Note: Under the Water Act 1912 and/or the Water Management Act 2000, the Applicant is required to obtain the necessary water licences for the development, including in respect of the extraction and/or interception of groundwater.*	6
Water Discharges Condition 16 – The Applicant must comply with the discharge limits in any EPL, or with section 120 of the POEO Act.	7
Surface Water Audit and Water Management Improvement Program Condition 17 – Within three months of the date of this consent, the Applicant must commission independent surface water expert/s, approved by the Secretary, to undertake an audit of current and proposed surface water management practices and infrastructure on the site. The audit must: • be undertaken in consultation with EPA and Water NSW • fully describe and audit existing site water management practices and consider the EIS's proposed water management practices • identify all reasonable and feasible measures to improve surface water management on the site, with particular reference to opportunities to divert clean water away from the quarry • recommend design parameters for proposed water management systems on the site.	10
Condition 18 – Unless otherwise agreed with the Secretary, the Applicant must submit the Surface Water Audit report to the Secretary within six months of commissioning the audit. The report must be accompanied by a Water Management Improvement Program, based on the report's recommendations, to improve surface water management practices on the site, including a program of proposed timeframes for implementation.	10
Condition 19 – The Applicant must implement the Water Management Improvement Program to the satisfaction of the Secretary.	10

Condition	Corresponding WMP Section
Water Management Plan Condition 20 – The Applicant must prepare and implement a Water Management Plan for the development to the satisfaction of the Secretary. This plan must: • be prepared by suitably qualified person/s approved by the Secretary • be prepared in consultation with the EPA, DoI and Water NSW • be submitted to the Secretary for approval at least 3 months prior to the commencement of quarrying operations under this consent, unless otherwise agreed by the Secretary • include a: (i) Site Water Balance that includes: • details of: • sources and security of water supply • water use and management on site • any off—site water transfers • reporting procedures. 1. measures that would be implemented to minimise clean water use on site (ii) Surface Water Management Plan, that includes: 2. detailed baseline data on surface water flows and quality in water bodies that could potentially be affected by the development 3. detailed description of the surface water management system on site including the: • clean water diversion system • erosion and sediment controls • dirty water management system • water storages 1. a program to monitor and report on: • any surface water discharges • the effectiveness of the water management system • surface water flows and quality in local watercourses (iii) Groundwater Management Plan, that includes: 1. baseline data on groundwater levels, yield and quality in local aquifers and privately- owned groundwater bores that could be potentially affected by the development 2. a program to monitor and report on groundwater inflows to the quarry pit and the impacts of the development on surrounding aquifers and privately—owned groundwater bores 3. an analysis of these monitoring results to predict long—term water levels within the quarry void (iv) Surface and Ground Water Contingency Strategy, that includes: 4. a protocol for the investigation, notification and mitigation of identified impacts on surface water flows and quality in water bodies and/or groundwater levels, yield and quality in local aquifers and privately—owned groundwater bores that could be potentially affected by the development • the procedures that would be followed if any unforeseen impacts are detected during the development. The Applicant must implement the Water Management Plan as approved by the Secretary.	Entire WMP 6 7 7 8 9
Schedule 5	
Management Plan Requirements Condition 2 – The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include:	3
• a summary of relevant background or baseline data	5.1

Condition	**Corresponding WMP Section**
• a description of: the relevant statutory requirements (including any relevant approval, licence or lease conditions) any relevant limits or performance measures/criteria the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures	3 3 3
• a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria	7
• a program to monitor and report on the: impacts and environmental performance of the development effectiveness of any management measures (see (c) above).	8
• a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible	9
• a program to investigate and implement ways to improve the environmental performance of the development over time	10
• a protocol for managing and reporting any: • incidents • complaints • non-compliances with statutory requirements • exceedances of the impact assessment criteria and/or performance criteria	 11 11 11 11
• a protocol for periodic review of the plan. *Note: The Secretary may waive some of these requirements if they are unnecessary or unwarranted for particular management plans.*	15
Revisions of Strategies, Plans & Programs Condition 5 – Within 3 months of the submission of an: annual review under condition 4 above incident report under condition 6 below audit report under condition 8 below any modifications to this consent. the Applicant must review the strategies, plans and programs required under this consent, to the satisfaction of the Secretary. Where this review leads to revisions in any such document, then within 4 weeks of the review the revised document must be submitted for the approval of the Secretary. *Note: The purpose of this condition is to ensure that strategies, plans and programs are updated annually at a minimum to incorporate any measures recommended to improve environmental performance of the development.*	15
Incident Reporting Condition 6 – The Applicant must immediately notify the Secretary and any other relevant agencies of any incident. Within 7 days of the date of the incident, the Applicant must provide the Secretary and any relevant agencies with a detailed report on the incident, and such further reports as may be requested.	11

3.2 ENVIRONMENT PROTECTION LICENCE 12323

Environment Protection Licence (EPL) 12323 will be updated following commencement of operations under the Consent. It is not anticipated that existing discharge water limit conditions will vary as a result. Therefore, Hy-Tec considers that the following conditions of EPL 12323 would remain appropriate to guide water management within the Quarry.

Water limit conditions

L1 Pollution of waters

L1.1 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.

L2 Concentration limits

L2.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.

L2.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.

L2.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table.

L2.4 Water and/or Land Concentration Limits

Point 11, 8, 9, 10, 1

Pollutant	***Units of Measure***	***100 percentile concentration limit***
Oil and grease	*Milligrams per litre*	*10*
pH	*pH*	*6.5-8.5*
Total suspended solids	*Milligrams per litre*	*30*

L2.5 The concentration limits stipulated by condition L2.1/L2.4 for EPA Identification Points 1,8, 9, 10 and 11 are deemed not to apply when the discharge from the stormwater control structures (sediment basins) occurs solely as a result of rainfall measured at the premises which exceeds:

a) a total of 44 millimetres of rainfall over any consecutive 5 day period.

Note: A 44mm rainfall event is defined by the EPA endorsed publication "Managing urban stormwater: soils and construction" (Landcom, 2004) as the rainfall depth in millimetres for a 95th percentile, 5 day rainfall event for the Central Tablelands which is also consistent with the storage capacity (recommended minimum design criteria) for Type D sediment basins for mines and quarries (see "Managing urban stormwater: soils and construction, Volume 2E, mines and quarries" (DECC, 2008)).

L2.6 The concentration limit for Total Suspended Solids stipulated by condition L2.1/L2.4 for EPA Identification Points 1, 8, 9, 10 and 11 are deemed not to have been breached where:

a) the water discharged is not covered by condition L2.5; and *b) the water discharged complies with a turbidity limit of 25 nephelometric turbidity units at the time of the discharge; and*

c) the EPA is advised within 3 working days of the completion of the sample testing and analysis as required by condition M2.1/M2.2 of any results above the concentration limit.

Note: The purpose of this condition is to expedite the assessment and subsequent discharge of any clarified water from the stormwater control structures (sediment basins).

It is noted that there are no further water limit conditions provided in the Consent. Water criteria are discussed in Section 7. Preliminary groundwater quality triggers, and a procedure to develop site specific triggers, are outlined in **Section 8**.

EPL 12323 also includes conditions relating to water monitoring which have been reflected in this WMP (see Section 9). The water monitoring program will also be updated in accordance with any variations of EPL 12323.

3.3 STATEMENT OF COMMITMENTS

The Statement of Commitments is included as *Appendix 3* of the Consent. Water-related commitments have been identified in **Table 3 – Water-related Commitments of the Statement of Commitments**, which also identifies where in the WMP individual requirements have been addressed.

Table 3
Water-related Commitments of the Statement of Commitments

Desired Outcome	Action	Corresponding WMP Section
Appropriately document water management measures including erosion and sediment control.	7.1 Ensure any off-site discharge is monitored and reported in accordance with EPL 12323.	7 EMSP Section 6.2
Capture of sediment-laden water flows from Proposal-related disturbance.	7.2 Ensure the capacity of the various sediment basins and water storage of the site provides the required water settlement and sediment storage volumes for a 5-day 95th percentile rainfall event.	7 EMSP Section 6.2
Manage the discharge of water from various sediment basins and storage dams.	7.3 Apply procedures established in the Water Management Plan for the appropriate treatment of water that is to be discharged to natural drainage.	7 EMSP Section 6.2
Prevention of hydrocarbon contamination of water on the Site.	7.4 Secure store all hydrocarbon products within designated and bunded areas.	7 EMSP Section 6.3
	7.5 Refuel and maintain all equipment within designated areas of the Site i.e. workshop area.	7 EMSP Section 6.3
Prevention of groundwater contamination.	8.1 Securely store all hydrocarbon products within designated and bunded areas.	7 EMSP Section 6.3
	8.2 Refuel and maintain all equipment within designated areas of the Site i.e. workshop area.	7 EMSP Section 6.3
Appropriately licence any removal of groundwater.	8.3 Obtain and maintain a Water Access Licence(s) for the volume of groundwater take, which would comprise seepage to excavation and water removed in extracted product.	8.1
	8.4 Report annual and projected groundwater extraction to NSW DoI.	8.1

4. OBJECTIVES AND OUTCOMES

The primary objectives of water management at the Quarry are to protect the riparian environment, and surface and groundwater resources of the area, and to minimise the likelihood of water-related pollution. **Table 4 – Objectives and Outcomes** details the objectives and outcomes with respect to water management of the Quarry Site.

Table 4
Objectives and Outcomes

Objectives	**Outcomes**
• To ensure compliance with the criteria of the Consent, EPL 12323.	• Compliance with all relevant licenced criteria.
• To implement appropriate water management measures during all stages of Quarry operation.	• All identified water management measures implemented.
• To implement an appropriate water and groundwater monitoring program to establish compliance or otherwise with relevant criteria during all stages of Quarry operation.	• All identified monitoring undertaken in accordance with the Plan.

- Ensure that water discharging from disturbed areas on-site does not impact aquatic ecosystems or water quality downstream of the quarrying operations.
- Water leaving the Quarry during and post extraction operations are of no lesser quality than that which exited the Site pre-development.
- Ensure the capacity of the various sediment basins and water storages of the Quarry provides the required water settlement and sediment storage volumes for a 5-day 95th percentile rainfall event (56.4 mm).
- Site discharge waters must comply with the Water Quality Criteria prescribed by Condition L2.4 of the EPL, refer to ***EPL: Water Quality Criteria*** below.

EPL: Water Quality Criteria

Monitoring Point	***Frequency***	***Sampling Method***	***Pollutant***	***Units of Measure***	***100th percentile concentration limit***
EPL Points 1, 8, 9, 10, 11	*Daily During Discharge*	*Grab Sample*	*Oil and Grease*	*mg/L*	*10*
			pH	*pH*	*6.5 – 8.5*
			Total Suspended Solids	*mg/L*	*30*
EPL Points 2, 3	*Special Frequency 1**	*Grab Sample*	*Oil and Grease*	*mg/L*	*10*
			pH	*pH*	*6.5 – 8.5*
			Total Suspended Solids	*mg/L*	*30*

*Special Frequency 1 = collection of samples monthly, exception when discharge is occurring from Point 1, where samples must be collected daily.

5. SUMMARY OF SURFACE AND GROUNDWATER ASSESSMENT FINDINGS

5.1 PHYSICAL SETTING AND BASELINE DATA

A summary of the background conditions relevant for water management are presented below.

5.1.1 Surface Water

Groundwork Plus (September 2014) conducted an assessment of the surface waters of the Quarry (reported in full in the document *Austen Quarry Stage Two Extension, Surface Water Assessment*).

Average annual rainfall is bounded by the 15^{th} and 90^{th} percentile annual rainfalls of 694 and 1,166 mm respectively. Annual average evaporation is 1,341 mm.

The Quarry is characterised by a series of ridges with general southwest to northeast orientation, typically reaching an elevation of approximately 800 m AHD. The surrounding gullies typically flatten out at an elevation of approximately 700 m AHD, but continue to drain into the Coxs River, which has an elevation of approximately 660 m AHD to the north of the Quarry and an elevation of approximately 630m AHD to the east of the Quarry.

Slopes on and surrounding the Quarry typically range between 20 and 30 degrees.

The Coxs River is the primary surface water drainage adjacent to the Quarry Site. Yorkey's Creek is the only other substantial drainage close to the Quarry Site. Yorkey's Creek stretches over a distance of approximately 4 km which is significant when compared to most gullies adjacent to the Quarry Site, which typically discharge surface water to the Coxs River within 1km of their headwaters. Yorkey's Creek runs in a south west to north east direction from Jenolan Caves Road to the Coxs River. Yorkey's Creek discharges into the Coxs River to the west of the Administration Area and secondary processing area. In the vicinity of the Quarry Site, Yorkey's Creek has an elevation less than 700 m AHD. Yorkey's Creek drains the elevated ridges along Jenolan Caves Road (in excess of 900 m). The Yorkey's Creek valley is a physical boundary which keeps surface water from the elevated western portion of the Hartley Pastoral Corporation Pty Ltd (HPC) property from the area immediately adjacent to the Quarry.

Gullies are typically too steep near the upper slopes to contain permanent water. Permanent water is present in the flatter gullies of the lower slopes adjacent to the Quarry.

Water falling within the existing extraction area is captured in a depression (sump) in the base of the extraction area. Water is stored here for later use at the Quarry. Excess water is pumped to several surface dams (i.e. Water Storage Dam (SD) 3 and SD4) to the north of the Quarry. Water is discharged occasionally into the Coxs River in accordance with EPL 12323.

The various sedimentation and storage dams on the Quarry receive a combination of surface and groundwater runoff, with the majority of water comprising surface water runoff.

The Environmental Values (EVs) of the Receiving Environment are shown in **Table 5 – EVs for Receiving Environment**.

Table 5
EVs for Receiving Environment

Type	EVs
Aquatic Ecosystems	Ecosystem protection (aquatic plants, fish and other flora and fauna habitat) for a moderately disturbed level of protection
Human Uses	Agricultural uses (e.g. Long-term irrigation and Livestock water)
	Drinking water for Human Consumption
	Recreation

The Surface Water Assessment Report (Section 8 – Receiving Environment, pp2-72 to 2-76) provides available water quality data for the Coxs River and Yorkey's Creek. A summary of water quality data is provided in **Table 6 – Background Water Quality Data – Coxs River** and **Table 7 – Background Water Quality Data – Yorkey's Creek**.

Table 6
Background Water Quality Data – Coxs River

Measure	Units	Min	Max	Median	LDWQO	Number of samples
Physico-Chemical						
pH	NA	6.6	9.2	7.5	6-8.5	80
Electrical Conductivity	Microsiemen/cm	140	740	273	322	80
Dissolved Oxygen	Mg/L	8.3	8.3	NA	NA	1
BOD_5	Mg/L	1	46	2	5	74
Turbidity	NTU	1	1,300	5	10	76
Total Suspended Solids	Mg/L	1	1,110	4	8	80
Total Dissolved Solids	Mg/L	12	530	188	2,500	80
Metals/Metalloids (Dissolved)						
Al (pH>5)	µg/L	20	20	NA	55	1
As	µg/L	<1	<1	NA	10	1
Cd	µg/L	<0.1	<0.1	NA	0.2	1
Cr (total)	µg/L	<1	<1	NA	NA	1
Cu	µg/L	2	2	NA	1.4	1
Fe (total)	µg/L	340	340	NA	NA	1
Ni	µg/L	1	1	NA	11	1
Pb	µg/L	<1	<1	NA	3.4	1
Zn	µg/L	<5	<5	NA	8	1
Metals/Metalloids (Total)						
Al (pH>5)	µg/L	180	180		NA	1
As	µg/L	<1	1		NA	2
Cd	µg/L	<0.1	0.1		NA	2
Cr (total)	µg/L	<1	<1		NA	2
Cu	µg/L	1	2		NA	2
Fe (total)	µg/L	760	760		NA	1
Hg	µg/L	<0.1	<0.1		NA	1
Mn	µg/L	38	325	101	NA	5
Ni	µg/L	2	2		NA	2
Pb	µg/L	<1	<1		NA	2
Zn	µg/L	<5	<5		NA	1
Major Ions and Nutrients						
NH_4	Mg/L	0.02	0.02		0.01	2
TN	Mg/L	0.3	0.4		1.4	2
NO_x-N	Mg/L	0.02	0.03		2.7	2
TP	Mg/L	<0.01	<0.01		0.05	2

Statistical summary of the water quality within Coxs River (upstream) for the period between August 2006 and August 2014.

