Hy-Tec Industries Pty Limited

ABN: 90 070 100 702

Austen Quarry
Stage 2 Extension Project

Surface Water Assessment

Prepared by

Groundwork Plus

September 2014

Specialist Consultant Studies Compendium
Volume 1, Part 2

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Surface Water Assessment

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CONTENTS

CONTENTS

Page

CONTENTS

CONTENTS

Page

TABLES

CONTENTS

Page

GRAPHS

DIAGRAMS

CONTENTS

Page

APPENDICES

FIGURES

EXECUTIVE SUMMARY

This Surface Water Management and Discharge Assessment (SWMDA) was prepared as Part 2 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.

The principal objectives of the SWMDA are as follows.

- To segregate stormwater sub-catchments with similar uses, levels of disturbance and risk of pollution as clean, dirty and contaminated sub-catchments.
- To ensure adequate control measures are implemented to manage runoff from disturbed areas.
- To implement appropriate measures to eliminate or reduce pollutant and sediment loading in stormwater discharges from disturbed areas.
- To preserve downstream water quality.
- To reduce the potential for erosion on-site and subsequent sedimentation of natural waterways.
- To prevent the release of untreated stormwater from disturbed areas.
- To provide a framework for the surveillance, response and reporting of incidents which may impact on stormwater quality.
- To provide a basis for the training of quarry personnel for the management of stormwater and minimisation of the potential for stormwater contamination.

The Stage 2 Extension would result in an increase in the impact footprint of those catchments associated with the overburden emplacement (A1) and extraction area (L1 and L2) and consequntial decrease in the area of a small number of undisturbed catchments (A2, B and F). The remaining catchments of the Stage 2 Site (operational catchments J3 and K3 and undisturbed catchments C, D, G1, G2, H, I1, I2, J1, J2, K1, K2 and K4) would remain unchanged.

The Stage 2 Extension proposes no new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI.

The Stage 2 Extension presents no greater opportunity for contaminants to enter the groundwater or adjacent water ways, with no uncontrolled releases predicted to occur from the extraction area catchments (L1 and L2). However, the extraction area is likely to require dewatering of groundwater and surface runoff collected within the extraction to ensure ongoing extraction operations. Dewatering of the extraction area would involve the transfer of water to storage dams SD1 and SD2 for appropriate treatment (i.e. flocculation) prior to being released into Coxs River. With no proposed changes in on-site water conveyancing structures or predicted change in geology within the extraction area, the water quality and maximum controlled discharge rate of treated waters are predicted to be similar to pre-Stage 2 Extension.

The proposed lateral extent of the extraction area is predicted to interfere with groundwater, however, no identifiable impact is predicted on groundwater recharge flows to adjacent waterways, users or on water quality (i.e. groundwater and surface).

Uncontrolled discharges of potentially sediment laden water are predicted to continue from existing ancillary operational catchments J3, K3 and A1 via sediment basins SB1, SB2b and SB3a/ SB3b respectively. The receiving environment is identified as a sensitive environment, which has a high conservation value and supports human uses (i.e. raw water supply) that are particularly sensitive to degraded water quality. In accordance with the *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, sediment basins on site are required to be designed to achieve required water quality for storms up to the nominated five-day duration for the 95th percentile event. An assessment of storage capacities of existing sediment basins (SB1, SB2b, SB3a, SD1, SD2 and SD6) was undertaken to determine whether these provide the required minimum design storage capacity, which found SB1, SB2b and SB3a to be undersized.

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 extraction area. The Water Balance model was used to estimate the potential frequency and volume of discharges (controlled and uncontrolled) from on-site storages for prolonged (over a period of 35 years) dry (15th percentile) and wet (90th percentile) climatic scenarios. Climate data was sourced from the 66 years of data from the nearest available meteorological station (Lowther Park), including with and without mitigative water management measures. The outcome of the water balance assessments predicted that uncontrolled discharges would continue to be released from existing operational catchments J3, K3 and A1 via SB1, SB2b, SB3 (a/b) respectively for the duration of the Stage 2 Extension.

For overburden emplacement catchment (A1), modelling predicts that the installation of SB3b would eliminate uncontrolled discharges during a dry year and restrict to three (3) the number of discharge events during a wet year (with a predicted total estimated volume of 1.4ML). The frequency and volume of uncontrolled discharges would improve upon the pre-Stage 2 Extension water management.

By optimising the design holding capacity of SB2b, which accepts runoff from the Yorkeys Creek stockpile area, the frequency and volume of discharges would be an improvement upon the pre-Stage 2 Extension water management. Through adoption of the recommended water management protocols (i.e. in-situ treatment and control discharging), zero uncontrolled discharge events can be achieved during a dry year, and four (4) untreated/uncontrolled discharge event (covering a total of 8 days) during a wet year, with a predicted total estimated volume of 1.2 ML discharged.

For catchment K3 modelling demonstrates that there will be no change in the predicted frequency or volume of waters discharged via SB1, with 10 and 29 uncontrolled discharges totalling 41.1ML and 74ML per annum predicted during a dry and wet year respectively. Through the continuation of on-site water management involving the transfer of excess waters from SB1 to alternative sediment basins that have sufficient excess holding capacity above their own design requirements (SD6, SD1 and SD2) and redirecting overflow from the clean water catchment sediment basin SD5, the frequency and volume of uncontrolled discharges from SB1 can be significantly reduced, to less than if the design holding capacity of SB1 was optimised to meet regulatory requirements without the on-site water management system continuing.

A review of available on-site water monitoring results indicate that water released from operational areas pose a potential risk to the receiving aquatic ecosystem/s and downstream water suitability for identified environmental values (EVs) as follows.

- Protection of Aquatic Ecosystems (elevated Turbidity, Total Suspended Solids, Total Nitrogen, Dissolved Copper).

- Recreation Purpose (elevated Turbidity, Total Suspended Solids, Total Manganese and Ammonia concentrations).
- Long-term irrigation (elevated Total Nitrogen).
- Drinking water supply (elevated Turbidity, Biochemical Oxygen Demand, and Total Aluminium and Total Nitrogen concentrations).

Although uncontrolled discharges of water 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 Proposal 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 would need to be considered.

- Ensure that all sediment basins, except 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).
- Installation of new sediment basin (SB3b), downstream of the overburden emplacement area footprint prior to the commencement of Stage 2 Extension, with a peak storage capacity of approximately 12.3ML to meet minimum regulatory requirements.
- Increase in the storage capacity of SB2b to achieve the required minimum design storage volume of 4ML.
- 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.
- Continuation of 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.
- Discharge of in-situ treated water from SB1 in SD1 and SD2 to Coxs River on an as needs basis to regain design storage capacity.
- Discharge of in-situ treated water 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 **Figure 6** to **18**.

On-going monitoring is also recommended of all implemented SSEC measures and on-site water releases (i.e. controlled and uncontrolled) to provide on-going assessment and improvement, if and where necessary to verify the carrying out of Stage 2 Extension has a neutral to beneficial effect on water quality of the receiving.

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1. INTRODUCTION

1.1 BACKGROUND

Groundwork Plus has been engaged by RW Corkery & Co Pty Ltd (RWC) on behalf of Hy-Tec Industries Pty Ltd (Hy-Tec) to prepare a Surface Water Management and Discharge Assessment (SWMDA) for the Stage 2 Extension of the Austen Quarry ("the Stage 2 Extension"), located on Jenolan Caves Road, Hartley.

The Stage 2 Extension represents a State Significant Development (SSD) in accordance with Schedule 1 (7) of the State Planning Policy (SEPP) (State and Regional Development 2011) and therefore requires an Environmental Impact Statement (EIS) to support the application pursuant to the requirements of the *Environmental Planning Assessment Act 1979* (EP&A Act). This report was prepared as Part 9 of a Specialist Consultant Studies as compendium which accompanies the EIS for the Stage 2 Extension.

1.2 SCOPE

The SWMDA provides strategies to control stormwater runoff from the proposed Stage 2 Extension and prevent or mitigate contamination of receiving aquatic environments and/or water bodies with pollutants such as silts and chemical residues (oils, greases and fuels).

This SWMDA sets out to:

- describe the site and identify potential impacts on the surrounding environment;
- identify legislation, impacts and issues associated with operations set practical and environmentally sound strategies and methods for the design, construction and management of stormwater runoff and erosion and sediment controls;
- describe audit and review processes;
- identify means of assessing whether non compliance events occur; and
- detail actions to be taken if objectives are not met.

This SWMDA also includes the following

- Catchment delineation and segregation of disturbed areas and undisturbed areas.
- Catchment hydrology and stormwater conveyance.
- Estimation of sediment transport from the disturbed areas of the quarry.
- Operational phase stormwater management and erosion and sediment control measures.
- Site Water Balance and estimation of frequency and volume of discharge from site water storages.
- Establishment of water quality objectives for the receiving waters.
- Assessment of discharge water quality against established water quality objectives for the receiving waters.
- Maintenance and Monitoring Program.

1.3 OBJECTIVES

The principal objectives of the SWMDA are as follows.

- To segregate stormwater sub-catchments with similar uses, levels of disturbance and risk of pollution as clean, dirty and contaminated sub-catchments.
- To ensure adequate control measures are implemented to manage runoff from disturbed areas.
- To implement appropriate measures to eliminate or reduce pollutant and sediment loading in stormwater discharges from disturbed areas.
- To preserve downstream water quality.
- To reduce the potential for erosion on-site and subsequent sedimentation of natural waterways.
- To prevent the release of untreated stormwater from disturbed areas.
- To provide a framework for the surveillance, response and reporting of incidents which may impact on stormwater quality.
- To provide a basis for the training of quarry personnel for the management of stormwater and minimisation of the potential for stormwater contamination.

These objectives would be achieved through the implementation of the following measures.

- Management strategies designed to minimise water pollution from the Stage 2 Extension Project.
- Specific operational phase controls to minimise sediment and nutrient export from the Stage 2 Extension Project.
- Optimising the volume of stormwater discharged from the Austen Quarry ("the Quarry") having regard to the mass and concentration of contaminants expected to reach the receiving waters.
- Segregating stormwater by quality or source.
- Reducing contaminant concentrations by the use of appropriate treatment methods.
- Designing a system able to accommodate staged development of the quarry.

1.4 PROJECT DESCRIPTION

1.4.1 Industry Type and Size

Hy-Tec has approval to operate the Austen Quarry on Lot 1 DP1005511, Jenolan Caves Road, Hartley, New South Wales ("the Site") owned by the Hartley Pastoral Corporation Pty Ltd (HPC); approximately 3.5km south-southwest of the village of Hartley and 10km south of Lithgow (see **Figure 1 – Site Location Plan**). The extent of the HPC owned land surrounding the Site provides a large buffer around the land leased by Hy-Tec.

The Quarry is currently operating under Development Consent No. 103/94 (DA 103/94), which based on the current quarry design and operations ("Stage 1"), is approved until March 2020. The current operation incorporates the following domain areas:

- The Stage 1 extraction area and associated overburden emplacement.
- A primary crushing station within the extraction area.
- A secondary processing area and associated product stockpiling areas.
- A product stockpile area referred to as "Yorkey's Creek Stockpile Area".
- Associated infrastructure including administration offices, amenities and weighbridges ("Administration Area").
- Structures associated with water supply, surface water and wastewater management and sediment and erosion control.

- Sealed quarry access road from Jenolan Caves Road to provide access to and from the Quarry for personnel and product transportation.

These site features of the existing quarry are shown on **Figure 2 – Quarry Layout Plan**.

The Stage 1 extraction area is approved to a depth of 730 m AHD and covers approximately 12.1 ha. Benches have been developed at between 10 m and 15 m vertical intervals with the extraction faces being 70° or steeper. Extraction of the resource is undertaken using conventional drilling and blasting methods. Surface vegetation is first cleared by bulldozer and stockpiled for placement over sections of the quarry to be rehabilitated. Any available soil resources are then stripped and stockpiled for spreading over rehabilitated slopes of the overburden emplacement, or other areas of the quarry to be rehabilitated. Any rippable rock below the soil and above the primary resource is ripped, loaded to haul trucks and placed within the rock emplacement. Non-rippable overburden and rhyolite is blasted (using ANFO) to fragment the material such that it can either be loaded and hauled to either the overburden emplacement or the primary crusher located on the 750m AHD level within the extraction area for crushing and delivery (by conveyor) to the remaining crushing and screening operations. Current blast sizes vary according to the location within the extraction area but generally vary from 10,000t through to 100,000t (with an average of approximately 60,000t).

The overburden emplacement has been developed immediately adjacent to the extraction area (to the south), partially in-filling the head of a gully between the 730 m AHD and 780 m AHD elevations. Covering an area of approximately 6.8 ha, the outer slopes of the overburden emplacement have been progressively rehabilitated through direct seeding and tube stock planting.

Hy-Tec proposes an extension of the extraction area and overburden emplacement covering approximately 25.7ha within Lot 1 and 2 on DP1005511 and Lot 31 on DP1009967 ("Stage 2 Extension"). All existing and proposed extraction, processing, stockpiling and transportation operations are located in an area leased by Hy-Tec from HPC. The Stage 2 Extension involves increasing the size and depth of the Stage 1 extraction area by 15.8 ha and overburden emplacement by 9.9 ha. The increase of the extraction area would be undertaken progressively via several stages. A list of these proposed stages of extraction area development and associated year of commencement has been presented in **Table 1 – Proposed Staging and Year of Commencement of Extraction Area Development**.

Table 1 – Proposed Staging and Year of Commencement of Extraction Area Development

Stage of Extraction Area Development	Predicted Year of Commencement
A	1
B	2
C	5
D	10
E	20
F	30
G	35

The footprints of the Stage 2 Extension are shown in **Figure A1** to **Figure A8** of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**.

The resource on-site consists of rhyolite, which is suitable as a source rock for aggregate, road pavements, drainage media, rip rap and a wide range of other hard rock quarry products. Quarrying of the rhyolite on the hilltop deposit would continue to entail open-face extraction by terracing using standard quarrying methodologies as follows.

- Clearing of areas to be quarried, and stripped of topsoil for reuse in rehabilitation.
- Stripping of overburden for relocation to an overburden emplacement or re-use as fill in on-site development/rehabilitation.
- Drilling and blasting of overburden and rhyolite.
- Loading of the blasted material into haul trucks for transport to onsite processing facilities (including belt conveyor transportation system, crushing and screening).
- Stockpiling of final products awaiting sale.

The existing development consent allows extraction to a depth of 730m AHD. The Stage 2 Extension proposes to increase the maximum depth of the extraction area to approximately 685m AHD. The extension will allow access to additional rhyolite (45 million tonnes), which would extend the life of the quarry by approximately 30 years.

Rhyolite extracted from the quarry would continue to be processed in the existing primary and secondary processing areas. Operation of the processing areas, stockpiling areas and administration areas of the quarry, which are approved under the existing development consent, are not expected to change as the quarry transitions into Stage 2.

The area encompassing the existing quarry and proposed extension is approximately 144 ha, which represents 0.21 per cent of the Coxs River Upstream Catchment from the head waters to Austen Quarry and approximately 0.08 per cent of the overall Coxs River Drainage basin. Although the Quarry covers only a small percentage of the overall catchment basin, based on its nature, area of disturbance and location within the Sydney Drinking Water Catchment (SDWC), the activity is considered to be high risk.

1.4.2 Existing Approvals

The Quarry is operated with the following development consent and licence.

- Development Consent DA 103/94 issued by the Council of the City of Greater Lithgow (now Lithgow City Council) on 22 March 1995, most recently modified by Lithgow City Council on 27 November 2012.
- Environment Protection Licence 12323 issued by the New South Wales (NSW) Environment Protection Authority (EPA). This licence is renewed annually with the renewal date being 1 July.

In addition, the following water licence has been issued to Hy-Tec under Section 87B of the *Water Management Act 2000* which provides access to water for harvesting and reuse on the Site.

- WAL 25616: allows for 20 units (1 unit = 2 ML) to be extracted from the Upper Nepean and Upstream Warragamba Water Source (Coxs River) of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources annually.

Hy-Tec has lodged an application with the NSW Office of Water (NOW) for a Controlled Activity Approval under the *Water Management Act 2000* for the ongoing activities within 40 m of the Coxs River. Hy-Tec has also lodged an application for a zero allocation Water Access Licence (WAL) for the Coxs River Fractured Rock Aquifer groundwater source.

1.4.3 Mobile Equipment

The Applicant currently operates the following mobile equipment within the extraction area and on the overburden emplacement.

- 1 x 85t excavator.
- 2 x 40t articulated haul trucks.
- 1x drill rig.
- 1 x bulldozer.

Two front-end loaders are also operated at the quarry with their use shared between the extraction area, processing area and various stockpiles. Depending on production rates, the above mobile equipment is supplemented by the hire of a second excavator and up to two additional haul trucks.

1.4.4 Hours of Operation

The current approved hours of operation is presented in **Table 2 – Hours of Operation** below.

Table 2 – Hours of Operation

Activity	Monday to Friday	Saturday	Sundays/Public Holidays
Extraction and Processing	6:00 AM to 6:00 PM	7:00 AM to 3:00 PM	No Activity
Blasting	9:00 AM to 5:00 PM	No Activity	No Activity
Product Loading and Transportation	5:00 AM to 10:00 PM	5:00 AM to 3:00 PM	No Activity

1.4.5 Existing Infrastructure and Services

Key infrastructure within the quarry includes the following:

- A hardstand area located to the immediate west of the processing operations (referred to as the Administration Area) on which the following has been constructed:
  - An administration centre incorporating demountable offices, amenities block and weighbridge.
  - An enclosed workshop constructed over a concrete floor.
  - An enclosed fuel storage building, constructed over a concrete bunded floor. Separate bunds are maintained within the structure for fuel, oils and lubricants.
  - Parking facilities for employees and visitors.
  - A meteorological station.
- A network of unsealed roads, tracks and erosion and sediment control structures.
- A sealed Quarry Access Road from the Jenolan Caves Road to Yorkeys Creek Crossing. This includes a centre-line the length of the road between the intersection with Jenolan Caves Road and a substantial culvert crossing of Yorkeys Creek to the immediate west of the weighbridge.
- Electrical power for all quarry operations is supplied by diesel powered generators. One large generator (1 000kVA) provides power to the primary crushing station, two large generators (1 000kVA) provide power to the secondary and tertiary crushing and screening operations and a fourth smaller generator provides power to the Administration Area.

1.4.6 Site Personnel

A total of 16 people are currently directly employed at the Austen Quarry. It is estimated that indirect employment, i.e. through transport operations, maintenance and other supply industries, of at least 40 people is also generated by the quarry.

1.4.7 Potential Contaminants of Concern

The most common sources of surface water contamination from on-site quarrying are summarised in **Table 3 – Potential Contaminants On-site**.

Table 3 – Potential Contaminants On-Site

Potential Source	Potential Contaminants
Sediment-laden runoff from overburden emplacements, waste-rock dumps, raw stockpiles, extraction area	Suspended Solids, pH, Salinity, Nitrate, Total Nitrogen, toxicants (metals/metalloids)
Sediment-laden runoff from erosion of exposed natural soils from land disturbance	Suspended Solids, Total Phosphorous, Nitrate, Total Nitrogen, pH, Salinity, toxicants (metals/metalloids)
Stormwater contamination from processing plant, workshops, fuel storage, vehicle wash-down areas, etc.	Salinity, Nitrate, Total Nitrogen, Pathogens (Faecal Coliforms), Heavy Metals, PAHs, Surfactants, hydrocarbons

2. SITE DESCRIPTION

2.1 CLIMATE

The climate of the Lithgow area is classified according to the Köppen climate classification as oceanic with warm summers, cool to cold winters and generally steady precipitation all year round.

2.1.1 Rainfall

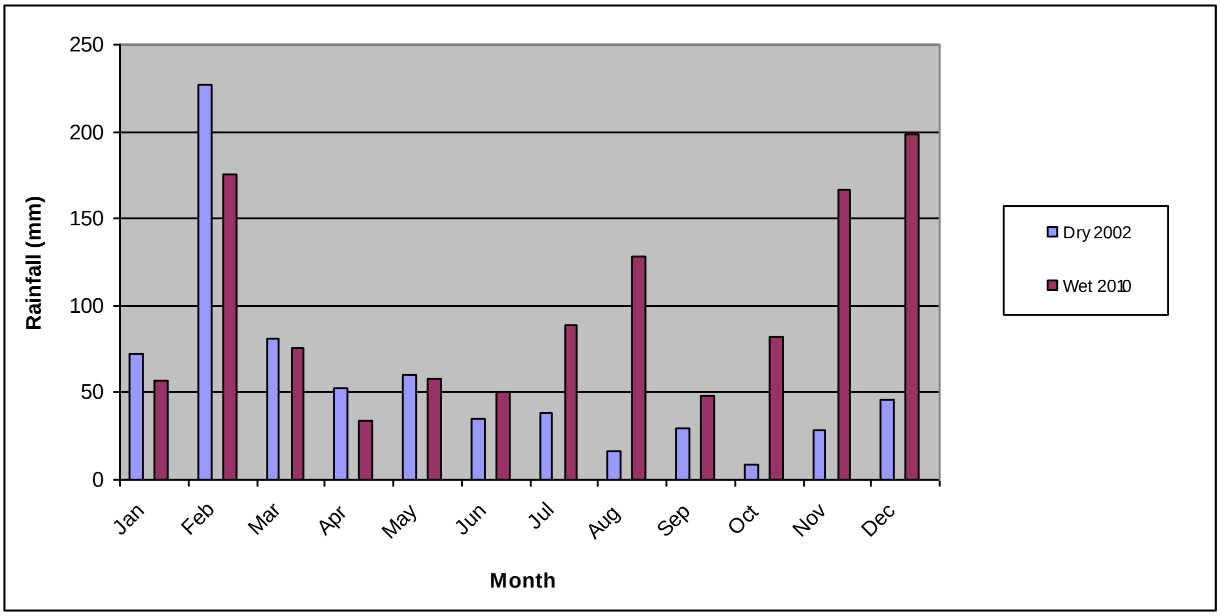
Daily rainfall observations were sourced from the Bureau of Meteorology (BoM) website for the synoptic open station Lowther Park (Station no. 063049), which is situated approximately 7 km southwest of the Site. From 66 years of data recorded at this open station, the rainfall statistics were derived to model the water balance for the dry (15^{th} percentile) and wet (90^{th} percentile) scenarios. See **Table 4 – 15^{th} and 90^{th} Percentile Rainfall Statistics** and **Graph 1 – 15^{th} and 90^{th} Percentile Monthly Rainfall** for the estimated rainfall statistics.

Table 4 – 15^{th} and 90^{th} Percentile Rainfall Statistics

15^{th} Percentile Rainfall (mm/month)													
YEAR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**ANNUAL**
2002	72.2	226.6	81.2	52.2	60.4	35.0	38.0	16.2	29.4	9.2	28.2	45.6	694.2
90^{th} Percentile Rainfall (mm/month)													
YEAR	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**ANNUAL**
2010	57.4	175.6	75.8	34.2	57.6	50.8	88.6	128.6	48.4	82.6	167.2	198.8	1165.6

Source – Lowther Park (Station No. 063049) opened in 1945)

Graph 1 – 15th and 90th Percentile Monthly Rainfall



2.1.2 Evaporation

Evaporation data is not measured by the Bureau of Meteorology in Lithgow. Evaporation is measured at the Bathurst Agricultural Station. The quarry is located approximately 55km east of Bathurst. Bathurst is at a similar elevation and a similar geographical location to the Site and is therefore considered to provide the most indicative evaporation data for the Site. The evaporation data is mean data for the period 1966 to 2013.

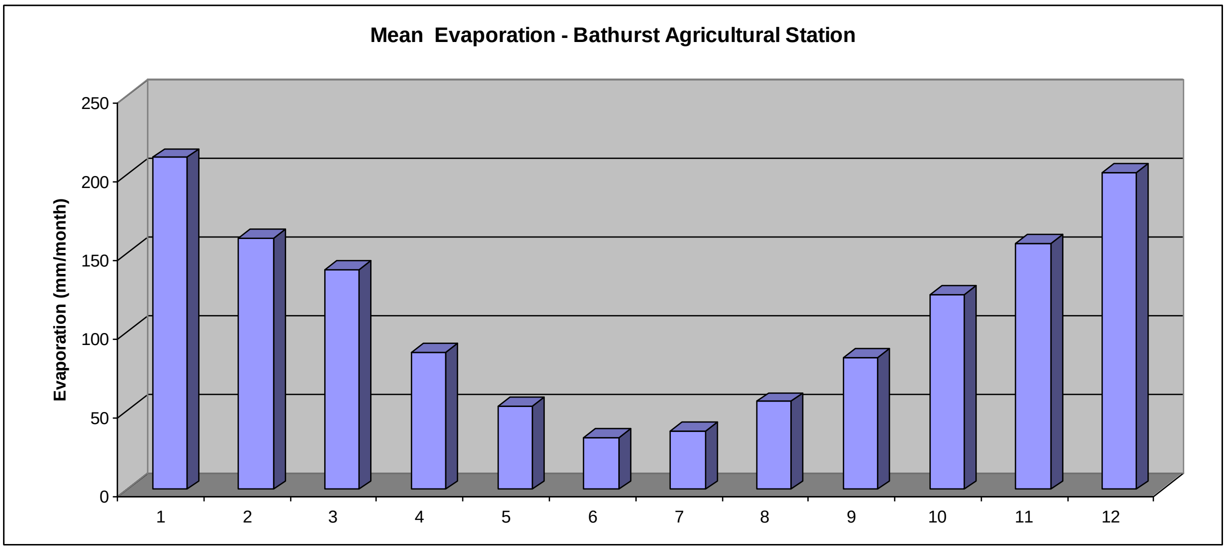
Mean daily evaporation rates sourced from the synoptic weather station Bathurst Agricultural Station (Station no. 063005) have been used to estimate mean monthly evaporation rates and these have been applied in the water balance assessment. The mean daily and mean monthly evaporation rates are summarised in **Table 5 – Mean Daily and Monthly Pan Evaporation Rates for Bathurst Agricultural Station** and graphically represented in **Graph 2 – Mean Monthly Pan Evaporation (Bathurst Agricultural Station)**.

Table 5 – Mean Daily and Monthly Pan Evaporation Rates for Bathurst Agricultural Station

Month	Mean Daily PE (mm)	Mean Monthly PE (mm)
Jan	6.8	210.8
Feb	5.7	159.6
Mar	4.5	140.0
Apr	2.9	87.0
May	1.7	52.7
June	1.1	33.0
July	1.2	37.2
Aug	1.8	55.8
Sept	2.8	84.0
Oct	4.0	124.0
Nov	5.2	156.0
Dec	6.5	201.5
Annual		1341.1

PE = pan evaporation

Graph 2 – Mean Monthly Pan Evaporation (Bathurst Agricultural Station)



Rainfall and evaporation data provided in **Section 2.1.1 Rainfall** and **Section 2.1.2 Evaporation** respectively, has been used to construct an MS-Excel based daily step probabilistic water balance model for various scenarios for the Stage 2 Extension. The Water Balance model was constructed to analyse potential discharges/annum, as well as dewatering rates from the quarry void and site water storages.

See **Section 4.0 Water Management** for details of the Water Balance Assessment for the Stage 2 Extension.

2.2 TOPOGRAPHY AND DRAINAGE

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

Elevated areas along the Jenolan Caves Road to the west of the Quarry Site reach elevations in excess of 900m AHD.

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

The Coxs River is the primary surface water drainage adjacent to the Quarry Site. Yorkeys Creek is the only other substantial drainage close to the Quarry Site. Yorkeys Creek stretches over a distance of approximately 4km 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. Yorkeys Creek runs in a south west to north east direction from Jenolan Caves Road to the Coxs River. Yorkeys Creek discharges into the Coxs River to the west of the Administration Area and secondary processing area. In the vicinity of the Quarry Site, Yorkeys Creek has an elevation less than 700m AHD. Yorkeys Creek drains the elevated ridges along Jenolan Caves Road (in excess of 900m). The Yorkeys Creek valley is a physical boundary which keeps surface water from the elevated western portion of the HPC property from the area immediately adjacent to the Site.

The elevated areas adjacent to the quarry typically drain into surrounding gullies which typically discharge into the Coxs River within 1km of the ridge tops

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, where colluvium is present.

Water falling within the existing extraction area is captured in a depression 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 / SD4) to the north of the Quarry. Water is discharged occasionally into the Coxs River in accordance with Environment Protection Licence 12323.

Surface water and groundwater seepage which accumulates in the depression adjacent to the primary crusher is removed periodically to SD3/SD4 for settlement and treatment.

2.3 GEOLOGY

The Site is located within the Central Tablelands of NSW. Based on information published in the "Sydney, 1:250,000 Geological Series Sheet S1 56-5 (1966)" the Site is situated on volcanics of the Lower to Middle Devonian to Lower Carboniferous Period. These include "rhyolite and rhyo-dacites", "adamellite, granite and granodiorite", "gabbro and diorite" and "quartzite, sandstone, siltstone and claystone". The extraction area of the Quarry targets an extrusion of rhyolite. The rhyolite is typically surrounded by granite. To the east of the Site sedimentary sandstones, shales and coal measures overly the volcanics and express themselves as the sandstone cliffs and escarpments of the Blue Mountains.

The Site is characterised by steep terrain with outcropping rock and little or no topsoil, and is bordered by the Coxs River to the north and east. Given the upland environment the Coxs River features large cobble and boulders and has little or no floodplain. Lower gullies at the Site appeared to feature accumulations of colluvium from the upper slopes. The gullies were typically became wider and flatter further down slope.

2.4 GROUNDWATER

A groundwater assessment for the Stage 2 Extension has been undertaken by Ground Doctor Pty Ltd (Ground Doctor, 2014). The assessment investigated the potential for Stage 2 Extension to impact on the quality and/or quantity of groundwater available within a 5 km radius of the proposed extension area. The proposed Stage 2 Extension is classified as an aquifer interference activity, and is therefore subject to the provisions of the *NSW Department of Primary Industries (DPI) Aquifer Interference Policy* (2012).

An assessment of available data indicated that groundwater is present beneath the Site at a depth of approximately 730m AHD, the elevation of the current extraction area floor. The proposed extension would result in the lateral extension of the extraction area to the east and to a maximum depth of RL 685m AHD, some 45m below the water table but will remain well above the Coxs River and above the elevation of most surrounding natural drainage gullies. Groundwater would have to be removed from the extraction area as it extends below the water table, resulting in a lowering of the water table of the Site and the adjacent fractured rock. Approximately 45m of drawdown would occur; however, drawdown is not expected to propagate a significant distance due to the low permeability nature of the fractured rock and the presence of aquifer boundaries in all directions from the extraction area. Drawdown from the proposed Stage 2 Extension may result in a minor reduction in the availability of groundwater to the upper slopes of gullies which direct flow to the Coxs River. These impacts would be restricted to slopes surrounding the extraction area only. It is predicted that

drawdown impacts would be negligible at a distance of approximately 225m from all sides of the extraction area (Groundwater Doctor, 2014).

No registered groundwater users have been identified within the maximum possible extent of the drawdown impacts around the quarry.

The preliminary groundwater assessment found that the proposed Stage 2 Extension presents little opportunity for contaminants to enter the groundwater. With the exception of fuel, hydraulic fluids, automotive chemicals and explosives, no chemicals would be used on the Site as part of the proposed Stage 2 Extension. Risks posed by the presence of these chemicals within the extraction area can be adequately addressed through implementation of appropriate environmental management procedures. Processing of extracted rhyolite is restricted to crushing and screening only.

Groundwater dependant ecosystems and culturally significant groundwater receptors have not been identified within the study area. Ground Doctor (2014) predicts that standing water levels between the extraction area and surrounding gullies, including Yorkeys Creek, would remain more elevated than the gullies; therefore a hydraulic gradient would be maintained toward the gullies allowing for groundwater to continue to discharge, or to maintain pre-development conditions.

Ground Doctor (2014) concludes that potential aquifer drawdown and water quality impacts associated with the Stage 2 Extension would be minimal, as defined by the *NSW Aquifer Interference Policy* (NSW DPI, 2012) and although Stage 2 Extension would intercept the water table, in accordance with section 89J of the EP&A Act, no water management or water supply work licence is required under the *Water Management Act 2000*.

2.5 SOILS AND EROSION HAZARD ASSESSMENT

2.5.1 Description of Site Soils

Soil mapping undertaken by the Department of Land and Water Conservation (DLWC) and the Sydney Catchment Authority (SCA) indicates that the existing processing area is located on the Marrangaroo Soil Landscape and both the existing and proposed extraction areas are located on the Mount Walker Soil Landscape.

The soil landscape mapping describes the Mount Walker Soil Landscape occurring on steep to very steep hills with narrow, rounded crests on the Lambie Group Metasediments. It comprises of yellow earths, lithosols, leached loams, red and yellow podzolic soils and soloths.

The soil landscape mapping describes the Marrangaroo Soil Landscape occurring on rolling hills and narrow flat to rounded convex crests on carboniferous granite. It comprises of yellow podzolic soils, earthy sands, siliceous sands, lithosols, minimal prairie soils, alluvial soils and yellow solodic soils.

An investigation of soils on the Site was undertaken by Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd. Soils were investigated within the proposed extraction area extension by hand digging two test pits and using other exposures of batters formed by the excavations for drill rig platforms.

The investigation showed the soils conform to the expectation of the soil landscape mapping. Very gravelly, quartz rich, shallow, soils (lithosols) were encountered over the proposed extraction area. The top soil is thin (50 – 100 mm) and poorly formed. It consists of sandy loam with a small (10%) portion of coarse fragments derived from the parent rock. The subsoil consists of fine sandy loam to fine sandy clay loam with variable gravel content (10 to 60 percent) of the parent material (angular quartzite and schists).

Occasionally there are thicker pockets of finer soil but, equally, there are localised areas where bedrock is exposed. Bedrock depth is consistently less than 1.0 m.

2.5.2 Soil Erosion Potential

The soils investigation (SEEC Pty Ltd, December 2013) also assessed the susceptibility of site soils to erosion (sheet and wind erosion). The results of the soil erodibility (K-factor) analyses on the four soil samples (top soil and sub soil samples from two test pits) indicates that the K-factor ranges from 0.023 (moderate) to 0.048 (high). Therefore, despite the gravelly nature of the soils in the work area, they have been found to be moderately to highly erodible.

Laboratory analysis was also undertaken to test the soils' susceptibility to wind erosion. The results of the analyses indicate that the soils have a moderate to high susceptibility to wind erosion.

2.5.3 Soil Dispersibility Potential

Emerson Aggregate Test (EAT) testing was undertaken as part of the soil investigation (SEEC Pty Ltd, October 2013) to identify potential for dispersibility. The results of the testing indicated that the soils encountered in the test pits are not dispersible.

Further analysis undertaken in accordance with methods listed in *Managing Urban Stormwater: Soils and Construction, 2004 (NSW Government)* indicated that the soils identified in Test Pit 1 (TP1) was found to be Type D – Significantly Dispersible, while the soils in Test Pit 2 (TP2) were classified as Type C – Coarse.

The Exchangeable Sodium Percentage (ESP) was calculated to determine the sodicity of the soils. The results of the calculation indicated that all soils encountered within the test pits were non-sodic.

2.5.4 Analysis of Chemical Test Results

The soils encountered in TP1 and TP2 were analysed for Salinity, Cation Exchange Capacity (CEC), Base Saturation, pH and Organic Matter during the course of the soul investigation (SEEC Pty Ltd, October 2013). The results of these analyses are summarised below:

- Soils in the test pits have been found to be non-saline.
- The soils have been found to have very low CEC, ranging between 2.5 and 5.6.
- The results of the base saturation analysis indicated that despite their relative infertility, nutrient status is moderate in all samples and that some leaching of nutrients has occurred.
- The results of pH testing indicated that the soils encountered in TP1 and TP2 are moderately to very strongly acidic (ranging from 4.6 to 5.6).
- Topsoil across the Site is believed to have very high organic matter content.

2.6 FLOODING

The Secondary Processing Area has been constructed on 'waterfront land', as defined by the *Water Management Act 2000*, incorporating an elevated hardstand and bund within 40m of the Coxs River channel. While not defined, this is likely to affect flows within this stretch of the river when the water level is elevated. It is noted that these works have been constructed in accordance with the development consent and following the issue of a Permit (No. PAR9012617) issued under the now repealed *Rivers and Foreshores Improvement Act 1948*. Hy-Tec has made application to the NSW Office of Water for a Controlled Activity Approval for these works to replace PAR9012617.

It is also noted that Yorkeys Creek is also subject to flooding. However, following a flood event in February 2005, considered a 1 in 150 year ARI event (Parsons Brinkerhoff, 2005), it is confirmed that the Secondary Processing Area is not affected (and therefore not constrained) by local flooding. The existing Yorkeys Creek crossing has been designed and constructed to account for the flood recorded in February 2005.

The Stage 2 Extension Project proposes no new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI; therefore, no detail flood assessment is considered warranted.

3. CATCHMENT DELINEATION AND HYDROLOGY

3.1 BACKGROUND INFORMATION AND CATCHMENT MAPPING

Mapping and analysis of the regional catchments of the Quarry have previously been undertaken as part of the Soil and Water Management Plan (July 2006) prepared by RW Corkery and Co Pty Ltd in conjunction with GSS Environmental (see **Appendix B Soil and Water Management Plan, RW Corkery**). These regional catchments are presented on Figure 1 – AUS10 Rhyolite Quarry Regional Catchments (RWC, July 2006) and summarised in **Table 6 – Regional Catchments, Austen Quarry**.

Table 6 – Regional Catchments, Austen Quarry

Catchment	Area (ha)	Description
1	103	Extraction area, processing area, Quarry site access road and quarry site facilities
2	115	Overburden emplacement
3	740	Site Access Road, Yorkeys Creek Crossing
4	195	Site Access Road

Source – Soil and Water Management Plan, RW Corkery and Co Pty Ltd, July 2006

3.2 PRE QUARRY EXTENSION

3.2.1 Catchment Delineation and Description of Existing Controls

Using available aerial imagery and topographical data for the site and its surroundings, a desktop analysis and mapping of the quarry catchments was undertaken by Groundwork Plus in November 2013. This was supported by a site assessment conducted by Groundwork Plus personnel on the 21st of November 2013.

A catchment delineation plan has been developed based on the findings of the desktop analysis and the site assessment; see **Figure 3 – Catchment Delineation Plan For Existing Operations** for details. The catchments have been segregated based on the level of disturbance, current use and existing stormwater management controls. These are listed in **Table 7 – Pre Quarry Catchment Delineation**.

Table 7 – Pre Quarry Catchment Delineation

Catchment	Area (ha)	Level of Disturbance	Description
A1	9.86	Partially Disturbed	Includes the existing overburden emplacement, access road and upstream densely vegetated area currently conveying runoff to existing Sediment Basin 3 (SB3). Overflows from SB3 are conveyed to Coxs River within an existing natural drainage line.
A2	104.86	Undisturbed	Includes densely vegetated and grassed areas currently conveying runoff to Coxs River within multiple existing natural drainage lines and as overland sheet flow.
B	17.79	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
C	12.91	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
D	6.96	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
E	24.75	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.

Table 7 – Pre Quarry Catchment Delineation (Cont'd)

Catchment	Area (ha)	Level of Disturbance	Description
F	9.61	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
G1	3.85	Partially Disturbed	Includes vegetated areas, previously established access track and Storage Dams 1 and 2 (SD1 and WSD2). SD1 and SD2 were originally constructed as farm dams. SD1 currently receives water pumped via sub-surface drainage from the quarry sump in the primary processing area. Overflows from SD1 are conveyed overland to SD2. WSD1 and SD2 also receive overland flow runoff from the surrounding undisturbed catchment. Water within SD2 is pumped via sub-surface drainage to Sediment Basin 1 (SB1) located in the quarry's processing and stockpiling area. During extreme rainfall events excess water within SD2 is discharged to Coxs River using existing infrastructure (pump and sub-surface drainage) to reinstate freeboard.
G2	7.47	Partially Disturbed	Includes vegetated areas and previously established access track. Runoff from this catchment is discharged to Coxs River as overland sheet flow. During extreme rainfall events water from SD2 is discharged to this catchment and eventually to Coxs River.
H	3.85	Undisturbed	Includes densely vegetated and grassed areas currently conveying runoff to Coxs River.
I1	5.20	Partially Disturbed	Includes vegetated areas and previously established access track conveying runoff to Coxs River.
I2	0.85	Partially Disturbed	Includes vegetated areas and previously established access track conveying runoff to Coxs River.
J1	9.34	Undisturbed	Includes densely vegetated areas conveying runoff to Storage Dam 4 (SD4). Overflows from SD4 are conveyed to SB1 via a series of catch drains.
J2	8.59	Partially Disturbed	Includes the extraction area access road and densely vegetated areas conveying runoff to Storage Dam 3 (SD3). Overflows from SD3 are conveyed to SB1 via a series of catch drains.
J3	17.60	Heavily Disturbed	Includes part of the Quarry Access Road, secondary processing area, Administration Area and other amenities conveying runoff to SB1 via a series of catch drains, sub-surface drainage and overland sheet flow. Overflows from SB1 are conveyed to Coxs River (licensed by EPL 12323) via existing outlet pipes (900 mm diameter and 1050 mm diameter) and an existing spillway.
K1	42.61	Partially Disturbed	Includes part of the Quarry's Access Road, Storage Dam 5 (SD5), Storage Dam 6 (SD6) and relatively undisturbed areas upstream of SD6. SD6 receives runoff in the form of concentrated flows within an existing natural drainage line as well as overland sheet flow. Overflows from SD5 are discharged to SD6 over an existing embankment between the two dams. SD5 and SD6 also receive runoff from the Quarry Access Road via a series of contour drains that have been established along the road. Water from SD6 is pumped to SB1 to reinstate freeboard within SD6 during periods of low rainfall. Water is regularly recycled between SD6 and SD2. It is also anticipated that during periods of extreme rainfall SD6 overtop and discharge to Yorkeys Creek.
K2	686.42	Undisturbed	Includes Yorkeys Creek catchment to the Yorkeys Creek crossing culvert on the Quarry Access Road.
K3	6.01	Heavily Disturbed	Includes Yorkeys Creek stockpile area with flows conveyed to Sediment Basin 2a (SB2a) which primarily acts as a sediment forebay. Overflows from SB2a are conveyed via a catch drain to Sediment Basin 2b (SB2b). Low flows from SD4 are conveyed to Yorkeys Creek via an existing pipe outlet while high flows are discharged via an existing spillway.

Table 7 – Pre Quarry Catchment Delineation (Cont'd)

Catchment	Area (ha)	Level of Disturbance	Description
K4	3.42	Undisturbed	Includes grassed areas downstream of SB2b and Yorkeys Creek Crossing conveying runoff to Coxs River.
L	13.31	Heavily Disturbed	Includes the extraction area, haul roads and the primary crushing station. This catchment also includes a sump located adjacent to the primary crusher structure as well as the quarry drop cut. Water within the sump is pumped to SD1, as well as gravity fed to SB1 using sub-surface drainage.

3.2.2 Catchment Volumetric Runoff

An estimate of the peak runoff volumes generated by the various catchments of the existing quarry has been calculated using the following formula in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW Department of Environment and Climate Change (DECC), 2008.*

$$\mathbf{V = 10 \times C_V \times A \times R_{Y\%ile,\ x\text{-}day}\ (m^3)}$$

Where:
10 = a unit conversion factor
C_V = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period
R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events.
A = total catchment area (ha)

Assumptions

The following assumptions have been made in the calculation of peak catchment runoff volumes from the various disturbed and undisturbed catchments of the quarry:

- A conservative C_V value of 0.74 has been assumed for all disturbed and undisturbed catchments of the quarry. The C_V values has been sourced from Table F2 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, DECC, 2008* and has been assumed based on the following assumptions:
  - Soils within the current operational area and Stage 2 Extension belong to Soil Hydrologic Group D; and
  - Rainfall depth of 56.4 (95^{th} percentile 5-day rainfall depth) for Lithgow in accordance with Table 6.3a of Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, DECC, 2008.

The peak runoff volumes generated by the existing catchments of the quarry are listed in **Table 8 – Pre Quarry Extension Catchment Runoff Volumes**.

Table 8 – Pre Quarry Extension Catchment Runoff Volumes

Catchment ID	Catchment Area (ha)	Runoff Volume (m^3)
A1	9.860	4,115
A2	104.860	43,764
B	17.790	7,425
C	12.910	5,388
D	6.960	2,905
E	24.750	10,330
F	9.610	4,011
G1	3.850	1,607
G2	7.470	3,118
H	3.850	1,607
I1	5.200	2,170
I2	0.850	355
J1	9.340	3,898
J2	8.590	3,585
J3	17.600	7,346
K1	42.610	17,784
K2	686.420	286,484
K3	6.010	2,508
K4	3.420	1,427
L	13.310	5,555

3.3 CHARACTERISATION OF ON-SITE WATERS

The following sections present a characterisation of the on-site waters based on available on-site analytical data provided by RWC.

3.3.1 Extraction Area

Groundwater seepage and stormwater runoff within the extraction area is directed to one of two sumps; 1) Extraction Area Sump (Sump 1) and 2) load-out conveyor sump (Sump 2). Water quality within Sump 1 and Sump 2, based on samples collected on 12 August 2014, is presented in **Table 9 – Extraction Area Water Quality**.

Table 9 – Summary of Extraction Area Water Quality

Parameter	LOR	Sump 1	Sump 2
Sample Date		12/08/2014	12/08/2014
Physico-Chemical			
Electrical Conductivity (EC) (µS/cm)	1	1,150	1280
Total Dissolved Solids (TDS) (mg/L)	1	780	840
Metals/Metalloids (Dissolved) (µg/L)			
Arsenic (As)	1	2	3
Cadmium (Cd)	0.1	<0.1	<0.1
Chromium (Total) (Cr)	1	<1	<1
Copper (Cu)	1	2	2
Nickel (Ni)	1	<1	<1
Lead (Pb)	1	<1	<1
Zinc (Zn)	5	<5	20
Mercury (Hg)	0.1	<0.1	<0.1
Metals/Metalloids (Total) (µg/L)			
Arsenic (As)	1	2	4
Cadmium (Cd)	0.1	0.2	<0.1
Chromium (Cr) (total)	1	<1	<1
Copper (Cu)	1	2	2
Lead (Pb)	1	<1	<2
Mercury Hg)	0.1	<0.1	<0.1
Nickel Ni)	1	2	3
Zinc (Zn)	5	<5	18
Major Ions and Nutrients (mg/L)			
Ammonia (NH_4)	0.01	1.85	4.27
Total Nitrogen (TN)	0.01	11.8	16.4
NO_x as N	0.01	9.21	11.9
Nitrite as N(NO_2)	0.01	0.37	0.44
Nitrate as N (NO_3)	0.01	8.84	11.5
TKN	0.01	2.6	4.5
Total Phosphorus (TP)	0.01	<0.01	<0.01

Notes: na = no data available; LOR = Limits of Reporting

3.3.2 Sediment Basin 3a

Stormwater runoff from the existing overburden emplacement is currently directed to an existing sediment dam, Sediment Basin 3a (SB3a). A historical statistical summary of the water quality within SB3a for the period between February and November 2013 is presented in **Table 10 – Summary Statistics of SB3a Water Quality**.

Table 10 – Summary Statistics of SB3a Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)	2	6.4	7.7	-	-	-
Electrical Conductivity (EC) (µS/cm)	2	180	680	-	-	-
Dissolved Oxygen (DO) (mg/L)	1	8.0	8.0	-	-	-
Biological Oxygen Demand (BOD) (mg/L)	1	1	1	-	-	-
Turbidity (NTU)	2	65	938	-	-	-
Total Suspended Solids (TSS) (mg/L)	2	22	354	-	-	-
Total Dissolved Solids (TDS) (mg/L)	2	121	456	-	-	-
Metals/Metalloids (Dissolved) (µg/L)						
Aluminium (Al) (pH > 5)	1	20	20	-	-	-
Iron (Fe)	1	<1	<1	-	-	-
Metals/Metalloids (Total) (µg/L)						
Aluminium (Al) (pH > 5)	1	1,210	1,210	-	-	-
Arsenic (As)	1	3	3	-	-	-
Cadmium (Cd)	1	<1	<1	-	-	-
Chromium (Cr) (total)	1	<1	<1	-	-	-
Chromium VI (Cr IV)	1	<1	<1	-	-	-
Copper (Cu)	1	4	4	-	-	-
Iron (Fe)	1	1,350	1,350	-	-	-
Lead (Pb)	1	2	2	-	-	-
Manganese (Mn)	1	672	672	-	-	-
Mercury (Hg)	1	<0.1	<0.1	-	-	-
Nickel (Ni)	1	<1	<1	-	-	-
Zinc (Zn)	1	9	9	-	-	-
Major Ions and Nutrients (mg/L)						
Ammonia (NH_4)	1	0.14	0.14	-	-	-
Total Nitrogen (TN)	1	3.2	3.2	-	-	-
NO_x-N	1	1.81	1.81	-	-	-
Total Phosphorus (TP)	1	0.08	0.08	-	-	-

Notes: na = no data available
- = n is insufficient to calculate statistic
LOR = Limits of Reporting

3.3.3 Sediment Basin 1

Sediment laden runoff from the secondary processing and Administration Areas (i.e. Catchment J3) is directed into Sediment Basin 1 (SB1) through a series of existing stormwater conveyance structures (culverts, sub-surface drainage and catch drains). SB1 also receives runoff from a small undisturbed catchment area upstream of the pug mill, see **Figure 3 – Catchment Delineation Plan for Existing Operations**. Additionally, overflows from clean catchment water storage dams SD3 and SD4 are also diverted to SB1 via a series of conveyance structures (culverts, sub-surface drainage and catch drains). A historical statistical summary of the water quality within SB1 for the period between February and November 2013 is presented in **Table 11 – Summary Statistics of SB1 Water Quality:**

Table 11 – Summary Statistics of SB1 Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	10	6.6	7.9	7.5	0.4	7.9
EC (µS/cm)	10	200	780	330	157	605
DO (mg/L)	1	8.3	8.3	na	-	-
BOD_5 (mg/L)	8	1	3	1	0.9	3
Turbidity (NTU)	10	2	1,244	201	485	1,119
TSS (mg/L)	10	<5	520	108	231	516
TDS (mg/L)	10	58	368	206	90	355
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	20	20	-	-	-
Fe (total)	1	70	70	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	7,630	7,630	-	-	-
As	1	3	3	-	-	-
Cd	1	1.1	1.1	-	-	-
Cr (total)	1	3	3	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	1	14	14	-	-	-
Fe (total)	1	7,700	7,700	-	-	-
Pb	1	31	31	-	-	-
Mn	1	325	325	-	-	-
Hg	1	<0.1	<0.1	-	-	-
Ni	1	2	2	-	-	-
Zn	1	92	92	-	-	-
Major Ions and Nutrients (mg/L)						
NH_4	1	0.02	0.02	-	-	-
TN	1	1	1	-	-	-
NO_x-N	1	0.35	0.35	-	-	-
TP	1	0.05	0.05	-	-	-

Notes: ① = 20th Percentile: 7.4; 80th Percentile: 7.8; - = n is insufficient to calculate statistic

3.3.4 Storage Dam 2

Storage Dam 2 (SD2) receives inflows from SD3, excess water dewatered from SB1 and the extraction area, and runoff from an upstream slightly disturbed catchment attributed to historical and current grazing practices. A historical statistical summary of the water quality within SD2 for the period between December 2007 and August 2014 is presented in **Table 12 – Summary Statistics of SD2 Water Quality**.

Table 12 – Summary Statistics of SD2 Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	21	6.7	9.4	7.9	0.7	9.0
EC (µS/cm)	9	190	630	450	135	602
BOD_5 (mg/L)	19	1	10	3	3	10
Turbidity (NTU)	2	3	15	-	-	-
TSS (mg/L)	21	<5	495	9	118	277
TDS (mg/L)	22	96	836	280	173	741
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	10	10	-	-	-
As	1	<1	<1	-	-	-
Cd	1	<0.1	<0.1	-	-	-
Cr (total)	1	<1	<1	-	-	-
Cu	1	2	2	-	-	-
Ni	1	1	1	-	-	-
Pb	1	<1	<1	-	-	-
Zn	1	<5	<5	-	-	-
Fe (total)	1	<1	<1	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	40	40	-	-	-
As	1	1	1	-	-	-
Cd	1	<0.1	<0.1	-	-	-
Cr (total)	1	<1	<1	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	1	2	2	-	-	-
Fe (total)	1	70	70	-	-	-
Pb	1	<1	<1	-	-	-
Mn	1	20	20	-	-	-
Hg	1	<1	<1	-	-	-
Ni	1	<1	<1	-	-	-
Zn	1	<5	<5	-	-	-
Major Ions and Nutrients (mg/L)						
NH_4	1	0.02	0.02	-	-	-
TN	1	0.3	0.3	-	-	-
NO_x-N	1	<0.1	<0.1	-	-	-
TP	1	<0.1	<0.1	-	-	-

Notes: ① = 20th Percentile: 7.4; 80th Percentile: 8.3; na = not applicable; - = n is insufficient to calculate statistic
Analysis data assumed to be representative of untreated water within SD4.

3.3.5 Storage Dam 6

Storage Dam 6 (SD6) is located near the Quarry Access Road, adjacent to Yorkeys Creek. Overflows from SD5 are discharged to SD6 over an existing embankment/grass spillway or siphoned via an existing pipe for supplementary water reuse on-site, inflows of excess water dewatered from SB1 is also received by SD5 and SD6 also receives overland flows from a small, partially disturbed catchment. A historical statistical summary of the water quality within SD6 for the period between December 2007 and August 2014 is presented in **Table 13 – Summary Statistics of SD6 Water Quality**.

Table 13 – Summary Statistics of SD6 Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	24	6.5	9.7	8.0	0.5	8.7
EC (µS/cm)	8	200	830	453	241	812
BOD_5 (mg/L)	23	1	9	3	2	6
Turbidity (NTU)	2	74	133	-	-	-
TSS (mg/L)	24	<5	95	14	27	82
TDS (mg/L)	25	80	736	292	147	535
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	20	20	-	-	-
As	1	<1	<1			
Cd	1	<0.1	<0.1			
Cr (total)	1	<1	<1			
Cu	1	2	2			
Ni	1	<1	<1			
Pb	1	<1	<1			
Zn	1	<5	<5			
Fe (total)	1	<1	<1	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	1,250	1,250	-	-	-
As	2	1	1	1	-	-
Cd	2	0.1	0.2	-	-	-
Cr (total)	2	<1	<1	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	2	2	6	-	-	-
Fe (total)	1	1,850	1,850	-	-	-
Pb	2	<1	5	-	-	-
Mn	1	241	241	-	-	-
Hg	2	<0.1	<0.1	-	-	-
Ni	2	<1	1	-	-	-
V	1	20	20	-	-	-
Zn	1	<5	<5			
Major Ions and Nutrients (mg/L)						
NH_4	2	0.03	0.6	-	-	-
TN	2	3.4	9.5	-	-	-
NO_x-N	2	2.32	8.29	-	-	-
TP	2	<0.01	0.05	-	-	-

Notes: ① = 20th Percentile: 7.7; 80th Percentile: 8.2; - = n is insufficient to calculate statistic

3.3.6 Sediment Basin 2b

Overflows from SB2b containing finer sediments from the Yorkeys Creek Stockpile Area are discharged to SB2b via an existing catch drain. SB2b also receives runoff carrying finer sediments produced by the existing steep batters of material stockpiles along the edge of the Yorkeys Creek Stockpile Area. A summary of the water quality within SB2b based on a sample collected in November 2013 is presented in **Table 14 – Summary Statistics of SB2 Water Quality**.

Table 14 – Summary Statistics of SB2b Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	1	8.2	8.2	-	-	-
EC (µS/cm)	1	860	860	-	-	-
DO (mg/L)	1	8.6	8.6	-	-	-
BOD_5 (mg/L)	1	127	127	-	-	-
Turbidity (NTU)	1	31	31	-	-	-
TSS (mg/L)	1	576	576	-	-	-
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	20	20	-	-	-
Fe (total)	1	<LOR	<LOR	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	2,060	2,060	-	-	-
As	1	<LOR	<LOR	-	-	-
Cd	1	0.3	0.3	-	-	-
Cr (total)	1	<1	<1	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	1	8	8	-	-	-
Fe (total)	1	2,940	2,940	-	-	-
Pb	1	6	6	-	-	-
Mn	1	232	232	-	-	-
Hg	1	<0.1	<0.1	-	-	-
Ni	1	<1	<1	-	-	-
Al (pH > 5)	1	29	29	-	-	-
Major Ions and Nutrients (mg/L)						
NH_4	1	0.03	0.03	-	-	-
TN	1	3.3	3.3	-	-	-
NO_x-N	1	2.17	2.17	-	-	-
TP	1	0.08	0.08	-	-	-

Notes: - = n is insufficient to calculate statistic

3.4 POST QUARRY EXTENSION

3.4.1 Catchment Delineation

The post quarrying catchments for each stage of quarry development (Stage A through to Stage G) are listed in **Table 15 – Post Quarry Development Catchment Delineation** and shown on Figure A1 to Figure A8 of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**.

Table 15 – Post Quarry Development Catchment Delineation

<table>
<tr><th colspan="2" rowspan="2">Catchment ID</th><th colspan="8">Catchment Area (ha)</th></tr>
<tr><th>Existing</th><th>Stage A</th><th>Stage B</th><th>Stage C</th><th>Stage D</th><th>Stage E</th><th>Stage F</th><th>Stage G</th></tr>
<tr><td colspan="2">A1</td><td>8.47</td><td>8.38</td><td>18.970</td><td>19.500</td><td>18.810</td><td>17.250</td><td>16.490</td><td>16.490</td></tr>
<tr><td colspan="2">A2</td><td>12.65</td><td>11.01</td><td>89.880</td><td>88.860</td><td>88.860</td><td>88.190</td><td>87.100</td><td>87.100</td></tr>
<tr><td colspan="2">A3</td><td>90.54</td><td>90.39</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">B</td><td>17.67</td><td>17.420</td><td>16.990</td><td>16.370</td><td>15.390</td><td>15.260</td><td>15.260</td><td>15.260</td></tr>
<tr><td colspan="2">C</td><td>12.91</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td></tr>
<tr><td colspan="2">D</td><td>6.96</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td></tr>
<tr><td colspan="2">E</td><td>25.54</td><td>25.060</td><td>24.180</td><td>23.590</td><td>21.970</td><td>21.970</td><td>20.600</td><td>20.600</td></tr>
<tr><td colspan="2">F</td><td>9.24</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td></tr>
<tr><td colspan="2">G1</td><td>3.85</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td></tr>
<tr><td colspan="2">G2</td><td>7.47</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td></tr>
<tr><td colspan="2">H</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td></tr>
<tr><td colspan="2">I1</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td></tr>
<tr><td colspan="2">I2</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td></tr>
<tr><td colspan="2">J1</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td></tr>
<tr><td colspan="2">J2</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td></tr>
<tr><td colspan="2">J3</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td></tr>
<tr><td colspan="2">K1</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td></tr>
<tr><td colspan="2">K2</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td></tr>
<tr><td colspan="2">K3</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td></tr>
<tr><td colspan="2">K4</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td></tr>
<tr><td rowspan="2">L</td><td>L1</td><td rowspan="2">16.35</td><td>16.180</td><td>16.520</td><td>16.290</td><td rowspan="2">26.27</td><td rowspan="2">28.62</td><td rowspan="2">31.83</td><td rowspan="2">31.83</td></tr>
<tr><td>L2</td><td>2.850</td><td>4.750</td><td>6.690</td></tr>
</table>

3.4.2 Catchment Volumetric Runoff

The peak runoff volumes generated by the post Stage 2 Extension catchments have been calculated using the formula and the assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff** The peak runoff volumes for the post quarry development catchments are summarised in **Table 16 – Post Quarry Development Catchment Runoff Volumes**.

Table 16 – Post Quarry Development Catchment Runoff Volumes

Catchment ID	Current Operations	End of Stage 1	Stage						
			A	B	C	D	E	F	G
A1	4,115	3,535	3497	7,917	8,139	7,851	7,199	6882	6882
A2	43,764	43,067	42320	37,512	37,087	37,087	36,807	36352	36352
B	7,425	7,375	7270	7,091	6,832	6,423	6,369	6,369	6,369
C	5,388	5,388	5388	5,388	5,388	5,388	5,388	5,388	5,388
D	2,905	2,905	2905	2,905	2,905	2,905	2,905	2,905	2,905
E	10,330	10,659	10459	10,092	9,846	9,169	9,169	8,598	8,598
F	4,011	3,856	3827	3,827	3,827	3,827	3,827	3,827	3,827
G1	1,607	1,607	1607	1,607	1,607	1,607	1,607	1,607	1,607
G2	3,118	3,118	3118	3,118	3,118	3,118	3,118	3,118	3,118
H	1,607	1,607	1607	1,607	1,607	1,607	1,607	1,607	1,607
I1	2,170	2,170	2170	2,170	2,170	2,170	2,170	2,170	2,170
I2	3,55	355	355	355	355	355	355	355	355
J1	3,898	3,898	3898	3,898	3,898	3,898	3,898	3,898	3,898
J2	3,585	3,585	3585	3,585	3,585	3,585	3,585	3,585	3,585
J3	7,346	7,229	7229	7,229	7,229	7,229	7,229	7,229	7,229
K1	17,784	17,784	17784	17,784	17,784	17,784	17,784	17,784	17,784
K2	286,484	286,484	286484	286,484	286,484	286,484	286,484	286,484	286,484
K3	2,508	2,508	2508	2,508	2,508	2,508	2,508	2,508	2,508
K4	1,427	1,427	1427	1,427	1,427	1,427	1,427	1,427	1,427
L – L1	5,555	6,824	6753	6,895	6,799	10,964	11,945	13,285	13,285
L – L2			1431	1,982	2,792				

Catchment A2 is split into two additional sub-catchments in the End Stage 1, Stage A and Stage B scenarios of extraction area development. For these stages the runoff volumes generated by sub-catchments A2 and A3 have been combined.

3.4.3 Comparative Assessment of Pre and Post Extension Catchment Runoff Volumes

A comparative assessment of catchment runoff volumes for the pre and post extension scenarios was undertaken. The results of this analysis are summarised in **Table 17 – Comparison Pre - Quarry and Post - Quarry Extension Catchment Runoff Volumes**.

The Stage 2 Extension Project would have no effect on the footprints of existing operational catchments J3 and K3 as well as the undisturbed catchments C, D, G1, G2, H, I1, I2, J1, J2, K1, K2 and K4; however, would have an increase in the footprints *of operational catchments A1* and L (sub-catchments L1 and L2), and reduction of the footprints of undisturbed catchments *A2,* B and F.

Table 17 – Comparison of Pre and Post Extension Catchment Runoff Volumes

Catch-ment ID	Current Operations	–End Stage 1	Change (Current – to End of Stage 1)	Stage A	Change	Stage B	Change	Stage C	Change	Stage D	Change	Stage E	Change	Stage F	Change	Stage G	Change
A1	4115	3,535	-16.4%	3497	-1.1%	7,917	55.8%	8,139	2.7%	7,851	-3.7%	7,199	-9.0%	6882	-4.6%	6882	0.0%
A2	43764	43,067	-1.6%	42320	-1.8%	37,512	-12.8%	37,087	-	37,087	-	36,807	-	36352	-	36352	-
B	7425	7,375	-0.7%	7270	-1.4%	7,091	-2.5%	6,832	-3.8%	6,423	-6.4%	6,369	-0.9%	6,369	0.0%	6,369	0.0%
C	5388	5,388	0.0%	5388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%
D	2905	2,905	0.0%	2905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%
E	10330	10,659	3.1%	10459	-1.9%	10,092	-3.6%	9,846	-2.5%	9,169	-7.4%	9,169	0.0%	8,598	-6.7%	8,598	0.0%
F	4011	3,856	-4.0%	3827	-0.8%	3,827	0.0%	3,827	0.0%	3,827	0.0%	3,827	0.0%	3,827	0.0%	3,827	0.0%
G1	1607	1,607	0.0%	1607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%
G2	3118	3,118	0.0%	3118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%
H	1607	1,607	0.0%	1607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%
I1	2170	2,170	0.0%	2170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%
I2	355	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%
J1	3898	3,898	0.0%	3898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%
J2	3585	3,585	0.0%	3585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%
J3	7346	7,229	-1.6%	7229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%
K1	17784	17,784	0.0%	17784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%
K2	286484	286,484	0.0%	286484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%
K3	2508	2,508	0.0%	2508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%
K4	1427	1,427	0.0%	1427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%
L – L1	5,555	6,824	18.6%	6753	-1.1%	6,895	2.1%	6,799	-1.4%	10,964	13%	11,945	8.2%	13,285	10.1%	13,285	0.0%
L – L2				1431	100.0%	1,982	27.8%	2,792	29.0%								

Notes:
1. Sub-catchments L1 and L2 represent the two extraction areas that will be merged to form one larger pit post Year 5 extraction. .
2. (-) indicates a decrease in the catchment run off volume.
3. 0 indicates no change in the catchment runoff volume.
4. In order to determine the change in runoff volume for the extraction areas, the runoff volumes for Catchments L1 and L2 for Years 1, 2 and 5 have been clumped together.
5. Catchment A2 is split into two additional sub-catchments in the End of Stage 1, Stage A and Stage B scenarios of pit development. For these stages of development, the runoff volumes generated by sub-catchments A2 and A3 have been combined.

3.4.4 Location and Configuration of Water Releases

Uncontrolled releases are predicted to occur from SB1, SB3a and SD2 into Coxs River, at monitoring EPL Point 1, 9 and 10 respectively, and SB2b and SD6 into Yorkeys Creek, at monitoring EPL Point 8 and 11 respectively, during or immediately following storm events that exceed the established sediment basin or storage dam holding capacity. Uncontrolled releases at each of these locates are released via an existing grass or rock lined emergency spillway or pipe outlet structure (i.e. SB1).

Controlled releases of treated sediment basin waters occasionally occur from SB2b into Yorkeys Creek, at monitoring EPL Point 8, and from SB3a and SD2 into Cox River at monitoring EPL Point 9 and 10 respectively. Treated Waters from operational areas waters at each location are release via existing pipe outlet structure using a pump or gravity fed in the case of SD2.

The location of the controlled and uncontrolled site water releases have been shown on **Figure 4 – Discharge and Water Monitoring Location Plan**.

4. WATER MANAGEMENT

The Applicant has implemented a sustainable water management system, which aims for the current and future operations to be 100% self-sufficient in water, excluding drinking water supply. A sustainable water management system has been developed based upon capturing stormwater run-off for dust suppression and environmental controls.

The system is based upon capturing the water supply within the extraction area and pre-quarry farm dams; SD1, SD2, SD5 and SD6. These dams capture water prior to being re-used on site or released directly, or indirectly via Yorkeys Creek, into the Coxs River as environmental flows.

Runoff from undisturbed areas is, and would continue to be diverted around areas disturbed by quarry operations wherever practicable. This will reduce the potential for clean runoff to be polluted by quarry activities. Diversion of clean waters will be affected by contour and diversion drains, perimeter bunds and pipe culverts wherever practicable.

During extension and operation of the extraction and overburden emplacement areas, drainage will convey water from areas of disturbance to sediment basins located within the extraction area and/or around the Site (i.e. SB1, SB2a, SB2b, SD6, SD1, SD2 and SB3a/b) to prevent sediment laden or contaminated runoff leaving the Site. Sediment traps and sediment ponds form part of the Site water management system and improve water quality at various points along water drainage networks.

Excess waters are treated in-situ within SB2b, SB3a/b and SD2 using a coagulant (i.e. NALCO 8187.15H) to improve water quality prior to being pumped or drained directly or indirectly via Yorkeys Creek into the Coxs River. NALCO 8187 is a patterned coagulant, which is widely used within the water treatment industry.

Potable water supply is supplied by Lithgow City Council on an as needs basis, while sewage treatment for the offices and amenities are comprised of a self contained unit that rely upon rainwater captured of the on-site infrastructures roof-tops. No treated effluent is discharged on-site.

A schematic overview of the drainage and water management network is shown in **Figure 5 – Water Management System Schematic**.

5. STORMWATER SEDIMENT AND EROSION CONTROL MANAGEMENT

5.1 OVERVIEW OF EXISTING AND PROPOSED EROSION AND SEDIMENT CONTROL

The existing Stormwater, Erosion and Sediment Control (SSEC) measures for the disturbed and partially disturbed catchments of the quarry are shown on the following figures attached with this report:

- **Figure 6 – Stormwater, Sediment and Erosion Control Measures, Current Extraction Area**
- **Figure 7 – Stormwater, Sediment and Erosion Control Measures, Storage Dams and Coxs River Discharge**
- **Figure 8 – Stormwater, Sediment and Erosion Control Measures, Extraction Area Access Road**
- **Figure 9 – Stormwater, Sediment and Erosion Control Measures, Secondary Processing and Administration Area**
- **Figure 10 – Stormwater, Sediment and Erosion Control Measures, Yorkeys Creek Stockpile Area**
- **Figure 11 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (End of Stage 1)**
- **Figure 12 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage A)**
- **Figure 13 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage B)**
- **Figure 14 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage C)**
- **Figure 15 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage D)**
- **Figure 16 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage E)**
- **Figure 17 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage F)**
- **Figure 18 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage G)**

The following assumptions and disclaimers are made in the preparation of these conceptual stormwater management and ESC plans.

- The location and configuration of proposed stormwater management and ESC measures shown on these figures are conceptual and subject to change to suit potential future amendments to quarry staging and footprint.
- All stormwater conveyance, retardation and diversion structures (including drains and bunds) would be designed for the design minor storm event (Q_5 or Q_{10}).
- All diversion drains, drainage channels and catch drains would be rock and/or grass lined.
- Proposed sumps are non-engineered storage structures and have been provided to aid the quarry operator for the effective management of stormwater within the extraction area. The sumps shown on the above Figures have not been drawn to scale.
- All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.

Stormwater management and ESC measures in the form of flow conveyance and retardation structures (catch drain, bunds, etc.) and the provision of inlet and outlet scour protection for the retardation of flow velocity have been proposed for the existing operational areas of the quarry. These measures (included on **Figure 6** to **18**) are conceptual and broad ranging at this stage and have been proposed with a view to reducing erosion, scour and sedimentation.

The receiving environment has been identified as a sensitive environment, which has a high conservation value and supports human uses of water that are particularly sensitive to degraded water quality. In accordance with *Table 6.1 Recommended minimum design criteria for temporary erosion and sediment control measures at mines and quarries* of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, sediment basins on site are required to be designed to achieve required water quality for storms up to the nominated five-day duration for the 95th percentile event.

The 95th percentile, five-day rainfall depth of 56.4 mm for Lithgow, listed in *Table 6.3a 75th, 80th, 85th, 90th and 95th-percentile 2 and 5-day rainfall depths for 59 sites in New South Wales* of *Managing Urban Stormwater, Soils and Construction – Volume 1, NSW DECC, 2008*, has been adopted as the design rainfall depth to calculate the required storage capacities of onsite sediment basins.

The formula listed below has been used to calculate the storage capacities of sediment basins.

$$V = 10 \times C_V \times A \times R_{Y\%ile,\ x\text{-day}}\ (m^3)$$

Where:
10 = a unit conversion factor
C_V = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period. A volumetric runoff coefficient of 0.74 has been adopted for the quarry.
R = is the adopted 95th percentile, 5-day total rainfall depth (mm) of 56.4 mm for Lithgow.
A = total catchment area (ha)

An assessment of storage capacities of existing sediment basins (SB1, SB2b and SB3) has also been undertaken to determine if these provided the minimum storage capacity required in accordance with the selected design criteria.

Water Storage Dams SD1, SD2, SD3, SD4, SD5 and SD6 have been used in the recycling, management and/or treatment of sediment laden water from disturbed areas. Hence, they have been considered to be sediment treatment dams and included in the assessment, where applicable.

The locations of SB1, SB2(b), SB3a/b, SD1, SD2, SD3, SD4, SD5 and SD6 are shown on **Figure 7 – Stormwater, Sediment and Erosion Control Measures, Water Storage Dams and Coxs River Discharge**, **Figure 9 – Stormwater, Sediment and Erosion Control Measures, Secondary Processing and Administration Area** and **Figure 10 – Stormwater, Sediment and Erosion Control Measures, Yorkeys Creek Stockpiling Area**.

5.2 OVERBURDEN EMPLACEMENT AREA

5.2.1 Current Scenario

Stormwater runoff from the existing overburden emplacement is currently discharged to an existing sediment basin (SB3a). No information is available regarding the current storage capacity or depth of SB3a. SB3a currently captures and treats runoff from disturbed and undisturbed areas of Catchment A1 (see **Figure 3 – Catchment Delineation Plan, Existing Operations**). Based on site observations (21 November 2013), SB3a has been assumed to have a total depth of approximately 3 m and a surface area of 1,015 m² (sourced from aerial imagery), SD1 is estimated to have a current treatment and storage capacity of approximately 3 ML. This estimated volume does not take into account batter slopes.

The design storage capacity requirement of SB3a was calculated in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, using the formula and assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**. On the basis of the conservative assumptions with respect to runoff, the analysis found that SB3a should have a total storage capacity of approximately 6.2 ML. This includes a conservative allowance of 50% of the settling zone capacity for sediment storage.

While the calculation of minimum sediment basin design capacity is likely to overestimate the minimum capacity requirement, the calculation indicates that SB3a does not have adequate storage and treatment capacity to treat sediment laden water from existing Catchment A1. The footprint of Catchment A1 is expected to increase with the proposed Stage 2 Extension (see Figure A1 to Figure A8 of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**) and therefore recalculation of an appropriately sized sediment basin, along with a review of stormwater management and ESC measures, will be necessary to ensure effective treatment of sediment laden water generated by these future proposed areas.

Stormwater, Sediment and Erosion Control (SSEC) management measures have been developed for the Stage 2 Extension in accordance with *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008* and *Best Practice Erosion and Sediment Control, International Erosion Control Association (IECA), 2008.* These SSEC management measures are explained in **Section 5.2.2 Stage 2 Extension and Development of Overburden Emplacement**.

5.2.2 Stage 2 Extension and Development of Overburden Emplacement

The development of the extraction area and the overburden emplacement would occur in 8 stages over a period of approximately 35 years. The development of the extraction area and overburden emplacement is shown on Figure A1 to Figure A8 of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**.

Specific SSEC management measures have been developed for the staged development of the extraction area and overburden emplacement. These measures are conceptual and broad ranging and designed for the effective management of stormwater runoff within the disturbed and undisturbed areas of the proposed staged development of the overburden emplacement and pit areas. These measures are shown on the following Figures:

- **Figure 11 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (End Stage1)**
- **Figure 12 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage A)**

- **Figure 13 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage B)**
- **Figure 14 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage C)**
- **Figure 15 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage D)**
- **Figure 16 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage E)**
- **Figure 17 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage F)**
- **Figure 18 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage G)**

Stormwater runoff from the overburden emplacement would be treated within a proposed new sediment basin (SB3b, see **Figure 11** to **Figure 18**) to be built downstream of the overburden emplacement area footprint. SB3b would need to be established prior to the commencement of Stage 2 Extension works (including the overburden emplacement) and has been designed in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*.

Stormwater runoff during the initial Stage 2 Extension establishment works (i.e. end of Stage 1) and Stage A would be treated within the existing sediment basin (SB3a) with overflows from SB3a discharged to the existing drainage gully and to SB3b. Therefore, SB3b would primarily function as a secondary treatment dam until Stage B of the Stage 2 Extension.

Using the same formula and conservative assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**, the minimum peak storage capacity of SB3b has been calculated as approximately 12.3 ML. The location and footprint of the proposed SB3b to provide this minimum capacity, along with associated SSEC management measures, are shown on **Figures 11** to **18**.

Flows generated within the proposed extraction area are to be managed using non-engineered sumps strategically located within the extraction area. The number and location of these sumps would vary between each stage of development of the extraction pit. The sumps have been provided to enable the quarry operator to effectively manage stormwater runoff, as well as dewater the extraction area as and when required.

See to **Figures 11** to **18** for location of the sumps and other SSEC management measures proposed for the staged extension of the extraction area.

5.3 SECONDARY PROCESSING AREA

Sediment laden runoff from the Secondary Processing Area is directed into SB1 through a series of existing stormwater conveyance structures (culverts, sub-surface drainage and catch drains) see Catchment J3 on **Figure 3 – Catchment Delineation Plan, Existing Operations**). Additionally, overflows from water storage dams SD3 and SD4 are also diverted to SB1 via a series of conveyance structures (culverts, sub-surface drainage and catch drains).

Water within SB1 is reused on-site for dust suppression of processing operations, hardstands and stockpiles. This involves the pumping of water on an as needs basis from SB1 via an existing pipeline to a 30kL above ground storage tank for the on-site water truck. As a result, the water level within SB1 is generally managed to maintain a minimum 2 m free board for stormwater control management, with excess water pumped via an existing piping system into SD1, SD2 and SD6 for temporary water storage and treatment prior to controlled discharge to Coxs River. When required, the water level within SB1 is supplemented for dust suppression by reversing the process (i.e. pumping water back from SD2 and SD6 into SB1).

Based on information received from RWC (Mr. Alex Irwin, 5 December 2013), SB1 has a total storage capacity of 6 ML. Calculated in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, using the formula and assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**, the minimum design treatment and storage capacity of SB1 is 11 ML. Even considering the conservative method of calculating sediment storage requirement (50% of settling zone), this indicates that SB1 has insufficient treatment and storage capacity to treat flows generated by Catchment J3 (under 5-day 95th percentile rainfall conditions).

The additional storage volume (5 ML) could be provided by either expanding the footprint of the existing dam or by increasing the settling depth of SB1 either via excavation or building up the embankment of the dam. Internal review of this option by Hy-Tec has been completed, however, with these options considered unfeasible due to constraints imposed by available area and geotechnical (dam wall) stability requirements.

The short fall in the total storage capacity of SB1 (i.e. approximately 5 ML) is currently managed by pumping excess water to other dams (e.g. SD1, SD2 and SD6) that have excess storage capacity above their required design capacity (by approximately 12 ML). Provided it is demonstrated to be adequate and accepted by the Environmental Protection Authority (EPA), the Applicant would continue using this alternative water management strategy over enlarging SB1. The required free board within these basins would continue to be maintained by current management practice adopted of treating excess waters in-situ (i.e. by flocculation) prior to control release off-site into the adjacent waterways.

Additionally, it is recommended that the quarry operator consider the installation of a control valve on the existing pipe outlets of SB1 to enable the operator to minimise the potential for untreated and uncontrolled releases from SB1. Other SSEC management measures recommended for the processing, stockpiling and administration areas of the quarry are shown on **Figure 8 – Stormwater and ESC Measures, Administration, Processing and Stockpiling Area**.

5.4 STORAGE DAMS 1 AND 2

On-site personnel on 21 November 2013 advised that SD1 and SD2 were historically constructed by the land owner for use as farm dams (i.e. stock watering). Currently SD1 is used as a holding dam to recycle water between Sump 1 adjacent the primary crusher within the extraction area and SB1, while SD2 is used for water treatment of excess on-site waters from Sump 1 and SB1 prior to being released under controlled conditions. SD2 is generally empty unless in use tor water treatment.

SD1 also receives overland flow runoff from an upstream clean catchment area of approximately 2.3 ha. Overflows from SD1 are discharged over an existing embankment/grassed spillway to SD2. SD2 also receives runoff from an upstream clean catchment of 1.55 ha approximately.

Advice received from RWC (Mr. Alex Irwin, 5 December 2013), current storage volume of SD1 and SD2 is approximately 3.5 ML and 5 ML respectively. An assessment of required storage volumes in accordance with *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008* revealed that SD1 and SD2 require a minimum storage capacity of approximately 1.5 ML and 1 ML respectively. Based on the above preliminary assessment, SD1 and SD2 have sufficient storage capacity to treat flows from the upstream catchments and hence there is no additional works required to increase the storage capacity of these dams. Observations made on 20 November 2013 also confirmed that appropriate freeboard is being maintained within SD1 and SD2.

Other SSEC management measures recommended for SD1 and SD2 are shown on **Figure 6 – Stormwater, Sediment and Erosion Control Measures, Water Storage Dams and Coxs River Discharge**.

5.5 STORAGE DAMS 5 AND 6

SD5 and SD6 are located to the south of the quarry access road, on an ephemeral drainage gully discharging to Yorkeys Creek. SD5 receives runoff from a clean upstream catchment covering approximately 36 ha. Overflows from SD5 are discharged to SD6 over an existing embankment/grass spillway or siphoned via an existing pipe for supplementary water reuse on-site. In addition, SD6 also receives overland flows from a small, partially disturbed catchment, covering 3.1 ha which includes a small section of the quarry access road.

In addition, excess water from SB1 is pumped to SD6 for temporary storage. On an as needs basis, water is recycled between SD6 and SB1 in order to maintain an on-site water supply for dust suppression and as a means of reinstating freeboard within SB1 following rainfall events. Overflows from SD6 are discharged to Yorkeys Creek via an existing vegetated spillway and ultimately conveyed to Coxs River.

Advice received from RWC (Mr. Alex Irwin, 5 December 2013), current storage volume of SD5 and SD6 are approximately 4 ML and 8 ML respectively. An assessment of the minimum storage volumes in accordance with Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries (NSW DECC, 2008) revealed that SD5 and SD6 require a storage capacity of approximately 22.83 ML and 2 ML respectively. Based on the above preliminary assessment, SD6 has sufficient storage capacity to treat flows from the upstream catchments and hence there is no additional works required to increase the storage capacity of this dam. The capacity of SD5 would need to be increased by 18.83 ML, however, to comply.

As an alternative, as water collected in SD5 is from non-operational areas (i.e. clean catchment), any overflow from SD5 could be diverted around SD6 and discharged directly into Yorkeys Creek. This alternative solution is preferred and would be implemented by the Applicant.

SSEC management measures recommended for SD5 and SD6 are shown on **Figure 9 – Stormwater, Sediment and Erosion Control Measures, Yorkeys Creek Stockpiling Area.**

5.6 YORKEYS CREEK STOCKPILE AREA

The Yorkeys Creek Stockpile catchment mainly comprises an area approximately 6 ha in size. Stormwater runoff from a majority of the stockpile area is conveyed overland to a non-engineered sediment basin (SB2a) located in the north-eastern corner of the stockpile area. SB2a primarily functions as a sediment forebay and captures any coarse materials while overflows containing finer sediments are discharged to SB2b via an existing catch drain. SB2b also receives a lot of runoff carrying finer sediments produced by the existing steep batters of material stockpiles along the edge of the stockpile area. Low flows from SB2b are discharged via a 200 mm diameter outlet pipe while high flows are discharged over an existing spillway and embankment to Yorkeys Creek.

No information is available regarding the current storage capacity or depth of SB2b. Based on site observations and advice received from quarry personnel during the site visit undertaken by Groundwork Plus personnel (21 November 2013), SB2b was observed to have a total depth of approximately 2 to 3 m. Based on a surface area of 935 m² (sourced from aerial imagery) and assumed total depth of 3 m, SB2b is estimated to have a current treatment and storage capacity of approximately 2.8 ML. This estimated volume does not take into account batter slopes or freeboard.

The design storage capacity of SB2b was calculated in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008* and using the formula and assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**. On the basis of the conservative assumptions with respect to runoff, the analysis found that SB2b should have a total storage capacity of approximately 4 ML. This includes a conservative allowance of 50% of the settling zone capacity for sediment storage.

While the calculation of minimum sediment basin design capacity is likely to overestimate the minimum capacity requirement, the calculation indicates that SB2b does not have adequate storage and treatment capacity to treat sediment laden water from existing Catchment K3. It is recommended that the storage capacity of SB2b be increased to achieve the required minimum design storage volume of 4 ML in accordance with *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008.* The additional storage volume can be provided by either increasing the footprint of SB2b or by raising the existing embankment and spillway.

Other SSEC management measures recommended for the Yorkeys Creek Stockpile Catchment including SB2b are shown on **Figure 10 – Stormwater and ESC Measures, Yorkeys Creek Stockpiling Area**.

6. WATER BALANCE ASSESSMENT

6.1 PURPOSE AND SCOPE OF WATER BALANCE ASSESSMENT

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 (15^{th} percentile) and wet (90^{th} percentile) rainfall scenarios. The climate data (rainfall and evaporation) used for the water balance assessment is summarised in **Section 3.1 Background Information and Catchment Mapping**.

6.2 HYDROGEOLOGICAL CONCEPTUAL MODEL

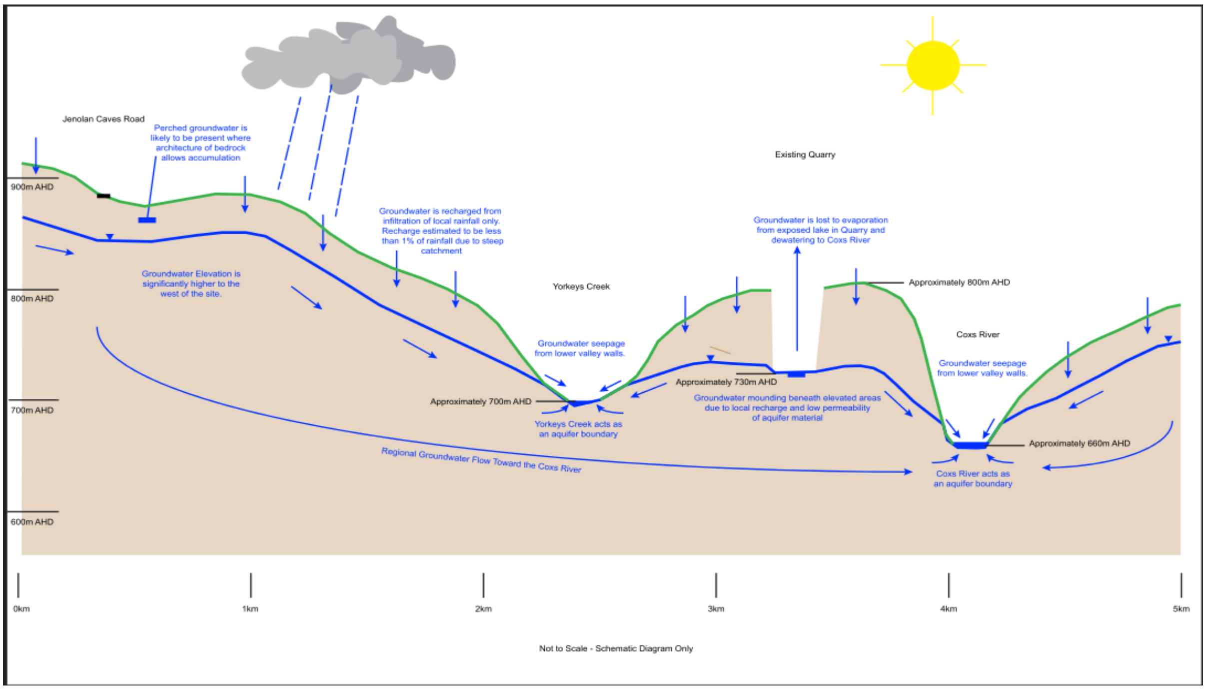
6.2.1 Existing Environment

The hydrogeological regime for the existing quarry is depicted in **Diagram 1 – Schematic of Conceptual Hydrogeological Model for the Existing Quarry** below. Groundwater beneath the Site is a mound as a result of recharge which occurs on the elevated areas of the Site and Surrounds. This water discharges into the surrounding valleys. This pattern is likely to occur across the local area beyond the Site, with local mounding of groundwater beneath elevated areas and discharge along drainage gullies and valleys. The Study Area is also likely to feature perched groundwater units where favourable architecture in bedrock allows local accumulations of rainwater infiltration above the regional water table. The valleys between elevated areas form boundaries which limit lateral movement of groundwater (Ground Doctor, 2014).

The Site is comprised of steep rocky slopes and rocky plateaus of limited area. It is expected that most rain falling within the Site would be lost to evaporation or would flow into surrounding gullies as surface runoff. Only a small portion of rainfall (less than 1%) would infiltrate the underlying fractured rock and become groundwater. The volume of rainfall infiltrating the subsurface would be offset by the volume of groundwater discharge occurring from the lower slopes or into the quarry. Groundwater discharge from the vicinity of the Site would drain into Coxs River (either directly or indirectly).

The findings of the Ground Water Assessment (Ground Doctor, 2014) have revealed that groundwater was encountered at a depth of 730 m AHD during the on-site investigation.

Diagram 1 – Schematic of Conceptual Hydrogeological Model for the Existing Quarry



Source: Draft Preliminary Groundwater Assessment –Austen Quarry Stage 2, Ground Doctor Pty Ltd, August 2013

6.2.2 Stage 2 Extension

The hydrogeological regime for Stage 2 Extension is depicted in **Diagram 2 – Schematic of Conceptual** Hydrogeological Model for Stage 2 Extension.

The main change to the groundwater regime at the Site would occur as a result of the need to lower the water table within the extraction area. The proposed Stage 2 Extension would result in extraction to a depth of approximately 685m AHD (some 45m below the current groundwater elevation). The average groundwater seepage rate over the life of the project has been predicted to be 4.3 ML/year (Groundwater Doctor 2014).

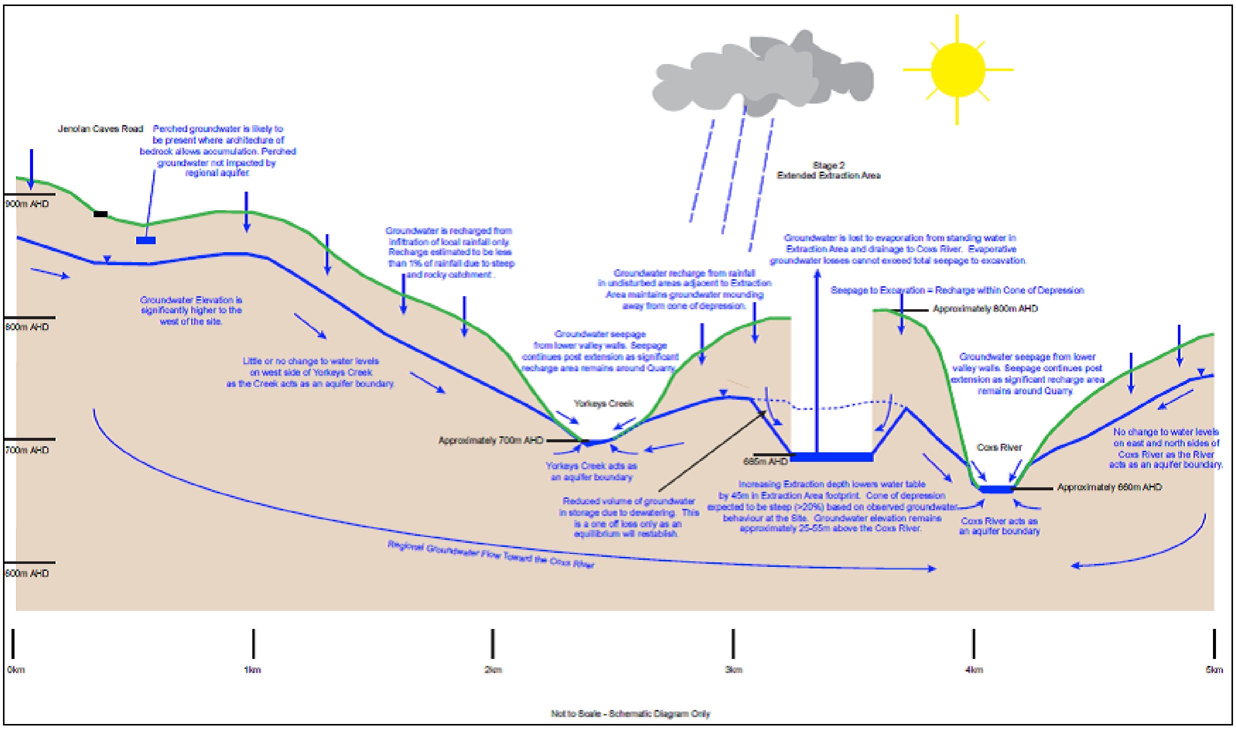
During and following extraction, a portion of the groundwater within the rhyolite hosted aquifer surrounding the extraction area would flow towards and seep into the extraction area. This is removed from the extraction area, along with accumulated surface water runoff by mechanical pumping of water from the extraction area or by gravity draining water from the extraction area to surrounding low lying areas. Some water would also be lost from the extraction area to evaporation. Ground Doctor (2014) describes this as a permanent drainage of groundwater from the aquifer within the surrounding zone of influence (cone of depression). The seepage of groundwater into the extraction area would result in the establishment of a new post-extraction SWL around the perimeter of the extraction area floor (at an elevation of approximately 685m AHD).