Table 7
Background Water Quality Data – Yorkey's Creek

Measure	Units	Min	Max	Median	LDWQO	Number of samples
Physico-Chemical						
pH	NA	6.4	8.1	7.5	6-8.5	27
Electrical Conductivity	Microsiemen/cm	26	550	341	322	28
Dissolved Oxygen	Mg/L	8.3	8.3	NA	NA	1
BOD_5	Mg/L	1	11	3	5	27
Turbidity	NTU	0	122	4	10	27
Total Suspended Solids	Mg/L	<5	96	<5	8	27
Total Dissolved Solids	Mg/L	70	382	239	2,500	28
Metals/Metalloids (Dissolved)						
As	µg/L	2	2	NA	55	1
Cd	µg/L	<0.1	<0.1	NA	10	1
Cr (total)	µg/L	<1	<1	NA	0.2	1
Cu	µg/L	<1	<1	NA	1.4	1
Ni	µg/L	<1	<1	NA	11	1
Pb	µg/L	<1	<1	NA	3.4	1
Zn	µg/L	<5	<5	NA	8	1
Metals/Metalloids (Total)						
As	µg/L	3	3		NA	1
Cd	µg/L	<0.1	0.1		NA	1
Cr (total)	µg/L	<1	<1		NA	1
Cu	µg/L	<1	<1		NA	1
Ni	µg/L	<1	<1		NA	1
Pb	µg/L	<1	<1		NA	1
Zn	µg/L	6	6		NA	1
Major Ions and Nutrients						
NH_4	Mg/L	0.02	0.02		0.01	2
TN	Mg/L	3.1	3.1		1.4	2
NO_x-N	Mg/L	2.7	2.7		2.7	2
TP	Mg/L	<0.01	<0.01		0.05	2

Statistical summary of the water quality within Yorkey's Creek (upstream) for the period between March 2007 and August 2014.

This data shows that waters of the receiving environment are generally pH neutral, clear (low turbidity and suspended solids), have low dissolved salt content and EC, and are unpolluted (low BOD).

On the basis of a comparison between the Numerical Guideline Assessment Criteria and established upstream background reference condition of the Coxs River at monitoring site EPL Point 2 - refer to the *Surface Water Assessment* (Groundwork Plus, 2014)(Section 9.1, p2-77) - it is clear that the local concentration for Turbidity exceeds that of the Numerical Guideline Assessment Criteria. The data also indicates that background reference conditions of the Coxs River for total Copper (Cu) and Ammonia (NH4) may also exceed the Numerical Guideline Assessment Criteria; however, the number of samples to make the assessment are universally below the number recommend (n=18). The dataset is currently not statically valid, with n=1. The higher ammonia level is to be expected given the Quarry's surrounding environmental setting/land use (i.e. beef cattle grazing), while the higher Cu concentration is likely to be attributed to the natural geology of the area. Additional sampling of background water quality, with representative samples collected and analysed during low, medium and high river flows, would be required to establish sound Background Reference Conditions for those parameters.

A full description of the Quarry and the climate of the region in which it lies can be found in the *Surface Water Assessment* (Groundwork Plus, 2014)(Section 2.1 Climate, pp2-18 to 2-20).

5.1.2 Ground Water

Ground Doctor (2014) assessed the site hydrogeological setting by conducting a desktop review of available groundwater and geological information. This included a review of the topography and geology of the Quarry and surrounding region and a review of all registered groundwater works located within an approximate 5km radius of the Quarry.

The existing Quarry and proposed Stage 2 extension of the Quarry are situated on an elevated ridgeline. This topographic isolation means that the groundwater system at the Quarry is a local system only, where minimal groundwater recharge occurs along the ridgelines and minimal groundwater discharges to the adjacent surrounding Coxs River and feeder creeks. Groundwater that will be intercepted by the Quarry excavation will be water that has flowed into rock on the elevated ridges adjacent to the excavation.

The groundwater elevation within or immediately adjacent to the existing Quarry excavation was approximately 730m AHD. The nearby Coxs River was at an elevation of less than 660m AHD to the north of the Quarry and less than 600m AHD to the south east of the Quarry. The Yorkeys Creek valley to the west was less than 700m AHD in the vicinity of the Quarry.

Information identified in registered groundwater works logs for groundwater works located within 5km of the site showed large variations in groundwater elevation, which generally corresponded with surface topography.

A total of 30 registered groundwater works were identified within 5km of the Quarry. The locations of registered groundwater bores relative to the Quarry are shown in **Figure 2 – Locations of Registered Groundwater Works Relative to the Quarry**. Bore details, as recorded on the Groundwater Work Summary Form, are summarised in **Table 8 -Summary of Registered Groundwater Works Information.**

Key information recorded in the Groundwater Work Summary forms is summarised as follows.

- Only 1 registered groundwater bore was located within 3km of the Quarry. The nearest registered bore to the Site was GW112395, which was located approximately 2.8km south of the Stage 2 Extension.
- The majority of the identified bores were located more than 4km from the Stage 2 Extension.
- Recorded bore depths ranged from 7m to 180m below ground level but most bores were between 30m and 70m deep.
- Recorded Standing Water Levels ranged from 3.6m to 70m below ground level. Using estimates of surface elevation at each bore location recorded standing water levels ranged from approximately 580m AHD and 924m AHD.

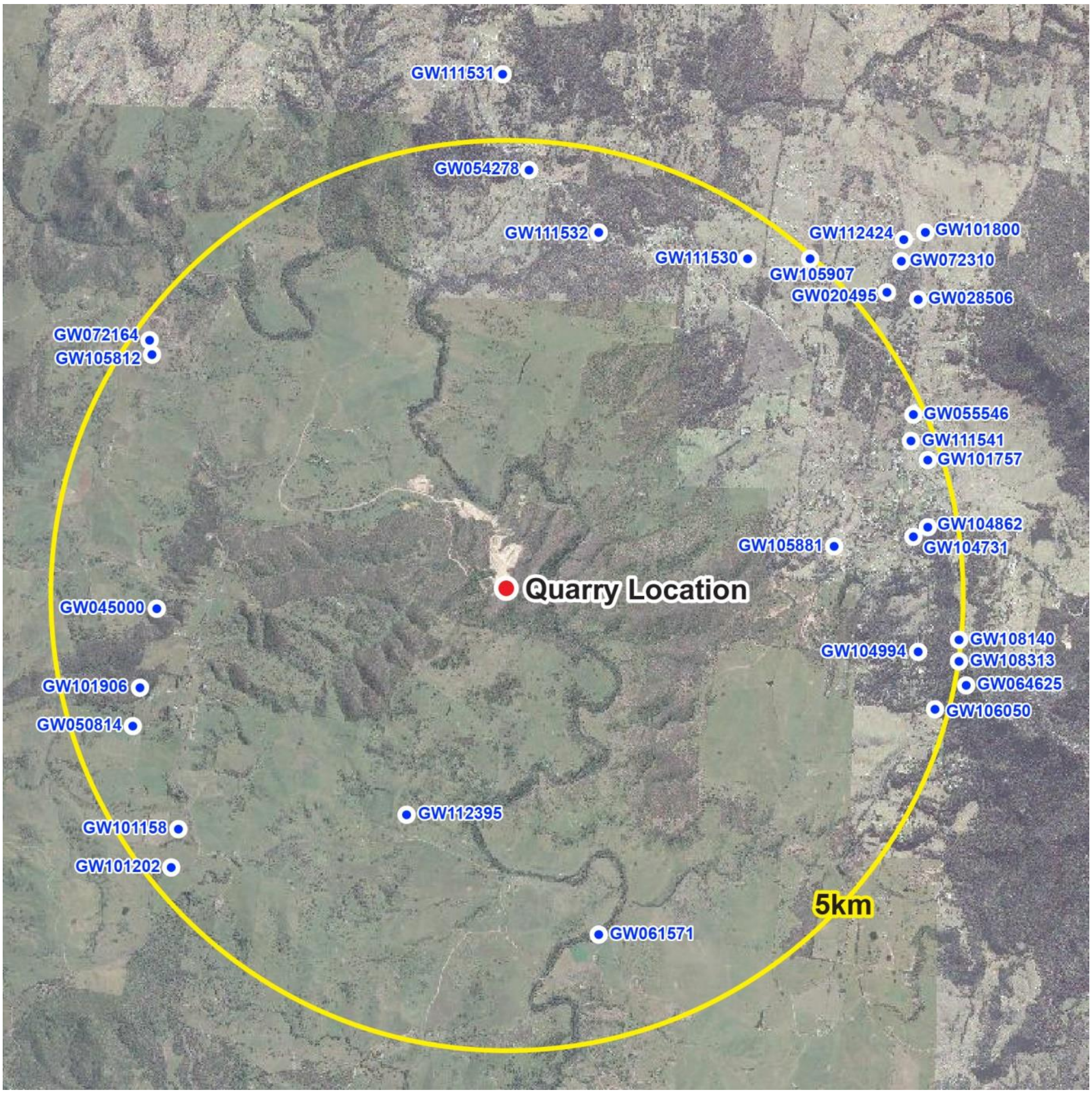

Figure 2 **Locations of Registered Groundwater Works Relative to the Quarry**

Table 8
Summary of Registered Groundwater Works Information

Bore ID	Registered Use	Depth (m)	Water Bearing Zones	SWL (m BTOC)	Approx Surface Elevation (m AHD)	Approx Groundwater Elevation (m AHD)	Yield (L/s)	Water Quality
GW112395	Stock and Domestic	60	10-12m (Granite)	9	650	641	0.32	-
GW105881	Stock and Domestic	-	-	-	810	-	-	-
GW045000	Stock and Domestic	38.1	10-11m (Granodiorite)	10.4	920	910	0.06	Fresh
GW101906	Stock and Domestic	60	-	-	-	-	-	-
GW104731	Domestic	42	32-33m (Shale)	6	800	794	0.38	-
GW050814	Stock and Domestic	68.6	25m (Sandstone) 37m (Sandstone)	12.2	920	908	0.3	Unknown
GW104994	Stock and Domestic	62	54-55m Porphyry	-	800	-	0.3	-
GW111532	Monitoring	12.4	-	-	780	-	-	-
GW104862	Stock and Domestic	48	38-39m (Shale)	16.5	800	783	0.5	-
GW111541	Monitoring	12.4	-	-	820	-	-	-
GW105812	Stock and Domestic	48	32-33m (Granite)	26	790	764	0.13	-
GW061571	Stock and Domestic	36.5	27m (Granite) 33m (Granite)	19.8	600	580	1	Unknown
GW101757	Stock and Domestic	36	30-31m (Shale)	9	820	811	1	-
GW101158	Stock and Domestic	122	15m (Sandstone) 26m (Sandstone)	6.1	930	924	0.25	Good
GW072164	Stock and Domestic	30.5	5-15m (Granite)	10	930	920	-	-
GW111530	Monitoring	14	-	-	790	-	-	-
GW055246	Stock and Domestic	38.1	18-20m (Shale) 26-28m (Shale)	15.2	800	785	0.5	Unknown
GW106050	Stock and Domestic	180	140-141m Unknown 165-166m Unknown	70	760	690	1.12	-
GW108140	Domestic	50	-	38	760	722	17.8	-
GW108313	Stock and Domestic	52	-	-	760	-	-	-
GW064625	Stock and Domestic	40.2	9-10m (Granite)	6.1	760	754	0.09	Good
GW101202	Stock and Domestic	45	35-36m (Granite)	19	900	881	0.1	Good
GW105907	Domestic	-	-	-	810	-	-	-
GW020495	Stock and Domestic	7	-	-	815	808	-	-
GW028506	Stock and Domestic	9.2	0-9.1m (Clay)	-	820	811	-	-
GW072310	Stock and Domestic	83.8	27m (Granite)	9.1	810	801	0.5	Good
GW054278	Stock	70.7	7-8m (Granite)	3.6	800	796	0.06	Good
GW112424	Stock and Domestic	37	30-37m (Sandstone)	-	800	770	0.17	-
GW101800	Stock and Domestic	37.2	13-29m (Sandstone)	6	780	774	2.15	Good
GW111531	Monitoring	15.2	-	-	800	-	-	-

- Recorded bore yields ranged from 0.06L/s to 17.8L/s but were typically less than 0.5L/s.
- All identified bores encountered groundwater in either weathered rock or within fractured bedrock. Groundwater was encountered in granite, shale and sandstone.
- Where a description was provided groundwater quality was described as "good" or "fresh".
- The identified bores were registered for stock, domestic and/or monitoring purposes.

Driller's logs and geological mapping indicate that basement rocks to the west of the site consist of granite from near the surface. In the eastern portion of the search area some bores encountered sedimentary sandstone, shale and siltstone above underlying granite.

Observations within the existing Quarry indicate that seepage occurs at a relatively slow rate from only some of the fractures visible on the walls and base of the excavation.

Based on the observed standing water level and topography of the site, groundwater in the vicinity of the extraction area is part of what is an isolated or closed system. Recharge to the ground occurs as a result of infiltration of precipitation from the immediate surrounds only. Groundwater discharges close to the area in which it fell as precipitation. Both surface water and groundwater discharge to the Coxs River. Recharge (infiltration of precipitation to the subsurface) is likely to be a very small portion of precipitation due to the steep nature of the Site and the presence of shallow soils, or total absence of soil cover. Both surface water and groundwater discharge to the Coxs River in close proximity to where precipitation falls.

Groundwater recharge is inferred to occur in elevated areas surrounding the Site. It is inferred that groundwater would discharge to the surface on the lower slopes and in particular near drainage lines. Groundwater is also likely to discharge into the adjacent Coxs River, which is the lowest point in the landscape within the vicinity of the Site.

Infiltration of rainfall on the elevated areas surrounding the Site is inferred to result in mounding of groundwater beneath the elevated areas. This storage of groundwater is isolated from adjacent aquifers due to the presence of low valleys (below the standing water level observed in the Quarry) in all directions from the Site. That is, the groundwater elevation beneath the existing Quarry (approximately 730m AHD) is above the surrounding valleys of Yorkeys Creek to the west (typically less than 700m AHD), the Coxs River to the north and east (typically less than 660m AHD), and an unnamed drainage to the south (typically less than 700m AHD).

The Coxs River, which is as low as 630m AHD to the east of the Stage 2 excavation will remain the primary groundwater sink post Stage 2 development.

Any groundwater seepage and accumulation within the Quarry will mix with surface water (from direct rainfall within the Quarry). Water within the base of the Quarry will be used to supply water for Quarry operations. Any excess water that accumulates within the Quarry would be treated in down gradient sediment dams before being re-used at a later time, or released to the Coxs River.

More information on the physical setting and baseline data for groundwater at the Quarry may be obtained by reading the *Austen Quarry Groundwater Management Plan* (Ground Doctor, April 2016) provided as Appendix V of the Austen Quarry EMSP.

6. SITE WATER BALANCE

A Water Balance was undertaken for the Quarry and presented in Section 6 (pp2-47 to 2-71) of the *Surface Water Assessment* (Groundwork Plus, 2014). An MS-Excel based daily probabilistic Water Balance model was constructed to analyse potential discharges/annum from on-site storages, as well as dewatering rates from the proposed Stage 2 Extension of the extraction area. The Water Balance model was used to estimate the potential number and volume of discharges from onsite storages for the dry (15th percentile) and wet (90th percentile) rainfall scenarios. Findings for various scenarios are summarised and water balance summary tables provided below, however the complete discussion may be reviewed in Section 6 of the *Surface Water Assessment* (Groundwork Plus, 2014)(pp2-47 to 2-71).