Once the drainage of groundwater from the cone of depression is complete, the water balance would return to pre-quarry conditions where the volume of rainfall infiltration is equal to the volume of groundwater discharge into the adjacent drains. A portion of this recharge which occurs over the cone of depression resultant from the extraction area would drain to the extraction area (and is referred to hereafter as the 'seepage' component of groundwater loss). As a result, during periods of higher infiltration, e.g. periods of heavy or sustained rainfall, groundwater seepage into the void of the final extraction area would be higher (as it would in other drains surrounding the extraction area) than during periods of low rainfall. Assuming groundwater inflow to the extraction area is redirected to the Coxs River there would be no significant long term change to the site water balance as a result of the proposed Stage 2 Extension. The only loss of water associated with the extension would be from the initial dewatering above and adjacent to the Quarry.

Elevated areas would remain around the periphery of the extraction area and groundwater recharge would still occur in these areas as it does at present. Groundwater mounding is expected to occur in the untouched areas adjacent to the extraction area and groundwater within the fractured rock adjacent to the Quarry would be expected to continue to discharge into the extraction area and into surrounding valleys.

Lowering of the water table within and surrounding the extraction area would result in a general lowering of the water table in the elevated area surrounding the Site. However, lowering of the water table beneath the extraction area is not expected to impact on areas to the west of Yorkeys Creek, to the north and east of the Coxs River and to the south of the unnamed drainage south of the Site, as these topographic features act as physical aquifer boundaries (Ground Doctor, 2014).

Diagram 2 – Schematic of Conceptual Hydrogeological Model for Stage 2 Extension of the Quarry



Source: Groundwater Assessment – Austen Quarry Stage 2, Ground Doctor Pty Ltd, August 2013

6.3 WATER BALANCE MODEL ASSUMPTIONS AND METHODOLOGY

For the purposes 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.

- 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.
- Water from the extraction area and SB1 is reused on site for dust suppression only (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 has been assumed 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.
- Water reuse 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.
- It has been assumed that dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.
- 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.

Additionally, Groundwork Plus has undertaken an analysis of daily rainfall observations sourced from the Bureau of Meteorology (BoM) website for the synoptic station Lowther Park (Station no. 063049). The data from this station was used to estimate rainfall statistics to model the water balance for the dry (15^{th} percentile) and wet (90^{th} percentile) scenarios. See **Table 3 – 15^{th} and 90^{th} Percentile Rainfall Statistics** and **Graph 1 – 15^{th} and 90^{th} Percentile Monthly Rainfall** of **section 2.1.1 Rainfall** for the estimated rainfall statistics.

As part of the climate analysis, mean daily evaporation rates sourced from the synoptic weather station Bathurst Agricultural Station (Station no. 063005) have been used to estimate mean monthly evaporation rates and these have been applied in the water balance assessment. The mean daily and mean monthly evaporation rates are summarised in **Table 4 – Mean Daily and Monthly Pan Evaporation Rates for Bathurst Agricultural Station** and graphically represented in **Graph 2 – Mean Monthly Pan Evaporation (Bathurst Agricultural Station)** of **section 2.1.2 Evaporation**.

6.4 EXTRACTION AREA WATER BALANCE

6.4.1 Scenario 1 – No Dewatering of the Extraction Area

A water balance assessment was conducted to determine the predicted standing water levels of the extraction area for the current and future development of the extraction area and associated facilities. Modelling was undertaken for the dry (15th percentile) and the wet (90th percentile) rainfall years. For the purpose of modelling, the following assumptions have been made:

- Inflows are segregated into; 1) direct rainfall, 2) overland flow and 3) groundwater seepage at an average rate of 0.0057 ML/day. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated extraction area/water storage, 2) supplementary water supply to SB1 and 3) water harvesting and reuse onsite at an average rate of 0.028 ML/day if volume is available. Evaporation from the land surface is not considered.
- Water from the extraction area is reused on-site for dust suppression which includes topping up water from the pit 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 the quarry extension.
- The residual/standing water level of the extraction area has been assumed to be zero (0) for the current year.
- The standing water level on the last day of the modelled dry and wet years have been assumed to the starting water depth/level for each succeeding year/stage of the Stage 2 Extension.
- The water balance does not take into account the additional storage that may be provided by sump/s or drop cuts.

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 18 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with No Dewatering** and **Table 19 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with No Dewatering**.

Table 18 – 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 19 – 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

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 climatic conditions. Given the nature of the extraction area, flooding of the extraction area would eventually disrupt the day to day operations of the quarry, therefore hinder quarry production rates.

Existing dewatering infrastructure (i.e. extraction area sump (sump 1) and gravity fed low flow control pipes to SB1, and SD1 and SD2, provides the capability to dewater the extraction area and transfer water from sump 1 to SB1, and SD1 and SD2 respectively. The predicted maximum daily dewatering rate of 1,900 kL/day has been calculated for each existing gravity fed low flow control pipe (i.e. two gravity fed low flow control pipelines at 950 kL/day/each) based on the assumption that the pit can be dewatered using the existing infrastructure for a maximum of 8 hours during a normal operational day at an estimated gravitational flow rate of 0.033L/s.

6.4.2 Scenario 2 – Dewatering of Extraction Area to SD1 and SD2

A water balance assessment was conducted to determine predicted dewatering rates to dewater the extraction area with water discharged to SD1 and SD2. The assessment also predicted estimated standing water levels of the extraction area for the current and future development of the extraction area and associated facilities. Modelling was undertaken for the dry (15th percentile) and the wet (90th percentile) rainfall years. For the purpose of modelling, the following assumptions have been made:

- Inflows are segregated into; 1) direct rainfall, 2) overland flow, and 3) groundwater seepage. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated extraction area 2) Supplementary water supply to SB1; 3) water harvesting and reuse onsite and 4) dewatering of pit inundated water to SD1 and SD2. Evaporation from the land surface is not considered.
- Water from the extraction area is reused on-site for dust suppression which includes topping up water from the extraction area 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 quarry pit 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 the quarry extension.
- The residual/standing water level of the extraction area has been assumed to be zero (0) for the current year.
- The standing water level on the last day of the modelled dry and wet years have been assumed to the starting water depth/level for each succeeding year/stage of the Stage 2 Extension Project.
- The predicted maximum possible daily extraction area dewatering rate has been estimated to be 950 kL/pipe line. This rate has been calculated based on the assumption that Sump 1 in the pit can be dewatered for a maximum of 8 hrs/day at an estimated peak gravitational flow rate of 0.033L/s.
- The maximum required dewatering rate to completely dewater the extraction area is dependant the physical capacity of the existing water infrastructure, standing water levels of SD1 and SD2 and prevailing climatic conditions to undertake water treatment using existing on-site methodology.
- The water balance does not take into account the additional storage that may be provided by a quarry sump/s or drop cuts.

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 20 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with Dewatering** and **Table 21 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with Dewatering**.

Table 20 – 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 21 – 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

The modelling indicated no uncontrolled discharges would occur with regular dewatering of the extraction area. 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).

6.5 STORAGE DAMS 1 AND 2

6.5.1 Scenario 1 - Water Balance of SD1 and SD2

Water balance assessments were conducted to investigate the potential frequency and volume of controlled and uncontrolled discharges to Coxs River from the existing storage dams SD1 and SD2. The assessments were conducted assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15^{th} and 90^{th} percentile rainfall respectively).

The following additional assumptions were made in the water balance assessments:

- Extraction Area is not dewatered using the existing infrastructure.
- Inflows to SD1 and SD2 are segregated into 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage and 2) uncontrolled discharges from SD1 and SD2. Evaporation from the land surface and stock watering is not considered.

The summary findings of these assessments are shown in **Table 22 – Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions** and **Table 23 – Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions**.

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.

It is understood that the current water management regime uses SD1 and SD2 to treat excess pit water and water captured in SB1 when capacity below the required freeboard is available within SD1 and SD2. A water balance assessment covering this scenario has therefore been undertaken to assess the predicted frequency and volume of controlled and uncontrolled discharges to Coxs River, see to **Section 6.5.2 Scenario 2 Water Balance of SD1 and SD2 receiving Dewatered Flows from Extraction Area**.

Table 22 – 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 23 – 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

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

Water balance assessments were conducted to investigate the potential frequency and volume of controlled and uncontrolled discharges to Coxs River from the existing water storage dams SD1 and SD2, receiving dewatered flows form the extraction area. The assessments were conducted assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively).

The following additional assumptions were made in the water balance assessments:

- For ease of modelling, the storage volumes of SD1 and SD2 have been combined.
- Inflows to SD1 and SD2 are segregated into 1) direct rainfall 2) overland flow 3) dewatered flows from the extraction area and 4) Flows pumped from SB1 to SD1 and SD2 as required to maintain freeboard within SB1. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage and 2) uncontrolled discharges from SD1 and SD2. Evaporation from the land surface and stock watering is not considered.

The summary findings of these assessments are shown in **Table 24 – Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions** and **Table 25** – **Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions**.

Table 24 – 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 25 – 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. The annual volume of controlled discharges from SD2 for the prolonged dry and wet climatic scenarios is summarised in **Table 24 – Water Balance Assessment for SD1 and SD2 Receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions** and **Table 25** – **Water Balance Assessment for SD1 and SD2 Receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions**.

The volume of water in SD2 to be treated and discharged can be reduced by diverting clean overland runoff to SD1 and SD2 which will maximise the storage capacity and hence reduce volume of discharges, see **Section 6.5.3 Scenario 3 – Water Balance of SD1 and SD2 Receiving Dewatered Flows from Extraction Area with catchment runoff diverted around SD1 and SD2** for details.

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

The Water Balance Assessments for the prolonged dry and wet climatic scenarios constructed for Scenario 2 (see **Section 6.5.2 Scenario 2 – Water Balance of SD1 and SD2 Receiving Dewatered Flows from Extraction Area**) was rerun with the assumption that the clean catchment runoff is diverted around SD1 and SD2. The results of these assessments are summarised in **Table 26 – Water Balance Assessment of SD1 and SD2 for Prolonged Dry Climatic Conditions receiving Pit Flows with Clean Runoff Diverted to Coxs River** and **Table 27 – Water Balance Assessment of SD1 and SD2 for Prolonged Wet Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River**.

Table 26 – 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 27 – 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).

6.6 SEDIMENT BASIN 3B

A water balance assessment was conducted to investigate the potential frequency of uncontrolled release to Coxs River from the proposed sediment basin 3b (SB3b) designed to receive and treat stormwater runoff generated by the proposed overburden emplacement. The assessment was conducted for a dry (15th percentile) and wet (90th percentile) rainfall year, using rainfall and evaporation data summarised in **Section 2.1.2 Rainfall** and **Section 2.1.3 Evaporation** of this report.

The water balance model for SB3b has been built based on the following assumptions:

- The storage volume of SB3b has been designed to treat runoff generated by the Year 35 footprint of the proposed overburden emplacement (i.e. peak storage capacity of 12.3 ML).
- SB3b will be constructed prior to the start of quarry and overburden emplacement extension works.

- Inflows can be segregated into; 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage, 2) controlled discharge of treated waters within 72 hours of a rainfall event, 3) uncontrolled discharges from site water. Evaporation from the land surface is not considered.

The findings of the water balance assessment for SB3b for a dry and wet rainfall year are summarised in **Table 28 - Findings of Water Balance Assessment – Proposed SB3b, Overburden Emplacement** below.

Table 28 – 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	63	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 uncontrolled 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.

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 this is as expected when considering the guidance provided by Table 6.1 of Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries (NSW DECC, 2008).

6.7 SEDIMENT BASIN 1

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

Water balance assessments were conducted to investigate the potential frequency and volume of uncontrolled discharges from SB1 to Coxs River assuming 35 consecutive years of prolonged dry (15th percentile rainfall) and wet (90th percentile rainfall) climatic conditions based on its current total storage capacity of 6 ML.

Scenario 1 for SB1 has been built based on the following assumptions:

- Inflows can be segregated into 1) direct rainfall 2) overland flow and 3) uncontrolled discharges from the overtopping of SD3 and SD4. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Minimum freeboard of 2 m or 2.34 ML is to be maintained within SB1 at all times in order to receive overland flow from the administration, processing and stockpiling areas.
- Outflows are; 1) direct evaporation from the inundated water storage, 2) extraction of water for dust suppression, and 3) uncontrolled discharges.
- Evaporation from the land surface is not considered.
- 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 has been assumed 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 dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.

The summary findings of these assessments are shown in **Table 29 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions** and **Table 30 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions**.

Table 29 – 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 30 –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 as shown in **Table 29 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions** and **Table 30 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions**.

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 minimise the frequency of uncontrolled discharges.

6.7.2 Scenario 2 – Water Balance of SB1 with Water Management

Water balance assessments were conducted to investigate the potential frequency and volume of uncontrolled discharges from SB1 to Coxs River assuming 35 consecutive years of prolonged dry (15^{th} percentile rainfall) and wet (90^{th} percentile rainfall) climatic conditions under the current water management regime. Scenario 2 for SB1 has been built based on the following assumptions:

- SB1 current total storage capacity volume of 6 ML.
- Inflows can be segregated into 1) direct rainfall 2) overland flow 3) water recycled from SD2 4) flows dewatered from extraction area using existing water management infrastructure in; the form of sump and gravity fed control pipeline and 5) water moved from SD6 as required. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Minimum freeboard of 2m or 2.34 ML is to be maintained within SB1 at all times in order to receive overland flow from the administration, processing and stockpiling areas.
- Outflows are; 1) direct evaporation from the inundated water storage, 2) extraction of water for dust suppression, 3) water moved from SB1 to SD6 and/or SD1/SD2 as and when required to reinstate freeboard within SB1. Evaporation from the land surface is not considered.

- 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 has been assumed 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 dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.

The summary findings of these assessments are shown in **Table 31 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions with On-site Water Management** and **Table 32 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions with On-site Water Management**.

Table 31 – 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	5	10.1
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 32 – 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	6	46.9
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that with on-site management of water within SB1, uncontrolled discharges from SB1 to Coxs River will be reduce 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 Yorkeys Creek, hence maximising the available storage capacity within SD6 to receive excess waters from SB1.

The following additional management measures could also be considered/adopted to reduce (if not completely eliminate) the frequency and volume of uncontrolled discharges from SB1 into Coxs River by:

- Undertaking controlled discharges of treated waters from SD6 to Yorkeys Creek to maximise the available storage capacity within SD6 to receive additional excess waters from SB1
- Undertaking controlled discharges of in-situ treated waters within SD1/SD2 to Coxs River to reinstate freeboard
- Undertaking controlled discharges of in-situ treated waters within SB1 to Coxs River to reinstate freeboard.

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

Water balance assessments were conducted for comparison to the current water management regime of the potential frequency and volume of uncontrolled discharges from SB1 to Coxs River assuming 35 consecutive years of prolonged dry (15th percentile rainfall) and wet (90th percentile rainfall) climatic conditions, in the event that the storage capacity of SB1 was to be increased to 11 ML with a minimum freeboard capacity of 7.3 ML to meet regulatory requirements.

Scenario 3 for SB1 has been built based on the following assumptions:

- SB1 has an optimised total storage and treatment capacity of 11 ML.
- Inflows can be segregated into 1) direct rainfall 2) overland flow and 3) uncontrolled discharges from the overtopping of SD3 and SD4. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Minimum freeboard holding capacity of 7.3 ML is to be maintained within SB1 at all times in order to receive overland flow from the administration, processing and stockpiling areas.
- Outflows are; 1) direct evaporation from the inundated water storage, 2) extraction of water for dust suppression, and 3) uncontrolled discharges. Evaporation from the land surface is not considered.
- 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 has been assumed 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 dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.

The summary findings of these assessments are shown in **Table 33 – Water Balance Assessment for Optimised Storage Volume of SB1 for Prolonged Dry Climatic Conditions** and **Table 34 – Water Balance Assessment for Optimised Storage Volume of SB1 for Prolonged Wet Climatic Conditions**.

Table 33 – 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	24	60.1	5	10.1
	End of Stage 1				
	A				
	B				
	C				
	D				
	E				
	F				
	G				

Note: ① without existing on-site water management regime

Table 34 – 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	22	97.3	6	46.9
	End of Stage 1				
	A				
	B				
	C				
	D				
	E				
	F				
	G				

Note: ①without existing on-site water management regime

Although there are obvious benefits of increasing the design storage capacity of SB1 to meet the regulatory requirements, hence reduce the frequency and number of uncontrolled discharges marginally, no benefit over the existing water management regime would be gained unless it to was continued. Given the direct (i.e. construction) and indirect (i.e. loss of processing/stockpile area) costs of increasing the size of SB1, the practicality due to the sediment basins location, and the on-going requirement to continue the existing water management regime, enlarging SB1 to meet regulatory requirements would not provide any significant net benefit over the current water management regime.

6.8 STORAGE DAMS 5 AND 6

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

Water balance assessments were conducted to investigate the potential frequency and volume of controlled and uncontrolled discharges to Yorkeys Creek from the existing water storage dams SD5 and SD6. The assessments were conducted assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively). The water balance model for SD6 has been built based on the following assumptions:

- Inflows to SD5 and SD6 are segregated into 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Additionally, SD6 receives uncontrolled discharges from SD5 over the existing embankment between SD5 and SD6, as well as low flows from SD5 via an existing low flow control pipe (i.e. lockable valves).
- Outflows are; 1) direct evaporation from the inundated water storage and 2) uncontrolled discharges from SD5 and SD6. Evaporation from the land surface and stock watering is not considered.
- SD6 has been modelled to maintain a freeboard volume of 2 ML to be available at all times to receive overland flows.

The summary findings of these assessments are shown in **Table 35 – Water Balance Assessment for SD5 and SD6 for Prolonged Dry Climatic Conditions** and **Table 36 – Water Balance Assessment for SD5 and SD6 for Prolonged Wet Climatic Conditions**.

Table 35 – Water Balance Assessment for SD5 and SD6 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	24	53.9
	End of Stage 1	27	63.7
	A		
	B		
	C		
	D		
	E		
	F		
	G		
SD5	Current	35	58.9
	End of Stage 1	31	62.8
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 36 – Water Balance Assessment for SD5 and SD6 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	31	133.3
	End of Stage 1	25	142.7
	A		
	B		
	C		
	D		
	E		
	F		
	G		
SD5	Current	27	131.0
	End of Stage 1	33	134.9
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that SD6, in its natural state, will receive approximately 58.9 ML and 131 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 134.9 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 Yorkeys 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 Yorkeys Creek from SD6 is estimated to increase to 63.7 ML/annum and 142.7 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. A water balance scenario has been undertaken to determine uncontrolled discharges from SD6 to Yorkeys Creek based on the water management regime currently in use at the quarry. See **section 6.8.2 Water Balance for SD5 and SD6 with SD6 Receiving Flows from SB1** for details.

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

Scenario 2 has been undertaken to predict the frequency of uncontrolled discharges from SD6 to Yorkeys Creek under the current water management regime at the quarry which includes SD6 receiving excess flows from SB1 in order to reinstate freeboard within SB1.

Scenario 1 was rerun for SD6 assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15^{th} and 90^{th} percentile rainfall respectively). Uncontrolled discharges from SD5 to SD6 were assumed to be the same as that predicted by the Scenario 1 water balance assessments and have been used in Scenario 2.

The summary findings of these assessments are shown in **Table 37 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions** and **Table 38 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Wet Climatic Conditions**.

Table 37 – 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	28	69.1
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 38 – 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	29	137.7
	End of Stage 1		
	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 Yorkeys Creek during the modelled scenarios of prolonged dry and wet climatic conditions.

The predicted uncontrolled discharges to Yorkeys Creek from SD6 can be reduced if discharges from SD5 to SD6 can be diverted to Yorkeys Creek. This option would 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 Yorkeys Creek, see to **Section 6.8.3 Scenario 3 – Water Balance for SD6 Receiving Flows from SB1 with Overflows from SD5 Diverted to Yorkeys Creek** for details.

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.

6.8.3 Scenario 3 – Water Balance for SD6 Receiving Flows from SB1 with Overflows from SD5 Diverted to Yorkeys Creek

Scenario 3 has been undertaken to predict the potential reduction in the frequency and volume of uncontrolled discharges from SD6 to Yorkeys Creek, with the diversion of overflows form SD5 diverted around SD6 to Yorkeys Creek.

Scenario 3 was 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 39 – Revised Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions** and **Table 40 – Revised Water Balance Assessment for SD6 receiving Flows from SB1 for Prolonged Wet Climatic Conditions**.

Table 39 – 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	12	7.2
	A	26	8.73
	B		
	C		
	D		
	E		
	F		
	G		

Table 40 – 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	22	4.9
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicted that by diverting overflows from SD5 around SD6 to Yorkeys Creek, the frequency and volume of uncontrolled discharges from SD6 can be significantly reduced during both the prolonged dry and wet climatic scenarios.

Controlled discharges from SD6 to Yorkeys Creek would be essential in order to reinstate freeboard within SD6. Alternatively water from SD6 can be hydraulically moved to SD3 and/SD4 using existing infrastructure for treatment and discharge to Coxs River.

6.9 SEDIMENT BASIN 2B

A water balance assessment was conducted to investigate the potential frequency of uncontrolled release to Yorkeys Creek from the Sediment Basin 2b (SB2b) designed to receive and treat stormwater runoff generated by the Yorkeys Creek Stockpile area. The assessment was conducted for a dry (15^{th} percentile) and wet (90^{th} percentile) rainfall year, using rainfall and evaporation data summarised in **Section 2.1.1 Rainfall** and **Section 2.1.2 Evaporation** of this report.

The water balance model for SB2b has been built based on the following assumptions:

- The storage volume of SB2b has been redesigned to treat runoff generated by the existing Yorkeys Creek Stockpile area, which is not affected by the Stage 2 Extension (i.e. peak storage capacity of 4 ML)
- Inflows can be segregated into; 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage, 2) controlled discharge of treated waters within 72 hours of a rainfall event, 3) uncontrolled discharges from site water. Evaporation from the land surface is not considered.

The findings of the water balance assessment for SB2b for a dry and wet rainfall year are summarised in **Table 41 – Water Balance Assessment for SB2b**.

Table 41 – 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 (15^{th} Percentile)	Pre- Stage 2 Extension	13	9.9	-	-
	Wet Rainfall Year (90^{th} Percentile)		22	18.9	12	3.9
Stage 2 Extension	Dry Rainfall Year (15^{th} Percentile)	Stage A to G	13	9.9	-	-
	Wet Rainfall Year (90^{th} 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, totally approximately 10 ML of treated water discharged to Yorkeys Creek and ultimately to Coxs River, would be required.

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) during a wet rainfall year, with approximately 1.2 ML of water discharged to Yorkeys Creek and ultimately to Coxs River. It is noted that this is as expected when considering the guidance provided by Table 6.1 of Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries (NSW DECC, 2008).

7. MONITORING AND MAINTENANCE OF SSEC

A monitoring and maintenance program has been prepared for the existing and proposed operations at the Austen Quarry. This program involves regular inspection of the erosion, drainage and sediment controls. All quarry personnel would be responsible for the general surveillance of the stormwater control devices; however, a surveillance program would be implemented to monitor the effectiveness of the implemented devices. Stormwater management devices identified by quarry personnel as having failed or as being laden with sediments will be reported to the Quarry Manager. A summary schedule of the various inspections, performance criteria and responses that must be performed is shown in **Table 42 – Maintenance Plan for Stormwater Control Devices**.

8. RECEIVING ENVIRONMENT

The receiving environment from the licensed discharge points of the Austen Quarry SB1, SB3b, SD2 (EPL 12323 Points 9, 1 and 10 respectively) consist of a well vegetated, upland, freshwater segment of the lower Coxs River. The initial receiving environment from the licensed discharge points of the Austen Quarry SB2b and SD6 (EPL 12323 Points 8 and 11 respectively) is Yorkeys Creek. Yorkeys Creek is a tributary of the Coxs River that consists of a shallow, ephemeral, erosional, freshwater stream before entering the Coxs River. The upper catchment of Yorkeys Creek is relatively undisturbed with only a small portion historically cleared for grazing.

The Coxs River drains a catchment of approximately 2,630 km^2 on the western side of the Blue Mountains. It is bound to the west by the Great Dividing Range, to the north by the upper Colo River Catchment, and to the south by the Wollondilly River catchment.

The Coxs River is a directional, integrated, converging, tributary stream that rises in Gardiners Gap, within Ben Bullen State Forest, east of Cullen Bullen, and flows through the Megalong Valley and parts of the Greater Blue Mountains Area World Heritage Site including the Blue Mountains and Kanangra-Boyd national parks, heading generally south and then east, joined by fifteen tributaries including the Little, Jenolan, Kedumba, Kowmung and Wollondilly rivers, before reaching its confluence with the Warragamba River to form Lake Burragorang (behind Warragamba Dam), the largest of Sydney's water supply reservoirs.

Over most of its length the Coxs River valley-floor trough is underlain by granite. The upper reaches of its eastern tributaries drain sandstone and shales; the western tributaries primarily drain granite. The granite-derived soils are typically thin and highly erodible (CSIRO Land and Water May 2000).

Table 42– Maintenance Plan for Stormwater Control Devices

Inspection	Minimum Frequency	Performance Criteria	Response
Inspect water conveyance structures such as catch drains, contour drains and diversions.	Following significant rainfall events.	Erosion in areas adjacent to water conveying structures.	Eroded areas will be riprapped as soon as practicable.
		Overtopping of water conveying structures (identified by the scouring of the drain batters perpendicular to the direction of flow).	The drain will be cleaned of sediments and riprapping replaced to the original design specifications. Rehabilitation with suitable grasses in the catchment of the drain may be required to reduce sediment loading.
		Deposition of material in the water conveying structure greater than half the design depth.	Sediment/grit will be removed from the structure and used in rehabilitation works.
Inspect potential sediment storage capacity of sediment basins.	Following significant rainfall events.	30 per cent of the total sediment capacity remaining.	Sediment will be removed from the structure and used in rehabilitation works.
		Overtopping of the sediment dams.	To recycle dam water to ensure that adequate free storage is maintained for the collection and holding of runoff.
Inspect check dams, rock armouring and riprap.	Following significant rainfall events.	Check dam walls have collapsed or riprap has moved.	Larger sized rocks will be used in the construction of check dams and riprap or the drain will be concreted or redesigned.
Inspect culverts, pipe inlets and outlets.	Following significant rainfall events.	Check for erosion of inlets and outlets.	Riprap inflows and outflows of pipes where erosion has been observed.
		Debris build-up in pipe inlets or outlets or in culverts.	Remove debris.
		Overflow of pipes.	Check pipes for debris or blockages and remove the offending materials.

Note: Significant rainfall event is rainfall greater than 25 mm in one day.

The majority of the river reaches and mid-catchment are highly degraded as the land has been extensively cleared for industry, agriculture and grazing, and some creeks are highly modified by urban developments. Wide spread grazing, forestry and coal mining occurs in the upper catchment (CSIRO Land and Water May 2000).

The flow regime of the lower Coxs River is strongly influenced by land clearing in the upper and central parts of the catchment, regional climatic variations and the construction and operation of river impoundments (CSIRO Land and Water May 2000). The river is impounded at Lake Wallace, where it forms a cooling source for Wallerawang Power Station, Lake Lyell for a water supply for the city of Lithgow and water cooling for Wallerawang Power Station and downstream of the Site release points at Lake Burragorang, a major water supply source for greater metropolitan Sydney, referred to as the “Warragamba water supply network”.

The Warragamba catchment covers approximately 9,051 square kilometres, with Lake Burragorang itself covering 75 square kilometres. Land in the catchment is predominantly natural bushland and unfertilised grazing land with approximately 25 percent of the catchment declared Special Area, comprising mainly unspoilt bushland where public access is restricted to protect water quality.

The segment of the Coxs River between the Site and Lake Burragorang has high public access and utilised for recreational fishing, non-motor boating and significantly irrigation water supply.

The Environmental Values (EVs) identified for the receiving aquatic environment has been provided in **Table 43 – Environmental Values for Receiving Environment**.

Table 43 – Environmental Values for Receiving Environment

Type	Environmental Values
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

Limited water quality data has been provided from current quarry operations for the receiving environments. A summary of the background water quality of the Yorkeys Creek and Coxs River have been presented in **Table 44 – Summary Statistics of Yorkeys Creek Background Water Quality** and **Table 45 – Summary Statistics of Background Coxs River Water Quality** respectively.

In comparison with that of the background reference condition of Coxs River, Yorkeys Creek water quality is very similar with the exception of slightly greater variation in EC and turbidity recorded and higher nitrogen concentrations. Given the Coxs River is the main receiving water environment from the Site and that a stronger dataset of background water quality is available, background reference conditions for the Coxs River has been adopted to assess potential impact of site release waters on the receiving aquatic environment.

Table 44 – Summary Statistics of Background Yorkeys Creek Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	75th Percentile	80th Percentile
Physico-Chemical							
pH (pH units)①	27	6.4	8.1	7.5	0.4	7.7	7.8
EC (µS/cm)	28	26	550	341	115	398	426
DO (mg/L)	1	8.3	8.3	-	-	-	-
BOD_5 (mg/L)	27	1	11	3	2.4	4.5	5
Turbidity (NTU)	27	0	122	4	24	13	14
TSS (mg/L)	27	<5	96	<5	18	5	7
TDS (mg/L)	28	70	382	239	75	259	274
Metals/Metalloids (Dissolved) (µg/L)							
As	1	2	2	-	-	-	-
Cd	1	<0.1	<0.1	-	-	-	-
Cr (Total)	1	<1	<1	-	-	-	-
Cu	1	<1	<1	-	-	-	-
Ni	1	<1	<1	-	-	-	-
Pb	1	<1	<1	-	-	-	-
Zn	1	<5	<5	-	-	-	-
Metals/Metalloids (Total) (µg/L)							
As	1	3	3	-	-	-	-
Cd	1	<0.1	<0.1	-	-	-	-
Cr (Total)	1	<1	<1	-	-	-	-
Cu	1	<1	<1	-	-	-	-
Ni	1	<1	<1	-	-	-	-
Pb	1	<1	<1	-	-	-	-
Zn	1	6	6	-	-	-	-
Major Ions and Nutrients (mg/L)							
NH_4	1	0.02	0.02	-	-	-	-
TN	1	3.1	3.1	-	-	-	-
NO_x-N	1	2.7	2.7	-	-	-	-
TP	1	<0.01	<0.01	-	-	-	-

Notes: Statistical summary of the water quality within Yorkeys Creek (upstream) for the period between March 2007 and August 2014; ① = 20th Percentile: 7.4; - = n is insufficient to calculate statistic.

Table 45 – Summary Statistics of Background Coxs River Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	75th Percentile	80th Percentile
Physico-Chemical							
pH (pH units)①	80	6.6	9.2	7.5	0.4	7.7	7.7
EC (µS/cm)	80	140	740	273	117	322	338
DO (mg/L)	1	8.3	8.3	-	-	-	-
BOD_5 (mg/L)	74	<1	46	2	5.8	4	4
Turbidity (NTU)	76	1	1,300	5	152	8	10
TSS (mg/L)	80	<1	1,110	4	124	6.9	8.2
TDS (mg/L)	80	12	530	188	96	238	250
Metals/Metalloids (Dissolved) (µg/L)							
Al (pH > 5)	1	20	20	-	-	-	-
As	1	<1	<1	-	-	-	-
Cd	1	<0.1	<0.1	-	-	-	-
Cr (Total)	1	<1	<1	-	-	-	-
Cu	1	2	2	-	-	-	-
Ni	1	1	1	-	-	-	-
Pb	1	<1	<1	-	-	-	-
Zn	1	<5	<5	-	-	-	-
Fe (total)	1	340	340	-	-	-	-
Metals/Metalloids (Total) (µg/L)							
Al (pH > 5)	1	180	180	-	-	-	-
As	2	<1	1	-	-	-	-
Cd	2	<0.1	0.1	-	-	-	-
Cr (total)	2	<1	<1	-	-	-	-
Cu	2	1	2	-	-	-	-
Fe (total)	1	760	760	-	-	-	-
Pb	2	<1	<1	-	-	-	-
Mn	5	38	325	101	115	104	148
Hg	1	<0.1	<0.1	-	-	-	-
Ni	2	2	2	-	-	-	-
Zn	1	<5	<5	-	-	-	-
Major Ions and Nutrients (mg/L)							
NH_4	2	0.02	0.02	-	-	-	-
TN	2	0.3	0.4	-	-	-	-
NO_x-N	2	0.02	0.03	-	-	-	-
TP	2	<0.01	<0.01	-	-	-	-

Notes: Statistical summary of the water quality within Coxs River (upstream) for the period between August 2006 and August 2014; ① = 20th Percentile: 7.2; - = n is insufficient to calculate statistic.

9. ASSESSMENT CRITERIA

9.1 LOCALLY DERIVED WATER QUALITY OBJECTIVES

The assessment criteria for waters released from site have been derived from numerical guidelines published by the Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand Australian *Water Quality Guidelines for Fresh and Marine Waters* (ANZECC/ARMANZ, 2000) based on the identified EVs of the receiving environment and the applicable raw water quality established by the Sydney Catchment Authority (SCA).

Raw water quality within the Sydney Drinking Water Catchment is required to meet levels specified in the Australian Drinking Water Guidelines (NHMRC, 2011); however, for those water quality characteristics that may be expected to be improved through treatment processes, less stringent guidelines apply (Sydney Catchment Authority (SCA), *Annual Water Quality Monitoring Report 2011-12*). Applicable Numerical Guidelines for the assessment are presented in **Table 45 – Applicable Numerical Guidelines**.

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 (upstream of the Austen Quarry), 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 (NH_4) 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=2. The higher ammonia level is to be expected given the Sites 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 Background Reference Conditions for those parameters.

Where derived Numerical Guideline Assessment Criteria in **Table 45 – Applicable Numerical Guidelines** are exceeded by upstream background reference conditions at EPL Point 2, the latter have been adopted. From the numerical guidelines and available Background Reference Conditions, criteria for assessment have been established and are presented in **Table 46 – Locally Derived Water Quality Objectives**.

Table 46 – Applicable Numerical Guidelines

SUBSTANCES	**ANZECC/ARMANZ Guidelines ***				**NHMRC 2011**	**SCA①**
	Protection of Slightly to Moderately Disturbed freshwaters	Recreational Purpose	Irrigation	Livestock Watering	Drinking Water	Site Specific Raw Water Quality②
Physico-Chemical						
pH (pH units)①	-	6-8.5	-	-	6-8.5	6-8.5
EC (µS/cm)	-	-	-	-	-	-
DO (mg/L)	-	-	-	-	-	-
BOD_5 (mg/L)	-	-	-	-	5	-
Turbidity (NTU)	-	-	-	-	-	40
TSS (mg/L)	-	10,000		2,500	-	-
Metals/Metalloids in µg/L						
Al (pH < 6.5)	ID		5,000	5,000	200	-
Al (pH >6.5)	55		5,000	5,000	200	2,600
As	24	50	100	500	10	-
Barium (Ba)			-	-	2,000	-
Beryllium (Be)	ID		100	-	60	-
Cd	0.2	5	10	10	2	-
Cr VI	1.0	50	100	100	50	-
Cobalt (Co)	1.4[a]		50	1,000		-
Cu	1.4	1,000	200	1,000	1,000	-
Pb	3.4	50	2,000	100	10	-
Mn	1,900	100	200	-	100	1,400
Hg	0.06	1	2	2	1	-
Ni	11	100	200	1,000	20	-
Vanadium (V)	ID			100		-
Zn	8	500	2,000	20,000	3,000	-
Major Ions and Nutrients in mg/L						
Nitrite–N (NO_2)	-	1		9.1	0.9	-
Nitrate–N (NO_3)	1.7[b]	10	90.3	11.3		-
NH_4	0.9	0.01	-	-	0.5	-
TN	-	-	-	-	1.4	-
TP	-	-	0.05	-	-	-
Sulphate (SO_4)	-	400			250	-

Notes:
[a] = Low reliability guideline value (ANZECC and ARMCANZ 2000)
[b] = Revised Nitrate-N toxicity guideline value (Hickey & Martin 2009)
① SCA Annual Water Quality Monitoring Report 2011-12
② Site specific raw water quality standard for supply to Prospect, Warragamba and Orchard Hills water filtration plants
ID = Insufficient data to derive a reliable trigger value
- = no applicable criteria set

Table 47 – Interim Locally Derived Water Quality Objectives

Type	Parameter	Numerical Guideline	Source	Background Reference Condition	Interim Locally Derived Water Quality Objective (LDWQO)
Physico-Chemical	pH (pH units)	6 – 8.5	SCA Site Specific Raw Water guideline	7.2 - 7.7	6 – 8.5
	EC (µS/cm)	-	-	322	322
	DO (% satn.)	-	-	-	-
	BOD_5 (mg/L)	5	Drinking Water guideline	4	5
	Turbidity (NTU)	40	SCA Site Specific Raw Water guideline	10	10
	TSS (mg/L)	-	-	8	8
	TDS (mg/L)	2,500	Livestock water guideline	250	2,500
Metals/ Metalloids in (µg/L)	Al (pH<6.5)	200	Drinking Water guideline	-	200
	Al (pH>6.5)	55	SMDS protection	-	55
	As	10	Drinking Water guideline	-	10
	Ba	2,000	Drinking Water guideline	-	2,000
	Be	60	Drinking Water guideline	-	60
	Cd	0.2	SMDS protection	-	0.2
	Cr VI	1	SMDS protection	-	1
	Co	1.4[a]	SMDS protection	-	1.4
	Cu	1.4	SMDS protection	-	1.4
	Pb	3.4	SMDS protection	-	3.4
	Mn	100	Recreation guideline	-	100
	Hg	0.06	SMDS protection	-	0.06
	Ni	11	SMDS protection	-	11
	V	100	Livestock water guideline	-	100
	Zn	8	SMDS protection	-	8
Major Ions and Nutrients in mg/L	NO_2	1	Recreation guideline	-	1
	NO_3	1.7[b]	SMDS protection	-	1.7
	NH_4	0.01	Recreation guideline	-	0.01
	TN	1.4	SCA Site Specific Raw Water guideline	-	1.4
	TP	0.05	Long-term Irrigation guideline	-	0.05
	SO_4	250	Drinking Water guideline	-	250

Note:
[t] = total; [d] = dissolved;
[a] = Low reliability guideline value (ANZECC and ARMCANZ 2000)
① Current EPL limit for TSS is 30 mg/L
[b] = Revised Nitrate-N toxicity guideline value (Hickey & Martin 2009)
Source: ANZECC & ARMCANZ (2000) guidelines (SMDS, Recreation, Long-term Irrigation and Livestock); NHMRC 2011 (Drinking Water guideline);

9.2 STATE ENVIRONMENTAL PLANNING POLICY (SYDNEY DRINKING WATER CATCHMENT) 2011

The Site is situated within the Sydney drinking water's sub-catchment of Mid Coxs River (NSW Planning, State Environmental Planning Policy (NSW Government, *Sydney Drinking Water Catchment) 2011 Sheet 2 of 19),* within the Warragamba Dam Catchment.

For new activities under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), the *State Environmental Planning Policy (Sydney Drinking Water Catchment)* 2011 (the SEPP) states:

> "*A consent authority must not grant consent to the carrying out of development under Part 4 of the Act on land in the Sydney drinking water catchment unless it is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on water quality*."

Sydney Catchment Authority (2011) *Developments in Sydney's Drinking Water Catchment Water Quality Information Requirements* defines a neutral or beneficial effect on water quality as a development that:

- "*has no identifiable impact on water quality, or*
- *will be contain any water quality impact on the development site and stop it from reaching any watercourse, waterbody or drainage depression on site, or*
- *will transfer any water quality impact outside of the site where it is treated and disposed of to standards approved by the consent authority."*

10. IMPACT OF ON-SITE WATER RELEASES

10.1 RELEASE WATER QUALITY CHARACTERISTICS

No distinguishment between water quality of uncontrolled release waters and the water quality of water captured within on-site Sediment Basins or Storage Dams have been provided. It has therefore been assumed that on-site water quality data as presented in **Table 9** to **13** is also representative of uncontrolled release waters from the Site.

No characterisation data of treated release waters has been provided for assessment, however, it is assumed that water quality of any controlled discharges would comply with the Interim Locally Derived Water Quality Objectives (ILDWQO) or alternative release water quality conditions prescribed by the Site's Environmental Protection Licence.

10.2 DISCUSSION

10.2.1 Extraction Area

Water quality within the sumps (i.e. Sump 1 and Sump 2) of the extraction area represents a mixture of groundwater and surface water (see **Table 9 – Extraction Area Water Quality**). No detailed statistical analysis can be undertaken due to the small dataset available ($n \leq 2$); however, based on the limited water quality data available, the following water quality parameters equal or exceed the ILDWQO; EC, Dissolved metals (Cu and Zn) and Nutrients (NO_x-N, TN and NH_4).

Water EC concentration within the extraction area sumps poses a potential risk to the receiving freshwater ecosystem without sufficient dilution.

Based on the surrounding, location and current activity on-site, the elevated dissolved heavy metals (i.e. Cu and Zn) are considered to be reflective of the local geology and not related to unnatural sources. The measured Cu and Zn concentrations are considered to pose a potential risk, if not adequately diluted, on the receiving aquatic environment ecosystem. A one-fold dilution in the receiving environment would reduce the Cu and Zn concentrations below the respective ILDWQO.

Elevated nitrogen concentrations are likely to be attributed to explosives residual used for blasting within the extraction area and to a less extent organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/sediment. The elevated nitrogen concentrations (TN, NO_x and NH_4) have the potential to cause oxygen depletion and nuisance algal problems, particularly if released during no or base flow conditions. The elevated TN concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for drinking water raw supply use. The elevated NH_4 concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for drinking water raw water supply and recreational use, while the elevated NO_x concentration also pose a potential low risk, if not adequately diluted, on the receiving waters suitability for long-term irrigation, livestock watering and recreational use.

Given no change in site geology is predicted to be encountered as part of the Stage 2 Expansion, no change in groundwater chemistry entering the extraction area is also predicted; however, water quality within the extraction area sumps are likely to be strongly influenced by seasonal conditions (i.e. rainfall, dry prolonged periods, etc.).

10.2.2 Sediment Basin 3a/b Water Quality

No detailed statistical analysis can be undertaken due to the small dataset available ($n \leq 2$); however, the following water quality parameters have equalled or exceed the ILDWQO; EC, Turbidity, TSS, Total metals (Al, Cu, Mn and Zn), TN, TP and NH_4 (see **Table 10 – Summary Statistics of SB3a Water Quality**).

Water EC has exceeded the ILDWQO of 322 μS/cm; however, the levels measured (i.e. maximum level 680 μS/cm) is considered to pose no genuine risk to the receiving waters EVs. Water turbidity and TSS concentrations of SB3a are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without sufficient dilution.

Although concentrations for some total metals (Al, Cu and Zn) exceeded the ILDWQO, it is not possible to assess the true risk to aquatic ecosystems on the basis of analysis of metals concentrations in unfiltered water samples. If a worst case scenario is assumed (dissolved metal concentrations equal total concentrations) the measured Al, Cu and Zn concentrations would pose a potential risk, if not adequately diluted on the receiving aquatic environment ecosystem. A one-fold dilution in the receiving environment would reduce the Zn concentrations below the respective locally derived release limit, while a two-fold dilution would be required for Cu concentrations, three-fold dilution for Mn and five-fold for Al. Given the location and current activity on-site, the elevated total heavy metals (i.e. Al, Mn, Cu and Zn) are considered to be reflective of the local geology, therefore, most likely associated with suspended particulates/sediment and not related to unnatural sources. In such case, dissolved metal concentrations are likely to be low than total concentrations as determined at other monitoring locations on-site where both have been analysed, so would the risk.

Of the elevated total metal concentrations, the Mn concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for recreational and long term irrigation use.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from on-site operations is disposed of on-site, the elevated nutrient levels are considered to be associated with organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/soils; however, on-site activities have the potential to promote their release.

The elevated TN and TP level has the potential to cause nuisance algal problems, particularly if released during no or base flow conditions. The elevated TN, TP and NH_4 concentrations also pose a potential low risk, if not adequately diluted, on the receiving waters suitability for drinking water, long-term irrigation and recreational use respectively.

If not adequately diluted, uncontrolled waters released from SB3a present a low risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

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

Ongoing monitoring of background water quality within the Coxs River is required to establish local background reference conditions, therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point within Coxs River, pending accessibility, and on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include, but not be limited to Turbidity, TSS, total Mn and dissolved Cu, TP and NH_4. Dissolved Al and Zn have not been included as these parameters have not been detected above the ILDWQO were such analysis have been conducted on similar surface waters on-site.