Figure 3 Catchment Delineation Plan Existing Operations describes the existing site layout and the locations of catchments, sediment basins and storage dams.

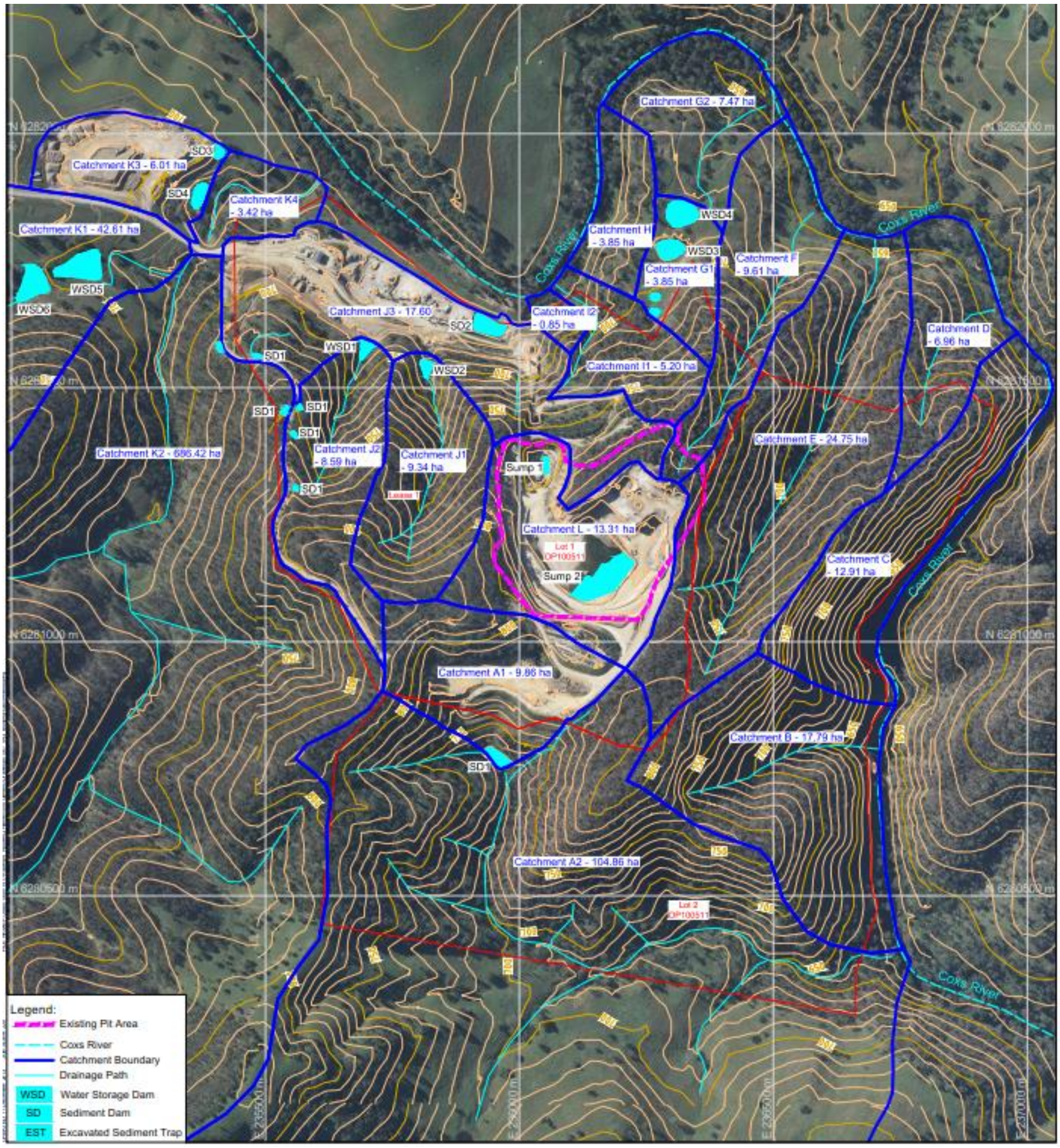

Figure 3 **Catchment Delineation Plan Existing Operations**

6.1 METHODOLOGY

For the purposes of modelling, the following general assumptions have been made for the Site and have been applied to water balance assessments conducted for the extraction area and various other existing and proposed water storages on–site.

These assumptions describe the sources of water available to, and also describe the consumption of water on, the site.

- Inflows can be segregated into 1) direct rainfall, 2) overland flow, 3) water moved/recycled between various on-site water storages and 4) groundwater seepage. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Dewatering rates adopted for the Water Balance model has been based on the existing physical capacity of the on-site water infrastructure, on-site water treatment methodology and the number of predicted suitable days for water treatment (i.e. periods of fine weather ≥ 3 days).
- Outflows are; 1) direct evaporation from the inundated extraction area/water storage (including sediment basins), 2) dewatering flows from the extraction area, 3) controlled and/or uncontrolled discharges from site water storages 4) water harvesting and reuse onsite and 5) water moved/recycled between water storages onsite to maintain freeboard. Evaporation from the land surface is not considered (as volumes are generally negligible from dry land).
- Water from the extraction area and SB1 is used on site for dust suppression only, via water truck and sprays fitted to the crushing plant (in accordance with advice received from Quarry personnel, Groundwork Plus Site Assessment – 21 November 2013).
- In accordance with advice received from quarry personnel during the site assessment conducted by Groundwork Plus personnel on 21 November 2013, the daily dust suppression demand from SB1 for haul road watering has been calculated to be approximately 78 kL. This has been calculated based on the assumption that a water truck (with a storage capacity of 13 kL) is topped up with water at least 6 times during the course of an operational shift.
- It has been assumed that haul road dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.
- Dust suppression water use also includes topping up water from the extraction area sump to an existing 100 kL tank located adjacent to the primary crusher within the extraction area. For the purpose of modelling and in accordance with advice received from quarry personnel during the Groundwork Plus site assessment, the water use demand from the extraction area for the purpose of topping up the 100 kL tank has been assumed to be 200 kL/week for the current and all future stages of extension.
- The water balance does not take into account any additional storage that may be provided by sumps and drop cuts.

- The soil group has been assumed to be Group C Loamy Clay for areas within the extraction area that have not been subject to extraction including the other developed and undeveloped catchments of the Site. In accordance with Table B7 of the IECA Guidelines, single storm event runoff coefficients ranging between 0.09 and 0.75 have been used in the model to calculate daily runoff volumes from these areas.

All water balance scenarios presented in the following sections assume the full extent of quarry development in accordance with the approval extraction and overburden areas.

6.2 EXTRACTION AREA WATER BALANCE

6.2.1 Scenario 1 – No Dewatering of Pit Water

Water balance assessments were undertaken assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively). The summary findings of these assessments are shown in **Table 9 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with No Dewatering** and **Table 10 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with No Dewatering**

The modelling predicted that the extraction area will have adequate storage capacity to contain flows within the extraction area for all Stages (estimated Year 35) under prolonged wet (and dry) climatic conditions.

Table 9
Extraction Area Water Balance Assessment for Prolonged Dry Climate Conditions with No Dewatering

Water Storage	Stage of Quarry Development	Estimated Extraction Area Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Supplementary flows discharged from Extraction Area to SB1 (ML)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)		
Extraction Area	Current	1,175	0	0	11.0	3.3
	End of Stage 1	1,175	0	0	10.9	3.4
	A	1,342	0	0	11.8	5.0
	B	1,342	0	0	11.8	8.1
	C	1,424	0	0	11.8	16.4
	D	1,803	0	0	11.8	29.5
	E	3,325	0	0	11.8	22.5
	F	572	0	0	11.3	15.1
	G	3,231	0	0	11.8	22.7

Table 10
Extraction Area Water Balance Assessment for Prolonged Wet Climate Conditions with No Dewatering

Water Storage	Stage of Quarry Development	Estimated Extraction Area Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Supplementary flows discharged from Extraction Area to SB1 (ML)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)		
Extraction Area	Current	1,175	0	0	17.0	34.0
	End of Stage 1	1,175	0	0	8.1	64.7
	A	1,342	0	0	8.1	99.8
	B	1,342	0	0	8.1	139.3
	C	1,424	0	0	8.1	257.6
	D	1,803	0	0	8.1	460.2
	E	3,325	0	0	8.1	834.5
	F	572	0	0	8.1	420.1
	G	3,231	0	0	8.1	187.6

6.2.2 Scenario 2 – Dewatering of Extraction Area to Storage Dams 1 and 2

Water balance assessments were undertaken assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively). The summary findings of these assessments are shown in **Table 11 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with Dewatering** and **Table 12 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with Dewatering**.

The modelling indicated no uncontrolled discharges would occur with regular dewatering of the pit. Predicted daily average pumping rates required to dewater the extraction area for all years of pit development range between 0 to 1.13 ML/day, which is well below the existing water management drainage infrastructure's maximum capacity of 1.9 ML/day (i.e. 2 pipelines at 950 KL/day/each).

Table 11
Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with Dewatering

Water Storage	Stage of Quarry Development	Estimated Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Predicted Volume of Controlled Discharges to SD1/SD2 (ML)	Supplementary flows discharged from to SB1 (ML)	Required Average Daily Pumping rate to Dewater (ML/day)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)				
Extraction Area	Current	1,175	0	0	3.3	11.0	0.011	0
	End of Stage 1	1,175	0	0	3.3	10.9	0.011	0
	A	1,342	0	0	5.0	11.8	0.017	0
	B	1,342	0	0	7.1	11.8	0.024	0
	C	1,424	0	0	7.1	11.8	0.024	0
	D	1,803	0	0	10.1	11.8	0.034	0
	E	3,325	0	0	0	11.8	0	0
	F	572	0	0	15.1	11.3	0.051	0
	G	3,231	0	0	0	11.8	0	0

Table 12
Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with Dewatering

Water Storage	Stage of Quarry Development	Estimated Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Predicted Volume of Controlled Discharges to SD1/SD2 (ML)	Supplementary flows discharged to SB1 (ML)	Required Average Daily Pumping rate to Dewater (ML/day)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)				
Extraction Area	Current	1,175	0	0	34.1	16.9	0.123	0
	End of Stage 1	1,175	0	0	43.2	8.1	0.150	0
	A	1,342	0	0	46.9	8.1	0.163	0
	B	1,342	0	0	37.2	8.1	0.120	0
	C	1,424	0	0	55.3	8.1	0.192	0
	D	1,803	0	0	65.1	8.1	0.266	0
	E	3,325	0	0	33.4	8.1	0.139	0
	F	572	0	0	37.0	8.1	0.154	0
	G	3,231	0	0	37.9	8.1	0.154	0

6.3 STORAGE DAMS 1 AND 2 (SD1 AND 2)

6.3.1 Scenario 1 – Water Balance of SD1 and 2

The summary findings of these assessments are shown in **Table 13 – Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions** and **Table 14 – Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions**.

Table 13
Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD1	Current End of Stage 1 A B C D E F G	39	2.42
SD2	Current End of Stage 1 A B C D E F G	0	0

Table 14
Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD1	Current End of Stage 1 A B C D E F G	84	10.5
SD2	Current End of Stage 1 A B C D E F G	30	10.4

Modelling indicated that SD2 would receive approximately 2.42 ML/annum and 104.8 ML/annum of overflows respectively from SD1 for the prolonged continuous dry and wet climatic scenario respectively. Modelling also indicated that SD2 currently has sufficient capacity to receive overflows from SD1 and would not result in uncontrolled discharges to Coxs River for the prolonged dry climatic conditions scenario.

However, during a prolonged wet climatic conditions scenario, modelling has predicted that SD2 would generate approximately 104.3 ML of uncontrolled discharges to Coxs River.

6.3.2 Scenario 2 - Water Balance of SD1 and SD2 receiving Dewatered Flows from Extraction Area

The summary findings of these assessments are shown in **Table 15 – Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions** and **Table 16 – Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions**.

Table 15
Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	10.2
	End of Stage 1	0	0	10.2
	A	0	0	11.8
	B	0	0	13.8
	C	0	0	13.8
	D	0	0	16.8
	E	0	0	7.5
	F	0	0	21.8
	G	0	0	7.5

Table 16
Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	42.6
	End of Stage 1	0	0	51.6
	A	0	0	55.3
	B	0	0	37.2
	C	0	0	63.7
	D	0	0	73.5
	E	0	0	41.8
	F	0	0	45.4
	G	0	0	45.4

The modelling indicated no uncontrolled discharges would occur from SD1 and SD2 during the prolonged dry and wet climatic scenarios. Treated and controlled discharges from SD2 would be undertaken by quarry personnel as soon as practicable following a storm event.

6.3.3 Scenario 3 - Water Balance of SD1 and SD2 Receiving Dewatered Flows from Extraction Area with catchment runoff diverted around SD1 and SD2

The results of these assessments are summarised in **Table 17 – Water Balance Assessment of SD1 and SD2 for Prolonged Dry Climatic Conditions receiving Area Flows with Clean Runoff Diverted to Coxs River** and **Table 18 – Water Balance Assessment of SD1 and SD2 for Prolonged Wet Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River**.

Table 17
Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	4.9
	End of Stage 1	0	0	4.9
	A	0	0	6.4
	B	0	0	8.3
	C	0	0	8.3
	D	0	0	11.3
	E	0	0	1.9
	F	0	0	16.3
	G	0	0	2.2

Table 18
Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	34.6
	End of Stage 1	0	0	43.6
	A	0	0	46.9
	B	0	0	29.2
	C	0	0	55.7
	D	0	0	65.5
	E	0	0	33.8
	F	0	0	37.4
	G	0	0	37.6

Modelling has predicted that the annual volume of controlled discharges from SD2 for the prolonged dry and wet climatic scenarios would be significantly reduced (i.e. a median reduction of approximately 46 percent during a dry year and approximately 17 percent during a wet year).

6.4 SEDIMENT BASIN 3B

The findings of the water balance assessment for SB3b for a dry and wet rainfall year are summarised in **Table 19 - Findings of Water Balance Assessment – Proposed SB3b, Overburden Emplacement** below.

Table 19
Findings of Water Balance Assessment – Proposed SB3b, Overburden Emplacement

Water Storage	Rainfall Scenario	Stage of Quarry Development	Predicted Frequency of Treated / Controlled Discharges (per annum)	Predicted Total Estimated Treated Volume Discharged (ML)	Predicted Frequency of Uncontrolled Discharges (days per annum)	Predicted Total Estimated Volume Discharged (ML)
SB3b	Dry Rainfall Year (15th Percentile)	Year 0 – Year 35	17	29.8	-	-
	Wet Rainfall Year (90th Percentile)		22	6.3	3	1.4

No uncontrolled discharges are predicted from SB3b during a modelled dry rainfall year, provided controlled discharges are regularly carried out following rainfall events. To prevent un-controlled discharge events from occurring, it is estimated that 17 control discharge events, with a total of approximately 30 ML of treated water discharged to the existing drainage line and ultimately to Coxs River, will be required during dry periods.

In wet periods, even with regular controlled discharges (i.e. 22 controlled discharge events with a total of approximately 63 ML of treated water discharged), modelling predicts that uncontrolled discharges will occur at least once per annum at SB3b over a duration of 3 days, during a wet rainfall year, with approximately 1.4 ML of water discharged to the existing drainage line and ultimately to Coxs River.

It is noted that since the assessment in 2014, a review of overburden placement requirements has been conducted within the catchment contributing to SB3b. As a result, construction of SB3b will not be required immediately, as the extent of overburden does not encroach into currently undisturbed areas. Furthermore, most of the overburden embankment that reports to the currently instated SB3a has been rehabilitated and the contributing catchment is now considered clean.