10.2.3 Sediment Basin SB2b Water Quality

No detailed statistical analysis can be undertaken due to the small dataset provided (*n=1*); however, based on the available water quality data, the following water quality parameters have equalled or exceed the ILDWQO; EC, BOD_5, Turbidity, TSS, Total metals (Al, Cd, Cu, Pb, Mn and Zn), TN, TP and NH_4 (see Table 14 – Summary Statistics of SB2 Water Quality).

Water EC (860 μS/cm) exceeded the ILDWQO of 322 μS/cm; however, the level measured is considered to pose no genuine risk to the receiving waters EVs.

Water turbidity and TSS concentrations of SB2b are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without sufficient dilution.

Although concentrations for some total metals (Al, Cd, Cu, Pb, Mn and Zn) exceeded the ILDWQO, it is not possible to assess the true risk to aquatic ecosystems on the basis of analysis of metals concentrations in unfiltered water samples. If a worst case scenario is assumed (dissolved metal concentrations equal total concentrations) the measured Al, Cd, Cu, Pb, Mn and Zn concentrations would pose a potential risk, if not adequately diluted on the receiving aquatic environment ecosystem. A one-fold dilution in the receiving environment would reduce the Cd and Pb concentrations below the respective locally derived release limits, while a two-fold dilution would be required for Mn and Zn concentrations, three-fold dilution for Cu and six-fold for Al. Given the location and current activity on-site, the elevated total heavy metals are considered to be reflective of the local geology, therefore, most likely associated with suspended particulates/sediment and not related to unnatural sources. In such case, dissolved metal concentrations are likely to be lower than total concentrations measured, as determined at other monitoring locations on-site where both have been analysed, hence so would the potential risk.

Of the elevated total metal concentrations, the Mn concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for recreational and long term irrigation use.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from on-site operations is disposed of on-site, the elevated BOD_5 and nutrient levels (i.e. TN, TP and NH_4) are considered to be associated with organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/sediment. The elevated nutrient levels have the potential to cause toxicity or nuisance algal problems, particularly if released during no or base flow conditions. The elevated TN, TP and NH_4 also pose a potential low risk, if not adequately diluted, on the receiving waters suitability for raw water drinking supply, long-term irrigation and recreational use respectively.

If not adequately diluted, uncontrolled waters released from SB2b may present a risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS and potentially dissolved Al, Cd, Cu, Pb and Zn)
- Recreation Purpose (elevated turbidity, TSS, Mn and NH_4 concentrations)
- Long-term irrigation (elevated TP)
- Drinking water supply (elevated BOD_5, Turbidity, Al and TN concentrations).

Ongoing monitoring of background water quality within Coxs River is required to establish local background reference conditions; therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point (i.e. EPL Point 3) on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include but not be limited to Turbidity, TSS, BOD_5, total metals (Mn and Al), dissolved Cu, TN, TP and NH_4. Dissolved Al, Cd and Zn have not been included as these parameters have not been detected above the ILDWQO were such analysis have been conducted on similar surface waters on-site.

10.2.4 Storage Dam 2 Water Quality

Some detailed statistical analysis can be undertaken given the available dataset ($n \leq 22$ for Physico-chemical and n=1 for toxicity analysis); however, based on the available water quality data, the following water quality parameters have equalled or exceed the ILDWQO; pH, EC, Turbidity, TSS, Dissolved Cu and NH_4 (see **Table 12 – Summary Statistics of SD2 Water Quality**).

Water pH typically exceeds the locally derived release upper limit range of 8.5 pH units, with a 95^{th} percentile level of 9.0 based on dataset of *n*=22. The elevated pH is likely to be attributed to incorrect dosing of waters within SD2 with water treatment chemical/s and/or the presence of algal blooms.

Water EC (i.e. median concentration 450 μS/cm) typically exceeds the locally derived release limit of 320 μS/cm; however, the level measured is considered to pose no genuine risk to the receiving waters EVs.

Water turbidity and TSS concentrations of SD2 are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without sufficient dilution.

The measured dissolved Cu concentration exceeds the ILDWQO; therefore, indicates waters pose a potential risk if not adequately diluted on the receiving aquatic environment ecosystem; however, caution should be exercised as the data set is small (*n*=1). A less than one-fold dilution in the receiving environment would be required to reduce the dissolved Cu concentration below the respective locally derived release limit.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from quarry operations is disposed of on-site, the elevated BOD_5 and NH_4 (equal to the ILDWQO) are likely to be associated with organic matter (e.g. manures) associated with suspended particulates/soils; however, on-site activities have the potential to promote their release.

Although the NH_4 concentration exceeded the respective locally derived release limit, it is equal to the NH4 concentration measured at the Coxs River background reference condition sample of 0.02 mg/L, therefore concentration is unlikely to pose any genuine risk to the downstream receiving waters suitability for recreational use.

If not adequately diluted, uncontrolled waters released from SD2 may present a risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated pH, Turbidity, TSS and dissolved Cu)
- Recreation Purpose (elevated turbidity and TSS concentrations)
- Drinking Water Supply (elevated BOD_5).

Ongoing monitoring of background water quality within Coxs River is required to establish local background reference conditions, therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point (i.e. EPL Point 3) on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include but not be limited to Turbidity, TSS, BOD_5, dissolved Cu and NH_4.

10.2.5 Storage Dam 6 Water Quality

Some detail statistical analysis can be undertaken given the available dataset (*n≤24* for Physico-chemical and *n*=1 for toxicity analysis); however, based on the available water quality data, the following water quality parameters have equalled or exceed the locally derived release limits; pH, EC, Turbidity, TSS, BOD_5, Total metals (Al and Mn), Dissolved Cu, TN, TP and NH_4 (see **Table 13 – Summary Statistics of SD6 Water Quality**).

Generally, the water quality of SD6 is similar to SB1. This is to be expected given excess water from SB1 is transferred to SD6 for storage as part of the on-site water management regime.

Water pH occasionally exceeds the ILDWQO upper range of 8.5 pH units, with a 95th percentile level of 8.7, based on dataset of *n*=24; however, the water pH is not considered to pose any genuine risk to the receiving waters EVs as the median pH level is below the ILDWQO at 8.0.

Water EC typically exceeds the ILDWQO of 322 μS/cm, with a median concentration of 453 μS/cm based on small dataset of *n*=8. Although median concentration is elevated compared to background conditions, the EC concentration of the SD6 waters is considered to pose only a low potential risk to the receiving waters EVs.

Water turbidity and TSS concentrations of SD5 are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without adequate dilution.

The measured dissolved Cu concentration exceeds the ILDWQO; therefore, indicates waters pose a potential risk if not adequately diluted on the receiving aquatic environment ecosystem; however, caution should be exercised as the data set is small (*n*=1). A less than one-fold dilution in the receiving environment would be required to reduce the dissolved Cu concentration below the respective locally derived release limit.

The elevated total metals (i.e. Al and Mn) are considered to be reflective of the local geology and not related to unnatural sources. A two-fold dilution in the receiving environment would reduce the Total Mn concentration below the ILDWQO, while a five-fold would be required for Total Al.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from on-site operations is disposed of on-site, the elevated BOD_5 and nutrient levels (i.e. TP and NH_4) are considered to be associated with organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/sediment. The elevated TN and TP level has the potential to cause nuisance algal problems, particularly if released during no or base flow conditions. The elevated BOD_5, TN, TP and NH_4 concentrations also pose a potential low risk if not adequately diluted on the receiving waters suitability for drinking water, long-term irrigation and recreational use respectively.

If not adequately diluted, uncontrolled waters released from SD6 may present a risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS, TN, TP, NH_4, dissolved Cu)
- Recreation Purpose (elevated turbidity, TSS and Mn and NH_4 concentrations)
- Long-term irrigation (elevated TP)
- Livestock watering (elevated Al)
- Drinking water supply (elevated Turbidity, BOD_5 and TN concentration).

Ongoing monitoring of background water quality within Coxs River is required to establish local background reference conditions, therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point (i.e. EPL Point 3) on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include but not be limited to Turbidity, TSS, BOD_5, Total Al and Mn, Dissolved Cu, NH_4 and TP.

11. ASSESSMENT AGAINST THE SEPP

11.1.1 Introduction

As stated in Section 9.2, the SEPP states:

> "*A consent authority must not grant consent to the carrying out of development under Part 4 of the Act on land in the Sydney drinking water catchment unless it is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on water quality*."

Sydney Catchment Authority (2011) *Developments in Sydney's Drinking Water Catchment Water Quality Information Requirements* defines a neutral or beneficial effect on water quality as a development that:

- "*has no identifiable impact on water quality, or*
- *will be contain any water quality impact on the development site and stop it from reaching any watercourse, waterbody or drainage depression on site, or*
- *will transfer any water quality impact outside of the site where it is treated and disposed of to standards approved by the consent authority."*

11.1.2 Stage 2 Extension Environmental Impacts

The Stage 2 Extension poses no new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI.

No uncontrolled releases are predicted to occur for the Stage 2 Extension of the extraction area (sub-catchments L1 and L2). The water management regime employed on the Site involves the dewatering/treatment of waters collected within the extraction area prior to controlled release via SD1 and SD2 into the receiving environment.

With no proposed changes to on-site water conveyancing structures or predicted change in geology within the extraction area, the water quality and maximum controlled discharge rate of waters collected within the extraction area are proposed to be similar to pre-Stage 2 Extension conditions.

The proposed lateral extension of the extraction area to a maximum depth of RL 685m AHD, some 45m below the water table, would remain well above the Coxs River and the elevation of most surrounding natural drainage gullies. The impact on standing water levels between the extraction area and surrounding gullies, including Yorkeys Creek and Coxs River, would be restricted to a distance of approximately 225m (Ground Doctor, 2104). As such, a hydraulic gradient would be maintained toward the gullies allowing for groundwater to continue to discharge towards these, i.e. maintain pre-Stage 2 Extension conditions.

The proposed Stage 2 Extension also presents no greater opportunity for contaminants to enter the groundwater than the pre-Stage 2 Extension development. Risks posed by the ongoing presence of chemicals used on-site (i.e. diesel, hydraulic fluids, explosives) within the extraction area can be adequately addressed through implementation of appropriate environmental management procedures.

On the basis of the above discussion, the Stage 2 Extension has no identifiable impact on groundwater recharge flows to adjacent waterways or users, or water quality (surface and groundwater) provided adequate water treatment is undertaken prior to release. Therefore a neutral effect on receiving aquatic environment water quality is predicted for this sub-catchment.

11.1.3 Ancillary Sub-Catchment Environmental Impacts

It is predicted that potentially contaminated (i.e. sediment laden) waters would continue to be released from existing ancillary operational sub-catchments J3, K1, K3 and A1 via SB1, SB2b, SD6 and SB3a/b respectively. Uncontrolled waters released from site operational areas have been identified to pose a potential risk to the receiving aquatic ecosystem and water suitability for the following identified EVs:

- Protection of Aquatic Ecosystems
- Recreation Purpose
- Long-term irrigation
- Livestock watering
- Drinking water supply.

These releases are predicted to occur during times of event flows occurring within the natural waterways, hence any potential risk to receiving waters would be greatly reduced.

Carrying out of the Stage 2 Extension would result in no change in the catchment area, land use and runoff volumes between the pre and post extension (Stage A to Stage G) for catchments J3, K1 and K4, hence the potential risks identified are considered to be no greater than those present prior to the Stage 2 Extension.

Existing and/or new sediment basins would be re-sized, where necessary, to ensure their design capacity meets the minimum regulatory requirements (i.e. SB2b and SB3b). The resizing of the basins to meet the minimum regulatory requirement, would provide additional capacity compared to pre-extension; hence provide a beneficial effect on receiving water quality for those catchments by reducing the current discharge frequency and volume of untreated waters from catchment K4.

Proposed changes to the existing stormwater management on-site would separate overland flows from undisturbed catchment areas (i.e. clean waters) from potentially contaminated waters from disturbed operational areas by diverting clean overland flows or waters released from clean water storage dams around established treatment and/or sediment basins, where practicable as follows.

- Control discharging of treated excess waters in SB1 via SD1 and SD2 to Coxs River.
- A diversion bund to divert overland flows from the clean catchment above SD1 and SD2 to maximise capacity to receive water from SB1 for treatment prior to being discharged to Coxs River.
- 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 access water from SB1.
- Control discharging of treated excess waters in SD6 to Yorkeys Creek to gain additional water storage capacity to dewater excess waters from SB1.

The implementation of the above stormwater management controls would further reduce the volume of potentially contaminated waters generated on-site and the frequency and volume of potentially contaminated waters released; hence provide a beneficial effect on receiving water quality from those catchments.

11.1.4 Conclusion

On the basis of the above discussions, it is evident that the proposed Stage 2 Extension can operate to achieve a neutral to beneficial effect on water quality in the drinking water catchment; however, there is the need for ongoing careful management and impact amelioration measures to limit any potential adverse impacts, particularly relating to possible indirect affects off-site. Improvements, as identified in other sections of this report, and on-going monitoring and maintenance of the on-site Stormwater, Sediment and Erosion Controls are required to prevent any potential adverse impacts on the water quality downstream of the Site.

12. RELEASE WATER MONITORING PROGRAM

To measure the performance on-site water management and potential on-going release water quality impacts on receiving waters, the following water monitoring program would be implemented.

12.1 PARAMETERS

The initial parameters that would be analysed are detailed below in **Table 47 – Water Quality Monitoring Parameters**; however, the list of parameters would be regularly review (i.e. annually) and revised as necessary based on water quality data collected.

Table 48 – Water Quality Monitoring Parameters

Parameter	Units	Sample Type
pH	pH units	Grab Sample or *In-situ*
Turbidity	NTU	Grab Sample or *In-situ*
Total Suspended Solid	mg/L	Grab Sample
BOD_5	mg/L	Grab Sample
Total Al and Mn	μg/L	Grab Sample
Dissolved Cu	μg/L	Grab Sample
Ammonia	mg/L	Grab Sample
Total Nitrogen	mg/L	Grab Sample
Total Phosphorus	mg/L	Grab Sample
Visual Oil & Grease/Litter	Present/Absent	Visual observation
	mg/L	Grab Sample

12.2 MONITORING LOCATIONS

Water quality sampling sites and monitoring frequency for discharge events are described in **Table 49 – Water Quality Monitoring Frequency and Points**, while locations of monitoring points are also shown on **Figure 4 – Discharge and Water Monitoring Location Plan**.

Table 49 – 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 weekly 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 then weekly during site discharge events
EPL Point 3	Downstream Coxs River	

12.3 CONTAMINANT RELEASE LIMITS

Based on the locally derived water quality objectives presented in **Table 47 – Locally Derived Water Quality Objectives** of this report, monitoring results at EPL Points 1, 8, 9, 10 and 11 would be compared against the following contaminated release limits presented in **Table 50 – 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.

Table 50 – Contaminant Release Limits

Parameter	Release Criteria	Type
Turbidity	Less than or equal to locally derived release limit (i.e. ≤11 NTU) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Total Suspended Solids	Less than or equal to locally derived release limit (i.e. ≤8 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
pH	6.0 – 8.5	Range
BOD_5	Less than or equal to locally derived release limit (i.e. ≤5 mg/L)	Maximum
Total Al	Less than or equal to locally derived release limit (i.e. ≤55 µg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Total Mn	Less than or equal to locally derived release limit (i.e. ≤100 µg/L) or Less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Dissolved Cu	Less than or equal to locally derived release limit (i.e. 1.4 µg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum

Table 50 – Contaminant Release Limits (Cont'd)

Parameter	Release Criteria	Type
TN	Less than or equal to locally derived release limit (i.e. ≤1.4 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
TP	Less than or equal to locally derived release limit (i.e. ≤0.05 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
NH_4	Less than or equal to locally derived release limit (i.e. ≤0.01 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Visual Oil & Grease/Litter	Greater than 10 mg/L (current EPL release limit)	Maximum

12.4 CORRECTIVE ACTION

If contaminant release limits are exceeded at EPL Points 1, 8, 9, 10 and 11, corrective action would be implemented as presented in **Table 51 – Corrective Action to Exceedance of Contaminant Release Limits**.

Table 51 – 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/retest 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 >10mg/L advise EPA, investigate and implement immediate action to rectify and to prevent reoccurrence, arrange contractor to remove visual contamination and appropriately dispose/recycle contaminated water off-site at an appropriately licensed facility.

12.5 INTEGRITY OF WATERWAYS

While drainage pathways (man-made and natural) and banks of the drainage lines at the points of release are well vegetated, discharge can potentially increase stream erosion. To measure the water quality impacts of any quarry discharges on the integrity of receiving waterways, visual surveillance on at least a weekly basis during and then immediately following discharge events is proposed.

12.6 DRAINAGE STRUCTURES

Apart for the purpose built spillway, culverts and outlet pipes of the Sediment Basins and Storage Dams no other on-site drainage structures are likely to be affected by quarry discharges.

Corrective action, if required, will involve ceasing or scaling back the rate of discharge, where practicable, until remediation to drainage structures can be completed.

12.7 DRAINAGE DEPRESSION BED AND BANK INTEGRITY

Visual assessment of water clarity and drainage depression bed and bank integrity during water monitoring would be carried out to determine whether scouring is occurring. As per the proposed monitoring program described in the **section 12.8 Release Water Monitoring** below, the performance of drainage structures, corrective action, if required, would involve ceasing or scaling back the rate of discharge until remediation can be completed.

12.8 RELEASE WATER MONITORING

As part of the proposed monitoring program, an initial visual inspection of outlet structures and, bed and banks of the drainage depressions directly downstream of the discharge points will be conducted and documented (including photographs). Subsequent inspection would be conducted at commencement of discharge and then weekly until it is established that scouring is not occurring. Any bypassing of, or damage to, drainage structures and bed and banks of the drainage depressions/outlets would be repaired immediately. Discharge will be ceased or reduced until such repair is complete.

13. CONCLUSION AND RECOMMENDATIONS

The Stage 2 Extension is predicted to have no effect on the footprints of existing operational catchments, with the exception of increasing the footprints of operational sub-catchments A1 (overburden emplacement) and L (L1 and L2 of the extraction area).

No new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI are proposed by the Stage 2 Extension.

The Stage 2 Extension is considered to present no greater opportunity for contaminants to enter the groundwater or adjacent water ways than pre-Stage 2 Extension development, with no uncontrolled releases predicted to occur for the Stage 2 Extension of the extraction area (sub-catchments L1 and L2). The existing water management regime employed at the quarry is proposed to continue, which involves dewatering and treatment of waters collected within the extraction area prior to controlled release via SD2 into the receiving environment. With no proposed changes in on-site water conveyancing structures or predicted change in geology within the extraction area, the water quality and maximum controlled discharge rate of waters collected within the extraction area are proposed to be similar to pre-Stage 2 Extension conditions.

The Stage 2 Extension would interfere with groundwater; however, no identifiable impact is predicted on groundwater recharge flows to adjacent waterways, users or on water quality (surface and groundwater) (Ground Doctor, 2014).

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. The frequency and volume of these discharges would be reduced by the proposed additional stormwater management recommended and limited to high or prolonged wet weather conditions when compared to pre-Stage 2 Extension conditions. Water contained within these releases 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 BOD_5, 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 Stage 2 Extension 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 \ mitigation measures is recommended.

- Ensuring sediment basins, except 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 95^{th} percentile 5-day rainfall event).
- Installation of a new sediment basin (SB3b), with a peak storage capacity of approximately 12.3 ML to meet minimum regulatory requirements, downstream of the overburden emplacement area footprint prior to the commencement of Stage 2 Extension.
- Increase of 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.
- Continuation of 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.
- Discharge 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.
- Discharge 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 **Figure 6** to **18**.

On-going monitoring is also recommended of all implemented SSEC measures and on-site water releases (i.e. controlled and uncontrolled) to provide on-going assessment and improvement, if and where necessary to verify the carrying out of Stage 2 Extension has a neutral to beneficial effect on water quality of the receiving.

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Appendix A

Proposed Quarry Development Layout and Post Quarrying Catchment

Delineation Plans for Stage 2 Extension of the Austen Quarry

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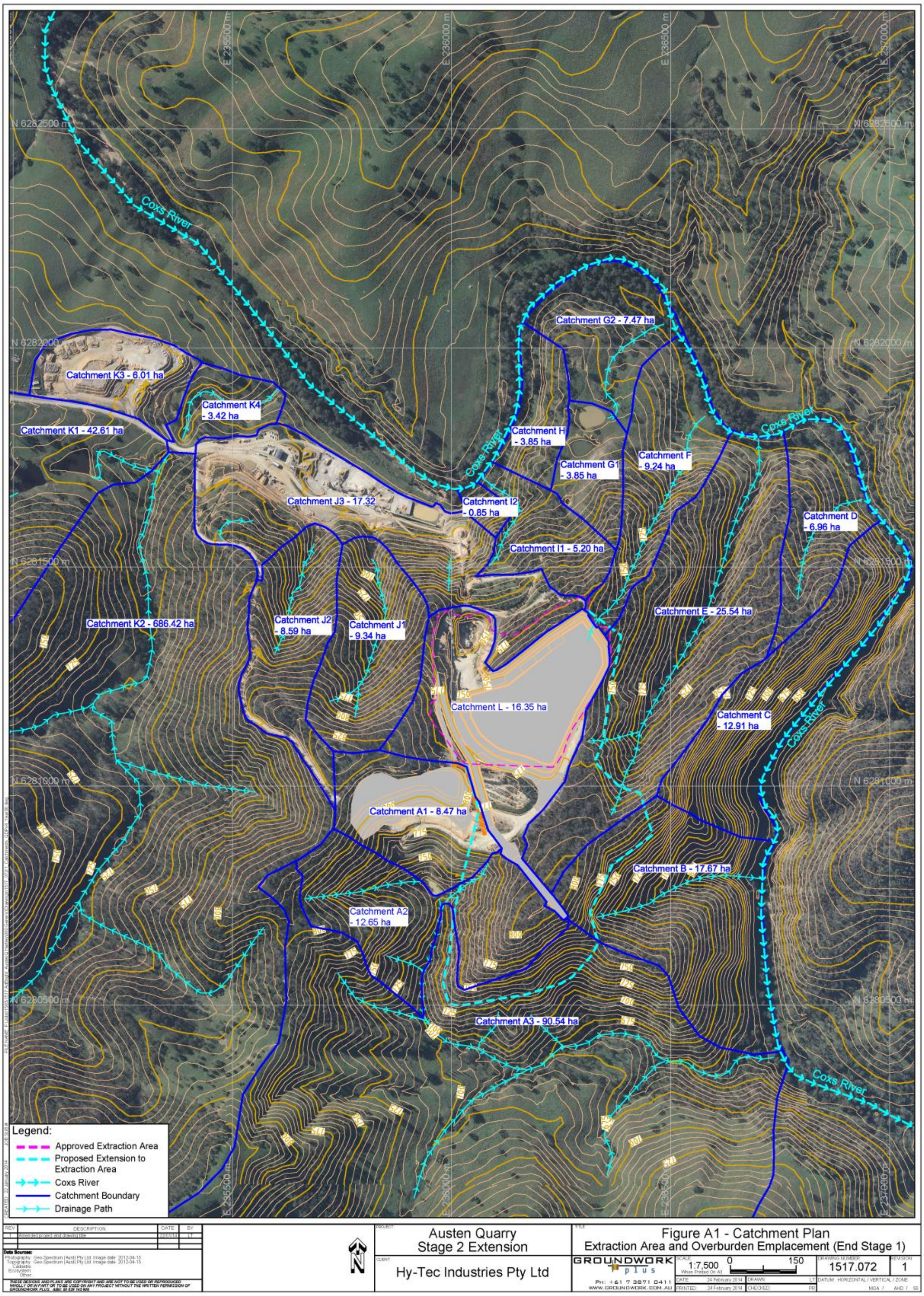
Coxs River
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Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.24 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment E - 25.54 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment L - 16.35 ha
Catchment C - 12.91 ha
Catchment A1 - 8.47 ha
Catchment B - 17.67 ha
Catchment A2 - 12.65 ha
Catchment A3 - 90.54 ha
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A1 - Catchment Plan
Extraction Area and Overburden Emplacement (End Stage 1)
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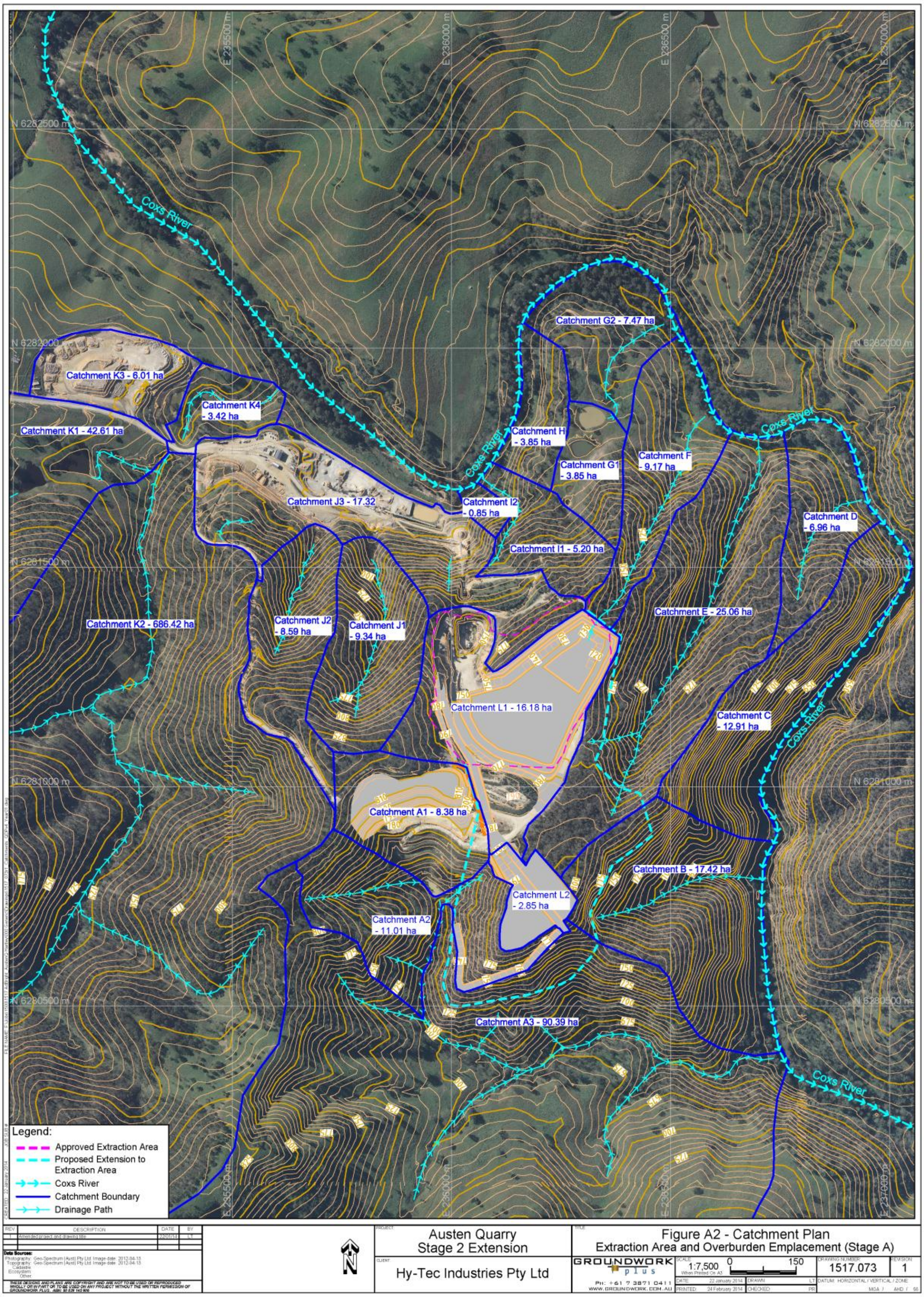
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment K2 - 686.42 ha
Catchment J3 - 17.32
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment G2 - 7.47 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment I2 - 0.85 ha
Catchment I1 - 5.20 ha
Catchment D - 6.96 ha
Catchment E - 25.06 ha
Catchment L1 - 16.18 ha
Catchment C - 12.91 ha
Catchment A1 - 8.38 ha
Catchment B - 17.42 ha
Catchment L2 - 2.85 ha
Catchment A2 - 11.01 ha
Catchment A3 - 90.39 ha
Coxs River
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A2 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage A)
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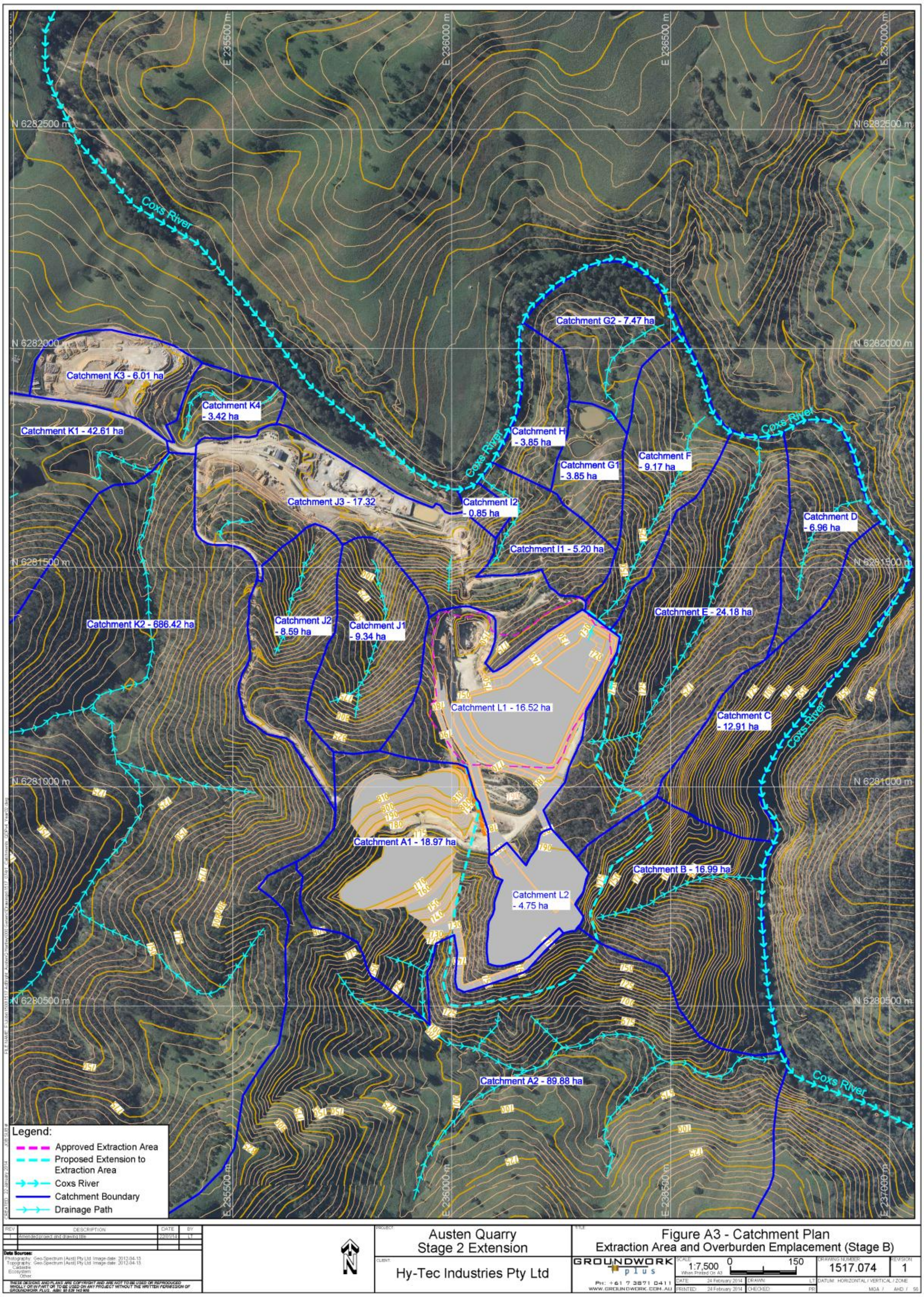
Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment E - 24.18 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment L1 - 16.52 ha
Catchment C - 12.91 ha
Catchment A1 - 18.97 ha
Catchment B - 16.99 ha
Catchment L2 - 4.75 ha
Catchment A2 - 89.88 ha
N 6282500 m
N 6282000 m
N 6281500 m
N 6281000 m
N 6280500 m
E 235500 m
E 236000 m
E 236500 m
E 237000 m
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A3 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage B)
GROUNDWORK plus
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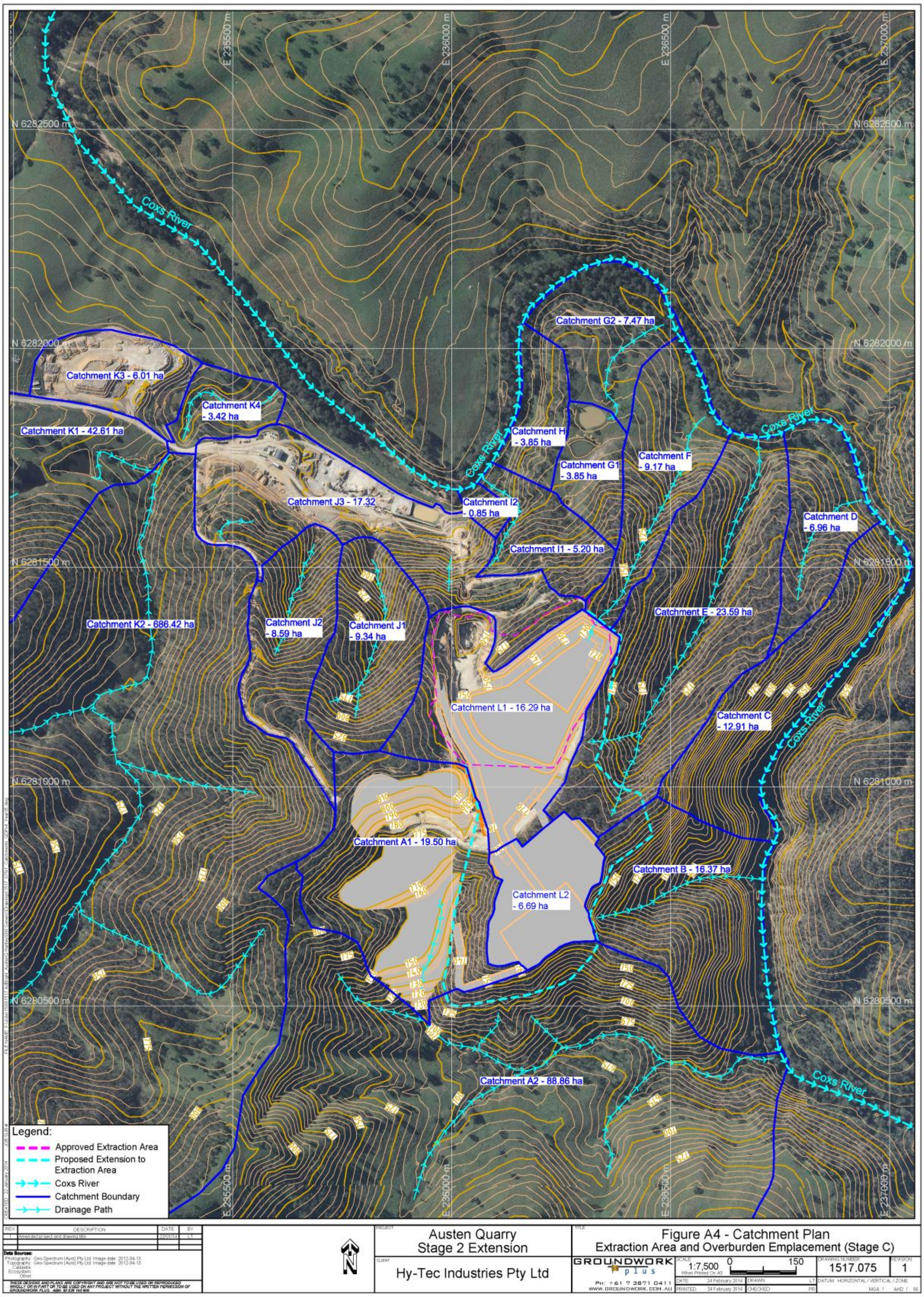
DRAWING NUMBER 1517.074
REVISION 1
DATE 24 February 2014
PRINTED 24 February 2014
DRAWN LT
CHECKED PR
DATUM: HORIZONTAL / VERTICAL / ZONE MGA / AHD / 56


Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment E - 23.59 ha
Catchment L1 - 16.29 ha
Catchment C - 12.91 ha
Catchment A1 - 19.50 ha
Catchment B - 16.37 ha
Catchment L2 - 6.69 ha
Catchment A2 - 88.86 ha
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A4 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage C)
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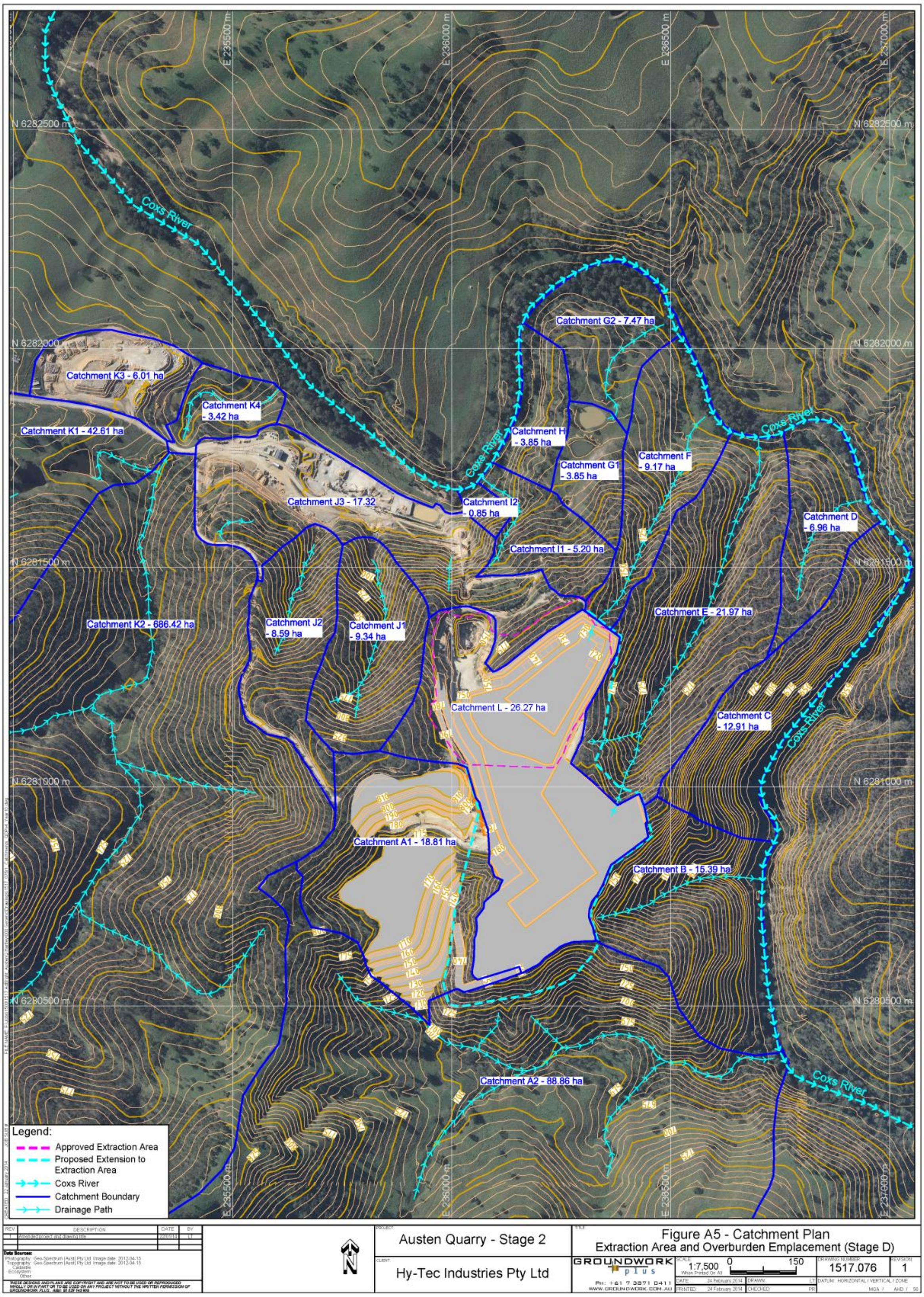
Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment E - 21.97 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment L - 26.27 ha
Catchment C - 12.91 ha
Catchment A1 - 18.81 ha
Catchment B - 15.39 ha
Catchment A2 - 88.86 ha
N 6282500 m
N 6282000 m
N 6281500 m
N 6281000 m
N 6280500 m
E 235500 m
E 236000 m
E 236500 m
E 237000 m
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry - Stage 2
Hy-Tec Industries Pty Ltd
Figure A5 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage D)
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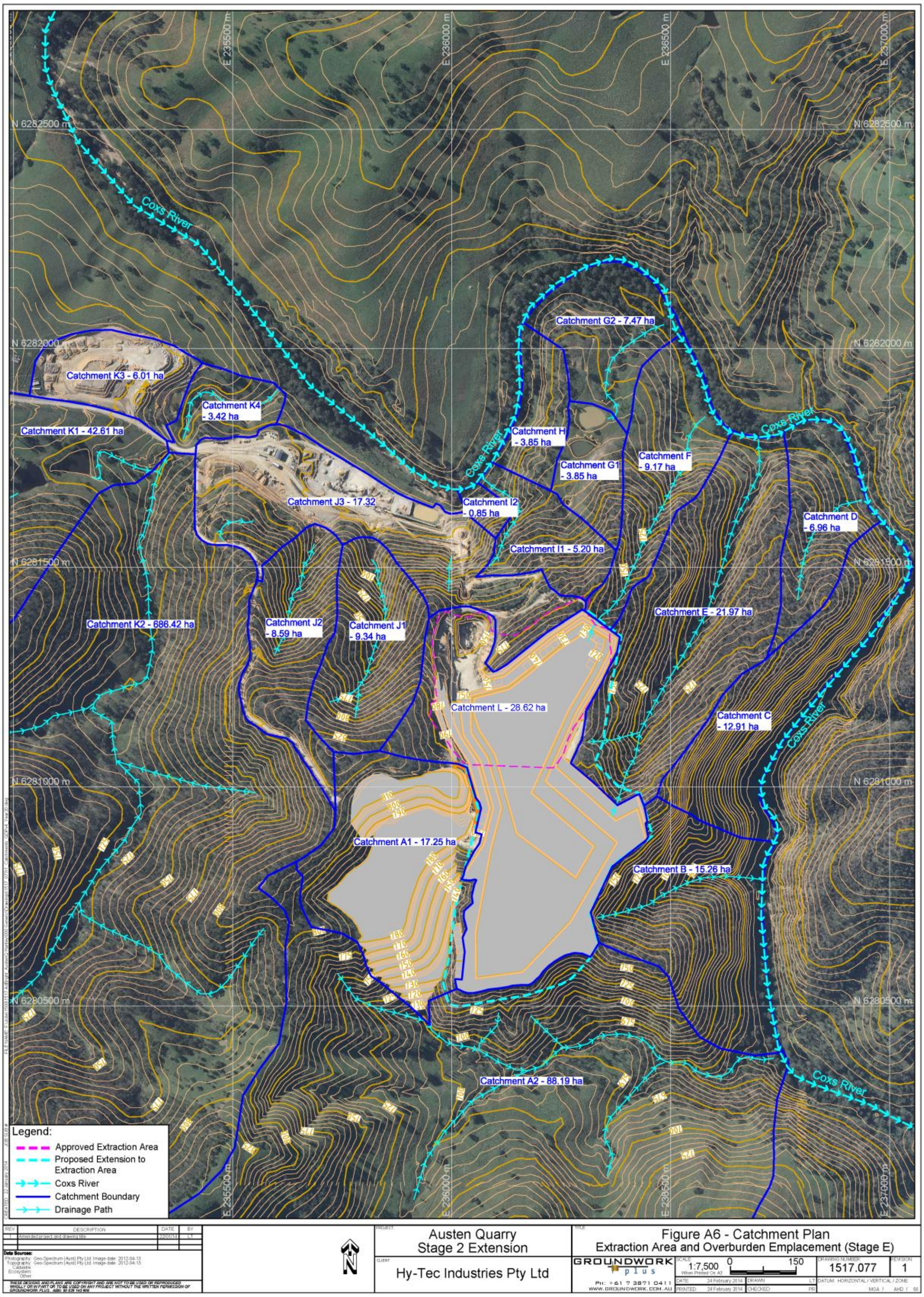
Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment E - 21.97 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment L - 28.62 ha
Catchment C - 12.91 ha
Catchment A1 - 17.25 ha
Catchment B - 15.26 ha
Catchment A2 - 88.19 ha
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A6 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage E)
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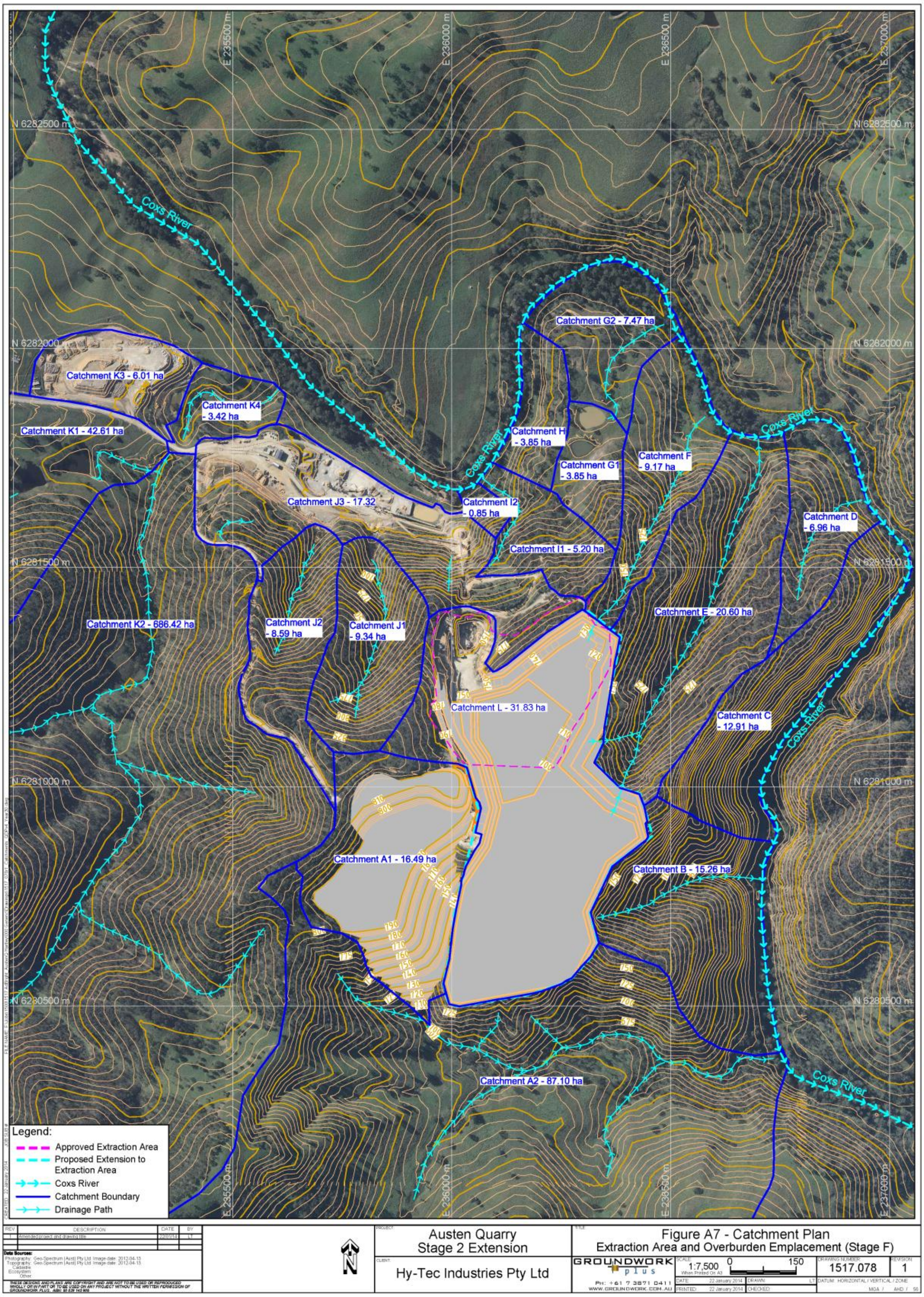
Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment E - 20.60 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment L - 31.83 ha
Catchment C - 12.91 ha
Catchment A1 - 16.49 ha
Catchment B - 15.26 ha
Catchment A2 - 87.10 ha
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A7 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage F)
GROUNDWORK plus
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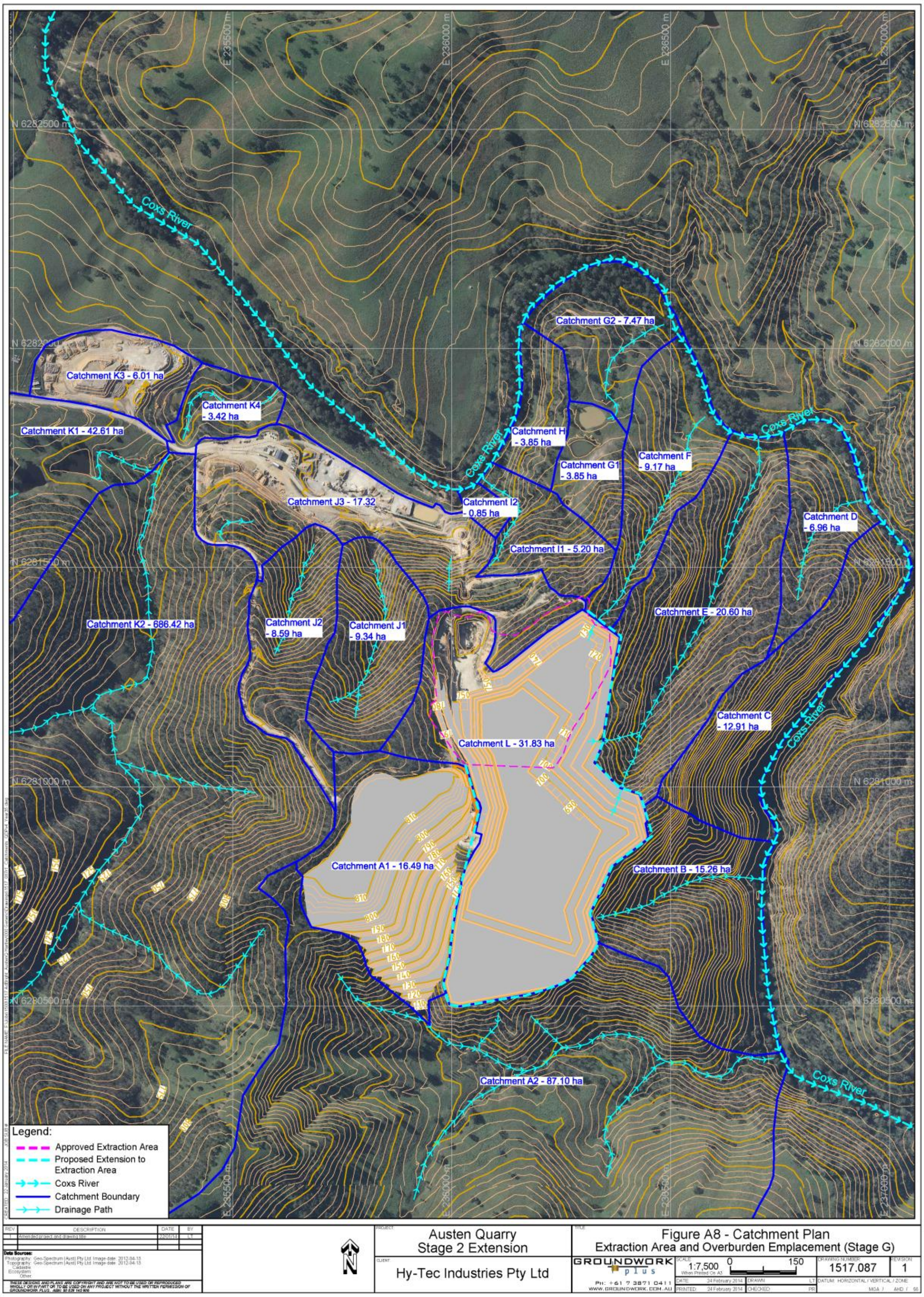
Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.17 ha
Catchment J3 - 17.32
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
Catchment E - 20.60 ha
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment C - 12.91 ha
Catchment L - 31.83 ha
Catchment A1 - 16.49 ha
Catchment B - 15.26 ha
Catchment A2 - 87.10 ha
Legend:
Approved Extraction Area
Proposed Extension to Extraction Area
Coxs River
Catchment Boundary
Drainage Path
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure A8 - Catchment Plan
Extraction Area and Overburden Emplacement (Stage G)
GROUNDWORK plus
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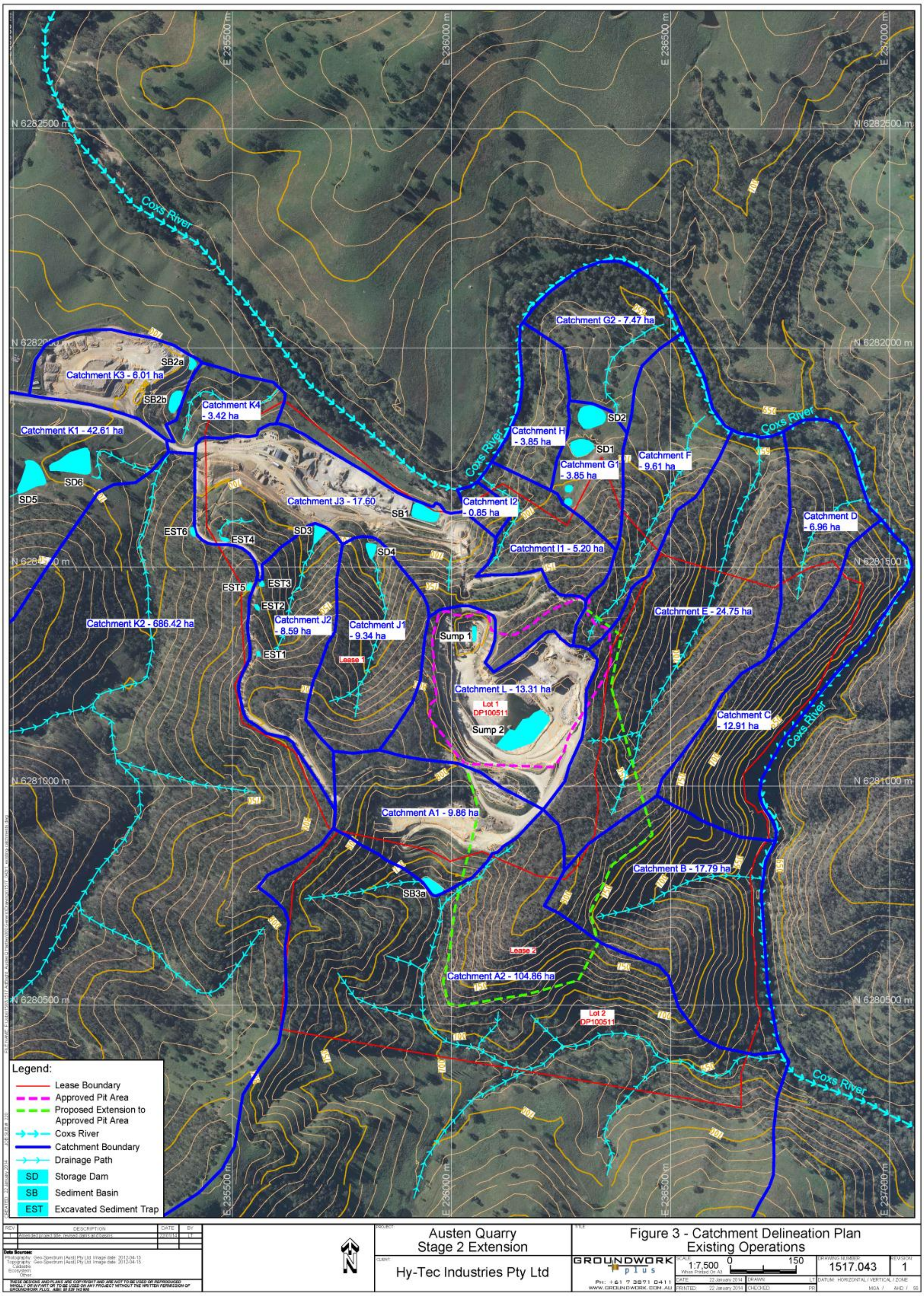
Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
SB2a
SB2b
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
SD6
SD5
SD2
SD1
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.61 ha
Catchment J3 - 17.60
SB1
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
Catchment I1 - 5.20 ha
EST6
EST4
SD3
SD4
EST3
EST5
EST2
EST1
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Catchment E - 24.75 ha
Sump 1
Catchment L - 13.31 ha
Lot 1 DP100511
Sump 2
Lease 1
Catchment C - 12.91 ha
Catchment A1 - 9.86 ha
Catchment B - 17.79 ha
SB3a
Lease 2
Catchment A2 - 104.86 ha
Lot 2 DP100511
Legend:
Lease Boundary
Approved Pit Area
Proposed Extension to Approved Pit Area
Coxs River
Catchment Boundary
Drainage Path
SD Storage Dam
SB Sediment Basin
EST Excavated Sediment Trap
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 3 - Catchment Delineation Plan Existing Operations
GROUNDWORK plus
1:7,500
1517.043
1

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Appendix B

Soil and Water Management Plan, RW Corkery (July 2006)

Note: This Appendix is only available on the Project CD

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Adelaide Brighton Limited
ABN: 15 007 596 018

Soil and Water Management Plan

for the

Austen Quarry, Hartley

Prepared by:

R.W. CORKERY & CO. PTY. LIMITED

in conjunction with:

GSS Environmental

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Adelaide Brighton Limited
ABN: 15 007 596 018

Soil and Water Management Plan

for the

Austen Quarry, Hartley

Prepared by:

R.W. Corkery & Co. Pty. Limited
Geological & Environmental Consultants
75 Kite Street
ORANGE NSW 2800

ABN: 31 002 033 712

Telephone: (02) 6362 5411
Facsimile: (02) 6361 3622
Email: RWC@cww.octec.org.au

In conjunction with:

GSS Environmental
55 Tumbi Road
WAMBERAL NSW 2260

July 2006

On behalf of:
Adelaide Brighton Limited
Level 1, 157 Grenfell Street
ADELAIDE SA 5000

ABN: 15 007 596 018

Mobile: (0437) 773 343

Ref No. 652/05

R. W. CORKERY & CO. PTY. LIMITED

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R. W. CORKERY & CO. PTY. LIMITED

FOREWORD

This Soil and Water Management Plan (SWMP) for the Austen Quarry, has been prepared in compliance with *Condition 9(a)* of a development consent (development application No. 103/94) issued by the Council of the City of Greater Lithgow (now Lithgow City Council) for the quarry site. It represents an update of an Erosion and Sediment Control Plan for the Hartley Rhyolite Quarry Site Access Road. This was prepared by the Department of Land and Water Conservation in 1995, which prior to the purchase of the quarry site by Adelaide Brighton Limited in March 2002 has, in conjunction with a Rehabilitation and Environmental Management Plan (IEC, 1999), been viewed as the SWMP for the quarry.

This SWMP expands and updates the concepts presented in these documents through reference to relevant guidelines such as the Department of Housing guideline *"Managing Urban Stormwater: Soils and Construction"* Vol. 1, 4th eds. (Landcom, 2004).

GLOSSARY OF ACRONYMS AND REFERENCE TERMS

GLOSSARY

BMP	-	Best Management Practice
CB	-	Catch Bank
DB	-	Diversion Bank
DEC (EPA)	-	Department of Environment and Conservation (Environment Protection Authority)
DNR	-	Department of Natural Resources
DoP	-	Department of Planning
EIS	-	Environmental Impact Statement
ESCP	-	Erosion and Sediment Control Plan
LS	-	Level Spreader
RS	-	Rock-lined Spillway
SB	-	Sediment Basin
SD	-	Clean Water Storage Dam
SeD	-	Sediment Dam
SpD	-	Spoon Drain
SWMonP	-	Surface Water Monitoring Program
SWMP	-	Soil and Water Management Plan
TSS	-	Total Suspended Solids
WW	-	Waterway

TERMS

Conveyor System	Series of conveyors and towers to transfer the rhyolitic material from the primary crusher to the processing infrastructure of the processing area.
Extraction Area	12.9ha area designated for the extraction of rhyolitic material.
Primary Crusher	Crushing plant located on the 737m bench of the extraction area.

TERMS (CONTINUED)

Processing Area	3.2ha constructed hardstand area adjacent to the Coxs River designated for the secondary and tertiary crushing and screening of extracted rhyolitic material, product stockpiling and storage of surface water.
Processing Pad	Area within the processing area designated for rhyolitic material crushing, screening and stockpiling.
Processing Area Bund	Bund constructed between the processing area and Coxs River to prevent the discharge of surface water.
Quarry	The combination of the extraction area, processing area and all related roads.
Quarry Access Road	Constructed road between the processing area and extraction area.
Site Access Road	Constructed and eventually sealed road between the processing area and Jenolan Caves Road.
Visual Bund	Earthen and vegetated bund constructed to provide a visual screen to vantage points to the north and west.
Yorkeys Creek Crossing	Crossing of Yorkeys Creek constructed at the instruction of DPI (MR).

CONTENTS

CONTENTS

Page

APPENDICES

CONTENTS

Page

FIGURES

TABLES

1 INTRODUCTION

This Soil and Water Management Plan (SWMP) for the Austen Quarry ("the quarry site"), has been prepared in compliance with *Condition 9(a)* of a development consent (DA No. 103/94) issued by the Council of the City of Greater Lithgow (now Lithgow City Council). It has been prepared in accordance with the Landcom document *Managing Urban Stormwater: Soils and Construction, Vol. 1, 4th eds.* (Landcom, 2004).

The Austen Quarry has been owned and operated by Adelaide Brighton Limited (ABL) since March 2002. The SWMP updates and replaces water management features and concepts presented in an "Erosion and Sediment Control Plan for the Hartley Rhyolite Quarry Site Access Road" (DLWC, 1995) and the "Rehabilitation and Environmental Management Plan" (IEC, 1999) prepared on behalf of the previous owner of the Austen Quarry, Aus10 Rhyolite Pty Limited of the Premier Resource Group. The SWMP incorporates:

- an identification and categorisation of the water catchments of the quarry site and associated infrastructure (**Section 2**);
- a description of the local soil types and their potential influence on the design and construction of water management structures (**Section 3**);
- an assessment of constraints posed by the location of the quarry site and characteristics of the local soils and surface water catchments (**Section 4**);
- a description of soil and water management at the quarry site including:
  - soil and water management objectives (**Section 5.1**);
  - soil best management practices (**Section 5.2**);
  - water best management practices including a description of the structures used on the quarry site to control and store water flows (**Section 5.3**);
  - a water balance and internal water transfer regime for the quarry site (**Section 5.4**).
- an Erosion and Sediment Control Plan (ESCP) (**Section 6**); and
- a Surface Water Monitoring Program (SWMonP) (**Section 7**).

For management purposes, the water within the quarry site has been divided into two classes.

1. **"Clean" water** - surface runoff from rehabilitated catchments or catchments undisturbed or relatively undisturbed by extraction, processing or related activities.
2. **"Dirty" water** - surface runoff from disturbed catchments such as the active extraction area and overburden emplacement, processing area, quarry site product stockpiles, internal roads, soil and subsoil stockpiles and rehabilitated areas (until stabilised), all of which could produce significant concentrations of suspended sediment.

2 CATCHMENTS OF THE AUSTEN QUARRY

Figure 1 presents the regional catchments of the Austen Quarry, identified as Catchments 1, 2, 3 and 4. **Table 2.1** presents information on the area covered by, and the type of quarry site related disturbance to occur in each.

Table 2.1
Austen Quarry Catchments

Catchment	Area (ha)	Quarry site Related Disturbance
1	103	Extraction area, processing area, Quarry Site Access Road, and quarry site facilities
2	115	Overburden emplacement
3	740	Site Access Road, Yorkeys Creek Crossing
4	195	Site Access Road

Figure 2a presents the local sub-catchments surrounding the quarry site, overburden emplacement, processing area and Quarry Access Road. **Figure 2b** presents the identified sub-catchments surrounding the Site Access Road. These sub-catchments are categorised as either clean, partially disturbed or disturbed, where each category is as follows:

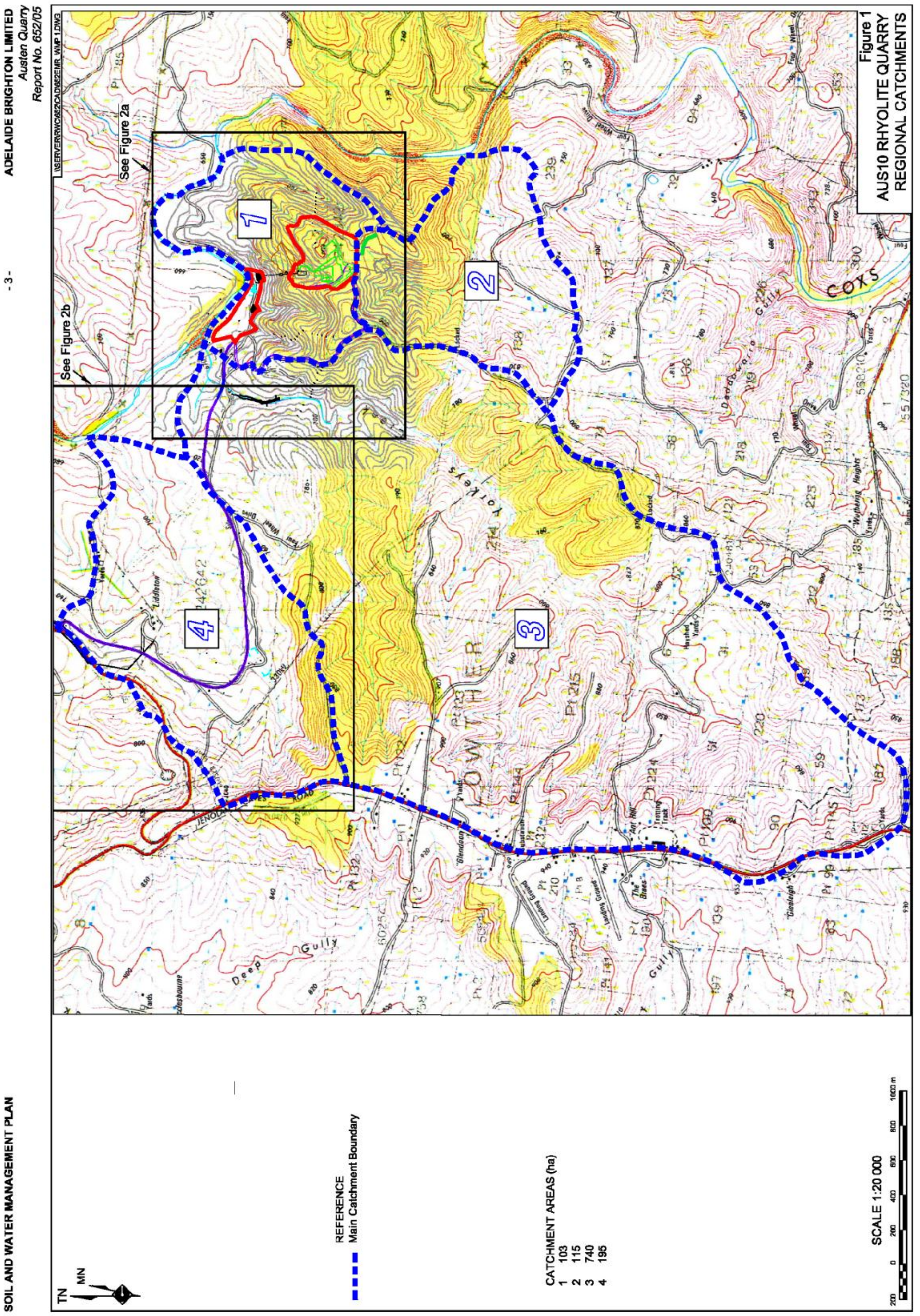
- **Clean catchments** reference those which do not include any areas of quarry related disturbance.
- **Partially disturbed catchments** reference those which include only areas of minor quarry site related disturbance or rehabilitation under maintenance.
- **Disturbed catchments** reference those which include areas of major quarry related disturbance.

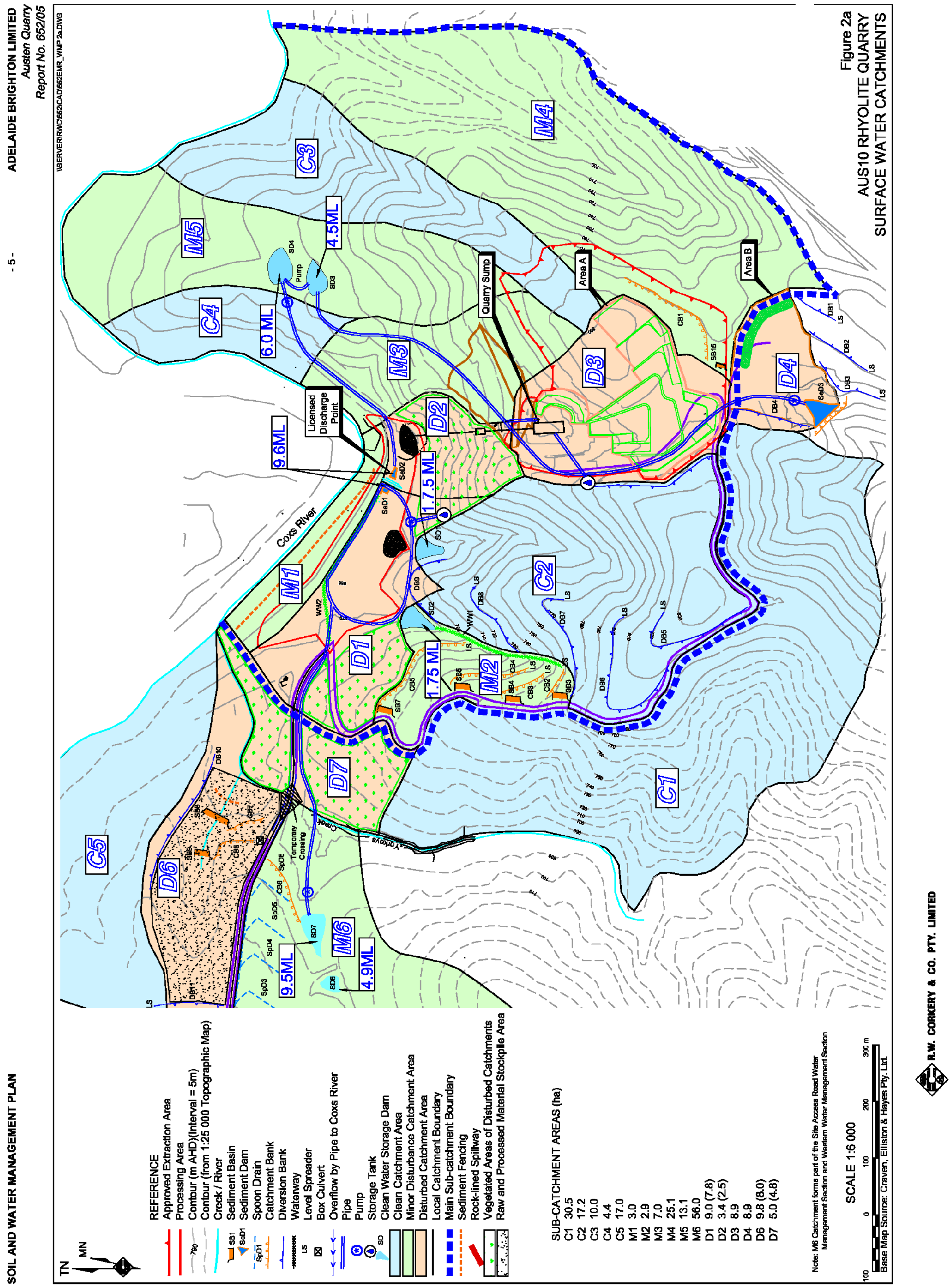
Table 2.2 presents the area of each of these sub-catchments as calculated from the surveyed and interpreted topographic base of **Figure 2**. **Table 2.2** also identifies the water storage structures within each of the nominated catchments.

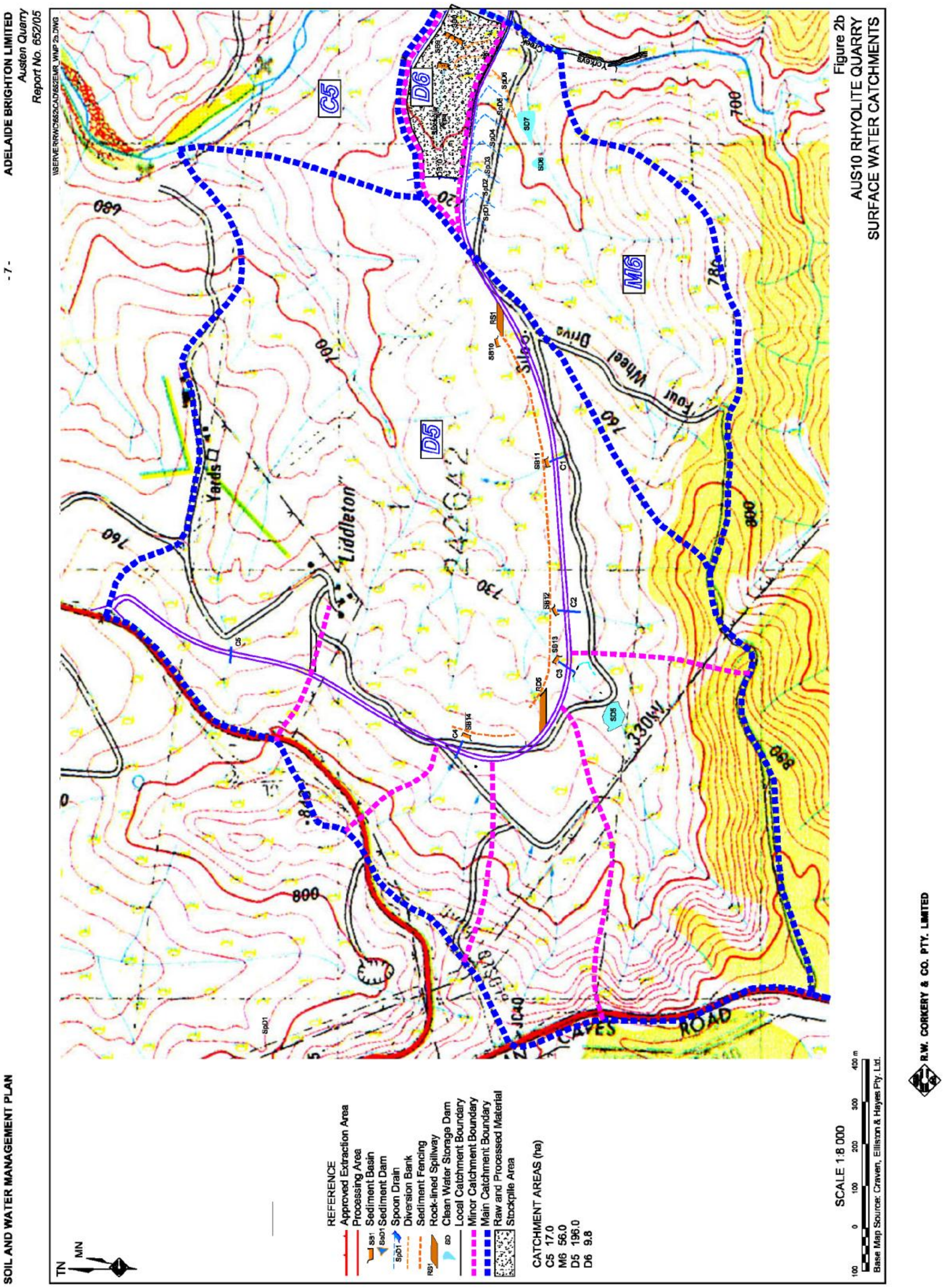
Table 2.2
Austen Quarry Catchments

Clean Catchments#			Partially Disturbed Catchments#			Disturbed Catchments#		
	Area	Water Storages*		Area	Water Storages*		Area	Water Storages*
C1	30.5	-	M1	3.0	-	D1	9.0	SeD1
C2	17.2	SD1	M2	2.9	SB3, SB4, SB5, SB7, SD2	D2	3.4	SeD2
C3	10.0	-	M3	7.0	-	D3	8.9	Quarry Sump
C4	4.4	-	M4	25.1	SB13	D4	3.1	SeD3
C5	17.0	-	M5	13.1	SD3, SD4	D5	196.0	SD5, SB10 – SB12
			M6^	56.0	SD6, SD7	D6	9.8	SB8, SB9
						D7	5.0	

Refer to **Figure 2a** * Refer to Sections 5.3.3.6 and 5.3.4.3 for detail
^ It is the objective of water management on the site to operate sub-catchment M6 as a clean water catchment following the completion of road construction and installation of associated erosion and sediment controls


ADELAIDE BRIGHTON LIMITED
Austen Quarry
Report No. 652/05
- 3 -
SOIL AND WATER MANAGEMENT PLAN
Figure 1
AUS10 RHYOLITE QUARRY
REGIONAL CATCHMENTS
See Figure 2a
See Figure 2b
1
2
3
4
COXS
REFERENCE
Main Catchment Boundary
CATCHMENT AREAS (ha)
1 103
2 115
3 740
4 195
SCALE 1:20 000
TN
MN
R.W. CORKERY & CO. PTY. LIMITED


SOIL AND WATER MANAGEMENT PLAN
- 5 -
ADELAIDE BRIGHTON LIMITED
Austen Quarry
Report No. 652/05
Figure 2a
AUS10 RHYOLITE QUARRY
SURFACE WATER CATCHMENTS
REFERENCE
Approved Extraction Area
Processing Area
Contour (m AHD)(Interval = 5m)
Contour (from 1:25 000 Topographic Map)
Creek / River
Sediment Basin
Sediment Dam
Spoon Drain
Catchment Bank
Diversion Bank
Waterway
Level Spreader
Box Culvert
Overflow by Pipe to Coxs River
Pipe
Pump
Storage Tank
Clean Water Storage Dam
Clean Catchment Area
Minor Disturbance Catchment Area
Disturbed Catchment Area
Local Catchment Boundary
Main Sub-catchment Boundary
Sediment Fencing
Rock-lined Spillway
Vegetated Areas of Disturbed Catchments
Raw and Processed Material Stockpile Area
SUB-CATCHMENT AREAS (ha)
C1 30.5
C2 17.2
C3 10.0
C4 4.4
C5 17.0
M1 3.0
M2 2.9
M3 7.0
M4 25.1
M5 13.1
M6 56.0
D1 9.0 (7.8)
D2 3.4 (2.5)
D3 8.9
D4 8.9
D6 9.8 (8.0)
D7 5.0 (4.8)
Note: M6 Catchment forms part of the Site Access Road Water Management Section and Western Water Management Section
SCALE 1:6 000
Base Map Source: Craven, Elliston & Hayes Pty. Ltd.
R.W. CORKERY & CO. PTY. LIMITED
Coxs River
Licensed Discharge Point
Quarry Sump
Area A
Area B
Temporary Crossing
C1
C2
C3
C4
C5
M1
M2
M3
M4
M5
M6
D1
D2
D3
D4
D6
D7
4.5ML
6.0 ML
9.6ML
1.75 ML
1.7.5 ML
9.5ML
4.9ML


ADELAIDE BRIGHTON LIMITED
Austen Quarry
Report No. 652/05
SOIL AND WATER MANAGEMENT PLAN
- 7 -
REFERENCE
Approved Extraction Area
Processing Area
Sediment Basin
Sediment Dam
Spoon Drain
Diversion Bank
Sediment Fencing
Rock-lined Spillway
Clean Water Storage Dam
Local Catchment Boundary
Minor Catchment Boundary
Main Catchment Boundary
Raw and Processed Material Stockpile Area
CATCHMENT AREAS (ha)
C5 17.0
M6 56.0
D5 196.0
D6 9.8
SCALE 1:8 000
Base Map Source: Craven, Elliston & Hayes Pty. Ltd.
C5
D6
D5
M6
Liddleton
Yards
Four Wheel Drive
CAVES ROAD
330kV
Figure 2b
AUS10 RHYOLITE QUARRY
SURFACE WATER CATCHMENTS
R.W. CORKERY & CO. PTY. LIMITED

It is worthy of note that water captured within the sub-catchments of D3 and D4 will be pumped to SD3 / SD4 within catchment M5 following an accumulation of water in the either SeD3 or the Quarry Sump. As a consequence, catchment M5 has been classified as a partially disturbed catchment.

A basic objective of water management on any quarry site is to segregate clean and dirty water. To aid in achieving this objective at the Austen Quarry, the sub-catchments of the quarry site, (ie. those identified in **Figure 2a)**, have been further categorised into water management sections (WMS') for either clean or dirty water (see **Figure 3**).

Dirty Water

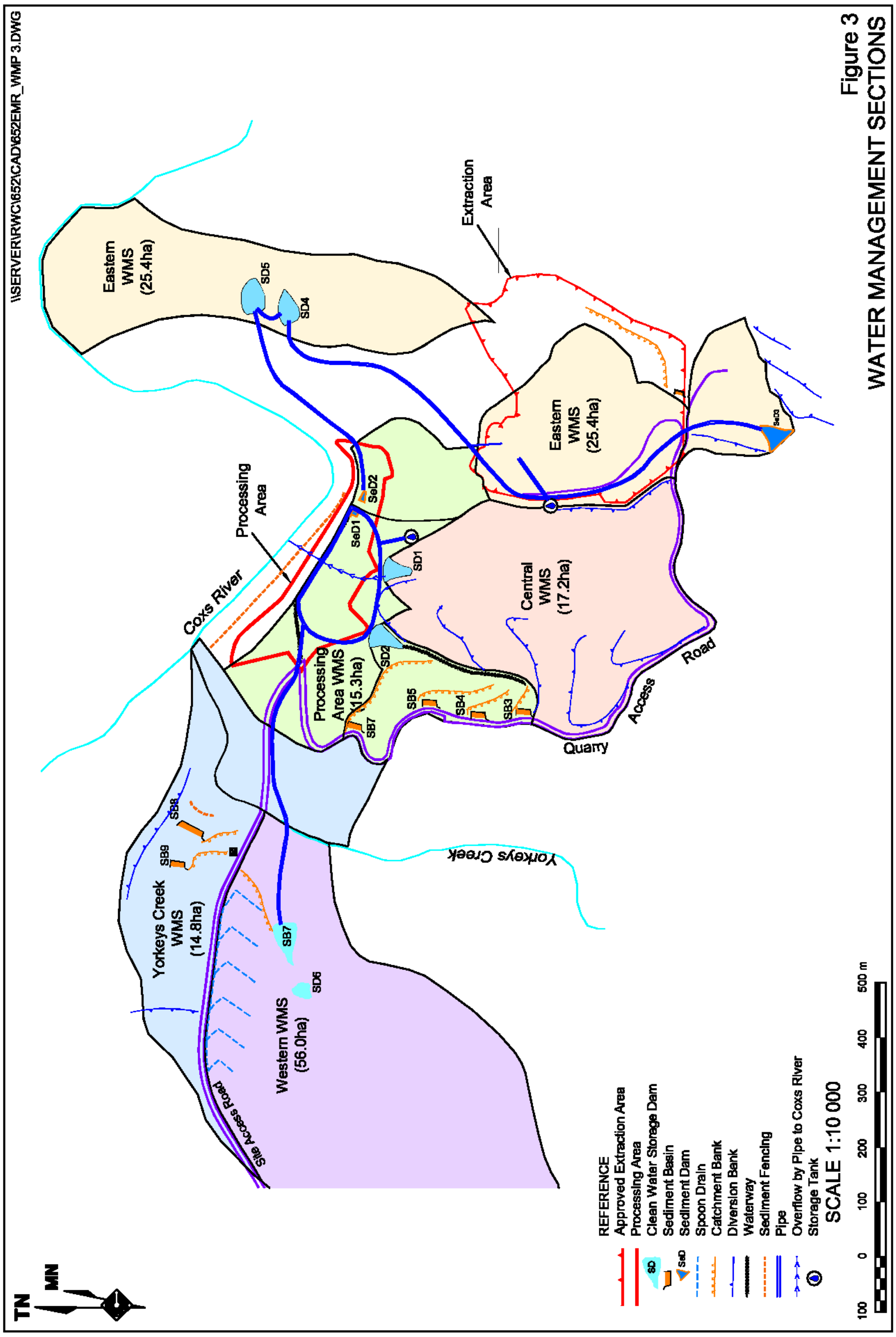
- Eastern WMS – which incorporates sub-catchments D3, D4 & M5 for a total catchment area of 25.1ha. Dirty water will be stored in SD4 for operational use whereas SeD3 and SD3 will be kept largely empty to ensure the capture and storage of water during and following a 20 day 95^{th} percentile rain event. Dirty water will be pumped to SD5 as required with this water treated with a flocculant, sampled and analysed prior to discharge.
- Processing Area WMS – which incorporates sub-catchments D1, D2 and M2 for a total catchment of 15.3ha. It will also include runoff from the Quarry Access Road from the top of the ridge to the processing area. All water storage structures within this WMS will be operated predominantly as sediment retention structures and therefore will be preferentially kept dry. As such, settled water will be transferred to SD4 within the Eastern WMS as required. It is noted that this represents a variation from water management on the processing area proposed in the EIS. It is considered appropriate to minimise the volume of water in and around the more disturbed areas of the quarry and thereby reduce the risk of incidents related to the discharge of dirty water from the processing area.
- Yorkeys Creek WMS – which incorporates sub-catchments D6 and D7 for a total catchment of 14.8ha. These sub-catchments will not contribute to water storage, rather, they will be managed such that water flowing to Yorkeys Creek has been sufficiently treated through diversion and/or settlement as not to pollute the creek or Coxs River further downstream.

Clean Water

- Central WMS – which incorporates sub-catchment C2 only for a total catchment area of 17.2ha. Diversion structures will direct water to SD1 from where the water may be pumped directly to the Coxs River or transferred to SD7 for storage.
- Western WMS – which incorporates sub-catchment M6 only for a total catchment area of 56.0ha. This WMS will capture natural flows from within the M6 sub-catchment as well as water discharged via spoon drains from a 0.35ha area of the Site Access Road. SD6 and SD7 may also accept water from SD1.

By considering water management on the quarry site within these dirty and clean WMS', segregation of clean and dirty water will be achieved while also allowing for sediment retention structures to be kept empty, thereby maximising their water storage / sediment retention capacity during and following heavy rain.

ADELAIDE BRIGHTON LIMITED - 10 - **SOIL AND WATER MANAGEMENT PLAN**
Austen Quarry
Report No. 652/05



R.W. CORKERY & CO. PTY. LIMITED

3 SOILS OF THE AUSTEN QUARRY

3.1 Introduction

With the exception of a single soil horizon sample, analysed in September 1995, no specific assessment of quarry site soils has been undertaken. A description of quarry site soils has been based on three primary sources.

(i) Definition of the Marangaroo soil landscape from the Katoomba 1:100 000 soil landscapes mapsheet area (King, 1994).

(ii) Environmental Impact Statement prepared for the Hartley Rhyolite Quarry by Sinclair Knight Merz (1994).

(iii) Erosion and Sediment Control Plan for Hartley Rhyolite Quarry Access Road prepared by the Department of Land and Water Conservation (1995).

3.2 Quarry Soils and Soil Erodibility

The quarry site is located within the Katoomba 1:100 000 scale soil landscapes map sheet area (King 1994). On this map sheet area, limited areas to the south of the quarry site access road are located on the Round Mount Soil Landscape with the quarry site activities located predominantly on the Marangaroo Soil Landscape. Soils of the Marangaroo Soil Landscape generally display the following characteristics.

- Location: Generally occurring on rolling hills and narrow flat to rounded converse crests of Carboniferous granites, local relief to 90m and slopes <30°.
- Texture: Shallow (<80cm) loamy sand to sandy loam above clayey sand changing to coarse, gravely sand or sandy clay at depth.
- pH: Moderately to slightly acid in topsoil layers. Subsoil is slightly acid to slightly alkaline (6.5 to 8.0).
- Permeability: Highly permeable with low water holding capacity.
- Fertility: Low fertility.
- Erodibility: High erodibility. King (1994) attributes a USLE K factor of between 0.024 and 0.031.

Soils of the Marangaroo Soil Landscape are considered to show slight dispersibility (EAT Classes 3(1), 3(2) and 5) and generally moderate dispersion (0% - 60%) (King, 1994).

Based on this description of the soil, careful management is required to reduce the erosion hazard.

3.3 Implications for Soil and Water Management of the Quarry

The soil characteristics described in Section 3.2 would suggest that unless carefully controlled, surface water flows on the quarry site will tend to cause erosion. However, due to the slight dispersibility and generally moderate dispersion of the soil (King, 1994), settlement time for captured surface water may be relatively low, which could therefore, reduce the size of the storage structures required.

Ultimately the location and size of surface water management and storage structures will need to account for soil type and catchment size.

4 ASSESSMENT OF CONSTRAINTS

4.1 Introduction

As noted in Landcom (2004), a proper assessment of site constraints is a prerequisite to the preparation and implementation of a SWMP. Constraints are classified as either:

(i) on-site, ie. relating to soils, landforms, ecology pollutants and hydrology occurring on the site of the proposed or approved activities; or

(ii) downstream, ie. relating to aquatic ecosystem sensitivity and the social and aesthetic values of the community.

Based on the identified constraints and opportunities, best management practices (BMPs) can be developed for the site to minimise the potential degradation of soil and water resources and/or other aesthetic/environmental assets while maximising the achievement of outcomes in accordance with principles of Ecologically Sustainable Development (ESD).

It is noted that an assessment of constraints is generally undertaken at the conceptual stage of project development. Despite the fact that conceptual planning for the Austen Quarry occurred over ten years previous to the preparation of this SWMP, it is still considered appropriate to consider the constraints of the site given that the SWMP is to become the focal document in the management of soil and water resources.

4.2 Riparian Lands

Waterfront Lands (formally known as Riparian Lands under the *Rivers and Foreshores Improvement Act 1948*) are those vegetated lands immediately next to waterbodies such as rivers, creeks, estuaries, lakes and wetlands. The Austen Quarry includes development on riparian lands and therefore is constrained:

(i) to protect and enhance the social, economic, cultural, spiritual and heritage values of waterfront land for aboriginal groups and the wider community; and

(ii) to avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, salinity hazards and decline of native vegetation.

4.3 Flooding

A 1 in 150 year ARI storm of 1 February 2005 (Parsons Brinkerhoff, 2005) has illustrated that the processing area of the quarry site is not affected (and therefore not constrained) by local flooding.

Local flooding of Yorkeys Creek during 1 in 100 year, 72 hour ARI or greater events is, however, a constraint on the design and construction of the crossing of Yorkeys Creek. Flooding levels recorded following the February 2005 storm event identified a high water mark of 5.2m above the bed of Yorkeys Creek at a location approximately 150m upstream of the crossing (see **Figure 4**). These historic values must be accounted for in crossing design and construction management.