At all times, any disturbed catchment areas will be directed to a sediment basin, sized adequately in accordance with the requirements of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008.*

In accordance with the Surface Water Audit and Water Management Improvement Program (WMIP) completed in 2016, construction of SB3b will be staged progressively over the life of the development of Stage 2, if the basin is required. Capacity will be sized to Type-D criteria against the total contributing area at all times (refer Section 10).

6.5 SEDIMENT BASIN 1

6.5.1 Scenario 1 – Water Balance of SB1 with no Water Management

The summary findings of these assessments are shown in **Table 20- – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions** and **Table 21 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions**.

Table 20
Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	10	38.0
	End of Stage 1	10	38.0
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 21
Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	23	102.3
	End of Stage 1	23	102.3
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that SB1 will have approximately 10 and 23 uncontrolled discharges, totalling 38.0 ML and 102.3 ML for the current dry and wet climatic scenarios respectively. The annual volume of uncontrolled discharges from SD2 to Coxs River is predicted to remain unchanged with Stage 2 Extension.

However, SB1 is currently part of the on-site water management system that allows excess water to be transferred to and from SD1 and SD2, and SD6 via existing stormwater drainage infrastructures in the form of hydraulic pumps and flow control pipes in order to reinstate or maintain freeboard within SB1, hence minimising the frequency of uncontrolled discharges.

In accordance with the Surface Water Audit and Water Management Improvement Program (WMIP) completed in 2016, this pumping will eventually be phased out after SB1 is increased in capacity to "Type D" sizing criteria as a commitment by the quarry to improve water quality within the site. Pumping may still be utilized to maximize water storage for the quarry operations (refer Section 10).

6.5.2 Scenario 2 – Water Balance of SB1 with Water Management

The summary findings of these assessments are shown in **Table 22 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions with On-site Water Management** and **Table 23 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions with On-site Water Management**.

Table 22
Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions with On-site Water Management

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current End of Stage 1 A B C D E F G	5	10.1

Table 23
Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions with On-site Water Management

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current End of Stage 1 A B C D E F G	6	46.9

Modelling predicts that with on-site management of water within SB1, uncontrolled discharges from SB1 to Coxs River will be reduced by approximately 73 and 54 percent for the prolonged dry and wet climatic conditions scenarios respectively.

The volume of uncontrolled discharges to Coxs River can be further reduced by diverting overflows from SD5 around SD6 to Yorkey's Creek, hence maximising the available storage capacity within SD6 to receive excess waters from SB1.

6.5.3 Scenario 3 – Water Balance of SB1 meeting Regulatory Storage Capacity

The summary findings of these assessments are shown in **Table 24 – Water Balance Assessment for Optimised Storage Volume of SB1 Vs Current Water Management Regime for Prolonged Dry Climatic Conditions** and **Table 25 – Water Balance Assessment for Optimised Storage Volume of SB1 Vs Current Water Management Regime for Prolonged Wet Climatic Conditions**.

Table 24
Water Balance Assessment for Optimised Storage Volume of SB1 Vs Current Water Management Regime for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Regulatory Required SB1 Storage Capacity (11 ML) ①		Current Water Management Regime	
		Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current End of Stage 1 A B C D E F G	24	60.1	5	10.1

Note: ①without existing on-site water management regime

Table 25
Water Balance Assessment for Optimised Storage Volume of SB1 Vs Current Water Management Regime for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Regulatory Required SD2 Storage Capacity (11 ML)①		Current Water Management Regime	
		Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current End of Stage 1 A B C D E F G	22	97.3	6	46.9

This scenario analysis showed that there are benefits of increasing the design storage capacity of SB1 to meet Type D Dam regulatory requirements, hence reducing the frequency and number of uncontrolled discharges marginally.

In accordance with the Surface Water Audit and Water Management Improvement Program (WMIP) completed in 2016, SB1 will be increased in capacity to "Type D" by 30th September 2016 (refer Section 10).

6.6 STORAGE DAMS 5 AND 6

6.6.1 Scenario 1 – Water Balance for SD5 and SD6 with no Water Management

The summary findings of these assessments are shown in **Table 26 – Water Balance Assessment for SD5 and SD6 for Prolonged Dry Climatic Conditions** and **Table 27 – Water Balance Assessment for SD5 and SD6 for Prolonged Wet Climatic Conditions**.

Table 26
Water Balance Assessment for SD5 and SD6 for Prolonged Dry Climatic Conditions

<table>
<tr><th>Water Storage</th><th>Stage of Quarry Development</th><th>Predicted Uncontrolled Discharge Frequency</th><th>Predicted Uncontrolled Discharge Volume (ML)</th></tr>
<tr><td rowspan="9">SD6</td><td>Current</td><td>26</td><td>53.9</td></tr>
<tr><td>End of Stage 1</td><td rowspan="8">28</td><td rowspan="8">63.7</td></tr>
<tr><td>A</td></tr>
<tr><td>B</td></tr>
<tr><td>C</td></tr>
<tr><td>D</td></tr>
<tr><td>E</td></tr>
<tr><td>F</td></tr>
<tr><td>G</td></tr>
<tr><td rowspan="9">SD5</td><td>Current</td><td>32</td><td>58.9</td></tr>
<tr><td>End of Stage 1</td><td rowspan="8">32</td><td rowspan="8">62.8</td></tr>
<tr><td>A</td></tr>
<tr><td>B</td></tr>
<tr><td>C</td></tr>
<tr><td>D</td></tr>
<tr><td>E</td></tr>
<tr><td>F</td></tr>
<tr><td>G</td></tr>
</table>

Table 27
Water Balance Assessment for SD5 and SD6 for Prolonged Wet Climatic Conditions

<table>
<tr><th>Water Storage</th><th>Stage of Quarry Development</th><th>Predicted Uncontrolled Discharge Frequency</th><th>Predicted Uncontrolled Discharge Volume (ML)</th></tr>
<tr><td rowspan="9">SD6</td><td>Current</td><td>31</td><td>133.3</td></tr>
<tr><td>End of Stage 1</td><td rowspan="8">32</td><td rowspan="8">144.8</td></tr>
<tr><td>A</td></tr>
<tr><td>B</td></tr>
<tr><td>C</td></tr>
<tr><td>D</td></tr>
<tr><td>E</td></tr>
<tr><td>F</td></tr>
<tr><td>G</td></tr>
<tr><td rowspan="3">SD5</td><td>Current</td><td>30</td><td>131.0</td></tr>
<tr><td>End of Stage 1</td><td rowspan="2">35</td><td rowspan="2">135.0</td></tr>
<tr><td>A</td></tr>
</table>

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that SD6, in its natural state, will receive approximately 58.9 ML and 135 ML respectively of uncontrolled discharges from SD5 during a current dry and wet rainfall year. This volume of discharge is expected to increase to 62.8 ML and 135 ML respectively for each succeeding year of the modelled prolonged dry and wet climatic condition scenarios, on account of SD5 being inundated.

SD6 is predicted to discharge approximately 53.9 ML and 133.3 ML respectively to Yorkey's Creek during a current dry and wet rainfall year respectively. During the course of the modelled prolonged dry climatic conditions scenario (Stage A to Stage G) the volume of annual discharges to Yorkey's Creek from SD6 is estimated to increase to 63.7 ML/annum and 144.8 ML/annum during the modelled prolonged wet climatic conditions scenario.

However, SD6 is currently used to receive and store flows from SB1 to reinstate freeboard within SB1.

6.6.2 Scenario 2 - Water Balance for SD5 and SD6 with SD6 receiving Flows from SB1

The summary findings of these assessments are shown in **Table 28 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions** and **Table 29 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Wet Climatic Conditions**.

Table 28
Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	25	59.3
	End of Stage 1	31	64.9
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 29
Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Wet Climatic Conditions

Water Storages	Stage of Quarry Development	Predicated Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	29	137.7
	End of Stage 1	31	146.3
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling indicated that the current water management regime in place at the Quarry will result in increased discharges from SD6 to Yorkey's Creek during the modelled scenarios of prolonged dry and wet climatic conditions.

The predicted uncontrolled discharges to Yorkey's Creek from SD6 can be reduced if discharges from SD5 to SD6 can be diverted to Yorkey's Creek. This option will provide greater storage capacity within SD6 to receive more flows if required from SB1, as well as reduce the frequency and volume of uncontrolled discharges from SD6 to Yorkey's Creek.

The diversion of overflows from SD5 around SD6 will also provide greater storage capacity within SD6 to receive additional excess flows from SB1 and hence reduce the frequency and volume of uncontrolled discharges from SB1 to Coxs River while allowing SB1 to be returned to required free board condition as soon as possible.

In accordance with the Surface Water Audit and Water Management Improvement Program (WMIP) completed in 2016, this pumping will eventually be phased out after SB1 is increased in capacity to "Type D" sizing criteria as a commitment by the quarry to improve water quality within the site. Pumping may still be utilized to maximize water storage for the quarry operations (refer Section 10).

6.6.3 Scenario 3 – Water Balance for SD6 Receiving Flows from SB1 with Overflows from SD5 Diverted to Yorkey's Creek

The summary findings of these assessments are shown in **Table 30 – Revised Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions** and **Table 31 – Revised Water Balance Assessment for SD6 receiving Flows from SB1 for Prolonged Wet Climatic Conditions**.

Table 30
Revised Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	26	2.83
	End of Stage 1	26	8.73
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 31
Revised Water Balance Assessment for SD6 receiving Flows from SB1 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	30	9.5
	End of Stage 1	33	17.2
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicted that by diverting overflows from SD5 around SD6 to Yorkey's Creek, the predicted uncontrolled discharge frequency changes little; however, the volume of uncontrolled discharges from SD6 can be significantly reduced during both the prolonged dry and wet climatic scenarios.

Controlled discharges from SD6 to Yorkey's Creek would be essential in order to reinstate freeboard within SD6 and also prevent the predicted uncontrolled discharge frequency and volume of uncontrolled discharges from SD6. Alternatively water from SD6 can be hydraulically moved to SD3 and/SD4 using existing infrastructure for treatment and discharge to Coxs River.

6.7 SEDIMENT BASIN 2B

The findings of the water balance assessment for SB2b for a dry and wet rainfall year are summarised in **Table 32 – Water Balance Assessment for SB2b**.

Table 32
Water Balance Assessment for SB2b

Scenario	Rainfall Scenario	Stage	Predicted Frequency of Treated / Controlled Discharges (per annum)	Predicted Total Estimated Treated Volume Discharged(ML)	Predicted Frequency of Uncontrolled Discharges (days per annum)	Predicted Total Estimated Volume Discharged (ML)
Current	Dry Rainfall Year (15th Percentile)	Pre- Stage 2 Extension	13	9.9	-	-
	Wet Rainfall Year (90th Percentile)		22	18.9	12	3.9
Stage 2 Extension	Dry Rainfall Year (15th Percentile)	Stage A to G	13	9.9	-	-

Scenario	Rainfall Scenario	Stage	Predicted Frequency of Treated / Controlled Discharges (per annum)	Predicted Total Estimated Treated Volume Discharged(ML)	Predicted Frequency of Uncontrolled Discharges (days per annum)	Predicted Total Estimated Volume Discharged (ML)
	Wet Rainfall Year (90th Percentile)		22	21.5	8	1.2

No uncontrolled discharges are predicted from SB2b during a modelled dry rainfall year, provided controlled discharges are regularly carried out following rainfall events. To prevent uncontrolled discharge events from occurring, it is estimated that 13 control discharge events, totalling approximately 10 ML of treated water discharged to Yorkey's Creek and ultimately to Coxs River, would be required.

In wet periods, even with regular controlled discharges (i.e. anticipated 22 controlled discharge events, totalling approximately 21.5 ML of treated water discharged), modelling has indicated that SB2b would overtop its spillway on 8 days (i.e. representing 4 discharge events, each of estimated 2 day duration) during a wet rainfall year, with approximately 1.2 ML of water discharged to Yorkey's Creek and ultimately to Coxs River.

In accordance with the Surface Water Audit and Water Management Improvement Program (WMIP) completed in 2016, SB2b will be increased in capacity to meet Type-D sizing (refer Section 10).

6.8 WATER BALANCE RESULTS AND SUMMARY

Uncontrolled discharges are predicted to continue to be released from existing ancillary operational catchments J3, K3 and A1 via SB1, SB2b and SB3a/b respectively, limited to high or prolonged wet weather conditions at a reduced frequency and volume to pre-Stage 2 Extension conditions. The release of these potentially contaminated waters from operational areas is considered to pose a potential risk to the receiving aquatic ecosystem/s and downstream water suitability for identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS, TN, Dissolved Cu)
- Recreation Purpose (elevated turbidity, TSS, Mn and NH_4 concentrations)
- Long-term irrigation (elevated TP)
- Drinking water use (elevated BOD5, Al and TN concentrations).

Although these uncontrolled discharges of untreated waters are mostly likely to occur during high and/or prolonged wet weather when natural stream flows are high, hence reducing the potential risk, there is the need for ongoing careful management and impact amelioration measures to limit any potential adverse impacts, particularly relating to possible indirect affects downstream off-site.

The proposed Stage 2 Extension can be operated in a manner to achieve a neutral to beneficial effect on water quality in the drinking water catchment by containing and/or reducing existing uncontrolled water releases from operational areas, where practicable, compared to pre-Stage 2 Extension. By doing so, the development would meet the requirement of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 for new activities under Part 5 of the Environmental Planning Assessment Act 1979 that are situated within the Sydney Drinking Water Catchment.

To achieve a neutral to beneficial effect on water quality, the implementation of the following recommended mitigation measures will be considered as part of the Water Management Improvement Program:

- Ensuring sediment basins, including SB1, are constructed and their design holding capacity maintained to capture all rainfall runoff for a “designed” rainfall event (i.e. Type D basins capable of storing a 95th percentile 5-day rainfall event).
- Staged development of a new sediment basin (SB3b) downstream of the overburden emplacement area footprint to Type-D sizing if required. It is anticipated that the development and size of SB3b will be dependent upon any increased disturbance within the contributing catchment in each development stage. The timing of the initial development of SB3b will be triggered by the movement of the development onto Catchment A2, which is nominally anticipated to be Year 5 of the development, but which will be driven by market requirements and could be as late as Year 13 or not actually required at all.
- Increasing the storage capacity of SB2b to achieve the required minimum design storage volume of 4 ML.
- Installation of a diversion channel to divert overflows from the clean catchment dam SD5 around SD6 in order gain additional water storage capacity in SD6 to receive additional excess waters captured in SB1.
- Continuing the management of the short fall in the total storage capacity of SB1 by pumping excess waters to other basins (e.g. SD1, SD2 and SD6) that have sufficient excess storage capacity.
- Discharging of in-situ treated excess waters from SB1 in SD1 and SD2 to Coxs River on an as needs basis to regain design storage capacity.
- Discharging of treated in-situ waters in SD6 to Yorkeys Creek, on an as needs basis, to regain/maximise additional water storage capacity to dewater excess waters from SB1.
- Installation of a diversion bund around SD1, SD2 and SD6 to divert clean overland flows from mixing with potentially contaminated waters from operational areas, which would also maximize the dams capacities to treat excess waters captured in SB1 and/or dewatered from the extraction area.
- Installation of SSEC management measures as shown on Figures 6 to 18 of the *Surface Water Assessment* (Groundwork Plus 2014).

7. SURFACE WATER MANAGEMENT

7.1 IMPLEMENTATION STRATEGY, MITIGATION MEASURES AND WATER QUALITY MANAGEMENT

A number of key administrative controls / actions are to be prepared and implemented, including the following:

- An audit of current and proposed surface water management practices and infrastructure on the Quarry.
- Preparation of a Water Management Improvement Program, based on the audit report's recommendations, to improve surface water management practices on the Quarry, including a program of proposed timeframes for implementation.
- Implementation of this Water Management Plan.
- Preparation of a Site Water Balance.

Regarding the above, a draft Water Management Plan was prepared during the EIS phase as a part of the document Surface Water Assessment, which also includes a Site Water Balance **(**refer **EMSP Appendix T – Surface Water Assessment**). Baseline data for the receiving environment may be found in that document also. Additionally a Soil and Water Management Plan was also prepared as part of the EIS (refer **EMSP Appendix U – Soil and Water Management Plan**). An audit has been undertaken, and a Water Management Improvement Program prepared.

Mitigation and other measures include:

- A sustainable water management system has been implemented at the Quarry, which aims for the current and future operations to be 100 % self-sufficient in water, excluding drinking water supply. This system is based upon capturing rainfall for amenity building use (not drinking water) and stormwater run-off for dust suppression and environmental controls.
- A Site Water Balance complying with Development Consent requirements has been submitted as part of the *Surface Water Assessment* (Groundwork Plus, 2014)(Section 6, pp2-47 to 2-71).
- Water supply is captured within the extraction area and pre-quarry farm dams (i.e. SD1, SD2, SD5 and SD6). These dams capture water prior to being re-used on site or released directly, or indirectly via Yorkey's Creek, into the Coxs River as environmental flows.
- Runoff from undisturbed areas is to be diverted around areas disturbed by quarry operations wherever practicable to reduce the potential for clean runoff to be polluted by quarry activities.
- Diversion of clean waters will be effected by contour and diversion drains, perimeter bunds and pipe culverts wherever practicable.
- During the extension and operation of the current and future extraction area and overburden emplacement, drainage will convey water from areas of disturbance to sediment basins located within the extraction area and around the Quarry (i.e. SB1,SB2 and SB3) to prevent sediment laden or contaminated runoff leaving the Quarry.
- In order to implement the plan to eliminate water transfers from SB1 to SD6 that might result in discharges of clean and dirty water to the Coxs River it is planned that: water transfers from SB1 to SD6 would only occur during dry periods when water is in short supply, required for dust suppression and there is adequate freeboard available in SD6 to

reasonably prevent overflow and discharge; during wet periods no water would be transferred from SB1 to SD6 in order to avoid the risk of dirty water overflowing to the Coxs River – under such circumstances water would be treated to a suitable standard in either SB1 or another dam prior to discharge.

- It is intended to investigate as part of the Water Management Improvement Plan the opportunity to bypass some of the Catchment K1 around SD5 and SD6 in order to minimise the water that needs to be managed in these dams. This will facilitate the use of SD6 for water storage during dry periods for dust suppression without significant risk of releasing untreated quarry water (transferred from SB1 to SD6) from SD6.
- Sediment traps and sediment ponds form part of the Quarry water management system and improve water quality at various points along water drainage networks.
- Excess waters are to be treated in-situ if required within sediment basins SB2a, SB3a and SD2 using a coagulant (i.e. NALCO 8187.15H or similar) to improve water quality prior to pumping out or draining, directly or indirectly, via Yorkey's Creek into the Coxs River. (Note: NALCO 8187 is a patented coagulant, which is widely used within the water treatment industry).
- Potable water is supplied by Lithgow City Council on an 'as needs' basis.
- Sewage treatment for the offices and amenities are comprised of a self-contained activated sludge treatment unit that uses rainwater captured by the on-site infrastructures roof-tops for flush water. No treated effluent is discharged on-site.
- A schematic overview of the drainage and water management network is included **Figure 4 Water Management System Schematic**.

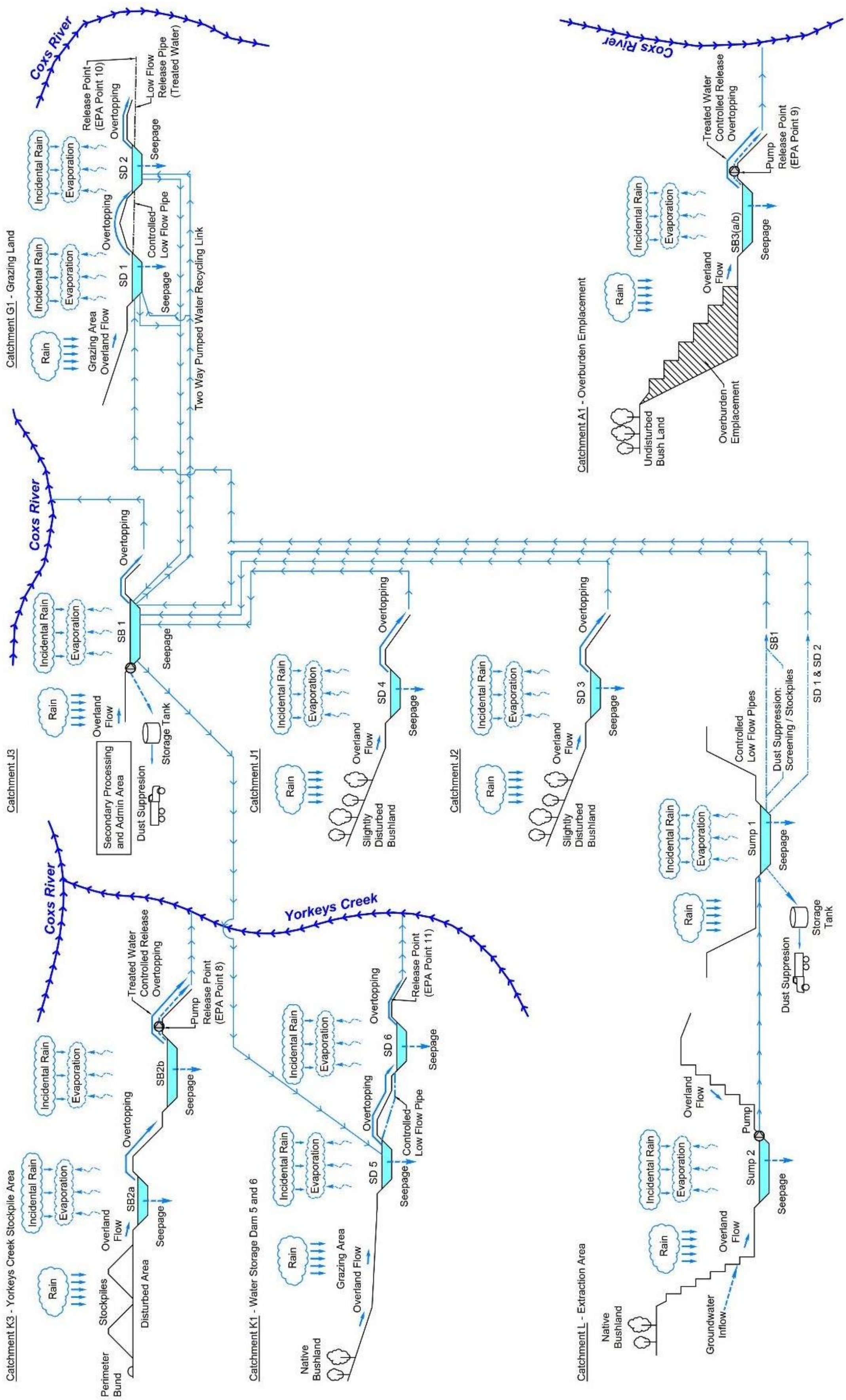

Figure 4 **Water Management System Schematic**

Discharge water quality will be managed via the measures mentioned above and will be informed by the Water Quality Management Program described in Section 8.1.

7.2 WATER USE MINIMISATION MEASURES

Site water balance modelling indicates that the Quarry will experience a substantial - but manageable from a water discharge quality perspective - surfeit of water during normal to wet seasons. During dry seasons the Quarry will generally collect sufficient overland surface water flow and direct rainfall as well as a smaller amount of intercepted groundwater to provide for its operational needs.

Rainfall intercepted and collected from rooves in tanks will provide for the majority of the potable water use, as well as purchased drinking water.

Generally the usage of water will be commensurate with the supply of water available. The main use of water at the Quarry is dust suppression via road and stockpile watering. If the water supply is such that water is in surfeit then water will be used liberally for dust suppression in order to minimise the amount of water that must be treated and/or discharged. If conditions are dry and less water is available then water will be used more sparingly. Watering would be limited to days when there is a high wind and it is crucial to minimising dust emissions that roads and stockpiles are watered. Additionally the use of crusting agent on stockpiles can be implemented/increased if water supply is short in order to minimise water use.

7.3 WATER MONITORING

Monitoring of the volume of release waters is to be undertaken daily during any discharge event at the prescribed discharge locations EPL12323 Point 1, 8, 9, 10 and 11 as per ***EPL: Discharge Volume Monitoring*** table below. Monitoring of locations Points 2 and 3 do not require volumetric monitoring as they are river, not discharge, monitoring locations.

EPL: Discharge Volume Monitoring

Monitoring Point	***Frequency***	***Sampling Method***	***Units of Measure***
EPL Points 1, 8, 9, 10, 11	*Daily During Discharge*	*Estimate*	*Kilolitres per day*

Table 33 – Release Water Monitoring Program: Water Quality Monitoring Parameters shows the parameters to be monitored.

Table 33
Release Water Monitoring Program: Water Quality Monitoring Parameters

Parameter	**Units**	**Sample Type**
pH	pH units	Grab Sample or *In-situ*
Total Suspended Solid	mg/L	Grab Sample
Visual Oil and Grease/Litter	mg/L	Grab sample

Water quality sampling sites and monitoring frequency for discharge events are described in **Table 34 – Release Water Monitoring Program: Water Quality Monitoring Frequency**

and Points while locations of monitoring points are also shown in **Figure 5 Discharge and Water Monitoring Location Plan.**

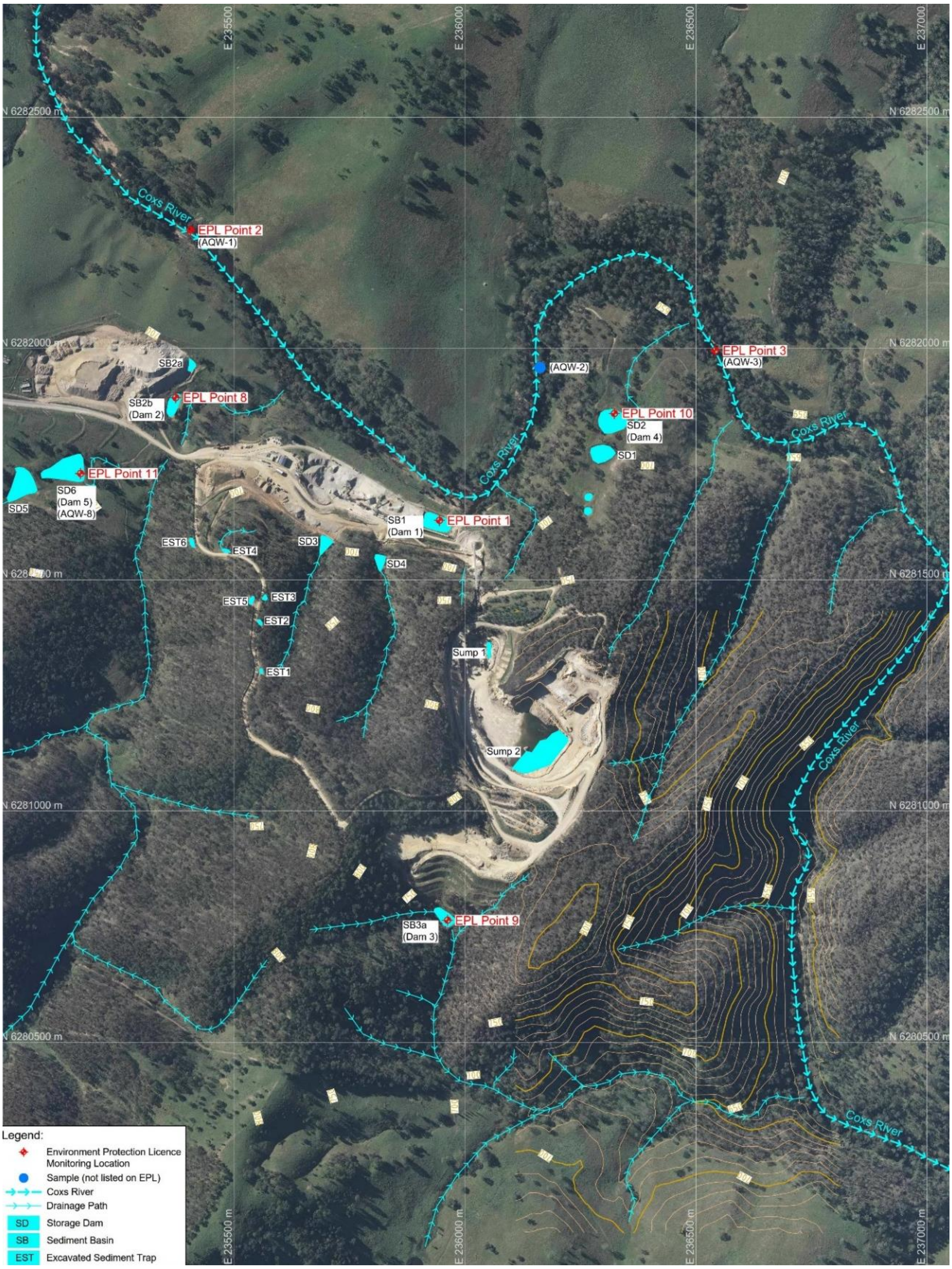

Figure 5 **Discharge and Water Monitoring Location Plan**

Table 34
Release Water Monitoring Program: Water Quality Monitoring Frequency and Points

Monitoring Point	Location Description	Monitoring Frequency
EPL Point 9	Release point from SB3(a/b)	Prior to a controlled discharge and within 24 hours, then daily during uncontrolled discharge events
EPL Point 1	Release point from SB1	
EPL Point 8	Release point from SB2b	
EPL Point 10	Release point from SD2	
EPL Point 11	Release point from SD6	
EPL Point 2	Upstream Coxs River	At commencement of discharge then daily during site discharge events for oil and grease; PH, and TSS, if there is any discharge at Points 1, 8, 9, 10 and 11.
EPL Point 3	Downstream Coxs River	

Based on the locally derived water quality objectives, monitoring results at EPL Points 1, 8, 9, 10 and 11 would be compared against the following contaminated release limits presented in **Table 35 – Release Water Monitoring Program: Contaminant Release Limits** or alternative contaminated release limits imposed by the EPL. The release criteria would be updated as more data is collected and Background Reference Conditions for metals and nutrients can be determined. The sampling location EPL Point 2 was identified as difficult to access during the planning and assessment stage, however there has been no problems accessing for the purposes of sampling to date, therefore no changes to the nominated location are proposed.

Table 35
Release Water Monitoring Program: Contaminant Release Limits

Parameter	Release Criteria	Type
Total Suspended Solids	30 mg/L)	Maximum
pH	6.5 – 8.5	Range
Oil and Grease	10 mg/L	Maximum

7.4 WATER QUALITY

As outlined in Section 3.3, water that accumulates within the base of the Quarry is expected to be comprised of groundwater seepage and rainfall. Rainfall will form the major component of inflow, as groundwater inflow is estimated to be a small portion of local rainfall only.

Water accumulating within the Quarry will be used on-site where possible (limited by dust suppression requirements). Any excess water will be managed using the existing water management regime. That is, it will be held within the Quarry excavation and then treated using the available capacity in down gradient sediment dams before being released to the Coxs River.

The release water quality monitoring measures proposed in the Groundwork Plus (2014) Surface Water Assessment (Section 12.2 Monitoring Locations, pp2-88 to 2-89) are considered appropriate for identifying loss of water quality up-gradient of release point to the environment.

8. GROUNDWATER

8.1 GROUNDWATER IMPACTS

8.1.1 DRAWDOWN

Extension of the Quarry will increase the depth to 685m AHD. Drawdown of approximately 45m AHD will occur within the footprint of the Quarry. This will occur primarily as a result of removal of the aquifer (by excavation) and removal of water from the base of the Quarry.