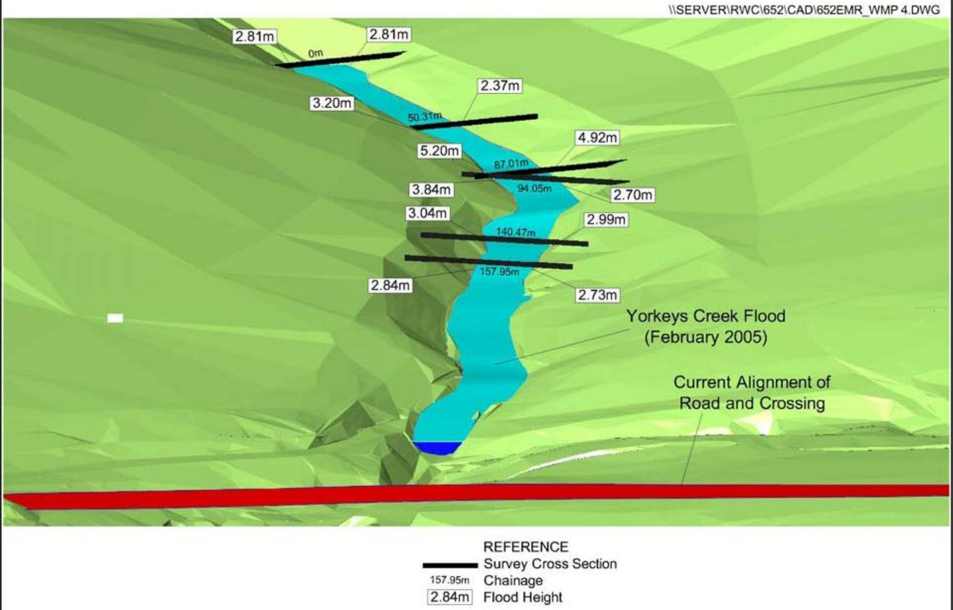


Figure 4
1 IN 150 YEAR ARI STORM
YORKEYS CREEK

4.4 Erosion (Rainfall Erosivity, Soil Erobility and Soil Erosion Hazard)

4.4.1 Rainfall Erosivity

The rainfall erosivity factor, R, is a measure of the ability of rainfall to cause erosion. It is the product of two components:

- total energy; and
- maximum 30 minute intensity for each storm.

Based on Map 10 of Landcom (2004), the Austen Quarry is located within a rainfall erosivity zone between 1 500 and 2 000. As the bulk of ground disturbing activities occur on slopes of 10% or less, the Austen Quarry presents a generally low erosion hazard (see Figure 4.6 of Landcom (2004)). Where the slope of land on which activities are to occur is greater than 10°, the design and development of these areas is constrained by a potentially high erosion hazard.

4.4.2 Soil Erodibility

Soil erodibility is a measure of the susceptibility of individual soil particles to detachment and transport by rainfall and runoff. Soil texture is the principal component affecting soil erodibility, but structure, organic matter and permeability also contribute.

As no comprehensive laboratory analysis of quarry soils has been completed, the soil erodibility can not be accurately determined. It is noted however, that soils of the Marrangaroo soil landscape tend to display moderate to high erodibility (King, 1994) and as such, the implementation of appropriate erosion and sediment controls will constrain development.

4.4.3 Soil Erosion Hazard

Soil erosion hazard refers to the susceptibility of land to the prevailing agents of erosion and must be distinguished from soil erodibility. Where soil erodibility is measured only on a sample of soil taken from the field to a laboratory and put through certain tests, soil erosion hazard is considerate of field conditions and is dependent on a number of factors, including climate (rainfall erosivity), landform, soils (soil erodibility), ground cover and land management.

A soil loss class for the quarry site is conservatively considered Class 4 to 5, moderate to high erosion hazard, with activities constrained by the implementation of the best management practise erosion and sediment controls, especially between December and February (when Landcom (2004) notes the erosion hazard is greatest).

4.5 Soil Characteristics

Section 3 provided a general description of the type of soils to be encountered at the quarry site. These will generally be Class C or F soils which are only moderately dispersible. As a consequence, soil characteristics do not pose a major constraint to soil and water management.

4.6 Surface Water Runoff

Given the steep relief within several quarry site sub-catchments, surface water runoff will be an important consideration in the design and location of best management practice water storages and catchment/diversion structures. The runoff coefficients of land within the quarry site sub-catchment will need to be accounted for in the preparation of a site water balance and best management practice erosion and soil control.

4.7 Groundwater Table

As the development and operation of the Austen Quarry is unlikely to have a significant impact on local water tables (SRK, 1994), this will not constrain development of best management practices water management.

4.8 Salinity and Acid Sulphate Soils

Soils of the Marrangaroo Soil Landscape do not pose a salinity or acid sulphate soil hazard.

4.9 Contaminated lands

Soil contamination can result from the actions associated with previous land uses where chemical concentrations have accumulated over time and, now, pose significant health risks to potential new occupiers and to the environment. To date no contaminated lands have been encountered, and none are expected, at the Austen Quarry. Should contaminated lands be identified soil and water management will be constrained by the guidelines prepared by the DEC.

4.10 Mass Movement

The soil layer on the steeper slopes of the quarry site is shallow and of low plasticity above a competent rock base. The potential for mass movement of soil is considered low and this will not constrain soil and water management of the quarry site.

5 SOIL AND WATER MANAGEMENT

5.1 Objectives

The principal objectives of soil and water management are as follows.

(i) To manage the soil resources of the site to minimise the risk of erosion and maximise the potential use of any stripped/disturbed soil in ongoing rehabilitation of the site.

(ii) To ensure appropriately designed and located water management structures are constructed and maintained to segregate "dirty" water from "clean" water.

(iii) To ensure that "dirty" water captured within the disturbed and partially disturbed sub-catchments of the quarry site is retained, retention time maximised and water appropriately treated such that any discharge occurs at the licensed discharge point and this meets the water quality objectives as follows:

- pH - 6.5 – 8.5;
- Oil and grease - 10 mg/L;
- Electrical Conductivity - <1500 us/cm;
- Total Suspended Solids - <30 mg/L; and
- Biochemical Oxygen Demand - 20.

(iv) To ensure sufficient quantities of water can be obtained through the capture of surface water to meet the operational and dust suppression requirements of the quarry site.

(v) To minimise erosion and sedimentation from all active and rehabilitated areas of the quarry site.

(vi) To monitor the effectiveness of surface water erosion and sediment controls such that the quarry site has no adverse impact on the water quality of the Cox's River.

The following sub-sections have been structured and prepared to provide appropriate best management practises (BMPs) to maximise the potential to achieve each of these objectives.

- Section 5.2 presents the soil BMPs to be adopted by ABL at the Austen Quarry.
- Section 5.3 presents the water BMPs to be adopted by ABL at the Austen Quarry. This includes a description of water management within the riparian zones on the quarry site, the internal pumping system installed to allow for the movement of water between various site storages and the design features and locations of structures constructed to control the flow of water on the quarry site.
- Based on the predicted runoff received within the quarry site sub-catchments, the location of the water management structures described in Section 5.3, and the operational requirements of the Austen Quarry, Section 5.4 presents a water balance for the quarry site. The water balance provides further details on the internal pumping system of the site and the likely requirement to move water between water storages in dry, average and wet years. This section also reviews the critical storage capacity of the site over which a controlled discharge to the Coxs River will be required.

5.2 Soil BMPs

Minimising the area of soil exposed to surface water flows, either as cleared surfaces ahead of extraction, soil stockpiles or respread soils over rehabilitated surfaces, is the primary aim of soil management. The secondary aim is to provide exposed soils with adequate protection to minimise disturbance caused by surface water flows. These aims are achieved through the adoption of the following BMPs, the detailed implementation of which is provided in *Procedure 3 - Soil Management*.

Planning Considerations

- As far as practical, ground disturbing activities (vegetation clearing, soil stripping and site development works) will be scheduled such that the time from commencement to completion is less than six months.
- Generally disturbance will begin at a point most distant from a waterway or drainage line and move closer.
- Genuine attempts will be made to minimise the areas cleared ahead of extraction.
- Access to areas designated for ground disturbing activities are to be limited to within 10m (and preferably 5m) of the designated area and identified with fencing, flagging or other methods.
- Prior to the commencement of any ground disturbing activities, upslope diversion banks (see Section 5.3.3.2) and downstream sediment fencing and/or other sediment retention structures (Section 5.3.5.2) are to be constructed / installed.
- The length of any exposed slope will be restricted to 80m or less prior to forecast rain or periods of non-activity in that area. On steeper slopes, mid-slope berms or up-slope water diversion works will be constructed.

Handling Soils

- Soil stripping areas will be clearly defined and marked prior to commencement.
- Ideally, grass and shrub layer will be stripped along with the soil.
- The topsoil will be stripped to a depth of between 100mm and 150mm and either transferred directly to rehabilitation area or placed in designated stockpile areas.

Soil Stockpiling

- Soil Stockpiles are to be managed in accordance with *Procedure No. 3 – Soil Management*, ie. no higher than 3m with a slope of <2:1(V:H) and the stockpile surface left roughened. Placement within natural or constructed drainage lines will be avoided, however, if unavoidable, upstream and downstream protection, in the form of diversion banks (see Section 5.3.3.2) and downstream sediment retention structures (see Sections 5.3.4 and 5.3.5) will be constructed/installed prior to commencement of stockpiling.
- Soil retained in stockpile for >3 months, will be stabilised in accordance with *Procedure No. 6 – Site Stabilisation and Short Term Rehabilitation.*

Soil Respreading

- Before soil respreading the ground surface will be scarified or ripped along the line of the contour to break any compacted and smooth surfaces and assist in keying the respread soil.
- Soil respread over areas of rehabilitation will be approximately 100mm on flat or shallow slopes (>4(H):1(V)) and no greater than 50mm on steeper slopes (<4(H):1(V)).

- The respread soils will be left with a roughened surface and sown with native grass species (or a non-persistent cover crop) as soon as possible to stabilise the soils.

5.3 Water BMPs

5.3.1 Introduction

Best management practises (BMPs) for water on the Austen Quarry consider the water management system of the Austen Quarry in it's entirety:

(i) management of water within riparian corridors of the quarry site;

(ii) the diversion and storage of clean water within a predominantly segregated clean water system;

(iii) the capture, storage and settling/treatment of dirty water within a segregated dirty water system;

(iv) the discharge of water from the quarry site;

(v) a water balance for the nominated clean and dirty water systems and an appropriate pumping regime to maximise storage capacity of the quarry site; and

(vi) capacity requirements, or management protocols, of the various water storages to retain sufficient capacity to handle a 20 day 95^{th} percentile rain event without overflow to the Cox River.

Detail is provided to the extent considered necessary to illustrate the concepts and objectives of water management implemented at the Austen Quarry and describe the appropriate design and function of the various water BMPs used to achieve these concepts and objectives. Specific design features for the water BMPs, as provided by GSS Environmental, are presented with detail on the construction and maintenance of the various structures described in the following sections provided in the following procedures:

(i) *Procedure No. 4 – Erosion and Sediment Control Design and Construction.*

(ii) *Procedure No. 5 – Erosion and Sediment Control Maintenance.*

5.3.2 Works within Riparian Corridors

The Austen Quarry has been approved to undertake operations that fall within, or adjacent to natural water bodies, namely:

- construction of a crossing of Yorkeys Creek; and
- construction of a processing area that encroaches within 40m of the Coxs River.

Management of works within these zones is as follows.

Yorkeys Creek Crossing

Given the level of disturbance required within Yorkeys Creek, ie. construction of a crossing sufficient for heavy vehicle traffic, and the ephemeral nature of the water body, this is considered Category 3 riparian land (Landcom, 2004) and is to be managed to ensure the maintenance of bank stability and water quality.

As a consequence of a 1 in 150 year ARI storm in the first quarter of 2005 (Parsons Brinkerhoff, 2005), construction of a DIPNR designed crossing was compromised and the partially completed structure washed away. At the request of the Department of Primary Industries (Mineral Resources), a replacement crossing has been constructed. The construction of this replacement crossing considered the recommendations of Landcom (2004) and incorporates the following design features:

- It was constructed using a 3m wide culvert to carry water beneath a raised gravel/rock carriageway.
- The rock used in the construction of the carriageway was sourced from the extraction area.
- The height of the carriageway at its most elevated point above the bed of Yorkeys Creek is approximately 8m. This reduces the slope of the Site Access Road entering and exiting the crossing.
- The carriageway is 7m in width with the culvert extending beyond the toe of the rock embankment.

Management of the replacement crossing will be as follows.

- The culvert will be regularly inspected and cleared of debris that might compromise its capacity or lead to blockage of the pipe.
- Regular inspections will be undertaken to observe whether any of the rock used in the construction of the carriageway and embankment have moved following rainfall events. Any material found to have moved will be replaced at the base of the embankment or disposed of in the overburden emplacement.
- A vegetative cover on the exposed slopes of the washed out crossing will be established and maintained. Where considered necessary, additional stabilisation works will be undertaken.
- If and when a replacement crossing is required, the existing crossing will be removed and the site rehabilitated in accordance with the site Stage Specific Management Plan (in preparation).

Processing Area

During the construction phase of the Austen Quarry it became apparent that the processing area, as designed, encroached within 40m of the Coxs Rover. Although this section of the Coxs River bank had been previously cleared, and as a consequence supported predominantly exotic vegetation, the area required for the construction of the processing area is considered Category 2 riparian land (Landcom, 2004). As such, it is to be managed as terrestrial and aquatic habitat and therefore must maintain the natural function of the river to:

- maintain and improve the viability of riparian vegetation;
- maintain/provide suitable habitat for terrestrial and aquatic fauna;
- provide bank stability; and
- protect water quality.

A permit under the *Rivers and Foreshores Improvement Act 1948* has been issued for operations within the 40m of the Coxs River (PAR9012617) and the construction, operations and rehabilitation of the processing area and processing area bund wall within this zone managed in accordance with PAR9012617. In summary, construction, operations and rehabilitation will be managed as follows.

- The processing area bund wall has been constructed with competent rock extracted from the quarry area and topsoil excavated from the site of the bund wall.[1]
- The bund wall was constructed in such a way as to not impact on the natural flow path, including riffles and pools, of the Coxs River.
- At the instruction of DIPNR, the topsoil was not compacted to encourage the establishment of riparian vegetation.
- The discharge of surface water from the processing area to the Coxs River will be prevented.
- Sediment fencing will be maintained between the toe of the bund wall and the main flow channel of the Coxs River and inspected fortnightly or after major rainfall events.
- Access within the riparian corridor created by the construction of the bund wall will be restricted to ABL personnel undertaking rehabilitation or maintenance activities and the land owner.
- The bund wall and parts of the processing area will be progressively revegetated in accordance with a Vegetation Management Plan (VMP) prepared by Geoff Cunningham Natural Resource Consultants Pty Limited (GCNRC, 2005).
- ABL will supply the Department of Natural Resources (DNR) a brief maintenance report on the status of activities within areas covered by PAR9012617 every 6 months (for as long as required) and respond in a timely fashion to recommendations and maintenance orders supplied by DNR.

[1] Following initial construction of the processing area bund wall of SED1 and SED2, a structural failure was identified leading to the discharge of water, within these structures discharging to the Cox's River. Subsequent investigations into the geotechnical characteristics were undertaken with additional clay lining and compaction to be included in the repair and reconstruction of SED1 and SED2.

5.3.3 Clean Water Diversion and Storage

5.3.3.1 Introduction

A primary objective of the management of water on the quarry site will be to segregate clean and dirty water flows (see Section 5.1) and diverting surface water flows away from areas of active disturbance or rehabilitating lands will assist in achieving this objective. Diverting water flowing over undisturbed areas of the quarry site, away from the active areas of disturbance and directing this water either to water storages or discharge points at non-erosive velocities, will also greatly reduce the risk of erosion, and therefore sedimentation.

The following section presents the surface water BMP structures to be employed on the quarry site to divert and store clean water.

Procedure No. 4 provides additional detail on the design and construction of these structures.

5.3.3.2 Diversion Banks (Low Flow)

These structures are simple earth banks which are generally constructed with a circular, parabolic or trapezoidal drain. They are designed to divert surface water flows from shallow to moderate slopes where the upslope length is less than 80m or within small or well vegetated catchments. The gradient of the diversion bank should be between 1% and 5% and the height of the bank at least 300mm. Within 10 days of construction, a grass cover, or some other form of stabilisation should be established to prevent the erosion of the bank and drain.

Depending on the volume of water carried by the diversion bank a level spreader (or sill) or rock-lined spillway (see Section 5.3.2.4) may be constructed at the bank discharge point to reduce the risk of erosion at this point.

The location of diversion banks on the quarry site are presented on **Figures 2a** and **2b** and are denoted by the prefix “DB”. The specific design features of the diversion banks of the quarry site are presented in **Table 5.1**.

These structures will be inspected fortnightly, or following a significant rain event to ensure that they are capable of carrying the surface water flow of the catchment at non-erosive velocities or concentrations. In the event that significant erosion is observed, the diversion bank will be upgraded to cater for high flows (see Section 5.3.4.2).

Table 5.1
Diversion Bank Specifications

Diversion Bank ID	Catchment Area (ha)	Channel Bottom Width (m)	Channel Grade (%)	Bank Height (m)	Sill Width (m)
DB1	0.23	3	1	0.7	4
DB2	1.12	3	1	0.7	4
DB3	0.79	3	1	0.7	4
DB4	0.26	3	1	0.7	4
DB5	0.75	3	1	0.7	4
DB6	1.25	3	1	0.7	4
DB7	1.32	3	1	0.7	4
DB8	0.90	3	1	0.7	4
* This is the maximum catchment area for the structure although it is noted this will vary dependant on the progress of mine and site development.					
Source: GSS Environmental (see Appendix 1)					

Appendix 1 presents the standard drawing and construction notes for a low flow diversion bank, as recommended by Landcom (2004).

5.3.3.3 Level Spreaders and Rock-lined Spillways

A level spreader, also known as a sill, is a shallow channel excavated at the outlet of a diversion bank or catchment banks/channels. A rock-lined spillway, as the name suggests, is a low gradient, rock-lined area at the discharge point of a bank, channel or water storage structure.

Appendix 1 presents the standard drawing and construction notes for a level spreader, as recommended by Landcom (2004).

In general, a level spreader (denoted by the prefix LS on **Figures 2a** and **2b**) will be constructed at the discharge point of a clean water diversion bank and a rock-lined spillway (denoted by the prefix RS on **Figures 2a** and **2b**) at the overflow point of sediment retention or water storage structures. *Procedure No. 4* provides the generalised design and construction details for these structures, the locations of which are presented in **Figures 2a** and **2b**.

These structures will be inspected at the same time as the diversion banks for signs of erosion and sedimentation. As noted in Section 5.3.3.2, any identified maintenance work is to be completed within 7 days of the inspection.

5.3.3.4 Culverts

Culverts are structures designed to carry water from one side of a constructed obstruction to the other. These structures may be open drains or pipe structures with pipe culverts generally constructed in preference to open drainage structure when the flow-through of water may adversely impact on operations. At the Austen Quarry 0.3m diameter (approximately) pipe culverts have been constructed to carry water beneath the Site Access Road at points C1 to C5, and a 3m pipe culvert installed as part of the replacement Yorkeys Creek Crossing.

The dimensions of these culverts were originally determined by DLWC (1995). Each culvert has been constructed with inlet and outlet protection in the form of rock lining with competent rock >80mm.

Inspections are to occur at least fortnightly with maintenance work completed within 7 days of the inspection.

5.3.3.5 Spoon Drains

Spoon drains are open drains constructed with a parabolic or trapezoidal channel and used to divert water flows from road side drainage to vegetated or otherwise erosion protected areas. The primary function of the spoon drain is to reduce the concentration and velocity of water flows within the road side drainage and therefore minimise the potential for erosion and transport of sediment to discharge points. Given that sections of the Site Access Road have been constructed at a relatively steep gradient, most notably within the 500m of the Yorkeys Creek Crossing, six spoon drains have been constructed along this section, namely SpD1 to SpD6 (see **Figures 2a** and **2b**).

Each spoon drain will be inspected at least fortnightly with particular emphasis on the condition of land immediately down-slope of the discharge point. Any maintenance work will be completed within 7 days of the initial inspection and commented on in the subsequent inspection sheet.

5.3.3.6 Water Storage Dams

Water Storage Dams (SDs) are water storage structures that hold clean water diverted around the areas of disturbed ground.

Soil type is crucial in determining the size and type of storage structure required. As noted in Section 3.2, the silt/clay content of the soils of the quarry site is low resulting in a low to moderate dispersibility and dispersion potential. The proportion of <0.02mm sediment of the quarry site soil is anticipated to be <15%, however, in order to provide for higher silt and clay content soils, Type F Soils (>33% silt and clay content (Landcom, 2004)) are assumed.

An inspection of the six SDs indicates that SD3, SD4, SD6 and SD7 are effectively modified agricultural dams. These have, however, operated effectively in storing water pumped from the extraction area and as such it is considered unnecessary to undertake any modification works to meet the design criteria of Landcom (2004). SD1 and SD2 appear to have been constructed generally in accordance with the criteria for a wet earth basin for Type F soils although the compaction of materials cannot be determined. As the water level with SD1 rises it will overflow through a pipe where it may either be transferred to SD7 or discharged to the Coxs River.

Figure 2a identifies the six SDs on the quarry site, and **Table 5.2** presents the dimensions of each storage dam identified on **Figure 2a** and **Figure 2b**.

Table 5.2
Storage Dam Specifications

Storage Dam ID	Effective Catchment Area (ha)*	Storage Capacity (ML)
SD1	17.2	1.75
SD2	2.9	1.75
SD3	25.1	4.5
SD4		6.0
SD6	56.0	4.6
SD7		9.5

* Effective catchment area refers to the total catchment of water reporting to this structure and may include water pumped from other catchments.

Procedure No. 4 provides the generalised design and construction details for a storage dam for Type F soils and **Appendix 1** presents the standard drawing and construction notes for these, as recommended by Landcom (2004).

SD4 and SD7 will be maintained as the primary storage structures for dirty and clean water respectively. The remaining four structures will be operated to capture runoff following rain but will be regularly emptied (through the transfer of water to either SD4 or SD7) such that storage capacity is maximised and able to manage runoff during and following a 20 day 95th percentile rain event. The maintenance of storage capacity for such an event is discussed in greater detail in Section 5.4.6, however, in summary, as storage capacity of all water storages combined reduces to below that required to manage a 20 day 95th percentile rain event, actions will be initiated to undertake a controlled discharge of water to the Coxs River.

A weekly inspection of all water storages on the quarry site will be undertaken where the following information is recorded.

- General condition.
- Water colour, eg. highly turbid, brown, clear etc.
- Evidence of overflow / erosion.
- Approximate retained capacity.

5.3.4 Dirty Water Capture and Settlement

5.3.4.1 Introduction

Diverting water away from disturbed land on the quarry site will not always be possible. However, by ensuring surface water which falls or flows over these areas is captured and diverted to structures designed to allow for the sediment of this water, the potential for downstream pollution of clean waters and/or lands will be minimised. The following sub-sections describe the design, location and construction of these structures aimed at diverting, capturing and settling dirty water on the quarry site.

5.3.4.2 Catch Bank (High Flow)

These structures are constructed channels and banks designed to carry concentrated water flows from the slopes of disturbed ground which will have an elevated run-off coefficient (≥0.5), overflow from sediment retention structures such as sediment basins or where the upslope length is greater than 80m. The gradient of the catchment bank should be ≤3%, the height of the bank at least 500mm and the depth of the channel at least 150mm. Each high flow catch bank constructed at the Austen Quarry requires the construction of a level spreader (see Section 5.3.3.4) at the discharge point to effectively manage erosion and sedimentation.

The location of catch banks at the Austen Quarry are presented on **Figures 2a** and **2b** and denoted by the prefix CB. **Table 5.3** presents the design details for each of these including length, channel width, depth and sill length

Table 5.3
Catch Bank Specifications

Catch Bank ID	Bank Length (m)	Channel Bottom Width (m)	Channel Grade (%)	Bank Height (m)
CB1	228	3	1	0.7
CB2	59	3	1	0.7
CB3	94	3	1	0.7
CB4	148	3	1	0.7
CB5	230	3	1	0.7
CB6	128	3	1	0.7
CB7	70	3	1	0.7
CB8	90	3	1	0.7
	Waterway Width (m)		**Bank Height (m)**	
WW1	2		0.5	
WW2	2		0.5	
Source: GSS Environmental (see Appendix 1)				

Within 10 days of construction, a grass cover, or some other form of stabilisation should be established to prevent the erosion of the bank and channel. The generalised design and construction of catch banks is provided by *Procedure No. 4*. **Appendix 1** presents the standard drawing and construction notes for a high flow catch bank, as recommended by Landcom (2004).

In addition to the catch banks, two waterways (prefix WW) will be constructed within sub-catchments M2 and D1/D2. These structures, which are essentially rock-lined channels, are designed to direct higher velocity surface water flows to a water storage or sediment retention structure. **Table 5.3** provides the design specifications for the two waterways, WW1 which directs water discharged from CB1 – CB4 to SD2, and WW2 which directs water discharged from the Quarry Access Road to SeD1/SeD2.

These structures will be inspected fortnightly, or following a significant rain event to ensure that they are capable of carrying the surface water flow of the catchment at non-erosive velocities or concentrations. Any maintenance work required will be undertaken within 7 days of the inspection.

5.3.4.3 Sediment Dams and Basins

A sediment dam or basin is located on a drainage line downstream of disturbed areas and is designed to intercept sediment laden runoff and retain the sediment. Sediment basins are generally smaller structures of $<20m^3$, designed to temporarily hold surface water runoff from smaller catchments. Sediment dams are larger structures designed to hold runoff from extended areas such as the quarry site processing area.

Sediment Dams

The sediment dams and the majority of the sediment basins of the quarry site are permanent structures.

Table 5.4 presents the specifications for each sediment dam identified on **Figure 2a**.

Table 5.4
Sediment Dam Specifications

Storage Dam ID	Effective Catchment Area (ha)*	Storage Capacity (ML)
SeD1	9.0	9.6
SeD2	3.4	
SeD3	3.1	>1.0

* Effective catchment area refers to the total catchment of water reporting to this structure and may include water pumped from other catchments.

The Sediment Dams will be regularly emptied (through the transfer of water to SD4) such that capacity is maintained within each to manage runoff from a 20 day 95th percentile rain event. The maintenance of storage capacity for such an event is discussed in greater detail in Section 5.4.6. In the event that the storage capacity of all dirty water storages combined is below that required to manage a 20 day 95th percentile rain event, actions will be initiated to treat the water such that a controlled discharge of water to the Coxs River may be undertaken (see Section 5.3.6).

Sediment Basins

Currently there are 12 sediment basins at the Austen Quarry, however, this is likely to change over the life of the quarry based on the location and extent of future disturbance. Any additional sediment basins will be constructed to the general design presented in *Procedure No. 4* (see also **Appendix 1**)

A weekly inspection of all sediment dams and basins on the quarry site will be undertaken where the following information is recorded.

- General condition.
- Evidence of overflow and condition of downstream catchment.
- Water colour, eg. highly turbid, brown, clear etc.
- Evidence of eroding surfaces.
- Evidence of sediment discharge.
- Approximate retained capacity.

5.3.4.4 Drop-Down Batter Drains

Drop-down batter drains ("drop-downs") are open drains constructed of erosion resistant material and used to convey runoff down slopes without causing erosion. Drop-downs are used on slopes where vegetation, biodegradable matting or other stabilising techniques has not established or been installed or would not effectively carry the runoff without causing erosion.

Drop-downs need to be large enough to carry runoff without washing out and therefore need to consider volume of water, gradient and length of slope. To prevent failure, the soil around the inlet may be compacted or stabilised using sandbags or similar materials. Geotextile under the entire structure may help to prevent failure of the structure. Energy dissipaters, ie. larger rocks may be required at the outlet to reduce the flow velocity.

At the Austen Quarry drop-downs are constructed of competent rock of >80mm in diameter and are located at two location along the Site Access Road (RD1 and RD2 – see **Figure 2b**).

Each drop-down will be inspected at least fortnightly with particular attention paid to the condition of the slope either side of the drain and land at the ultimate discharge point. Any maintenance work will be completed within 7 days of the initial inspection and commented on in the subsequent inspection sheet.

5.3.5 Additional Sediment Protection

5.3.5.1 Introduction

To ensure that water discharged from the quarry site, either as a natural discharge from undisturbed, partially disturbed or rehabilitating surfaces or controlled discharge from structures such as sediment basins, drop-downs and spoon drains, meets the TSS water quality objective of 30mg/L, additional sediment protection structures will be maintained at the Austen Quarry.

Additional protection will also be placed within catchment channels (such as the road side drainage of the Site Access Road) to reduce the velocity of flows and therefore reduce the potential for erosion within the channel and at the discharge point.

5.3.5.2 Sediment Fencing

A sediment fence (also known as a silt fence) is a temporary barrier of geotextile filter fabric, usually supported by steel wire and steel posts. A proprietary item known as Propex® Silt Stop Sediment Fence is used on the quarry site.

Sediment fences filter runoff flowing from the site, trapping the sediment and allowing filtered water to pass through.

Sediment fences have the following design limits:

- The area draining to the fence is 0.6 ha or less.
- The maximum slope gradient behind the fence is 2:1.
- The maximum slope length behind the fence is 60m.

Procedure No. 4 presents the general design features and construction notes to be adhered to when installing the sediment fencing (see also **Appendix 1**). It is noted that sediment fencing represents a secondary control in conjunction with other controls such as a sediment basin, rock lined spillway or vegetation and in no instance is it relied upon as the primary control.

Figures 2a and **2b** present the current locations of sediment fencing at the Austen Quarry although it is noted that these locations will vary over the life of the quarry.

Generally, these structures will be installed prior to disturbance within a catchment, however, they may also be installed in response to elevated sediment discharge levels observed on the quarry site.

5.3.5.3 Straw Bale Filters and Check Dams

A temporary barrier of straw bales laid end to end across the direction of flow, usually at the outlet of a drain or across a swale, diversion channel or waterway, provides for a similar level of protection as sediment fencing. That is, the straw bale filters are used to intercept and filter run off before it enters a channel and/or to direct water in low flow situations.

Check dams are primarily used to reduce the velocity of flow in channels and thus reduce erosion of the channel bed. These may be constructed of straw bale or gravel/aggregate material with the entrapment of sediment a secondary function of these structures as they are effective in catching course sediment only.

Procedure No. 4 presents the design features and construction notes for the installation of straw bale protection and check dams (see also **Appendix 1**).

5.3.5.4 Maintenance

More than any other structure, the additional sediment controls must be regularly inspected and maintained as these structures represent the final control point for water discharged from the quarry site. Each structure will be inspected weekly, or following significant rainfall and the general condition recorded, including:

- whether the structure(s) has been damaged or not;
- amount of sediment present upstream and downstream;
- breaches of the structure(s);
- presence of eroding surfaces; and
- requirement for maintenance.

In the event maintenance is required, this will be completed within 7 days of the inspection and status recorded on the following inspection sheet.

5.3.6 Water Discharge and Additional Water Treatment

There are two types of discharges from the quarry site.

Natural Discharge

As illustrated on **Figure 2a** and **2b**, a number of ephemeral drainage lines traverse the quarry site and Site Access Road. Within areas of the quarry site where there is none or minimal disturbance within the catchments of these drainage lines, water is allowed to discharge naturally following rainfall. At some points, notably along the Site Access Road, sediment fencing is installed given the rehabilitating surfaces within these catchments may not be completely stable.

Controlled Discharge

Water within the catchments identified on **Figure 2a** and **2b** is captured within clean water storages or sediment dams. These have been constructed to retain water from all but extreme rainfall events and to aide in the retention of water are linked together by an internal pumping system. As noted in Sections 5.3.3.6 and 5.3.4.3, these structures will be regularly inspected and the water contained within each pumped between them to ensure sufficient capacity is retained within each to hold water runoff following a 20 day 95th percentile rainfall event. In the event the retained storage capacity of all water storages combined is insufficient to capture runoff from the 20 day 95th percentile rainfall event, water will be discharged to the Coxs River via a DEC licensed discharge point (EP Licence 12323). This discharge point is currently adjacent to SeD2 on the processing area and will discharge water pumped from the clean water storage SD4. As a matter of urgency, EP Licence 12323 should be varied to include an additional discharge point direct from SD4. Water within SD4 is regularly treated with a flocculating agent (Ultiron 8187, manufactured by Nalco, active agent alum) to reduce the sediment loading of the water in preparedness for the immediate discharge of water.

Prior to discharge, a sample of the water will be taken and analysed by a NATA accredited laboratory against DEC criteria of pH, TS, EC and oil and grease. If the sample is within the criteria limits, up to 7ML of water will be discharged to the Coxs River. The results of the lab analysis will be forwarded to the DEC to confirm a compliant release of water. In the unlikely circumstance that water non-compliant with the DEC nominated criteria is discharged, the DEC will be immediately notified of the non-compliant discharge. Greater detail on monitoring associated with the controlled discharge is provided in *Procedure E1 – Surface Water Monitoring*.

5.4 Site Water Balance

5.4.1 Introduction

Water for operational use, ie. sprays on the crushing and screening plant and other dust suppression, will be preferentially sourced from the capture of dirty water, however, supplementary water supplies will be sourced from clean water storages. This section reviews site water requirements and available water storage against water availability in order to present a water balance for the quarry site. This water balance is provided for dry, average and wet years (10th, 50th and 90th percentile rainfall years respectively) and to account for major rainfall events (20 day 95th percentile rain event). Previous assessments of the Austen Quarry used the

1 in 100, 72 hour ARI rain event as a guide to designing water storages to retain water from major rainfall events. Best practice water management has since moved away from using this type of event to design water management structures and as such, the conservative 20 day 95th percentile rainfall event, recommended in Landcom (2004), has been referenced in determining the critical capacities required within the quarry water storages.

5.4.2 Site Water Requirements

Dust suppression is the major on-site water use and annual usage is approximately 25.0ML and includes:

- Dust suppression on the quarry floor, haul roads and hardstand area;
- Dust control during truck unloading and crushing operations; and,
- Dust suppression at all conveyor discharge and transfer points.

Smaller quantities of water will be required over the life of the Austen Quarry for activities such as truck washing, housekeeping, routine maintenance, and irrigation of rehabilitated areas. These volumes are not captured for water balance purposes as they will vary from year to year, however, by assuming a maximum dust suppression rate of 25.0ML/year, which accounts for dust suppression activities 10 hours per day, 200 days per annum, these other relatively minor water usages will be accounted for.

Table 5.5 provides a detailed breakdown of water usage for dust suppression at the Austen Quarry.

Table 5.5
Site Water Usage

Location		Water Usage (L)		
	No. of Sprays	Per hour*	Per day**	Per year***
Extraction Area				
Crusher Bin	8	160	800	160 000
Primary crusher	4	80	400	80 000
Transfer 1	6	120	600	120 000
Scalps plant	12	240	1 200	240 000
Transfer 2	6	120	600	120 000
Processing Area				
Conveyor discharge	4	80	400	80 000
Secondary Bin	8	160	800	160 000
Transfer 3	6	120	600	120 000
Secondary crusher 1	6	120	600	120 000
Screens	24	480	2 400	480 000
Secondary crusher 2	6	120	600	120 000
Screens	24	480	2 400	480 000
Discharge to stockpile	12	240	1 200	240 000
Quarry Site				
Roads		10 000	100 000	20 000 000
Total				**25 040 000**
*Note: Micro Dust sprays use 10 L/Hr		**Operating 10 hours per day	***200 days per year	
Source: ABL				

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An estimated 9.6ML/year will be lost as a result of evaporation, based on annual average evaporation rates. Therefore, total water requirement for the Austen Quarry is approximately 34.6ML/year.

5.4.3 Water Sources, Availability and Storage

Surface Water Runoff

Water for operational purposes (including dust suppression) will be predominantly sourced from surface water flows captured within six Storage Dams (SD1 – SD4 & SD6 – SD7). In addition, three sediment dams (SeD1 – SeD3) have been designed and constructed on the quarry site with a primary function being to allow for the settlement of suspended sediment. Noting the internal pumping system of the Austen Quarry, water stored within these Sediment Dams is also available for operational use or transfer to one of the Storage Dams[2].

Table 5.6 notes the storage capacity of the storage and settlement structures dams. These have been categorised as predominantly clean or dirty water structures.

Table 5.6
Quarry Site Water Storage and Settlement Structures

Storage or Settlement Structure	Catchment	Capacity (ML)	
		Dirty Water	Clean Water
SeD1/SeD2	D1/D2	9.6*	
SeD3	D4	1.0*	
SD2	M2	1.75#	
SD3	D3/M5	4.5*	
SD4		6.1	
SD1	C2		1.75#
SD6	M6		4.9*
SD7			9.5
Total Available Storage*		**7.85**	**11.25**

*Note: Given there function as water settlement structures, SD3, SD6 SeD1, SeD2 and SeD3 are to be kept empty to provide a buffer for storage following a large rainfall event.
#Note: Estimated size based on dam design of EIS (SKM, 1994).

Water will be preferentially sourced from dirty water storage (7.85ML capacity) with the clean water storage providing back-up supply during extended periods of limited precipitation. The available storage of the Austen Quarry (as calculated in **Table 5.6**) does not include the storage capacity of the water settlement structures (SD3, SD6, SeD1, SeD2 and SeD3) as water retained within these will be preferentially transferred to one or more of the Storage Dams[1].

Two water storage tanks will also be used to store water on the quarry site (see **Figure 2a**). The capacity of these storage tanks will be relatively minor and sufficient only to provide a surge head to initiate the pumping of water to either the extraction area or processing area. The storage tank located above the extraction area has a capacity of 15kL (0.015ML) and the storage tank located above the processing area a capacity of only 4kL (0.004ML).

Coxs River Water

[2] SD3/SD4 have been identified as the preferential storages of dirty water

ABL has obtained from the land owner (HPC) a licence to extract up to 20ML/year from the Coxs River. This licence allocation will only be taken up in the event that insufficient water is available on the quarry site for ongoing operational and dust suppression purposes.

Groundwater

ABL does not hold a groundwater pumping licence to obtain water. Following significant rainfall, infiltrating water seeps into the quarry pit through fractures in the rock for up to several days, ultimately reporting to the Quarry Sump. As a consequence, small quantities of groundwater will be used. The water balance does not account for this minor groundwater contribution, as given the water is effectively infiltrating surface water, it is already included through calculations to determine surface water runoff (see **Table 5.6**).

5.4.4 Surface Water Rainfall and Runoff

The water balance considers rainfall and runoff generated by low (annual 10^{th} percentile), average (annual 50^{th} percentile) and high (annual 90^{th} percentile) rainfall years for the City of Lithgow (provided by the Bureau of Meteorology).

- Annual 10^{th} percentile (dry year) = 612.7mm.
- Annual 50^{th} percentile (average year) = 858.6mm.
- Annual 90^{th} percentile (wet year) = 1117.7mm.

Rainfall is reasonably well distributed throughout the year, although there is a peak in summer and early autumn, with the lowest rainfall months being in winter and spring.

The average annual runoff likely to report to each storage or settlement structure for average, wet and dry years has been calculated by GSS Environmental. As detailed records of water accumulation in quarry site water storages have not been maintained, a number of assumptions were used in the calculation of annual runoff.

1. Only catchments D1, D2, D3, D4, M2, M5, M6 and C2 have been considered as these are the only catchments from which surface water is actively captured for potential operational use. The remaining catchments identified on **Figures 2a** and **2b** either divert clean water, or only temporarily hold dirty water within smaller sediment basins prior to discharge, and therefore do not contribute to the water balance of the Austen Quarry (at this time).
2. With the exception of sub-catchment C2, the clean and relatively undisturbed catchments have been assumed to have a runoff coefficient of 0.2. Anecdotal evidence provided by Austen Quarry personnel has indicated that the estimated volume of water available for capture in sub-catchment C2, assuming the co-efficient of 0.2, is still too high. As a result a co-efficient of 0.1 has been assumed for sub-catchment C2.
3. A runoff coefficient of 0.4 has been assumed for highly disturbed catchments with little to no vegetation.
4. Within those sections of sub-catchments defined as dirty, but where a significant cover of vegetation remains or has been established, a runoff coefficient of 0.2 has

been assumed. A runoff coefficient of 0.4 has been retained for those sections of the catchment without vegetation coverage. Effected sub-catchments include D1, D2 and D3.

5. A run-off coefficient of 0.5 has been applied to sections of roads within each catchment. This predominantly affects sub-catchment M2, which includes a 0.6ha area of the Quarry Access Road (based on a length of 600m (from the top of the ridge at the boundary of sub-catchments M2 and D3) and a width of 10m) and sub-catchment D1, which includes a 0.3ha area of the Quarry Access Road (based on a length of 300m (from the boundary of sub-catchments M2 and D1 and a width of 10m).

Table 5.7 presents the calculated annual average surface water runoff within the sub-catchments contributing to the water balance. Runoff has been calculated by GSS Environmental based on the area contained within each catchment, annual rainfall to determine the volume of water falling within the catchment and runoff coefficient which determines the proportion of this water which is not captured by soil, vegetation etc. of the catchment, eg. Coefficient of 0.1 indicates only 10% of total water is not captures within the catchment. In cases where several runoff coefficients are identified within a catchment, the runoff for the proportional area of each is used.

Table 5.7
Annual Average Runoff

Catchment	Area (ha)	Runoff Coefficient	Storage / Settlement Structure	Runoff* (ML)		
				Dry Year	Average Year	Wet Year
Primary Water Storage (Dirty Water)						
D1/D2	12.4	0.2/0.4/0.5	SeD1 / SeD2	17.8	24.9	32.4
D3	8.9	0.4	SD3 / SD4	21.8	30.6	39.8
D4	4.6	0.4	SeD3	11.3	15.8	20.6
M2 (including 0.6ha of Quarry Access Road)	3.5	0.2 / 0.5	SD2	5.4	7.6	9.8
M5	13.1	0.2	SD3 / SD4	4.9	6.9	8.9
Total		-		**61.2**	**85.8**	**111.5**
Additional Water Storage (Clean Water)						
C2	17.2	0.1	SD1	10.5	14.8	19.2
M6 (including 0.35ha of Site Access Road)	56.0	0.2/0.5	SD6 / SD7	56.2	78.8	102.6
Total				**66.7**	**93.6**	**121.8**
TOTAL WATER STORAGE				***127.9***	***179.4***	***233.3***
*Source: GSS Environmental						

5.4.5 Water Balance

Based on the estimated site water requirements presented in Section 5.4.2, and the calculated volume of water available in dry, average and wet years, a preliminary water balance suggests the quarry site will operate with a significant water surplus. **Table 5.8** presents the calculated annual average surface water runoff, usage and storage of water on the Site to provide a preliminary water balance.

Table 5.8
Water Balance for Dry, Average and Wet Years

	Preliminary Water Balance (Runoff – Usage – Primary Storage Capacity) (ML)		
	Dry Year	Average Year	Wet Year
Runoff (ML)	61.2	85.8	111.5
Usage (ML)	34.6	34.6	34.6
Primary Storage Capacity (ML)	7.9	7.9	7.9
Preliminary Water Balance	**+18.7**	**+43.4**	**+69.1**

The water balance of **Table 5.8** assumes that rainfall and runoff over the course of the year will be consistent leading to water being constantly available for operational use. In reality, and despite the fact that local rainfall is relatively evenly distributed through the year, the Austen Quarry will experience periods of heavier rainfall resulting in the need to discharge treated water from the quarry site, and dry periods when water may need to be drawn from the additional, clean water storage. During periods of extended drought, up to 20ML of water will be pumped from the Coxs River to meet the operational requirements of the quarry.

Based on the water balance presented within **Table 5.8**, it is expected that during wet years, or following particularly heavy rainfall, water discharge to the Coxs River is likely.

5.4.6 Water Balance Review

Given the lack of data on the response of storage structures to rainfall events, as well as the relatively small capacity of water storage structures, the preliminary water balance presented in **Table 5.8** is a relatively simplistic input/output water balance. Anecdotal evidence supplied by Austen Quarry site personnel suggests that this water balance may overestimate the quantity of water available from surface water run-off, ie. the run-off coefficients are generally too high, and/or underestimate the volume of water used for operational and dust suppression purposes.

As such, it is therefore imperative that the water balance is reviewed each year based on site specific values for rainfall, run-off and water use. To obtain these site specific values, detailed records are kept of:

- daily rainfall and rainfall intensity;
- the volume of water maintained within the water storage and settlement structures, especially following rainfall events;
- water usage on the quarry site; and
- volumes of water transferred between the various water storages and/or discharged to the Coxs River.

The water balance will therefore be reviewed and refined annually based on the site specific data collected. This annual review, and the necessary data collection, will continue until such time as variation in the water balance is reduced to a satisfactory level.

5.4.7 Water Storage, Transfer and Discharge

Figure 5 presents, in flow chart form, the inter-relationship between the various water storages of the quarry site. As far as practicable, the clean and dirty water systems will remain segregated from each other, although in order to retain sufficient capacity with the settlement structures of the quarry site, it may be necessary for dirty water retain within SeD1 and SeD2 to be transferred to SD6 and SD7.

The transfer of water between the various storages will be via four main pipelines, as follows.

(i) Southern Main Line – which allows for water captured within SeD3 and the Quarry Sump to be pumped and/or gravity fed to SD3. The Southern Main Line also incorporates the linking of a water storage tank above the pit (see **Figure 2a**) and the water usage points within the extraction area. Head pressure created by gravity from the water storage tank to the water usage points within the extraction area will initiate a pump to draw water from SeD3, the Quarry Sump of SD4 for operational use.