A cone of depression will be established around the perimeter of the Quarry. It is inferred that the cone of depression will be limited in extent for the following reasons.

The rock surrounding the Quarry has been observed to support relatively steep hydraulic gradients (as evidenced by the presence of groundwater at an elevation of 730m AHD relative to the nearby elevation of the Coxs River valley, which is as low as 630m AHD within 500m of the Quarry).

The Quarry is surrounded by valleys which act as a physical boundary beyond which drawdown impacts will not be able to propagate.

On this basis, drawdown which occurs as a result of the Stage 2 development will not impact on any of the identified registered groundwater bores (refer **Figure 1**).

Groundwater dependant ecosystems (GDEs) and culturally significant sites dependant on groundwater were not identified within the inferred extent of drawdown impacts.

The groundwater assessment (Ground Doctor, 2014) indicated that it was possible that groundwater may discharge into surrounding valleys such as Yorkeys Creek. It was possible (but unlikely) that drawdown associated with the Quarry could extend beneath Yorkeys Creek, in which case some groundwater seepage losses could occur.

8.1.2 Groundwater Take

Groundwater would be taken both directly and indirectly during operation of the Quarry.

- Water that accumulates in the base of the Quarry will be pumped for use in dust suppression or to meet any other non-potable water demand at the Quarry.
- Water will be taken indirectly from the base of the Quarry by evaporation.
- Water will be removed from the Quarry in the extracted rhyolite product.

Estimates of groundwater take outlined in the Groundwater Assessment (Ground Doctor, 2014) where based on limited hydrogeological information for the site. Key variables in modelling groundwater inflow, such as the average aquifer permeability have not been assessed. The topography of the site does not lend itself well to the adoption of simple analytical models. In particular, the aquifer is not infinite in extent and the adjacent water table is not flat. However, the adoption of complex numerical modelling of groundwater at the site is not warranted on the basis that potential groundwater impacts have been assessed as acceptable.

Ground Doctor has revised estimates of groundwater take associated with the Stage 2 extension using a "simple analytical equations for estimating groundwater flow into a mine pit" (Marinelli and Niccoli (2000)).

The analytical method of Marinelli and Niccoli (2000) requires a simplification of the hydrogeological environment and is used to provide a 'broad' range of potential drawdown and Quarry inflow. The equations calculate groundwater inflow from the adjacent aquifer through the walls and base of the excavation, based on the conceptual model of the excavation presented in *Diagram 1*.

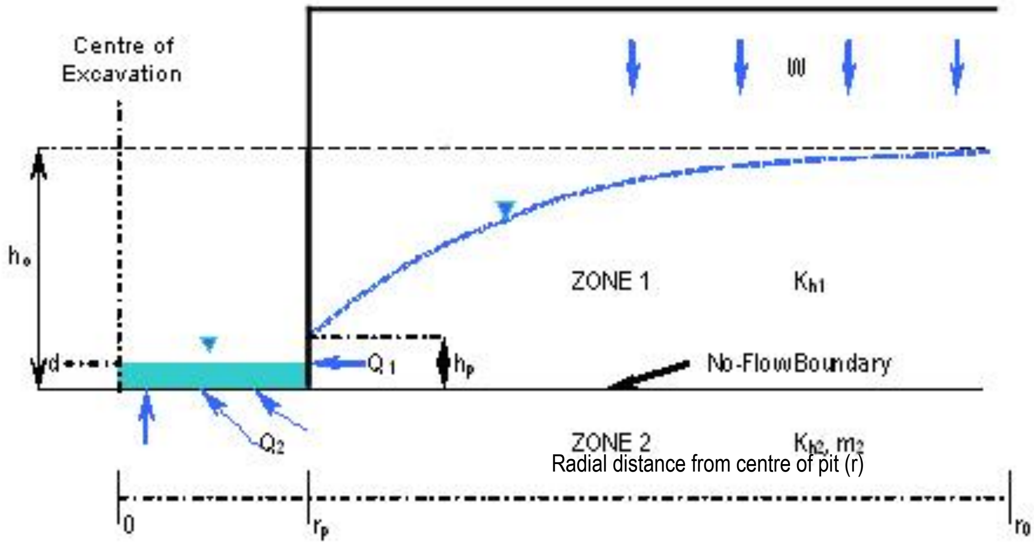

Diagram 1: Open Cut Inflow Analytical Model

Groundwater inflows were calculated for Zone 1 and Zone 2 using the following equations:

Zone 1

$$Q_1 = W\,\pi\,(r_o^2 - r_p^2)$$

Zone 2

$$Q_2 = 4\,r_p \left\langle \frac{K_{h2}}{m_2} \right\rangle (h_o - d)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

The extent of drawdown due to the nett groundwater inflow then allowed for determination of the radius of influence of the inflow on the water table by iteration from the following equation:

$$h_0 = \sqrt{h_p^2 + \frac{W}{K_{h1}} \left[r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \frac{(r_o^2 - r_p^2)}{2} \right]}$$

where:

- K_{h1} • *hydraulic conductivity value for the aquifer in Zone 1*
- h_o • *saturated thickness of aquifer*

W	• *rainfall recharge rate*
h_p	• *the height of the aquifer seepage face in the open excavation*
r_p	• *equivalent radius of pit as a cylinder*
K_{h2}	• *horizontal hydraulic conductivity value for the aquifer in Zone 2*
K_{v2}	• *vertical hydraulic conductivity values for the aquifer*
d	• *depth of water level in base of pit*

For Zone 1 the analytical solution considered steady-state, unconfined, horizontal, radial flow and assumed that:

- The excavation walls can be approximated as a circular cylinder.
- Groundwater flow is horizontal and the Dupuit-Forchheimer approximation can be used to account for changes in saturated thickness due to depression of the water table.
- The static (pre-quarry) water table is approximately horizontal.
- Uniform distributed recharge occurs across the site as a result of surface infiltration from rainfall;
- all recharge within the radius of influence (cone of depression), of the excavation is assumed to be captured by the excavation.
- Groundwater flow toward the excavation is axially symmetric.
- The aquifer is infinite in extent (i.e. - the cone of depression does not encounter any zero recharge boundaries).

In order to apply the Marinelli and Niccoli (2000) method the proposed excavation was approximated as being a cylinder with a radius of 175m. Seepage was assumed to occur from the lower 5m of the pit wall and through the base of the Pit.

A range of average aquifer permeability of $1x10^{-9}$m/s to $1x\ 10^{-8}$m/s was used in the analysis. Average permeability was selected based on Domenico and Schwartz (1990), which indicated average K of unfractured igneous and metamorphic rock ranging from $3\ x\ 10^{-14}$m/s to $2\ x\ 10^{-10}$ m/s and average K of fractured igneous and metamorphic rock ranging from $8\ x\ 10^{-9}$m/s to $2\ x\ 10^{-4}$ m/s. The selected range for average K fell at the lower end of the referenced K values for fractured igneous and metamorphic rock. Rock observed around the perimeter of the existing excavation featured sparsely spaced fractures and water flow was only observed from selected fractures suggesting limited fracture connectivity. The rock surrounding the excavation was observed to support steep hydraulic gradients, indicating low average permeability.

The average horizontal aquifer permeability was assumed to be the same as the average vertical permeability.

The NSW DPI Water (2011) Water Sharing Plan Greater Metropolitan Region - Background Document indicates that modelling of sustainable yields for the management unit assumed an infiltration rate (i.e. rainfall to groundwater recharge) of 4%. This was an average management unit wide rate. Conditions at the site are not favourable for groundwater recharge. The topography is steep, soil is shallow or non-existent, native vegetation cover exists and the site is situated on hard rock. Ground Doctor modelled inflows to the excavation based on rainfall infiltration of 1%, 2% and 3%.

The inputs used in the estimates were as follows:

k_{h1}	hydraulic conductivity for zone 1	=	1x 10^{-9}m/sec to 1 x 10^{-8}m/sec
k_{h2}	hydraulic conductivity for zone 2	=	1x 10^{-9}m/sec to 1 x 10^{-8}m/sec
k_{v2}	vertical hydraulic conductivity zone 2	=	1x 10^{-9}m/sec to 1 x 10^{-8}m/sec
h_o	saturated thickness of aquifer	=	25m (Scenario 1)
		=	45m (Scenario 2)
W	rainfall recharge to aquifer	=	1% to 3% of average annual rainfall or 8.6mm/yr to 19.2mm/yr
h_p	the height of seepage face in the Open Cut	=	5m
r_p	radius of Open Cut as a cylinder	=	175m
d	assumed depth of water level in base of Pits	=	1m

The range of inflow estimates and the inferred extent of the radius of the cone of depression for a range of modelled scenarios are summarised in **Table 36 - Range of Modelled Groundwater Inflow.**

Table 36
Range of Modelled Groundwater Inflow

h_o	W (percentage of average annual rainfall to groundwater)	Estimated Inflow K = 1 x 10^{-9}m/s	Estimated Inflow K = 1 x 10^{-8}m/s	Radius of Cone of Depression
25m	1%	1.6ML/yr	12.6ML/yr	220m to 309m
25m	2%	1.7ML/yr	13.2ML/yr	207m to272m
25m	3%	1.9ML/yr	13.6ML/yr	201m to 255m
45m	1%	2.0ML/yr	14.5ML/yr	255m to 409m
45m	2%	2.4ML/yr	15.6ML/yr	233m to 345m
45m	3%	2.6ML/yr	16.4ML/yr	222m to 316m

For the 25m total drawdown scenario the estimated groundwater inflow ranged from 1.6ML/yr to 13.6ML/yr and the radius of influence ranged from 201m to 309m (from the centre of the proposed excavation).

For the 45m total drawdown scenario the estimated groundwater inflow ranged from 2.0ML/yr to 16.4ML/yr and the radius of influence ranged from 222m to 409m (from the centre of the proposed excavation).

The modelled extent of the cone of depression were considered realistic based on hydraulic gradients observed at the site (at least 20%).

The volume of rock to be excavated from beneath the water table was approximated as a cylindrical excavation with diameter of 350m and depth of 45m. This equates to a volume of approximately 5,000,000m^3. Assuming the total saturated porosity is 1.1% (Ground Doctor, 2014) the volume of saturated rock removed from the Quarry as excavated product was estimated to be 55,000m^3, which is equivalent to 55ML of water.

This loss would occur over the 35 year operating period of the Stage 2 Extension. Based on the methodology described, the average yearly loss of groundwater attributable to removal of aquifer material (rock) would be 1.6ML/yr.

Hy-tec has purchased a groundwater entitlement for take of up to 20ML/yr of groundwater from the Coxs River fractured rock groundwater management unit. Modelling of groundwater inflow and estimate of groundwater loss associated with excavation of saturated rock indicates that the annual take of groundwater will be less than 20ML/yr throughout Stage 2.

8.1.3 Groundwater Quality

The proposed quarrying activities pose little risk to groundwater quality as the process is limited to blasting, excavation, crushing and screening of rock.

The groundwater assessment (Ground Doctor, 2014) identified the following potential risks to groundwater quality:

- Introduction of chemicals used in extraction processes such as fuels and lubricants for machinery and nutrients (nitrate and ammonia) within explosives.
- Increased salinity in water accumulating within the excavation due to evaporation.
- Potential for acid generation due to exposure of previously saturated rock to oxygen.

The risks are largely consistent with those posed by the pre-existing Stage 1 operations at the Quarry, which are not believed to have resulted in significant water quality impacts.

The plant and equipment used, consumes diesel fuel, hydraulic oils, lubricants and common automotive chemicals. The risk of chemical spill and/or the consequences of a spill will be managed by maintaining plant and equipment outside of the extraction area consistent with operational practise of Stage 1. Quarry vehicles will be refuelled beyond the active limit of the extraction area. If plant requires refuelling within the active extraction area, this will be completed away from any exposed groundwater, with appropriate controls (e.g. spill kits etc) on standby to contain and remove spills as soon as possible. In the event that a spill occurs within the excavation, earth moving equipment will be used to contain impacts and to remove any impacted media for treatment.

Explosives are used in the existing Quarry operations at the site and will continue to be used in the Stage 2 Extension. Explosives typically contain ammonium nitrate, which could potentially impact on groundwater quality. Explosives will be handled and used correctly at the site to minimise risks to water quality.

There is potential for salt to concentrate in water that accumulates in the base of the excavation as a result of evaporation. This risk will be controlled by limiting accumulation of standing water within the excavation. The excavation will be managed to minimise the time that standing water remains within the excavation.

Acid generation from oxidisation of sulphur is not expected to be a concern at the site as the targeted rhyolite and surrounding waste rock is low in sulphur.

The potentially contaminating activities described above have been occurring at the site as part of the existing approved Quarry operation. The Stage 2 Extension poses no further significant addition risk to groundwater quality at the Site.

Water that accumulates within the base of the Quarry is expected to be comprised of groundwater seepage and rainfall. Rainfall will form the major component of inflow. Only a small portion of total rainfall is expected to end up as groundwater due to the low permeability hard rock environment and steep topography of the Quarry surrounds.

Dewatering of the Quarry during extraction will result in groundwater seepage toward the Quarry. Any discharge of groundwater from the Quarry would occur in accordance with the proposed management of surface water as outlined in **Section 7** of this Water Management Plan.

8.2 GROUNDWATER IMPACT MONITORING

8.2.1 Groundwater Monitoring Locations

Three groundwater monitoring bores will be installed around the periphery of the Quarry. The approximate proposed monitoring bore locations (subject to land/site constraints) are shown in **Figure 6 Proposed groundwater monitoring locations**.

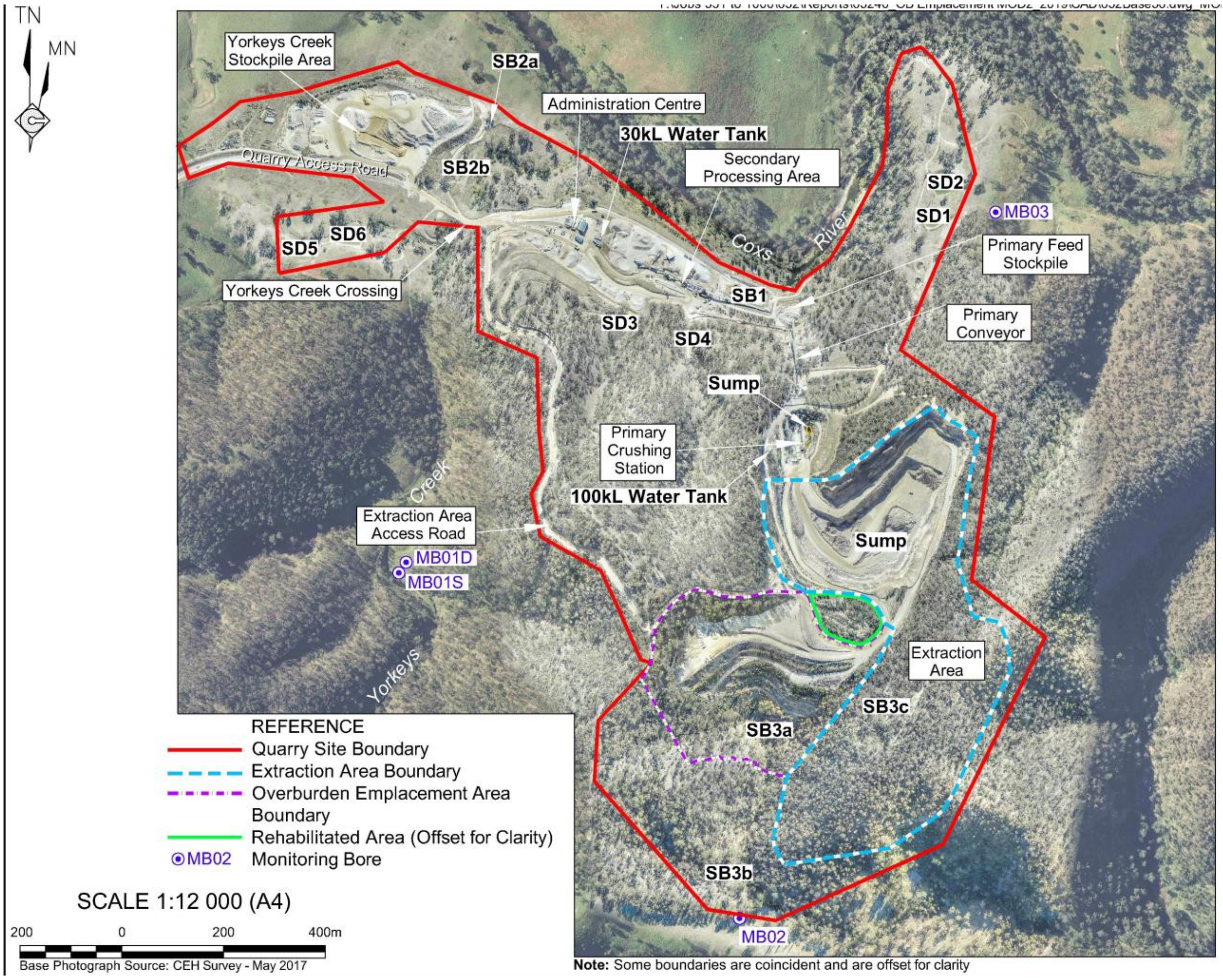

Figure 6 Proposed groundwater monitoring locations.

Monitoring Bore MB01 will be located to the west of the Quarry and situated between the excavation and Yorkeys Creek. Monitoring Bore MB02 will be located at the southern end of the proposed excavation. Monitoring Bore MB03 will b located to the north east of the Quarry. The 'as constructed' details and locations of the bores are to be surveyed appropriately. All bore data, is to be properly retained for the life of the project.

The Quarry excavation will include a sump at all stages of the project. The sump will move periodically (e.g. every 2-5 years) as the lateral and vertical extent of the Stage 2 excavation increases and/or changes. The sump will be adopted as a water quality monitoring point.

Dewatering of the excavation is expected to result in an inward (toward the excavation) hydraulic gradient. As such, the excavation sump is the monitoring location most likely to detect any loss of water quality associated with the Stage 2 works.

8.2.2 Groundwater Monitoring Bore Design

Monitoring bores will be installed to a depth of approximately 670m AHD, which is approximately 15m below the base of the proposed excavation.

Groundwater monitoring bores will be constructed using Class 18 uPVC casing and screen. The diameter of casing, positioning of screened interval(s) and length of screened interval(s) will be determined based on the depth to water and the depth to water bearing zones at each monitoring location. The need for multiple piezometers at each monitoring location will be assessed based on the depth of water bearing zones in relation to the identified elevation of the water table and the proposed maximum depth of excavation at the Quarry.

Each monitoring bore will be equipped with a data logging water level meter set to record water level once per day.

8.2.3 Groundwater Quality Monitoring

To establish baseline groundwater quality data water quality monitoring will be conducted at 6 monthly intervals for a period of two years after monitoring bores are installed.

Each monitoring bore would be purged and sampled during each monitoring event. The method of sampling would be determined based on the depth to water and yield of the monitoring bores.

In addition to monitoring bores, water samples would be collected from any water pooled within the proposed sump at the base of the Quarry excavation. Samples would be collected directly from pooled water within the sump. Sampling of excavation sump water would be conducted on a six monthly basis throughout the operational life of the Quarry.

A water quality meter will be used to measure water quality parameters immediately before groundwater or sump water samples are collected. The sampler will record the EC, pH, Eh and temperature of groundwater. The sampler will record calibration details for the water quality meter.

A groundwater sample from each groundwater bore and from the excavation sump will be analysed in a National Association of Testing Authorities (NATA) accredited laboratory for the analytes listed in **Table 37 - Water Quality Analytes for Groundwater Monitoring**. The suite of analysis listed in **Table 37** includes field measured water quality parameters, basic groundwater chemistry (cations and anions), heavy metals and nutrients.

Sump water will also be analysed for total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene, xylenes (BTEX) and “oil and grease”.

Table 37
Water Quality Analytes for Groundwater Monitoring

Analyte Group	**Analyte**
Physical Parameters (measure in field)	EC, pH, Eh, Temperature
Dissolved Solids	Total Dissolved Solids
Major Cations	Magnesium Calcium Sodium Potassium
Major Anions	Sulphate Chloride Hydroxide as $CaCO_3$ Carbonate as $CaCO_3$ Bicarbonate as $CaCO_3$

Heavy Metals (Dissolved)	Aluminium Arsenic Boron Barium Beryllium Cadmium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Silicon Silver Strontium Titanium Vanadium Zinc
Nutrients	Ammonia Nitrate Nitrite
Hydrocarbons (Sump water only)	TRH BTEX PAHs

8.2.4 Groundwater Inflow Monitoring

Hy-Tec has been granted a water access license (WAL 37423) which allows for the take of up to 20ML/yr of groundwater from the Quarry void. The licensed amount was based on estimates of seepage to the Quarry void during the life of the project and the loss of water in extracted product.

The conditions of consent require Hy-tec to report the take of groundwater to the NSW DoI on an annual basis. Hy-tec also has obligations to report the projected groundwater take associated with the project.

The aim of groundwater seepage monitoring would be to identify any gross underestimation of groundwater seepage so that groundwater losses (take) could be appropriately licensed.

A water balance will be conducted within the Quarry excavation on a quarterly basis. The water balance will be conducted at a time in which no rainfall has been recorded at the site for a period of 5 days or more, with the aim of assessing water level changes in the sump associated with groundwater inflow only. The water balance will proceed as follows.

- A water level gauge will be established within the excavation sump.
- The water level within the sump will be read at 9am at the start and end of the assigned 24hr gauging period.

- Pumping or discharging of water from the sump will be avoided during the assigned 24hr gauging period. If water use or discharge cannot be avoided, record the volume of water take or discharge and measure change in water elevation before and after removal of water.
- Measure rainfall over the 24hr period. If rainfall occurs over the gauging period conduct gauging event again during dry weather.
- Measure pan evaporation over the 24hr gauging period.
- Estimate the area of exposed water surface within the sump.
- Calculate the change in water storage over the monitoring period (i.e. change in water elevation in sump x estimated surface area).

Calculate seepage using the following water balance equation.

Water Level Change Due to Seepage = Total Water Level Change + Evaporation Rate (measured) + Change Due to Water Use

The volume of groundwater seepage can be estimated using the following formula.

Volume of groundwater seepage/day = Water Level Change due to Seepage x Estimated surface area of exposed water within excavation sump.

8.2.5 Groundwater Take Prediction

Hy-tec will adopt the methodology outlined in **Section 8.1.2** for making forward estimates of annual groundwater inflow to the excavation for the first 5 years of Stage 2.

After 5 years of Stage 2, or where observed inflows to the excavation exceed 15ML/yr, Hy-tec will reassess the adequacy of the analytical model estimates outlined in **Section 8.1.2**. Where estimates are proven to be unreliable (on the high or low side), a more robust method of predicting inflows will be developed to predict groundwater inflow.

8.3 GROUNDWATER TRIGGER ACTION RESPONSE PLAN

8.3.1 Groundwater Levels

A 10m or greater fall (below the maximum measured pre-development groundwater elevations) in at any monitoring bore will trigger further consideration of groundwater level results.

8.3.2 Groundwater Field Parameters

8.3.2.1 Triggers

Preliminary trigger levels for groundwater quality parameters are as follows.

When pH drops below 6.0 or rises above 8.5.

When EC exceeds 2000uS/cm.

The above triggers are arbitrary only due to absence of baseline data and updated triggers will be formulated using the ANZECC (2000) methods as soon as site date is available.

8.3.2.2 Actions and Response Plan

The following actions will be implemented if a water quality parameter trigger level has been exceeded.

Check instrument calibration.

Assess the appropriateness of the sampling method used to collect the sample.

Assess whether any anomalous result is representative of changing conditions in the aquifer or sample disturbance during sampling e.g. water bailing in observation bores.

Review previous monitoring data from the bore and assess whether there are any obvious trends which may indicate changing groundwater conditions.

Check monitoring results for nearby monitoring locations to see if there is a common trend.

If there is no obvious explanation for the trigger level exceedance collect a sample from the monitoring bore for laboratory analysis (analytical suite listed in **Table 37**).

Investigate the potential cause of the trigger level exceedance. If a cause is identified rectify the problem and report incident to DoI or the EPA.

If results are still in exceedance, DoI and the EPA will be consulted to determine the most appropriate actions to be implemented. The TARPS for level data, pit inflows and water quality must be reviewed after two years of baseline data have been gathered. This process should be undertaken in consultation with DoI.

8.3.3 Groundwater Analytical Data Triggers

8.3.3.1 Triggers

Detection of TRH, BTEX compounds and/or “oil and grease” within the sump water will trigger clean up action and/or further assessment.

The ANZECC (2000) guidelines recommend development of triggers using the following methodology:

- Establish the 80th percentile of the baseline data set.
- Compare the 80th percentile result to the generic ANZECC (2000) 95% protection of fresh water ecosystems trigger.
- If the 80th percentile of the baseline data set exceeds the generic ANZECC (2000) trigger adopt the 80th percentile concentrations as the site specific trigger.
- Where the 80th percentile result is less than the generic trigger, continue to adopt the generic trigger.

The ANZECC (2000) guidelines recommend the following methodology for applying triggers.

- Differentiate baseline data from post-disturbance data.
- Compare the median monitoring result (the 50th percentile result) to the adopted trigger.

The ANZECC (2000) methodology specifies that this method is ideally applied where monthly data is available over a period of at least 24 months. The method would ideally compare the median of the most recent 24 monitoring results to the 80th percentile of the baseline data.

In the case of the site the data sets will be much smaller and the number of measurements made over a longer monitoring interval. Ground Doctor proposes that the median result of available monitoring data for the previous 12 month period is compared to the 80th percentile of the baseline data.

In the absence of baseline data the preliminary trigger levels for potential groundwater contaminants are listed in **Table 38 – Preliminary Trigger Levels for Water Quality Analytical Results**. Trigger levels for concentrations of potential contaminants in groundwater are taken from the Australian and New Zealand ANZECC/ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Trigger values for 95% protection of fresh water ecosystems, the National Health and Medical Research Council (NHMRC) (2011) *Australian Drinking Water Guidelines* and/or the New Zealand National Institute of Water and Atmospheric Research (NIWA) updated guidance for Nitrate in water 2014. Where both a drinking water and protection of aquatic ecosystems threshold exist for the same compound, the lower of the referenced thresholds would be adopted as the preliminary groundwater quality trigger for the site.

Table 38
Preliminary Trigger Levels for Water Quality Analytical Results

Analyte Group	Analyte	ANZECC (2000) Trigger Level (ug/L)	Aust. Drinking Water (2011)	Baseline Data Range (mg/L)
Major Cations	Magnesium	-	-	-
	Calcium	-	-	-
	Sodium	-	-	-
	Potassium	-	-	-
Major Anions	Sulphate	-	-	-
	Chloride	-	-	-
	Hydroxide as $CaCO_3$	-	-	-
	Carbonate as $CaCO_3$	-	-	-
	Bicarbonate as $CaCO_3$	-	-	-
Heavy Metals (Dissolved)	Aluminium	55	-	-
	Arsenic	13	10	-
	Boron	370	4000	-
	Barium	-	2000	-
	Beryllium	-	60	-
	Cadmium	0.2	2	-
	Chromium	1	50	-
	Cobalt	-	-	-
	Copper	1.4	2000	-
	Iron	-	-	-
	Lead	3.4	10	-
	Manganese	1900	500	-
	Mercury	0.6	1	-
	Molybdenum	-	50	-
	Nickel	11	20	-
	Selenium	5	10	-
	Silicon	-	-	-
	Silver	0.05	10	-
	Strontium			-
	Titanium			-
	Vanadium	-	-	-
	Zinc	8	-	-

Analyte Group	Analyte	ANZECC (2000) Trigger Level (ug/L)	Aust. Drinking Water (2011)	Baseline Data Range (mg/L)
Nutrients	Nitrate*	10000 (asN)	50000 (as NO3)	-
	Nitrite	None	-	-
	Ammonia	900	-	-
Hydrocarbons	TRH	-	-	-
	Benzene	950	1	-
	Toluene	-	800	-
	Ethylbenzene	-	300	-
	Xylene	200	600	-
	Naphthalene	16	-	-
	Benzo(a)pyrene	-	0.01	-

* - Threshold for Nitrate taken from New Zealand National Institute of Water and Atmospheric Research (NIWA) 2014 updated guidance for Nitrate in water ("Excellent" quality ecosystem).

8.3.3.2 Actions and Response Plan

Where TRH, BTEX or "oil and grease" are detected in water sampled from the excavation sump:

- Cease use of water from the sump immediately.
- Cease discharge of water from the sump to downgradient treatment ponds immediately.
- Contact the analytical laboratory and have the sample in question re-analysed.
- Inspect water within the excavation sump for evidence of hydrocarbon contamination (e.g. presence of rainbow sheen on the surface).
- If a source or potential source of hydrocarbon impact is identified in the excavation implement controls to eliminate further impacts.
- Where significant impacts are identified implement controls to prevent migration from the excavation. (e.g. skim any product from the surface and aerate pond).
- Resample sump water within 2 weeks of detection or clean-up of impacts to confirm issue has been addressed.

The following actions will be implemented within 30 days of receipt of water quality data indicating that a water quality parameter trigger level has been exceeded.

- If ongoing analytical results are of similar concentration to baseline data, background, trigger levels will be reviewed in consultation with NSW DoI.
- Re-sample the subject bore or sump if analytical results are significantly different to previous monitoring data.
- Conduct a site inspection to check for possible causes for changed chemistry results.
- If sampling results indicate groundwater contamination is occurring investigate possible sources and apply additional controls as required.
- Consider the need for additional monitoring to delineate the extent of any significant groundwater contamination identified during routine monitoring.

9. SURFACE AND GROUNDWATER CONTINGENCY STRATEGY

9.1 SURFACE WATER

In the event of unforeseen impacts associated with surface water, the following protocol will be implemented:

- Raise an incident report in the Incident Management, Notification and Reporting System (refer Section 11).
- Undertake reporting of the incident to the regulatory agency in accordance with Incident Management, Notification and Reporting System (refer Section 11).
- A preliminary review will be conducted of the nature of the impact, including:
- any relevant monitoring data
- current quarrying activities and land use practices.
- Commission of an investigation by a groundwater expert into the unforeseen impact to confirm cause and effect and consider relevant options for amelioration of impact(s); prepare an action plan in consultation with the appropriate regulatory agency.
- Mitigate causal factors where possible.
- Implement additional monitoring as necessary to measure the effectiveness of the controls implemented. The outcomes of this protocol will be reported in the Annual Environmental Review report. The implementation of any mitigation measures will be undertaken in consultation with the relevant regulatory authorities.

The following contingency measures are considered suitable for addressing unforeseen surface water impacts to the Quarry.

- Review stormwater management structural controls and identify opportunities for improvements to infrastructure; and
- Review and amend Water Management Improvement Plan to implement any additional infrastructure that may be required.

It is anticipated that the Quarry Manager or his/her delegated nominee shall be responsible for all actions relating to this Contingency protocol consistent with Section 13 - Roles and Responsibilities.

9.2 GROUNDWATER

9.2.1 Unexpected Drawdown Impacts

The following actions are recommended in the event that more than 10 m of drawdown (below the maximum measured pre-development water level) is observed within the proposed groundwater monitoring wells.

Assess activity within the Quarry and whether it may have resulted in the water level decline. If there was no significant change to the Quarry depth or footprint during the time in which drawdown occurred then the observed changed is more likely to be associated with climatic variation in the previous monitoring period.