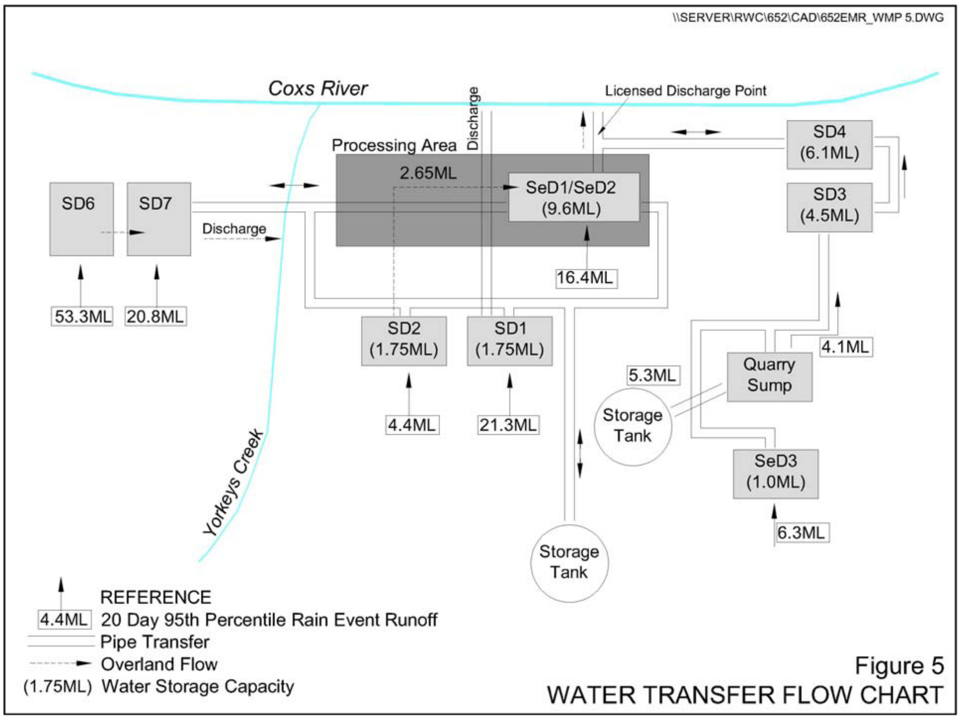

Figure 5
WATER TRANSFER FLOW CHART

(ii) Eastern Main Line – which allows for the transfer of water between SD3 / SD4 and the processing area (including water storages of SeD1, SeD2, SD1 and SD2, water usage points and the Ring Main Line).

(iii) Ring Main Line – links the Eastern Main Line and the Western Main Line with the various water storages of the processing area and a water storage tank located above the processing area (see **Figure 2a**). Head pressure created by gravity from the water storage tank to the water usage points of the processing area will initiate a pump to draw water from the primary or additional water storages for operational use.

(iv) Western Main Line – links SD6 and SD 7 with the Ring Main Line and the various water storages and usage points of the processing area. The draw of water through this line may either be gravity or pumping on the processing area.

Water will be transferred between water storages to ensure that sufficient storage capacity is retained in the settlement structures to prevent the discharge of dirty water from the quarry site[3].

Table 5.9 presents the required capacity of the primary settlement storages of the dirty water sub-catchments to retain runoff from the 20 day 90^{th} percentile rain event.

Table 5.9
Settlement Storage Capacity, 20 Day 95^{th} Percentile Event

Storage Dam	Current Capacity (ML)	Required Capacity (ML)	Differential
SD2	1.75[#]	1.3	+0.45
SD3	4.5	12.6	-8.1
SeD1	9.6	4.9	+2.7
SeD2		2	
SeD3*	<1	3.7	>-2.7

Note #: Estimated size based on dam design of EIS (SKM, 1994).
Note *: Water captured within this structure has also been incorporated into that of SD3, as this includes water from the sub-catchments of D3 and D4. .
Source: GSS Environmental

Based on the runoff expected during and following a 20 day 95^{th} percentile rainfall event, SD3 is the critical structure as this is predicted to overflow during and following such an event. It is noted however, that additional storage capacity would be retained within SeD1 / SeD2 (2.7ML) and potentially within SD4 (6.1ML), which would be sufficient to hold the 8.1ML exceedance predicted by the calculations of GSS Environmental. Under conditions of, or similar to, the 20 day 95^{th} percentile rainfall event, water within the dirty water storages will be managed as follows.

(i) Treated (flocculated) water within SD4 will pumped to the licensed discharge point and discharged to the Coxs River.

(ii) At this time a water sample will be taken from SD 4, immediately downstream of the discharge point and at the Coxs River top and bottom crossing monitoring sites.

(iii) SD4 will be emptied until such time as capacity is reduced to approximately 20% of the total capacity of SD4.

(iv) Once emptied, water will be allowed to overflow from SD3 via a grass lined spillway into SD4.

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3 As clean water will not result in the discharge of sediment laden water to the Coxs River, there is no requirement to retain capacity within the water storages of the clean water catchments.

(v) In the event the volume of water held within of SD4 approaches capacity again, the Eastern Main Line will be transferred from SD 4 to SD3 to allow overflowing water to be pumped to SeD1 and SeD2 where additional capacity is available. In this event, the water with SD4 will be treated again such that an additional discharge may be undertaken to further alleviate pressure on the storage capacity of the quarry site.

(vi) Following the cessation of the 20 day 95th percentile rainfall event or similar, water from SD3 and SeD1 / SeD2 will be pumped to SD4 for treatment and discharge to maximise the storage capacity of the quarry site.

Information provided by Austen Quarry personnel has indicated that high intensity, high rainfall events do occur at the quarry site, as evidenced by the 1 in 150 ARI event (Parsons Brinkerhoff, 2005). Under these events, the most vulnerable point of the quarry site is the processing area, given the relatively high degree of disturbance, its location at the bottom of several sub-catchments and the proximity of the Coxs River. The processing area bund wall was therefore designed and constructed to ensure that such a high intensity rain event does not result in the overflow of SeD1 / SeD2 and therefore uncontrolled discharge of dirty water to the Coxs River. Based on a 1 in 100 72 hour ARI rain event, GSS Environmental determined that up to 42.1ML of water would report to the processing area. Of this, 21.3ML would be supplied by sub-catchment C2, which as a clean water catchment and can be discharged directly to the Coxs River. 4.4ML would be supplied by sub-catchment M2, of which approximately 1.75ML would be held within SD2. The remaining 16.4ML would be supplied by sub-catchments D1 and D2 and report directly to the processing area. Under a 1 in 100 72 hour ARI event, and assuming SeD1 / SeD2 were effectively empty, water would cover the processing area to a height of 300mm, well below the 1m bund height created by the processing area bund wall.

Following such an event, water would need to be pumped to, treated and discharged from SD4 twice to remove the water from the operational area of the processing pad, and a further time to empty SeD1 / SeD2 in preparedness for the design rainfall event (20 day 95th percentile rainfall event) or another 1 in 100 72 hour ARI event.

6 EROSION AND SEDIMENT CONTROL PLAN

6.1 Sources of Erosion and Sedimentation

During to the operation of the Austen Quarry, erosion and sedimentation could potentially result directly or indirectly from:

(i) surface water runoff from areas cleared and/or stripped of overburden in advance of extraction;

(ii) surface water runoff from disturbed areas below the downhill conveyor;

(iii) surface water runoff from topsoil, subsoil and overburden stockpiles and emplacements prior to rehabilitation;

(iv) surface water runoff from the processing area;

(v) surface water runoff from rehabilitated areas prior to full stabilisation;

(vi) discharges of water at erosive velocities; and

(vii) runoff from roads at erosive velocities.

Elevated winds may also result in erosion from exposed surfaces.

6.2 Erosion and Sediment Control Management

6.2.1 Introduction

The control of erosion will be primarily achieved by managing runoff at non-erosive velocities, through minimising the area of cleared or disturbed land and by providing adequate protection to exposed soil surfaces, eg. soil stockpiles, newly constructed bunds. Ultimately however, it will not be possible to prevent some soil particles, especially over the more disturbed areas of the site, from being captured either by wind or surface water flows and management will then focus on ensuring the majority of this captured sediment is trapped and contained prior to discharge from the quarry site.

The following sub-sections summarise the general principles of erosion and sediment control management of the Austen Quarry. Where management principles and practices have been previously described in Section 5.3, these are noted but not described in detail.

6.2.2 Minimising and Managing Site Disturbance

As far as practicable, areas ahead of quarry site or construction related disturbances are to be minimised at any one time. Additionally, cut and fill associated with road construction activities is to be minimised. Cut and fill activities, for road construction, will be managed as follows.

Cut Batters

All cut batters are to be constructed with a slope not exceeding 1:2 (V:H) as the application and binding of topsoil to slopes of a steeper slope is difficult. By leaving the cut batter with a rough scarified or track-walked surface (along the contour), a 'key' for the topsoil to be applied is created which will minimise the potential for the soil to be mobilised by wind or water flows. On all cut slopes, a topsoil layer of approximately100mm is to be applied with either seed of a stabilising cover crop sown or mulch treatment provided as soon as practicable after soil respreading.

Fill Batters

Fill batters, including the overburden emplacement surface, should not exceed 1:2.5 (V:H) in slope and should be thoroughly compacted before the topsoil is applied.

One major potential problem is the scouring caused by water runoff flowing over the fill slopes. In areas of low fill (less than 600mm) it is best to accept the risk and repair the rills as necessary. If the batters are higher than this, however, the batter should be protected with a diversion bank along the top edge of the batter (see Section 5.3.3.2).

The use of subsoils obtained from the quarry site should be avoided as the higher clay percentage and dispersibility of these soils will increase the risk of erosion and sedimentation.

Where the predominant medium of the batter is competent rock, the topsoil layer is to be limited to that required to fill in the gaps between the rocks.

6.2.3 Soil Management

Minimising the area of soil exposed to surface water flows, either as cleared surfaces ahead of extraction, soil stockpiles or respread soils over rehabilitated surfaces, is the primary aim of soil management. The secondary aim is to provide exposed soils with adequate protection to minimise disturbance caused by surface water flows. These aims are achieved by implementing the BMPs of Section 5.2.

6.2.4 Clean Water Diversion

By diverting clean water, ie. water flowing over undisturbed areas of the quarry site, away from the active areas of disturbance and directing this water either to water storages or discharge points at non-erosive velocities, this risk is greatly reduced. Structures used at the Austen Quarry to divert and store clean water include Diversion Banks (Section 5.3.3.2), Level Spreaders (Section 5.3.3.3), Culverts (Section 5.3.3.4), Spoon Drains (Section 5.3.3.5) and Clean Water Storages (Section 5.3.3.6).

6.2.5 Dirty Water Capture and Settlement

Water flowing over disturbed / exposed surfaces is likely to pick up significant quantities of sediment and as a result cause gully or sheet erosion. By diverting these water flows via specifically constructed structures such as Catch Banks (Section 5.3.4.2), Waterways (Section 5.3.4.2), Drop-down batter drains (Section 5.3.4.3), to sediment dams and basins (Section 5.3.4.4) the flow of water will be controlled and provided time to settle out the suspended solids prior to discharge (if required).

6.2.6 Water Discharge Protection

To ensure any water exiting the quarry site meets the water quality objective for suspended sediment of 30mg/L, sediment fencing or straw bale protection is to be installed and regularly monitored and maintained downstream of natural discharge points of the quarry site with minimal upstream disturbance, or where minor construction works are being undertaken.

6.2.7 Progressive Rehabilitation and Re-establishing Vegetative Cover

As the quarry site, overburden emplacement and processing area bund wall develop, these will be progressively rehabilitated through the replacement of topsoil and revegetation with native tree, shrub and grass species. Soil replacement will be managed as the relevant BMPs presented in Section 5.2.

Disturbed areas such as road side verges, cut and fill batters constructed around quarry site roads and hard stand areas and other temporary areas of disturbance such as soil stockpiles will be stabilised in accordance with *Procedure No. 6 - Site Stabilisation and Short Term Rehabilitation.*

6.2.8 Environmental Training

Crucial to the management of erosion and sediment control is the provision of adequate training for on-site personnel responsible for constructing and installing erosion and sediment control structures and operating machinery within and around these structures. It will be the responsibility of the quarry manager to ensure that all personnel are aware of their responsibilities to reduce the risk of erosion and sedimentation on the quarry site. To assist in ensuring all relevant personnel have the appropriate knowledge and training, key procedures have been developed as follows.

1. Road Construction.
2. Land Preparation (Vegetation Clearing and Soil Stripping).
3. Soil Management.
4. Erosion and Sediment Control Structure Construction.
5. Erosion and Sediment Control Structure Maintenance.
6. Site Stabilisation and Short-Term Rehabilitation.
7. Dust Suppression.
8. Hydrocarbon Storage Management.
9. Hydrocarbon Spill Response Plan.

E1. Surface Water Monitoring

6.2.9 Monitoring and Maintenance

6.2.9.1 Water Management (Erosion and Sediment Control) Structures

One or more quarry site personnel are to hold the responsibility for regularly inspecting the water management (erosion and sediment control) structures of the site. On a fortnightly basis (minimum), or following a rainfall event of >25mm/24hr, the assigned personnel is to note the general condition and effectiveness of each of these structures. By numbering the different structures, the potential for confusion over referencing is avoided.

The erosion and sediment control structures will be cleaned of accumulated sediment material (or extended or replaced) as soon as 20% capacity is lost due to the accumulation of material such that the specified capacities are maintained.

The results of the fortnightly inspections are to be provided to the quarry manager who will then provide instruction as to any remedial works to be undertaken or construction / installation of additional structures or sediment protection.

Procedure No. 5 - Erosion and Sediment Control Maintenance provides greater details on the monitoring and maintenance to be undertaken.

6.2.9.2 Rehabilitation and Revegetation

Maintenance of at least 70% grass cover over quarry site surfaces will significantly reduce the potential for erosion and sedimentation from these. Quarry site management, or other nominated site personnel, will periodically inspect previously cleared surfaces for grass or other vegetation establishment. Where grass or other vegetation establishment does not attain the objective 70% cover, supplementary seeding or planting will be undertaken at the first practicable opportunity.

Procedure No. 6 - Site Stabilisation and Short-Term Rehabilitation provides further detail on maintenance and monitoring to be undertaken.

6.2.9.3 Water Quality Monitoring

As part of a surface water monitoring program, and prior to water discharge from the licensed discharge point, the water will be sampled and compared visually to a sample chart held by ABL's Environmental Officer. If the visual assessment determines the water is of suitable quality for discharge, the sample will be sent to a NATA accredited laboratory and analysed for pH, suspended sediment, electrical conductivity and hydrocarbon content.

7 SURFACE WATER MONITORING PROGRAM

7.1 Introduction

This **Surface Water Monitoring Program (SWMonP)** has been prepared in compliance with *Condition 18(b)* and includes:

(i) surface water impact assessment criteria; and

(ii) a program to monitor:

a. the quality of water contained in, or discharged from, water storages (including the mining void) associated with the mine;

b. surface water quality upstream and downstream of the mine site; and

c. the effectiveness of the ESCP.

This SWMonP has been prepared to complement *Procedure No. E1 – Surface Water Monitoring*.

7.2 Impact Assessment Criteria

Impact assessment criteria for surface water are only relevant to water discharged from the licenced discharge point.

Recorded values for pH, Total Suspended Solids (TSS), Electrical Conductivity (EC) and Biochemical Oxygen Demand from water discharged from the Austen Quarry will be compared against the criteria presented in **Table 7.1**.

Table 7.1
Assessment Criteria

Parameter	Unit of measure	100% concentration limit
Total Suspended Solids	mg/L	30
Electrical Conductivity	µS/cm	1 500
Biochemical Oxygen Demand		20
pH	pH	6.5 – 8.5

The recorded values for any other parameters measured will be plotted to identify any trends over time. The DEC will be notified in the event of increasing levels of any parameter.

7.3 Monitoring Locations

The location of all surface water monitoring points are presented on **Figure 7** and have been chosen for four purposes.

(i) To ensure discharged water meets the assessment criteria of **Table 7.1**.

(ii) To assess whether the quarry site may be having any impact on the water quality of the Cox's River.

(iii) To identify the quality of water held in various quarry site water storages.

(iv) To assess the effectiveness of erosion and sediment control measures.

Table 7.2 identifies the monitoring point locations, the type of monitoring point along with a brief description (where relevant) of the location and frequency.

Table 7.2
Monitoring Locations

Location	Type of Monitoring Point	Description of Location	Frequency
EP Licenced Discharge Point*	Water Quality	Sediment Dam licensed to discharge to Cox's River	Prior to any proposed discharge
Cox's River Top Crossing and Bottom Crossing*	Water Quality	Cox's River, upstream and downstream of the quarry site	Bi-monthly
Quarry site water storages*	Water Quality	All storage dams and the mining void on the mine site	Miscellaneous
Quarry site water management (erosion and sediment control) structures	Erosion and Sediment Control	All noted surface water management structures and areas of previously identified erosion or sedimentation.	Monthly

* see **Figure 6**

7.4 Monitoring Parameters

Table 7.3 presents the parameters measured at each monitoring location.

Table 7.3
Monitoring Locations

Location	Parameters		Sampling Method
EP Licenced Discharge Point	Total Suspended Solids		Representative sample
	Biochemical Oxygen Demand		
	pH		
	Electrical Conductivity		
Quarry site water storages	Total Suspended Solids		
	Biochemical Oxygen Demand		
	pH		
	Electrical Conductivity		
Cox's River Top Crossing and Bottom Crossing	pH	Chloride mg/L	Representative sample
	Total Suspended Solids mg/L	Iron (filterable) mg/L	
	Total Dissolved Solids mg/L	Potassium mg/L	
	Specific Conductance µS/cm	Magnesium mg/L	
	CO3 (as CaCO3) mg/L	Manganese mg/L	
	HCO3 (as CaCO3) mg/L	Sodium mg/L	
	OH (as CaCO3) mg/L	Sulfur (as SO4) mg/L	
	Calcium mg/L	Total Hardness (as CaCO3) mg/L	

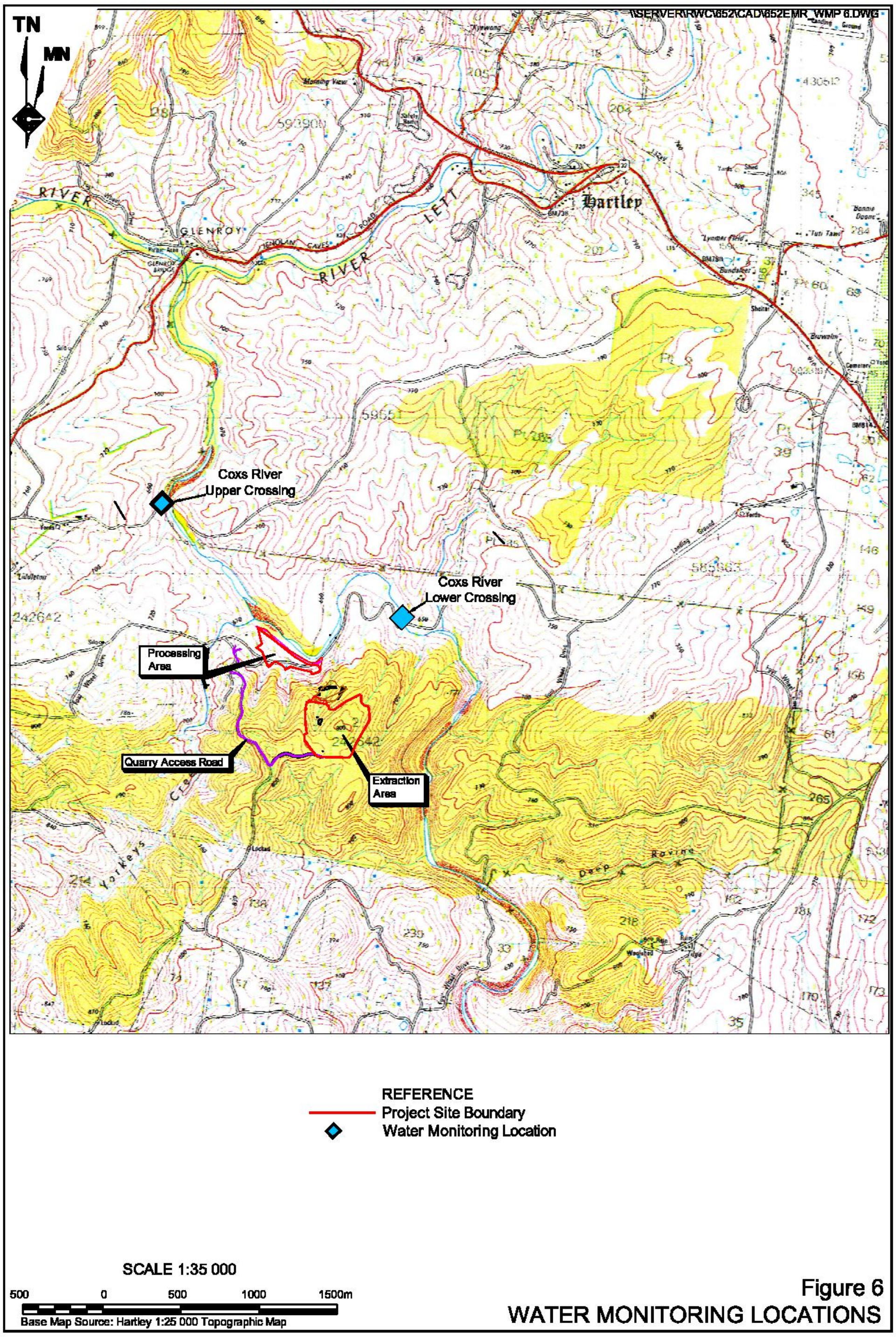

Figure 6
WATER MONITORING LOCATIONS

R.W. CORKERY & CO. PTY. LIMITED

8 REFERENCES

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APPENDICES

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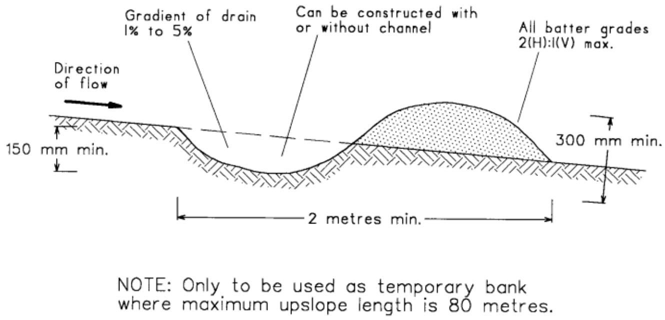
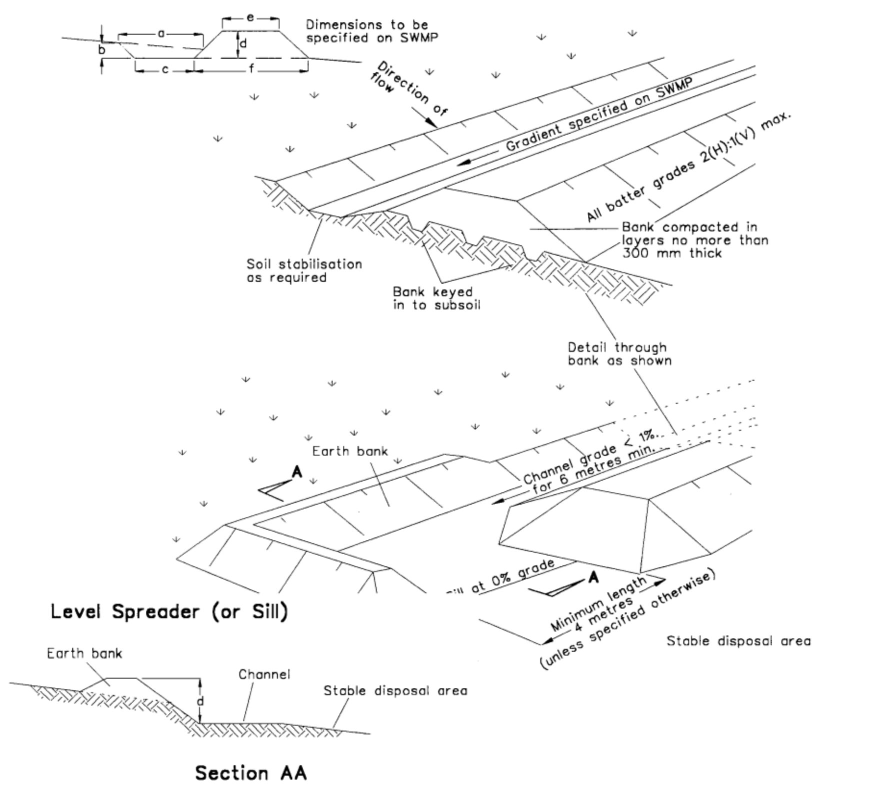
APPENDIX 1



EARTH BANK (LOW FLOW) SD5-2

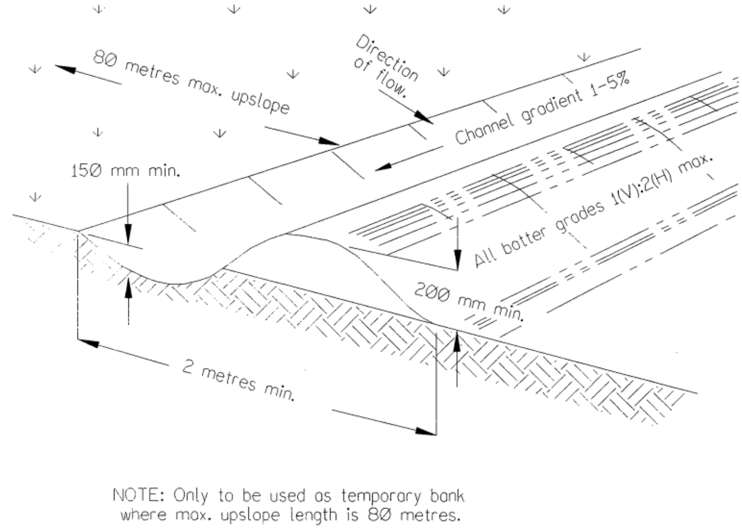
1. Construct with gradient of 1 per cent to 5 per cent.
2. Avoid removing trees and shrubs if possible.
3. Drains to be of circular, parabolic or trapezoidal cross section not V-shaped.
4. Earth banks to be adequately compacted in order to prevent failure.
5. Permanent or temporary stabilisation of the earth bank to be completed within 10 days of construction.
6. All outlets from disturbed lands are to feed into a sediment basin or similar.
7. Discharge runoff collected from undisturbed lands onto either a stabilised or an undisturbed disposal site within the same subcatchment area from which the water originated.
8. Compact bank with a suitable implement in situations where they are required to function for more than five days.
9. Earth banks to be free of projections or other irregularities that will impede normal flow.



EARTH BANK (HIGH FLOWS) SD 5-3

1. Construct along gradient as specified.
2. Avoid removing trees and shrubs if possible.
3. Drains to be of parabolic or trapezoidal cross section as opposed to V-shaped.
4. Earth banks to be adequately compacted in order to prevent failure.
5. Permanent or temporary stabilisation of the earth bank to be completed within 10 days of construction.
6. All outlets from disturbed lands are to feed into a sediment basin or similar.
7. Discharge runoff collected from undisturbed lands onto either a stabilised or an undisturbed disposal site within the same subcatchment area from which the water originated.
8. Compact with a suitable implement in situations where they are required to function for more than five days.
9. Earth banks to be free to projections or other irregularities that will impede normal flow.

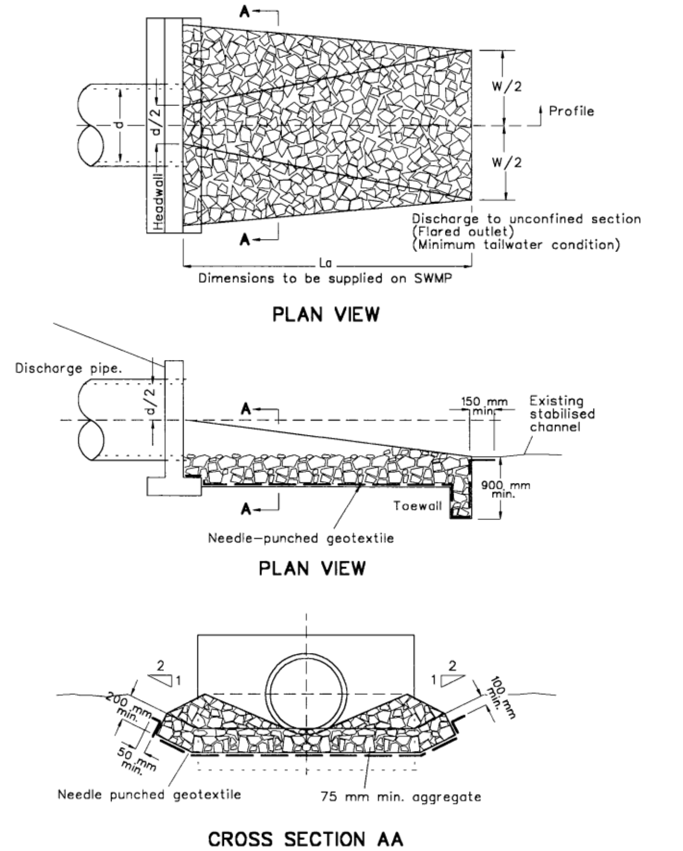
APPENDIX 2



CATCH DRAINS SD 5-8

1. Construct along gradient as specified.
2. Maximum spacing between banks shall be 80m.
3. Drains to be of parabolic or trapezoidal cross section not V-shaped.
4. Earth banks to be adequately compacted in order to prevent failure.
5. Construction is of a temporary nature and shall be completed at the end of days work or immediately prior to rain.
6. All outlets from disturbed lands are to feed into a sediment basin or similar.
7. Discharge runoff collected from undisturbed lands onto either a stabilised or an undisturbed disposal site within the same subcatchment area from which the water originated.
8. Compact with a suitable implement in situations where they are required to function for more than five days.
9. Earth banks to be free of projections or other irregularities that will impede normal flow.

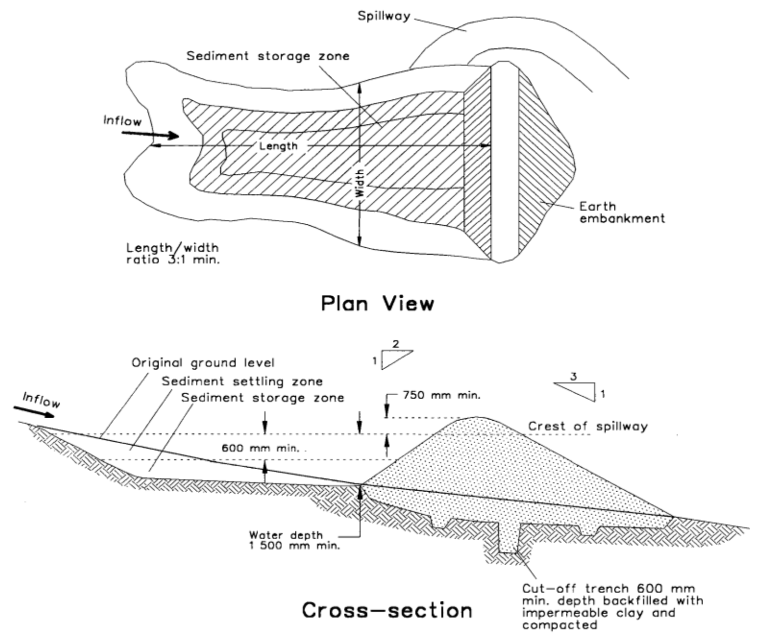
APPENDIX 3



ENERGY DISSIPATER SD 5-6

1. Subgrade fill to be compacted to the density of the surrounding undisturbed material.
2. Ensure that concrete or riprap used for energy dissipater or outlet protection conforms to the grading limits specified on the SWMP/ESCP.
3. Ensure that the geotextile does not sustain serious damage by preparing a smooth, even foundation.
4. Repair minor damage to the geotextile before spreading any aggregate. For repairs, patch one piece of fabric over the damage, making sure that all joints and patches overlap more than 300mm.

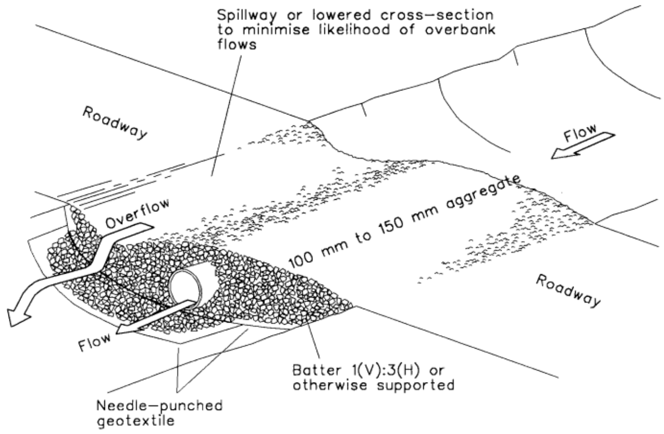
APPENDIX 4



EARTH BASIN –WET SD 6-4
(applies to *Type D* and *Type F* Soils only)

1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Construct a cut-off trench 500mm deep and 1 200mm wide along the centreline of the embankment extending to a point on the gully wall level with the riser crest.
3. Maintain the trench free of water and recompact the materials with equipment specified in the SWMP to 95 per cent Standard Proctor Density.
4. Select fill according to the directions of the SWMP that is free of roots, wood, rock. Large stone or foreign material.
5. Prepare the site under the embankment by ripping at least 100mm deep to help bond compacted fill to existing substrate.
6. Spread fill in 100mm to 150mm layers and compact at optimum moisture content in accordance with the SWMP.
7. Construct emergency spillway.
8. Rehabilitate structure in accordance with the SWMP.
9. Place a “Full of Sediment” marker to show when less than design capacity occurs and sediment removal is required.

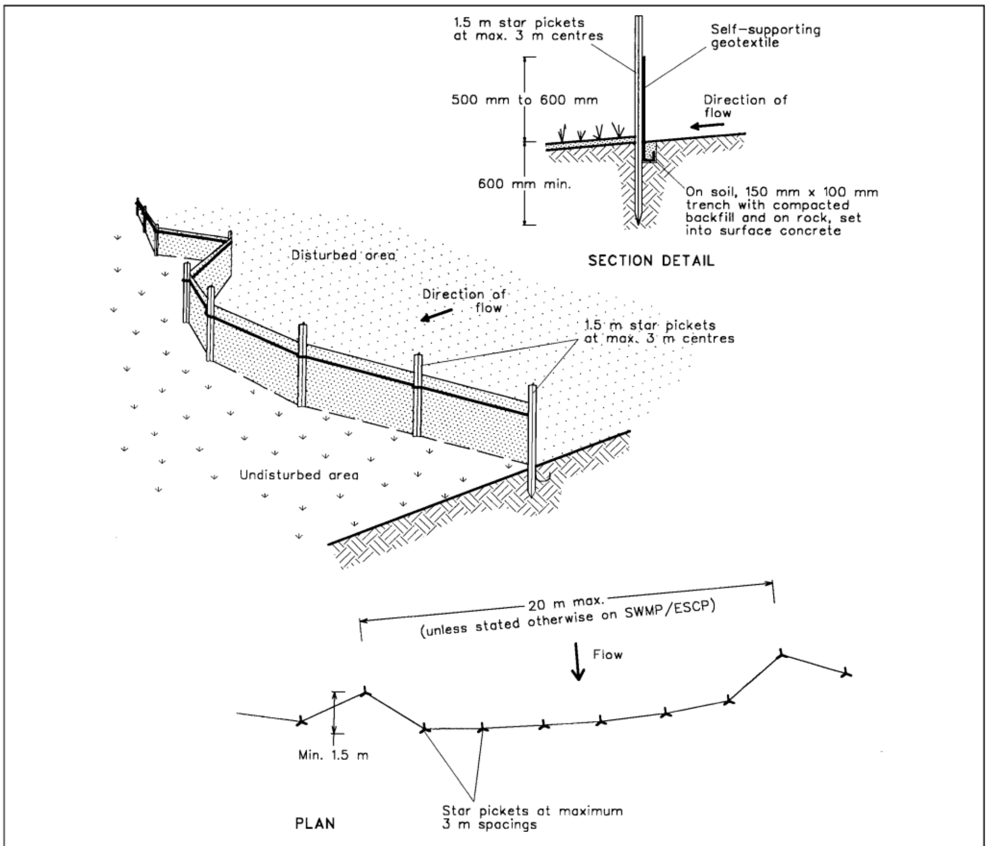
APPENDIX 5



TEMPORARY WATERWAY CROSSING SD 5-5

1. All traffic prohibited until access way is constructed.
2. Strip topsoil and place a needle punched textile over the base of the crossing.
3. Place clean rigid non-polluting aggregate or gravel in 100mm to 150mm class over fabric to a minimum depth of 200mm.
4. Provide 3 metre wide carriage way along with sufficient length of culvert pipe to all less than a 3(H):1(V) slope on side batters.
5. Ensure that culvert outlets extend beyond the toe of fill embankments.

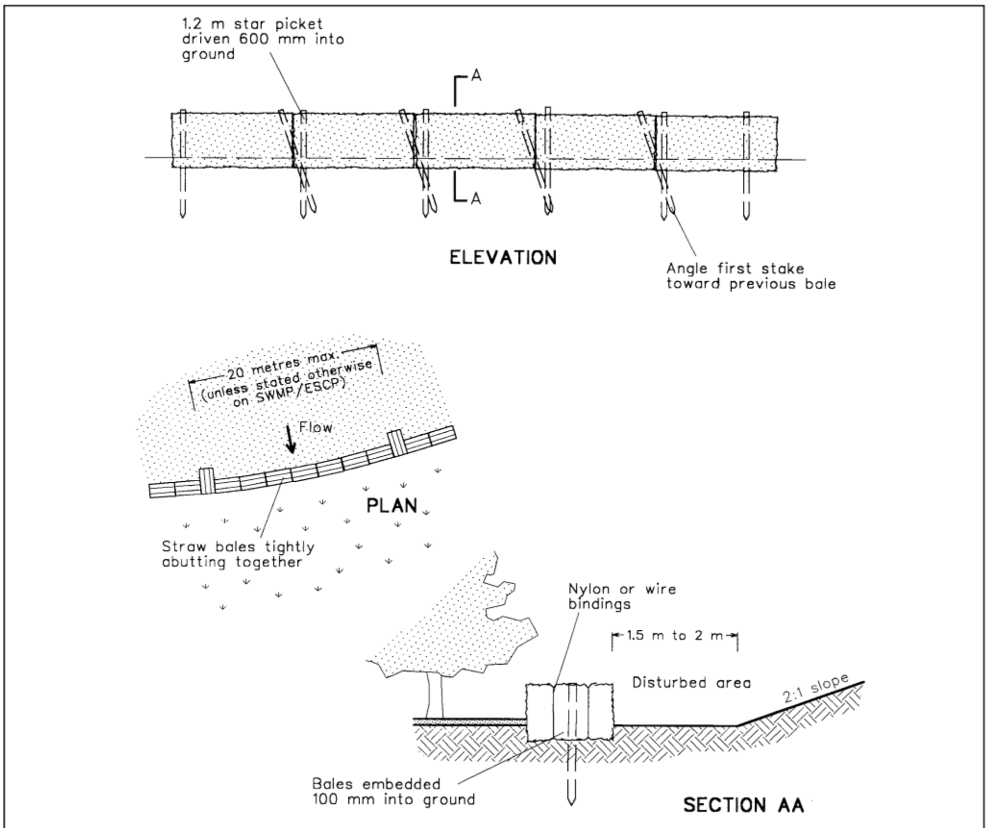
APPENDIX 6



SEDIMENT FENCE SD6-7

1. Construct sediment fence as close as possible to parallel to the contours of the site.

APPENDIX 7



STRAW BALE FILTER SD 6-6

1. Construct straw bale filter as close a possible to parallel to the contours of the site or at the toe of a slope.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws to be placed parallel to ground.
3. Maximum height of filter is one bale.
4. On soft materials, embed each bale in the ground 75mm to 100mm and anchor with two 1.2m star pickets. Angle the first stake in each bale towards the previously laid bale. Drive stakes 600mm into the ground and flush with the top of the bales.
5. Where a straw bale filter is constructed downslope from a disturbed batter the bales should be located 1.5 to 2m downslope from the toe of the batter.