Assess recent climatic conditions. Consider whether the observed fall in water levels corresponds with recent climatic conditions, such as a period of drought, or the summer period.

Assess the standing water level elevation relative to the elevation of nearby parts of Yorkey's Creek. If the standing water level has fallen below the Creek elevation then consider whether adverse impacts could be occurring to Yorkey's Creek.

If unexpected excessive drawdown impacts are observed in the proposed groundwater monitoring bores additional monitoring bores shall be considered closer to the receptor(s) at risk. This may include Yorkey's Creek and off-site groundwater works.

9.2.2 Groundwater Inflow / Take

The following contingency measures are considered suitable for addressing higher than expected groundwater inflow to the Quarry.

- Install additional water treatment capacity into the downgradient water treatment ponds and dams. This could include the establishment of an evaporation sump in the base of the Quarry; and
- Obtain additional water allocation to account for the additional take (or indirect take) of groundwater.

In-situ groundwater monitoring data will supersede the groundwater analytical modelling as soon as data is available.

9.2.3 Groundwater Quality

The following measures could be implemented to address any unforeseen issues with release water quality:

- Reassess the appropriateness of the trigger(s) that have been exceeded.
- If the exceeded trigger(s) is found to be appropriate then identify and eliminate the source of water quality decline. This could most likely be achieved by implementing more effective environmental management procedures to be determined by the nature of any identified unacceptable impact.
- Add additional water storage and/or treatment capacity into the downgradient water treatment ponds.
- Additional storage capacity could improve management of water releases to the Coxs River. For example, allow release of water at times when dilution will occur naturally.

10. WATER MANAGEMENT IMPROVEMENT PROGRAM

A Surface Water Audit and Water Management Improvement Program (WMIP) has been completed for the Site (April 2016) and has been included as Appendix U of the EMSP.

The WMIP is included here (refer **Table 39 – Water Management Improvement Plan**) and shows improvement actions identified from the Surface Water Audit, a status and timeframe of these actions is also provided, current as at the date of this revision (10 October 2017).

Table 39
Water Management Improvement Plan

Catchment	Action Required	Timeframe
A1	Construct and install a new sediment basin (SB3b), with a peak storage capacity of approximately 12.3 ML in accordance with the EIS documentation.	Construction will be staged progressively over the life of the development, and will be sized to Type-D criteria against the total contributing area at all times, to a total capacity of 12.3 ML if entire catchment is disturbed.
G1	Phase out pumping of water from Sediment Basin SB1 to Storage Dams SD1 & SD2	Completed
J3	Increase the capacity of Sediment Basin SB1 to allow 10.84 ML capacity to capture the 95^{th} percentile 5-day rainfall volume.	Completed
K1	Phase out pumping of water from Sediment Basin SB1 to Storage Dams SD5 & SD6 Construct Excavated Sediment Trap at the end of each cut off drain on the southern side of the access haul route and maintain in effective condition.	Pumping to K1 was to be phased out after SB1 was increased in capacity to "Type D" sizing criteria. This increase has occurred, and as such SB1 is now a Type D basin. Pumping may still be utilized to maximize water storage for the quarry operations. Excavated Sediment Traps were completed in February 2016, as per the requirements of the EPA Advisor Letter (Item 1, Section 2), dated 17 December 2015.
K3	Repair and reinstated scoured batters in Yorkeys Creek Stockpile area, and overland flowpath between Sediment Basin SB2a and SB2b. Desilt SB2a and SB2b as require to reinstate sediment storage capacity. Increase storage capacity of SB2b to 4ML to meet "Type D" criteria to treat Catchment K3.	Completed
L	Ensure effective management of quarry sumps to effectively manage stormwater runoff as well as dewatering of the pit as and when required.	Ongoing.

11. INCIDENT MANAGEMENT, NOTIFICATION AND REPORTING

SSD 6084 defines an incident as:

> "*An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance"*

Further to this, SSD 6084 defines material harm as follows.

> *Material harm……Is harm that:*

- *involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial, or*
- *results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000, (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment)*

> *This definition excludes "harm" that is authorised under either this consent or any other statutory approval'*

An incident which causes or threatens to cause material harm to the environment (and may or may not result in an exceedance of discharge water criteria) is referred to as a **Pollution Incident**.

An incident which occurs only as a result of an exceedance of water criterion, is referred to as a **Non-compliance Incident**.

Identification of Incident or Failure to Comply

- An incident or failure to comply may include, but may not be limited to:
    - Deterioration of water quality, with waters leaving the Quarry being of lesser quality than background values when monitored in accordance with the Release Water Monitoring Program.
    - Reported failure(s) to implement the programs or strategies outlined in the SWMDA.

11.1 INCIDENT MANAGEMENT AND NOTIFICATION

11.1.1 Pollution Incident

A water-related incident will be classified as a Pollution Incident and hence is included in the requirements of a Pollution Incident Response Management Plan.

In the event of a water pollution incident, the Quarry Production Manager will be notified and the event will be reported to the EPA immediately at the first practical opportunity (and within 24 hours of the incident).

An investigation into the source of the offending release will be immediately commenced and once identified the Quarry Production Manager or delegate will implement one or more of the corrective measures identified in the Water Management System (see Section 7).

Within 7 days of the incident, the Company will submit a report to DPE and any other required government agencies confirming the source of the offending release, actions taken and ongoing management to prevent future incident to the regulatory authorities.

- The EPA will be notified of the results of all monitoring undertaken in accordance with '*Section 6 Reporting Conditions*' of the EPL. Results of monitoring are to be submitted with the Annual Return documents at the end of each reporting period.
- Any incidents regarding water quality are to be immediately reported to the Quarry Production Manager or a person nominated by the Quarry Production Manager.
- In the event of an emergency or incident regarding water management at the Quarry, the Quarry Production Manager or a person nominated by the Quarry Production Manager shall notify the EPA in accordance with the PIRMP.
- All monitoring results will be included as part of the Annual Review as required under *Condition 4* of *Schedule 5* of the DC.
- Records, including monitoring results prepared in accordance with the Pollution Control Approval, results of any maintenance or monitoring program undertaken on-site, or incidents, will be kept for a minimum of four (4) years for inspection by the EPA.

11.1.2 Non-Compliance Incident

On identification of a non-compliance against discharge water criteria, which may follow receipt of monitoring results, the Quarry Production Manager will be notified and an investigation into the source of the non-compliance commenced in accordance with the response and corrective actions described in Section 11.1.1. Any non-compliance with discharge water quality criteria shall be reported to the regulatory authorities by the Quarry Production Manager.

11.2 INCIDENT REPORTING

Following implementation and review of the corrective measures, a short description of the incident, actions taken and results of the corrective actions will be documented by the Quarry Production Manager.

A summary of all incidents, including dates of occurrence, corrective measures taken and success of these measures will be compiled and reported in the Annual Review to the DPE and Annual Return to the EPA.

11.2.1 Corrective Action

The following general protocol will be implemented on identification of an incident and / or failure:

- Commence an investigation into the incident and / or failure.
- Notify regulatory authority of the results of the investigation (if required).

- Based on the findings on the investigation, update and revise management plans and procedures for ensuring the same incident and / or failure does not occur again.
- Following completion of any corrective actions, notify the appropriate regulatory authorities.
- Any deficiencies in the monitoring program or this WMP shall be reviewed and the required changes to the WMP made by the Quarry Production Manager or appointed representative.

EPL Requirements

- If a discharge of waters occurs as a result of on-site activities outside of the parameters conditioned by the EPL for the Quarry, an investigation will be conducted and corrective action taken to rectify the cause of the variation.

Release Water Monitoring Program

- If contaminant release limits are exceeded at EPL Points 1, 8, 9, 10 and 11, corrective action would be implemented as presented in **Table 40 – Corrective Action to Exceedance of Contaminant Release Limits**.

Table 40
Corrective Action to Exceedance of Contaminant Release Limits

Release Water Quality	Corrective Action(s)
Less than or equal to locally derived release limit or release limit prescribed by EPL or less than 10 % above background (as measured at EPL Point 2), whichever is greater	Nil
Greater than locally derived release limit or greater than release limit prescribed by EPL or greater than 10 % above background (as measured at EPL Point 2), whichever is greater	Cease discharge if practicable, advise EPA, investigate cause, implement immediate action to rectify (i.e. re-treat / re-test to confirm compliance or implementation of additional SSEC) prior to recommencing control discharge.
Presence of visual Oil and Grease	Cease discharge if practicable, test for Oil and Grease and if > 10 mg/L advise EPA, investigate and implement immediate action to rectify and to prevent reoccurrence, arrange contractor to remove visual contamination and dispose/recycle contaminated water off-site at a licensed facility.

12. DOCUMENTATION AND PUBLICATION OF MONITORING INFORMATION AND REPORTING

Hy-Tec will retain records of meteorological monitoring and water monitoring for the life of the quarry. Monitoring records will be made available to relevant government authorities following a written request.

Hy-Tec will include all attended water monitoring reports as appendices to the Annual Review. That document, once approved by the relevant government agencies, would be published on the Company's website.

In accordance with the requirements of Section 66(6) of the *Protection of the Environment Operations Act 1997*, Hy-Tec will publish a meaningful summary of all EPL required pollution monitoring data on the Company's website within 14 days from the end of the month of the data being collected. In addition, Hy-Tec will provide a copy of obtained data (the value of each individual monitoring sample) free of charge to a member of the public when requested. The data will be published in a format that includes raw data values, is comprehensible by the general public and also includes all accompanying necessary information. These requirements are presented in detail in *Requirements for Publishing Pollution Monitoring Data (*EPA, 2013*).*

13. ROLES AND RESPONSIBILITIES

Table 41 – Roles and Responsibilities of Personnel with Respect to Management of Surface and Groundwater outlines the roles and responsibilities of personnel with reference to management of groundwater impacts.

Table 41
Roles and Responsibilities of Personnel with Respect to Management of Surface and Groundwater

Role	Responsibilities
NSW Quarry Operations Manager	Ensure compliance with this Water Management Plan Ensure adequate resources are available to implement this Water Management Plan. Ensure suitably trained personnel are available to implement the responsibilities of the Quarry Production Manager during any time of the Quarry Production Manager's absence from site. Coordinate the review of the WMP (refer EMSP Section 6.1.7).
Quarry Production Manager, or his/her nominee	Ensure the implementation of the Water Management Plan. In the event of any unforeseen circumstances ensure that these are reported, investigated and action plans to prevent and ameliorate are developed in accordance with timeframes set down in Section 11.1.1. Ensure water monitoring results are reviewed, evaluated and entered into the environmental database as they are received. Record weather observations for the site. Prepare a report to government agencies or neighbours following a notifiable surface water or groundwater pollution incident. Inform the NSW Quarry Operations Manager of identified groundwater impacts and any alterations to site operations that may or has influenced the groundwater environment. Ensure employees are competent through training and awareness programs.
All On-site Personnel	Operate in manner that minimises risks of incidents to themselves, fellow workers or the surrounding environment. Fully implement the relevant control measures within the Water Management Plan. Report any anomalous or extraordinary groundwater events to the Quarry Production Manager. This would include spills or losses of chemicals at the site. Follow any instructions provided by the Quarry Production Manager.

14. COMPETENCE TRAINING AND AWARENESS

All personnel and contractors working at the Quarry undergo an induction. This induction includes information on the management of water while working on Site.

After completing the induction, workers will sign the statement of induction and a record of this is kept in the administration office.

Monthly toolbox meetings are held to discuss whole-of-site production, management, safety and environmental issues. Matters relating to Water Management are raised during these meetings, when necessary.

15. WMP REVIEW AND CONTINUAL IMPROVEMENT PROTOCOL

This WMP will be reviewed by the NSW Quarry Operations Manager or delegate every three years from the date of approval or (in accordance with *Condition 5* of *Schedule 5* of the Consent) within three (3) months of submission of an Annual Review, an incident report resulting from a notifiable incident, each independent environmental audit and any modification to the Consent. This will ensure the adequacy of the WMP and allow for opportunities of adaptive management and continual improvement. This will include a review of monitored water data and water management procedures, as necessary. Each review will also evaluate the effectiveness of the overall Water Monitoring Program and whether it should be modified.

The Operations Manager or delegate shall prepare a report on the review, which will then be issued for the consideration of agency stakeholders.

16. REFERENCES

Ground Doctor (2016), Groundwater Management Plan for the Austen Quarry Stage 2 Extension Project. Prepared on behalf of Hy-Tec Industries Pty Limited.

Groundwork Plus (2014), Austen Quarry Stage 2 Extension Project - Surface Water Assessment.

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ANZECC/ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* Trigger values for 95% protection of fresh water ecosystems.

Domenico, P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*, John Wiley & Sons, New York.

Ground Doctor Pty Ltd (2014) *Groundwater Impact Assessment for the Austen Quarry Stage 2 Extension Project*. Prepared on behalf of Hy-Tec Industries Pty Limited.

Groundwork Plus (2014) *Surface Water Impact Assessment for the Austen Quarry Stage 2 Extension Project*. Prepared on behalf of Hy-Tec Industries Pty Limited.

Groundwork Plus (2016) *Surface Water Management Plan for the Austen Quarry Stage 2 Extension Project*. Prepared on behalf of Hy-Tec Industries Pty Limited.

Marinelli F and Niccoli W (2000), Simple Analytical Equations for Estimating Ground Water Inflow to a Mine Pit", Ground Water, Volume 38, No. 2, March-April 2000.

New Zealand National Institute of Water and Atmospheric Research (NIWA) updated guidance for Nitrate in water (https://www.niwa.co.nz/, 19 September 2016).

NHMRC and ARMCANZ (2011). (National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand). *Australian Drinking Water Guidelines – 6*, 2011. National Water Quality Management Strategy.

NSW Department of Primary Industries Office of Water (2011), Water Sharing Plan Greater Metropolitan Region - Background Document, July 2011) (http://www.water.nsw.gov.au/__data/assets/pdf_file/0005/548105/wsp_metro_groundwater_background.pdf)

R.W. Corkery & Co (2014) *Environmental Impact Statement for the Austen Quarry Stage 2 Extension Project*. Prepared on behalf of Hy-Tec Industries Pty Limited.

R.W. Corkery & Co (2015) *Austen Quarry Stage 2 Extension Project Response to Submissions, January 2015*. Prepared on behalf of Hy-Tec Industries Pty Limited.

Attachments

Attachment 1 – Regulatory Agency Consultation Log

Agency	Details of Consultation
EPA	1517_610_002_Water Management Plan v3 issued to Matt Corradin (matt.corradin@epa.nsw.gov.au) on 15 June 2016. Letter response received 15 September 2016, advising that EPA acknowledge the development of these plans in consultation with the EPA is a general requirement, however in their capacity as a regulator, they do not review or approve such plans, as their role is to establish and regulate against environmental protection and management criteria.
DoI *(previously DPI Water)*	1517_610_002_Water Management Plan v3 issued to John Galea (john.galea@dpi.nsw.gov.au) on 15 June 2016. Response received via Department of Planning and Environment on 19 August 2016. Feedback incorporated into the Water Management Plan v5 issued to DPI Water 20 September. Meeting at DPI Water was held on 13 September 2016 to discuss monitoring approach and improvement to inflow estimates Response received via email on 14 December 2016 Feedback incorporated into Water Management Plan vFinal issued to DPI Water December 2016. Final feedback from DPI Water received 19 May 2017, and V8 amended to include responses to final comments.
Water NSW	Feedback from Water NSW via letter on 8 June 2016 incorporated into the Water Management Plan v3 issued to DPI Water 15 June 2016. 1517_610_002_Water Management Plan v3 issued to Ravi Sundaram (ravi.sundaram@waternsw.au) on 15 June 2016. Response received via Department of Planning and Environment on 19 August 2016. Feedback incorporated into the Water Management Plan v5 issued to Water NSW20 September. Response comments received via email on 17 November 2016. Feedback incorporated into Water Management Plan Final version issued to Water NSW December 2016.