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figures

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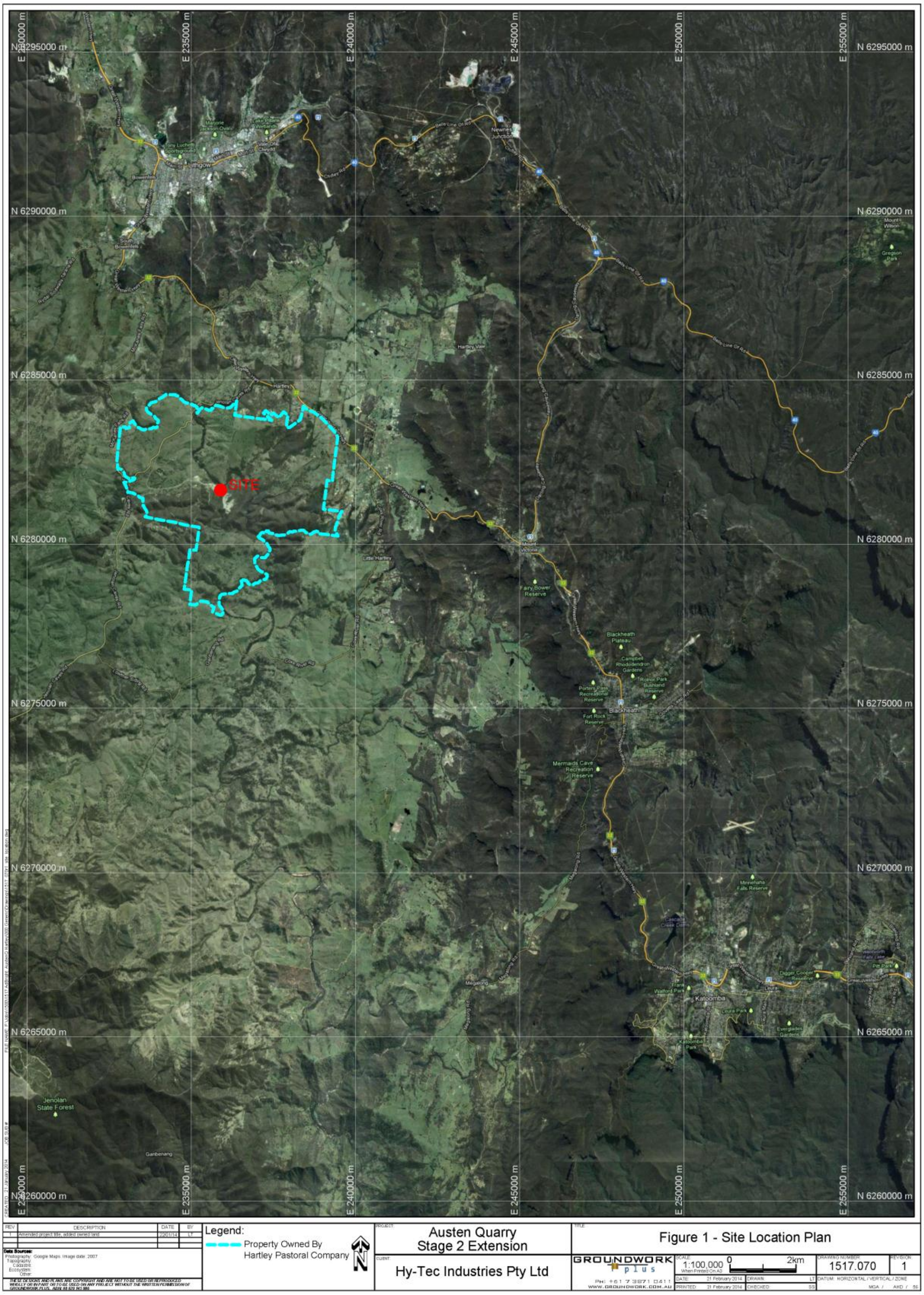
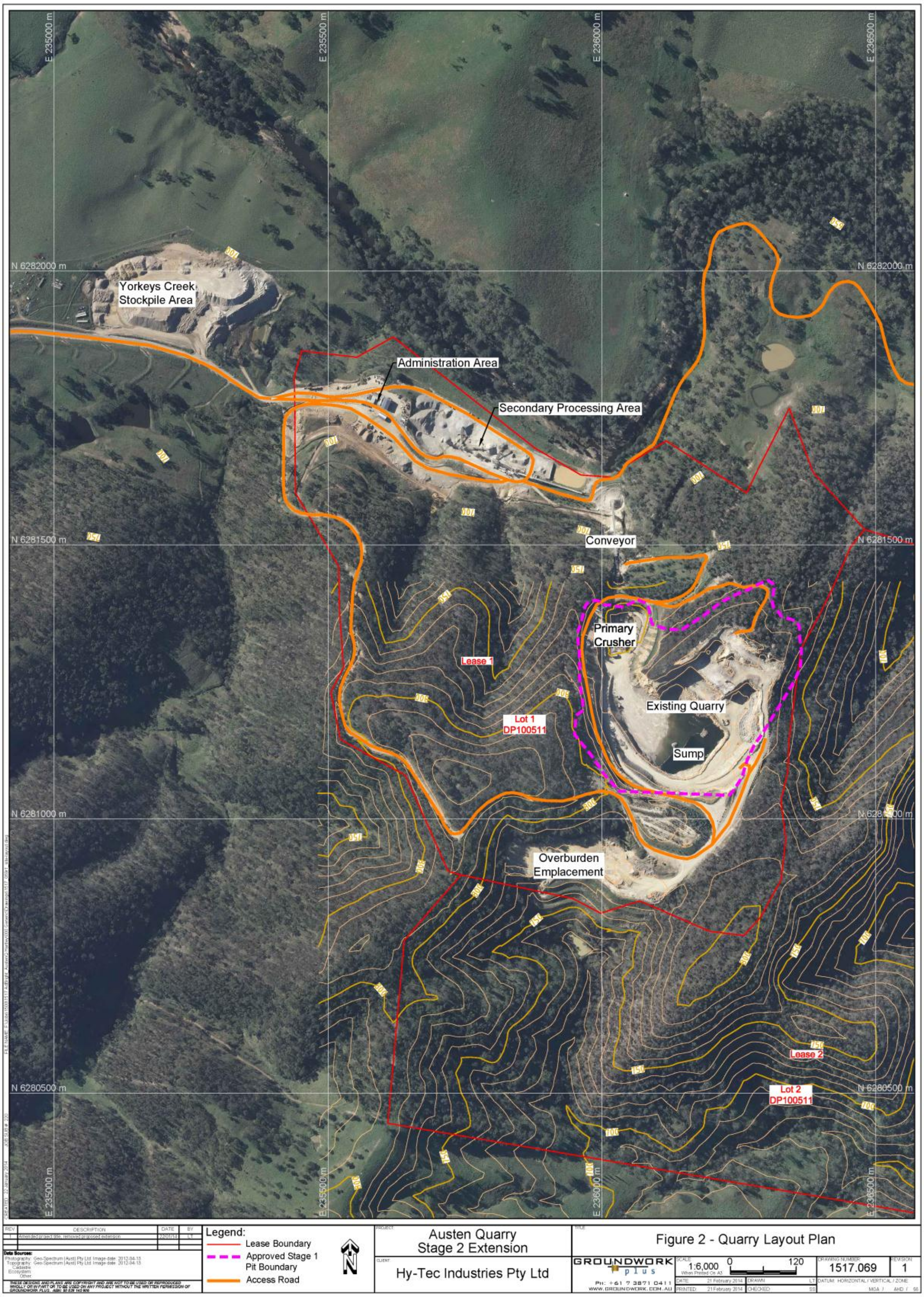
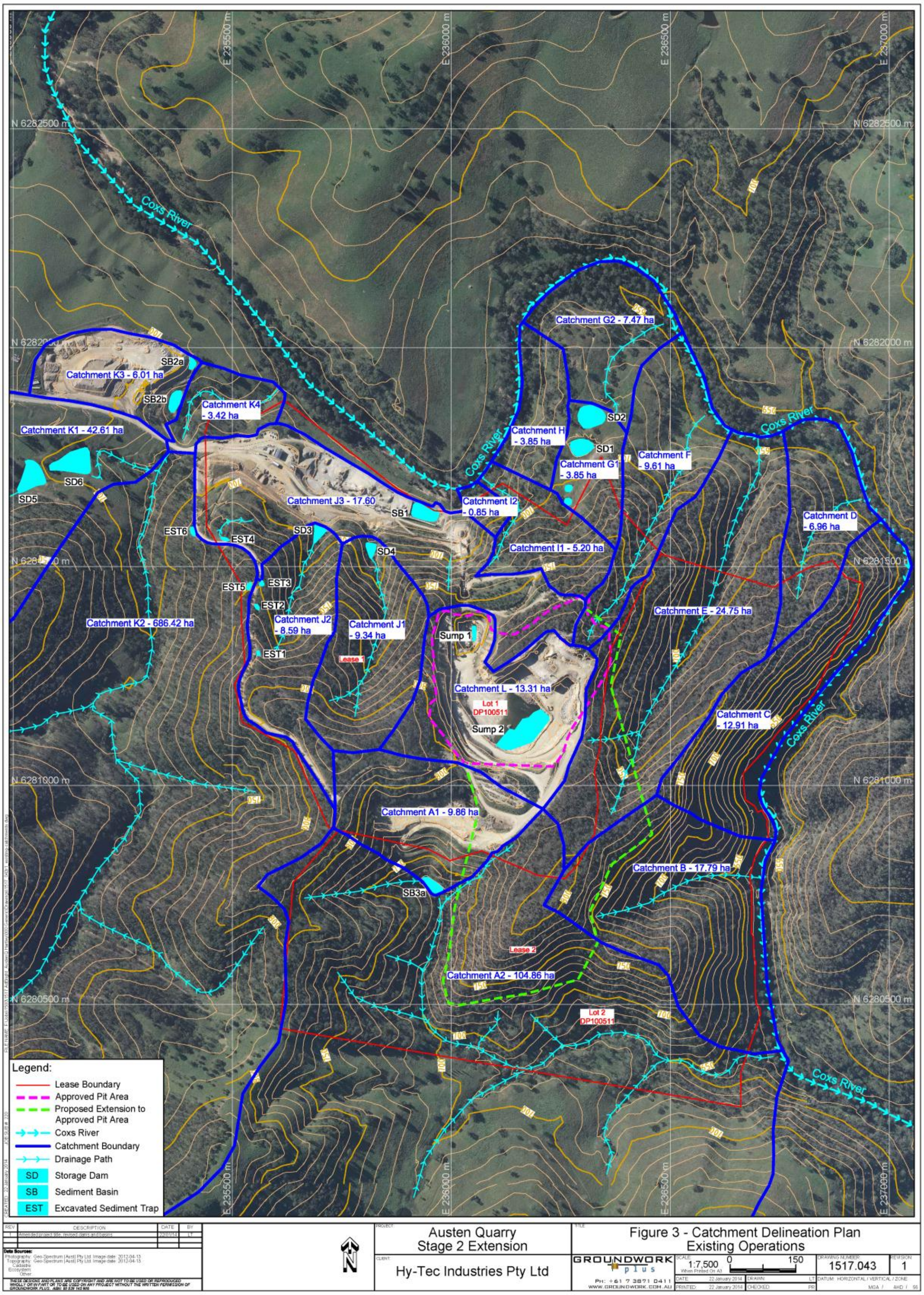

N 6295000 m
N 6290000 m
N 6285000 m
N 6280000 m
N 6275000 m
N 6270000 m
N 6265000 m
N 6260000 m
E 235000 m
E 240000 m
E 245000 m
E 250000 m
E 255000 m
SITE
Lithgow
Hartley Vale
Little Hartley
Blackheath
Katoomba
Jenolan State Forest
Ganbenang
Megalong
REV
DESCRIPTION
DATE
BY
1
Amended project title, added owned land
22/01/14
LT
Data Sources:
Photography: Google Maps. Image date: 2007
Legend:
Property Owned By Hartley Pastoral Company
PROJECT:
Austen Quarry
Stage 2 Extension
CLIENT:
Hy-Tec Industries Pty Ltd
TITLE:
Figure 1 - Site Location Plan
GROUNDWORK plus
SCALE: 1:100,000 When Printed On A3
0
2km
DRAWING NUMBER: 1517.070
REVISION: 1
DATE: 21 February 2014
PRINTED: 21 February 2014
DRAWN: LT
CHECKED: SS
DATUM: HORIZONTAL / VERTICAL / ZONE
MGA / AHD / 56
WWW.GROUNDWORK.COM.AU


Yorkeys Creek Stockpile Area
Administration Area
Secondary Processing Area
Conveyor
Primary Crusher
Existing Quarry
Sump
Overburden Emplacement
Lease 1
Lot 1 DP100511
Lease 2
Lot 2 DP100511
N 6282000 m
N 6281500 m
N 6281000 m
N 6280500 m
E 235000 m
E 235500 m
E 236000 m
E 236500 m
Legend:
Lease Boundary
Approved Stage 1 Pit Boundary
Access Road
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 2 - Quarry Layout Plan
GROUNDWORK plus
1:6,000
1517.069
1


Coxs River
Catchment G2 - 7.47 ha
Catchment K3 - 6.01 ha
SB2a
SB2b
Catchment K4 - 3.42 ha
Catchment K1 - 42.61 ha
SD5
SD6
SD2
SD1
Catchment H - 3.85 ha
Catchment G1 - 3.85 ha
Catchment F - 9.61 ha
Catchment J3 - 17.60
SB1
Catchment I2 - 0.85 ha
Catchment D - 6.96 ha
EST6
EST4
SD3
SD4
Catchment I1 - 5.20 ha
EST5
EST3
EST2
Catchment K2 - 686.42 ha
Catchment J2 - 8.59 ha
Catchment J1 - 9.34 ha
Sump 1
Catchment E - 24.75 ha
EST1
Lease 1
Catchment L - 13.31 ha
Lot 1 DP100511
Sump 2
Catchment C - 12.91 ha
Catchment A1 - 9.86 ha
Catchment B - 17.79 ha
SB3a
Lease 2
Catchment A2 - 104.86 ha
Lot 2 DP100511
Legend:
Lease Boundary
Approved Pit Area
Proposed Extension to Approved Pit Area
Coxs River
Catchment Boundary
Drainage Path
SD Storage Dam
SB Sediment Basin
EST Excavated Sediment Trap
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 3 - Catchment Delineation Plan Existing Operations
GROUNDWORK plus
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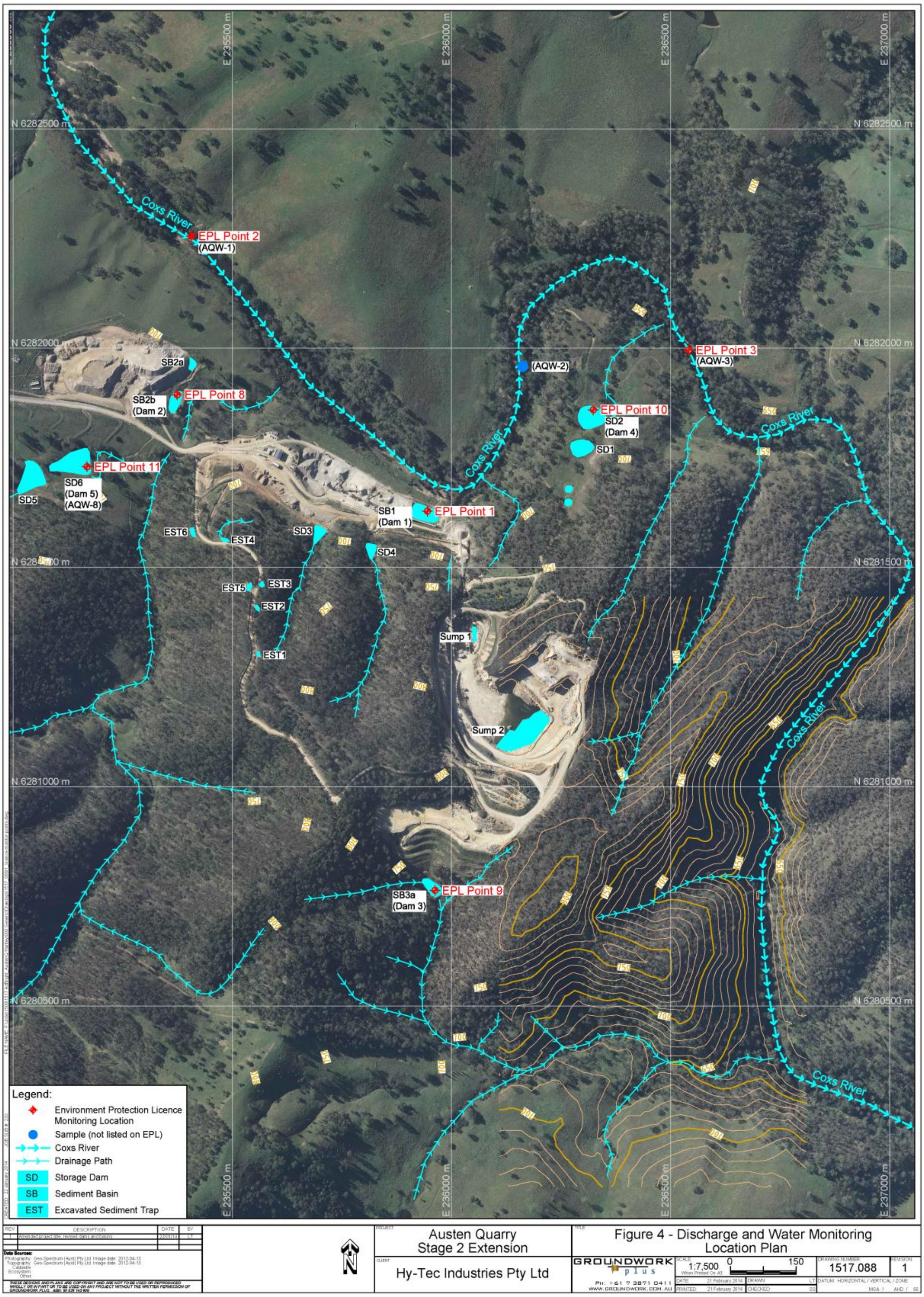
1517.043
1


EPL Point 2
(AQW-1)
Coxs River
EPL Point 3
(AQW-3)
(AQW-2)
EPL Point 10
SD2
(Dam 4)
SD1
SB2a
SB2b
(Dam 2)
EPL Point 8
EPL Point 11
SD6
(Dam 5)
(AQW-8)
SD5
SB1
(Dam 1)
EPL Point 1
EST6
EST4
SD3
SD4
EST5
EST3
EST2
EST1
Sump 1
Sump 2
SB3a
(Dam 3)
EPL Point 9
Legend:
Environment Protection Licence Monitoring Location
Sample (not listed on EPL)
Coxs River
Drainage Path
SD Storage Dam
SB Sediment Basin
EST Excavated Sediment Trap
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 4 - Discharge and Water Monitoring Location Plan
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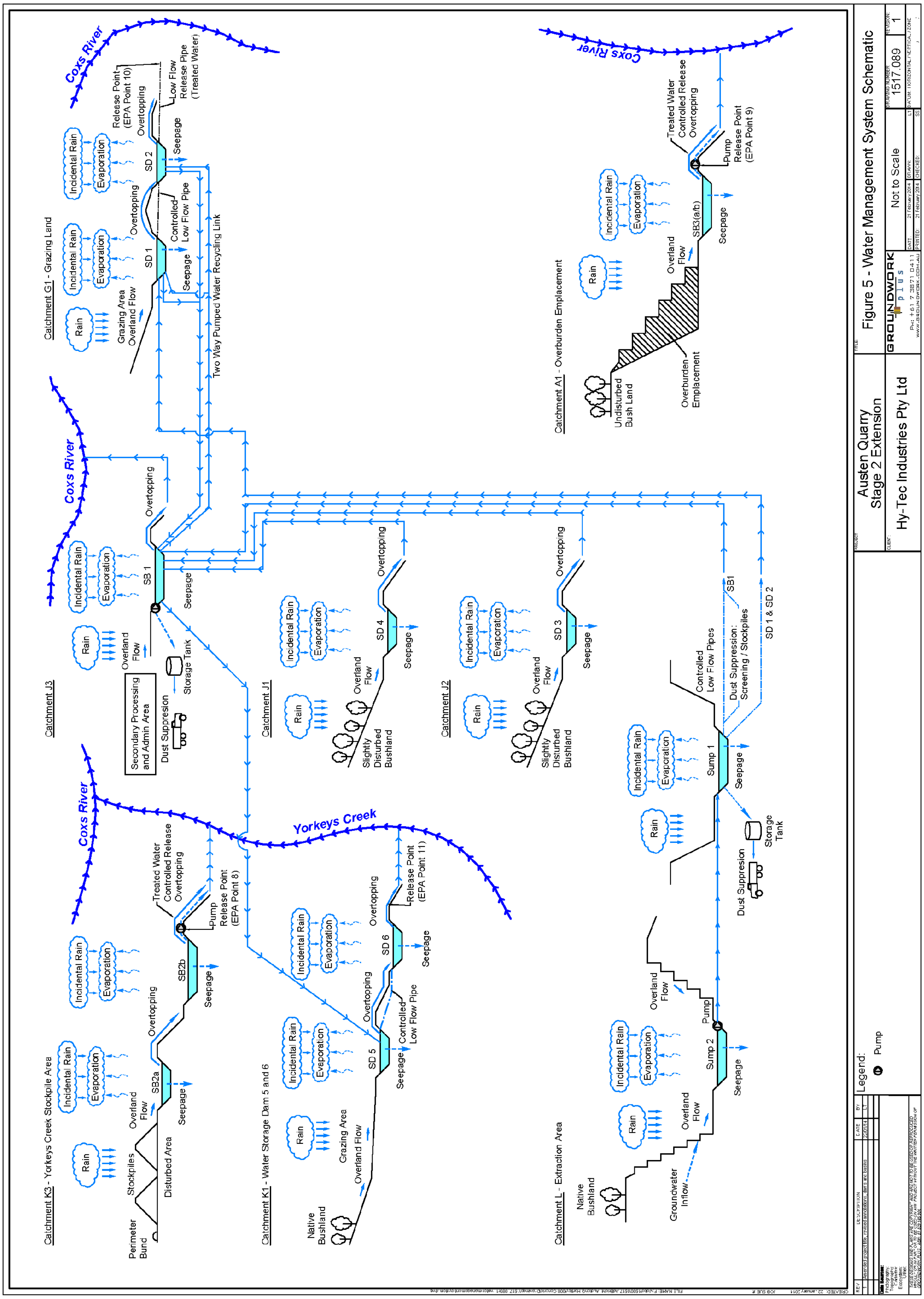
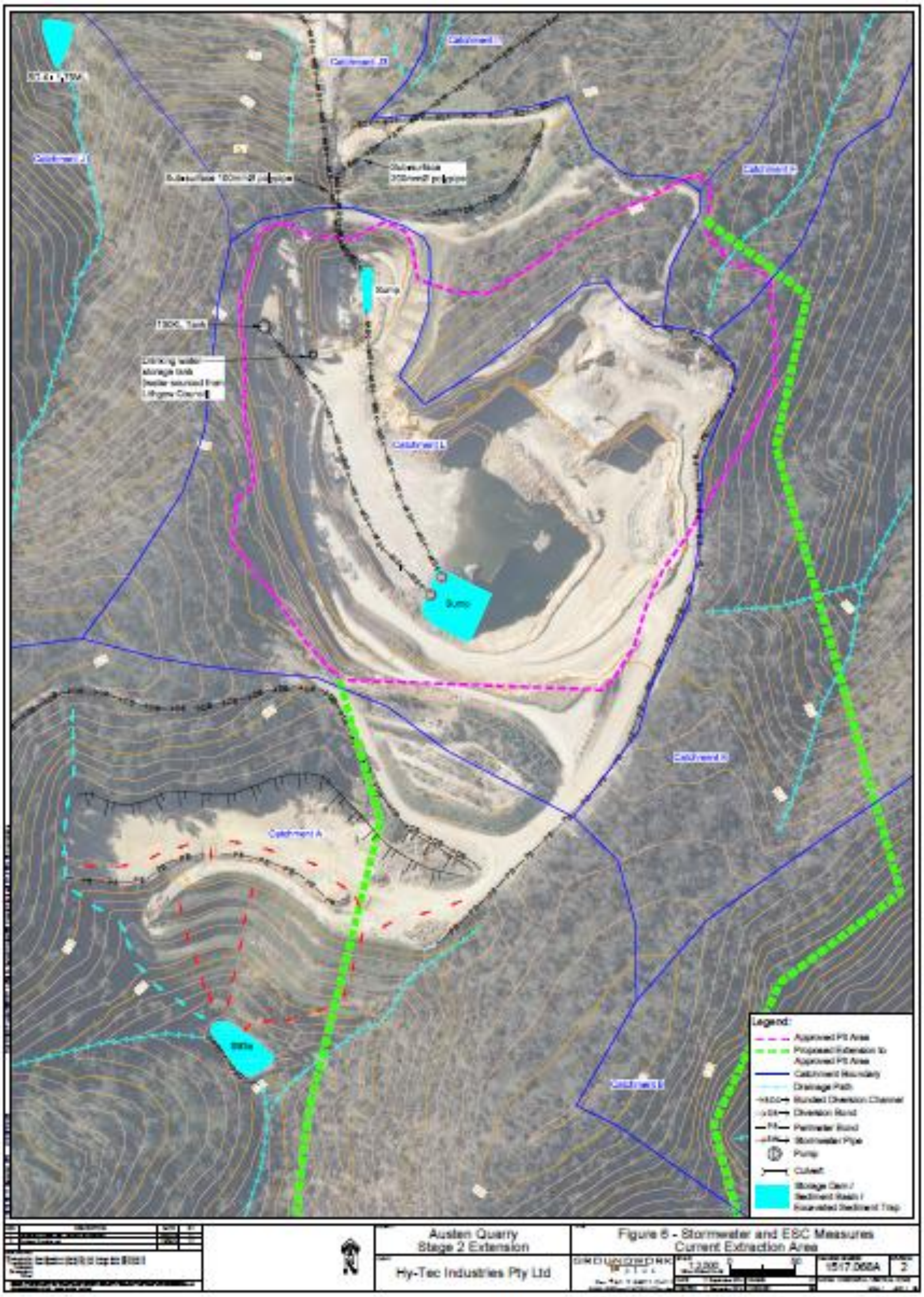
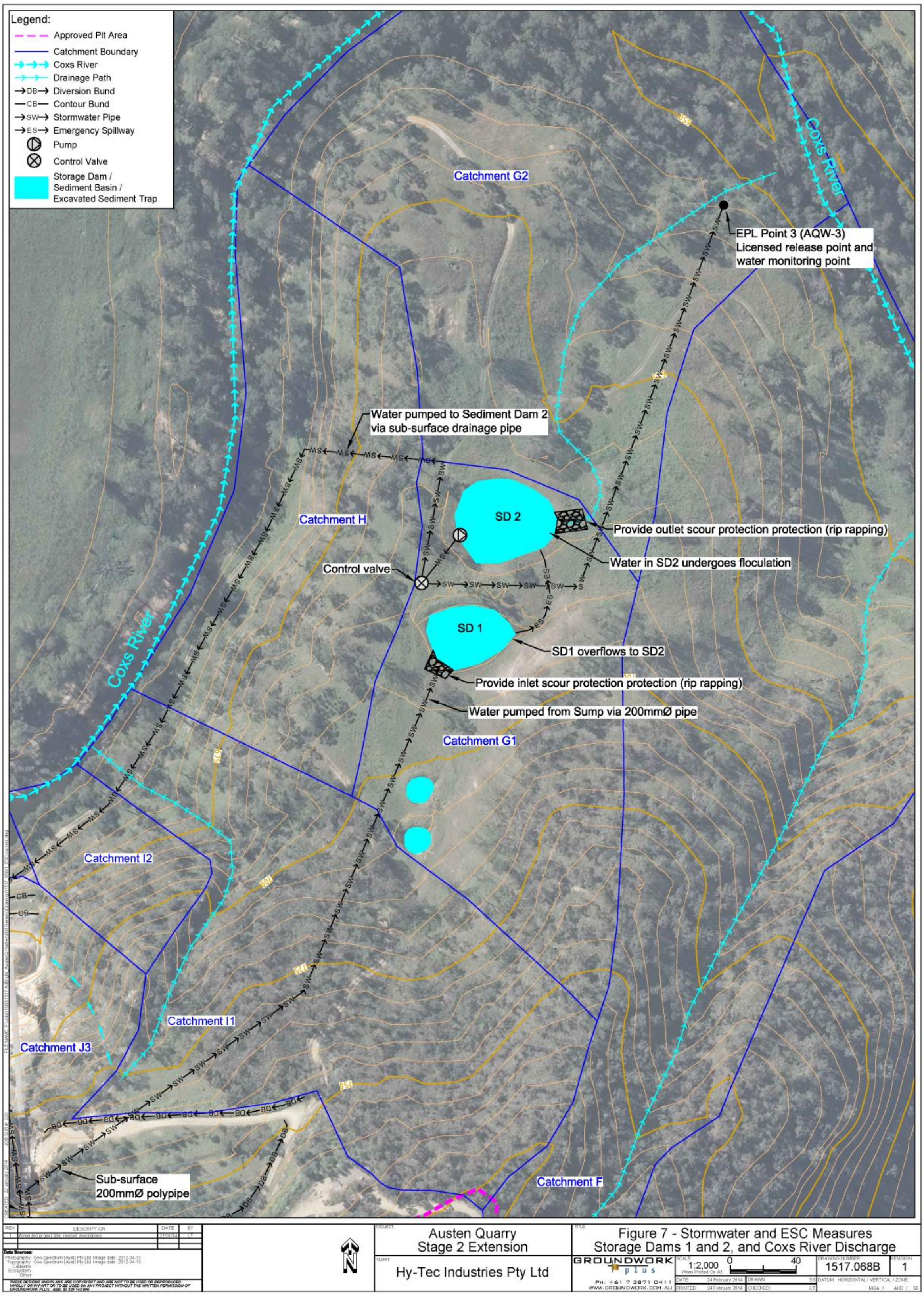
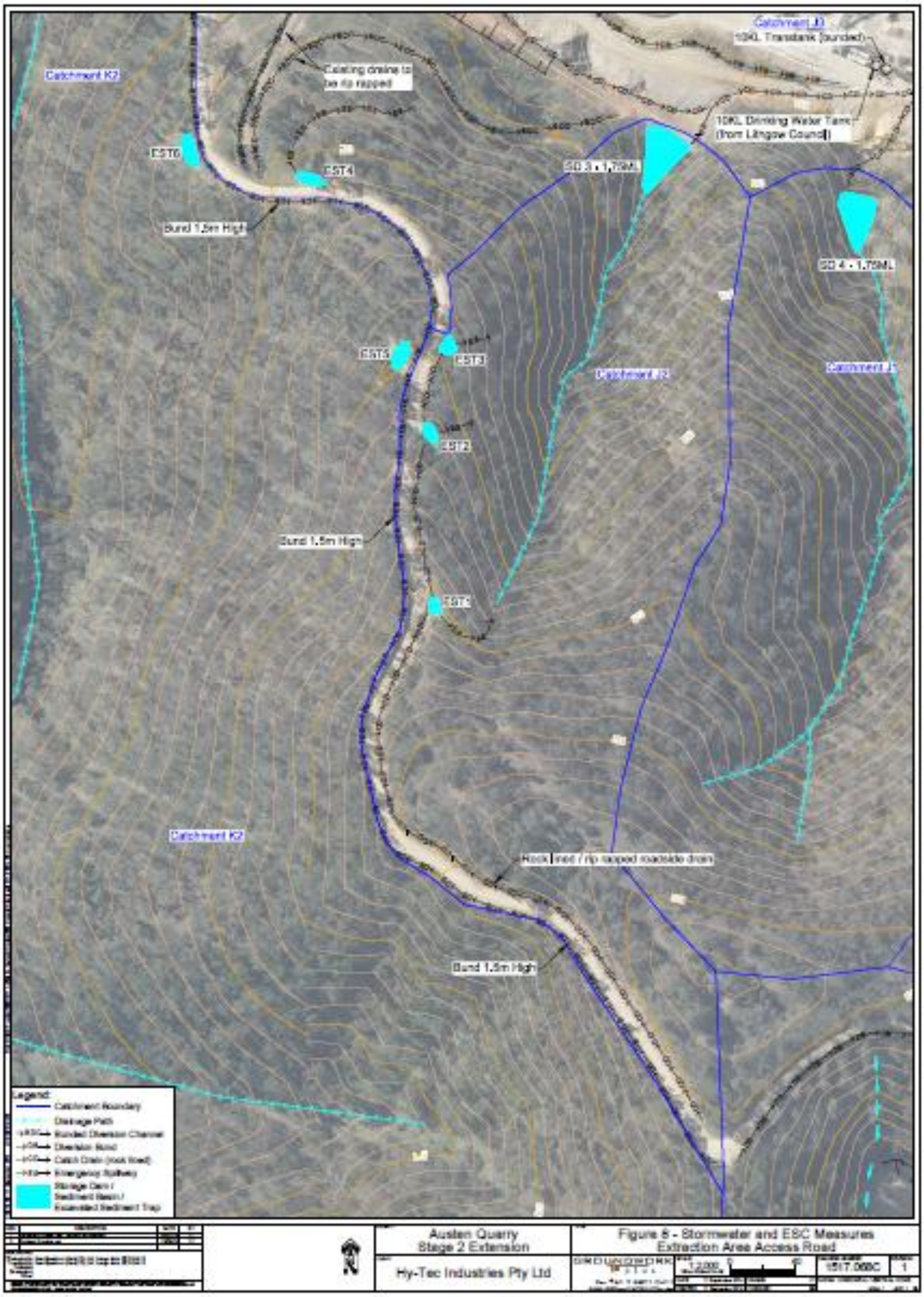
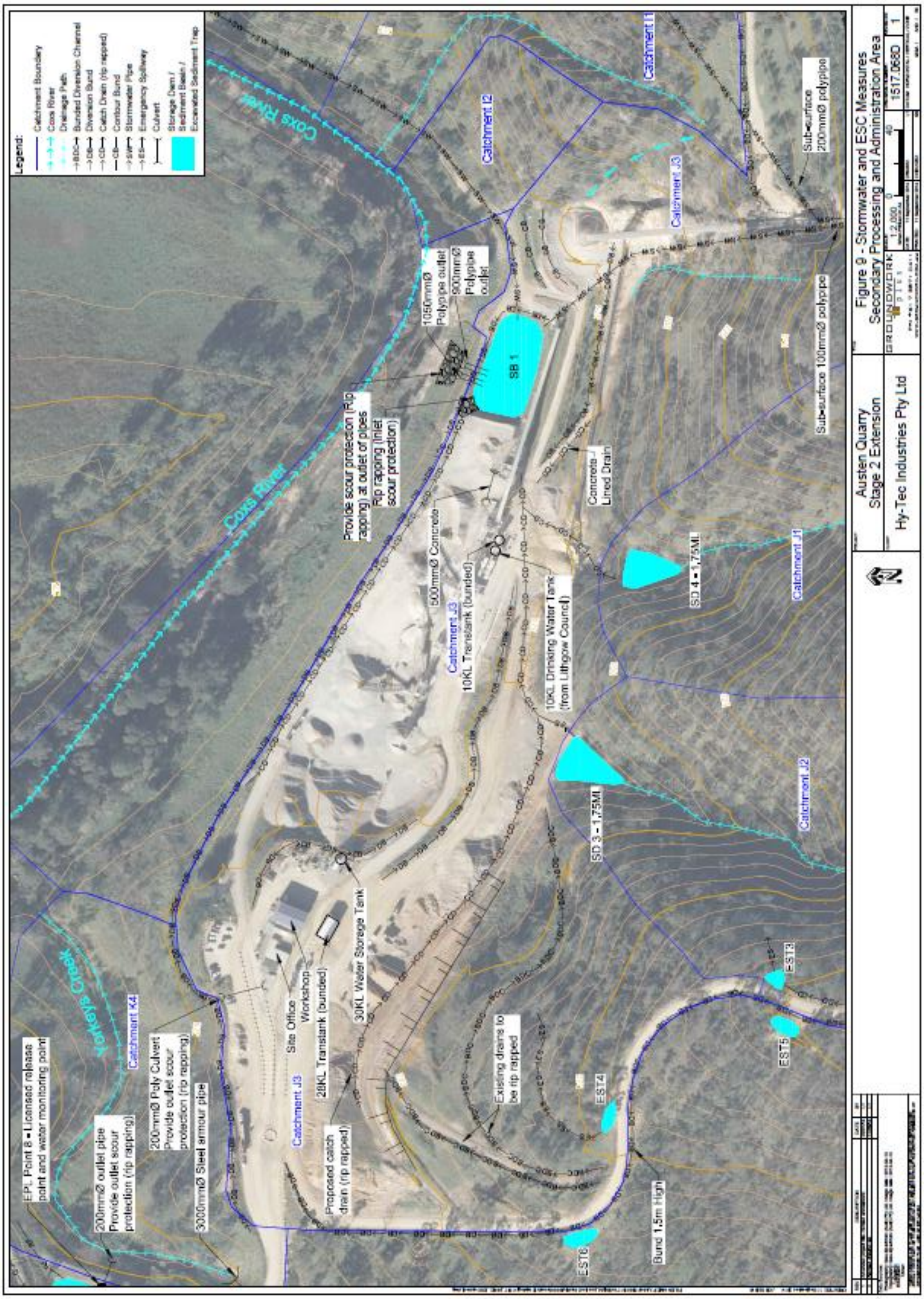


Figure 5 - Water Management System Schematic
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Not to Scale
1517.089
Legend:
Pump
Catchment G1 - Grazing Land
Catchment J3
Catchment K3 - Yorkeys Creek Stockpile Area
Catchment K1 - Water Storage Dam 5 and 6
Catchment J1
Catchment J2
Catchment A1 - Overburden Emplacement
Catchment L - Extraction Area
Coxs River
Yorkeys Creek
Two Way Pumped Water Recycling Link

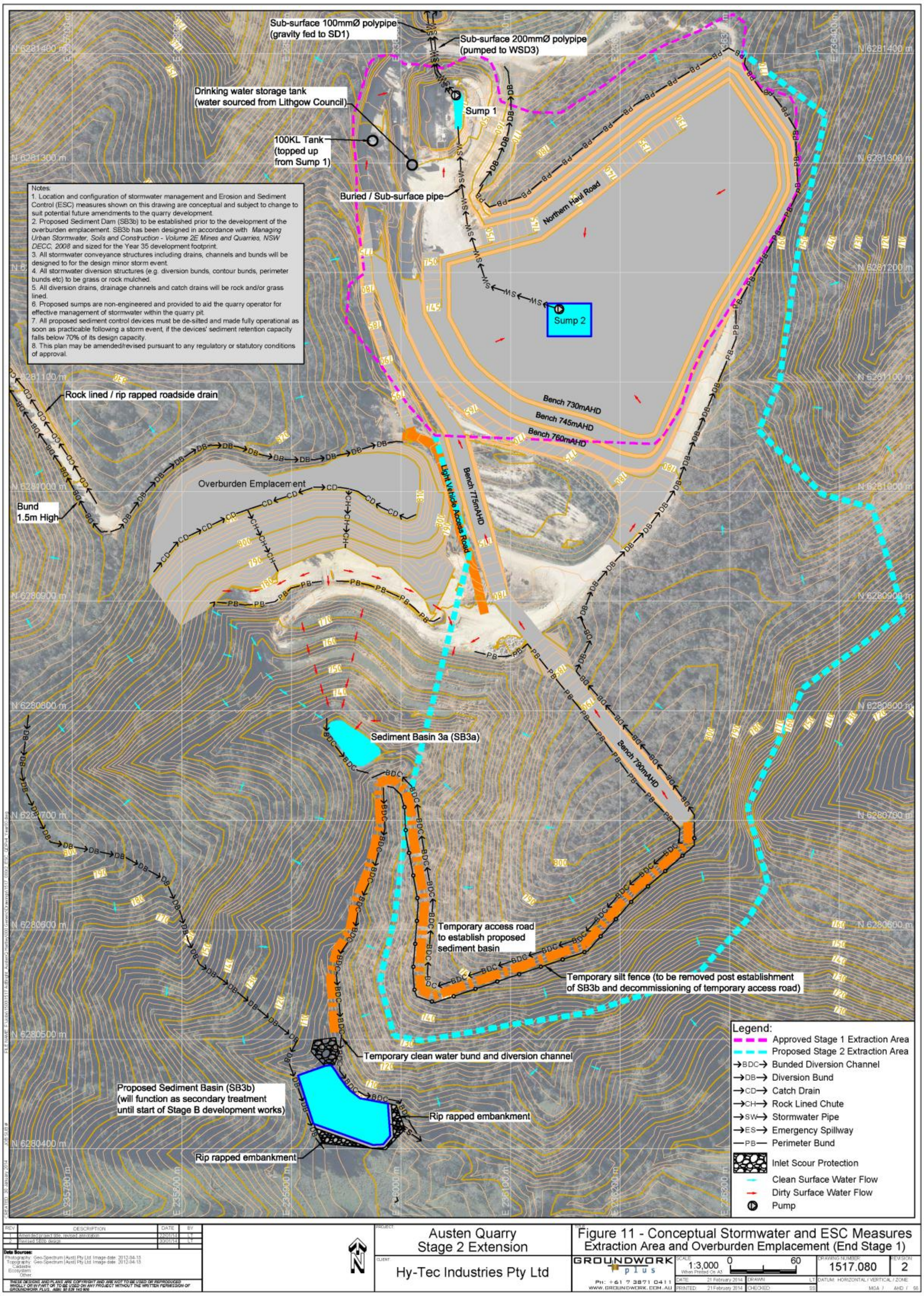

Catchment A
Sump
Legend:
Approved Pit Area
Proposed Extension to Approved Pit Area
Catchment Boundary
Drainage Path
Bunded Diversion Channel
Diversion Bund
Perimeter Bund
Stormwater Pipe
Pump
Culvert
Storage Dam / Sediment Basin / Excavated Sediment Trap
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 6 - Stormwater and ESC Measures
Current Extraction Area
1:2,000
1517.068A
2


Legend:
Approved Pit Area
Catchment Boundary
Coxs River
Drainage Path
Diversion Bund
Contour Bund
Stormwater Pipe
Emergency Spillway
Pump
Control Valve
Storage Dam / Sediment Basin / Excavated Sediment Trap
Catchment G2
Coxs River
EPL Point 3 (AQW-3) Licensed release point and water monitoring point
Water pumped to Sediment Dam 2 via sub-surface drainage pipe
Catchment H
SD 2
Provide outlet scour protection protection (rip rapping)
Control valve
Water in SD2 undergoes floculation
SD 1
SD1 overflows to SD2
Provide inlet scour protection protection (rip rapping)
Water pumped from Sump via 200mmØ pipe
Catchment G1
Catchment I2
Catchment I1
Catchment J3
Sub-surface 200mmØ polypipe
Catchment F
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 7 - Stormwater and ESC Measures Storage Dams 1 and 2, and Coxs River Discharge
GROUNDWORK plus
1:2,000
1517.068B
1


Catchment K2
Existing drains to be rip rapped
10KL Transtank (bunded)
10KL Drinking Water Tank (from Lithgow Council)
EST6
EST4
SD 3 - 1.75ML
SD 4 - 1.75ML
Bund 1.5m High
EST5
EST3
EST2
EST1
Catchment J2
Catchment J1
Catchment K2
Rock lined / rip rapped roadside drain
Bund 1.5m High
Legend:
Catchment Boundary
Drainage Path
Bunded Diversion Channel
Diversion Bund
Catch Drain (rock lined)
Emergency Spillway
Storage Dam / Sediment Basin / Excavated Sediment Trap
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 8 - Stormwater and ESC Measures
Extraction Area Access Road
1517.068C
1


Legend:
Catchment Boundary
Coxs River
Drainage Path
Bunded Diversion Channel
Diversion Bund
Catch Drain (rip rapped)
Contour Bund
Stormwater Pipe
Emergency Spillway
Culvert
Storage Dam / Sediment Basin / Excavated Sediment Trap
Coxs River
Catchment I1
Catchment I2
Catchment J3
Sub-surface 200mmØ polypipe
1050mmØ Polypipe outlet
900mmØ Polypipe outlet
SB 1
Provide scour protection (Rip rapping) at outlet of pipes
Rip rapping (inlet scour protection)
Sub-surface 100mmØ polypipe
Concrete-Lined Drain
500mmØ Concrete
Catchment J3
10KL Transtank (bunded)
10KL Drinking Water Tank (from Lithgow Council)
SD 4 - 1.75ML
Catchment J1
SD 3 - 1.75ML
Catchment J2
30KL Water Storage Tank
Site Office
Workshop
28KL Transtank (bunded)
Existing drains to be rip rapped
EST3
EST4
EST5
EST6
Yorkeys Creek
Catchment K4
EPL Point 8 - Licensed release point and water monitoring point
200mmØ outlet pipe Provide outlet scour protection (rip rapping)
200mmØ Poly Culvert Provide outlet scour protection (rip rapping)
3000mmØ Steel armour pipe
Catchment J3
Proposed catch drain (rip rapped)
Bund 1.5m High
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 9 - Stormwater and ESC Measures Secondary Processing and Administration Area
GROUNDWORK PLUS
1:2,000
1517.068D


Coxs River
Yorkeys Creek
Catchment K4
SB2a (acts primarily as sediment forebay)
Existing catch drain to be rip rapped
EPL Point 8 - Licensed release point and water monitoring point
200mmØ outlet pipe Provide outlet scour protection (rip rapping)
200mmØ Poly Culvert Provide outlet scour protection (rip rapping)
3000mmØ Steel armour pipe
Site Office
Workshop
28KL Transtank (bunded)
30KL Water Storage Tank
Catchment J3
Proposed catch drain (rip rapped)
Existing drains to be rip rapped
SB2b
Yorkeys Creek
Catchment K2
Catchment K3
Yorkeys Creek Stockpile Area
500mmØ Concrete
350mmØ Concrete
Provide outlet scour protection protection (rip rapping)
SD6 (pumped to SB1 and vice versa)
EPL Point 11 - Licensed release point and water monitoring point
Catchment K1
SD5
Provide inlet scour protection protection (rip rapping)
Legend:
Catchment Boundary
Coxs River
Drainage Path
Bunded Diversion Channel
Diversion Bund
Catch Drain
Perimeter Bund
Contour Bund
Proposed Rock Filter Bund
Stormwater Pipe
Emergency Spillway
Culvert
Storage Dam / Sediment Basin / Excavated Sediment Trap
Figure 10 - Stormwater and ESC Measures Yorkeys Creek Stockpile Area
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
1:2,000
1517.066E



Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Northern Haul Road
Sump 2
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008 and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Rock lined / rip rapped roadside drain
Bench 730mAHD
Bench 745mAHD
Bench 760mAHD
Bund 1.5m High
Overburden Emplacement
Light Vehicle Access Road
Bench 775mAHD
Bench 790mAHD
Sediment Basin 3a (SB3a)
Temporary access road to establish proposed sediment basin
Temporary silt fence (to be removed post establishment of SB3b and decommissioning of temporary access road)
Temporary clean water bund and diversion channel
Proposed Sediment Basin (SB3b) (will function as secondary treatment until start of Stage B development works)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 11 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (End Stage 1)
GROUNDWORK plus
1:3,000
1517.080
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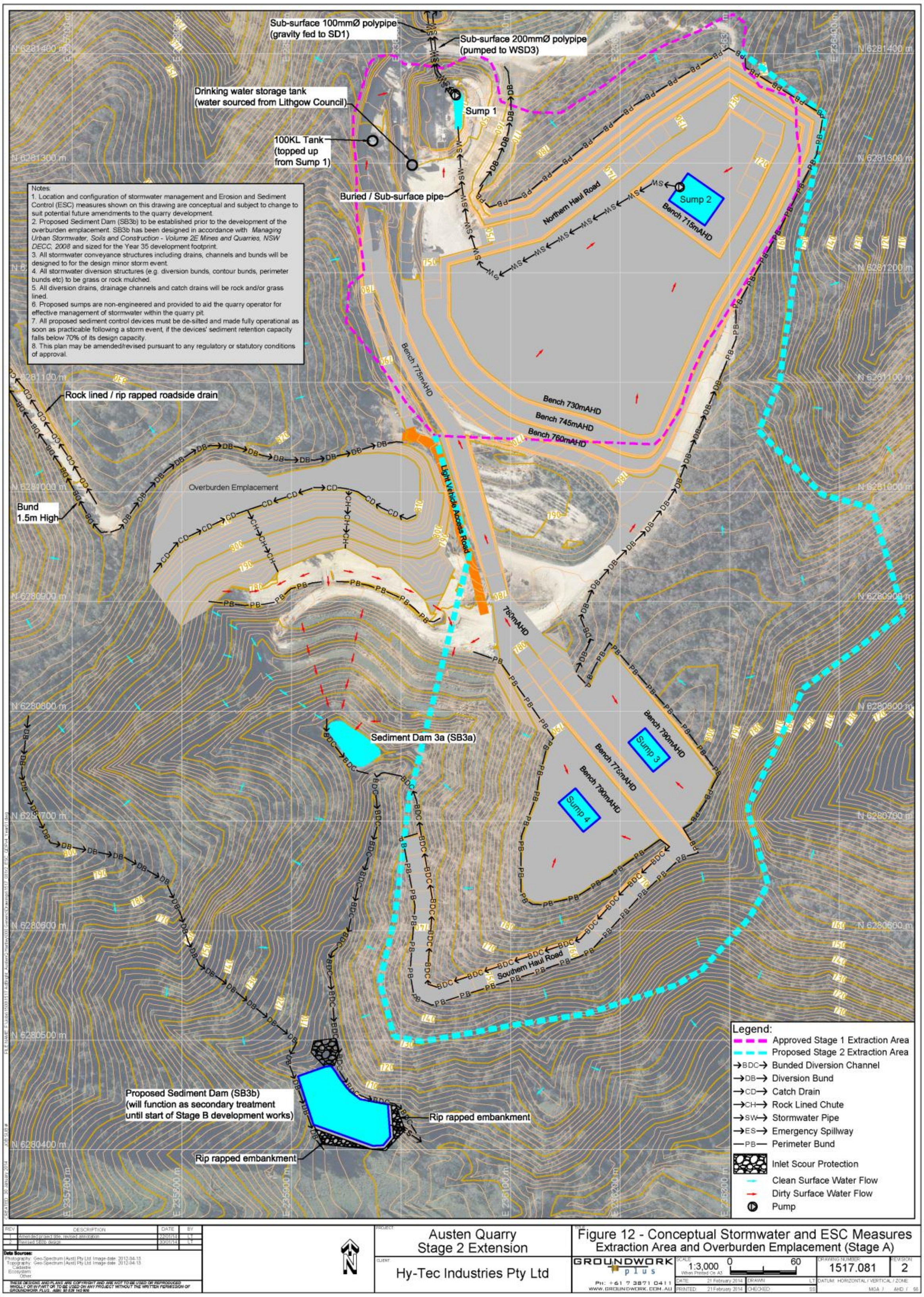
Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Sump 2
Northern Haul Road
Bench 715mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with *Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008* and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Rock lined / rip rapped roadside drain
Bench 775mAHD
Bench 730mAHD
Bench 745mAHD
Bench 760mAHD
Bund 1.5m High
Overburden Emplacement
Light Vehicle Access Road
780mAHD
Sediment Dam 3a (SB3a)
Bench 790mAHD
Sump 3
Bench 775mAHD
Bench 790mAHD
Sump 4
Southern Haul Road
Proposed Sediment Dam (SB3b) (will function as secondary treatment until start of Stage B development works)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 12 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (Stage A)
GROUNDWORK plus
1:3,000
1517.081
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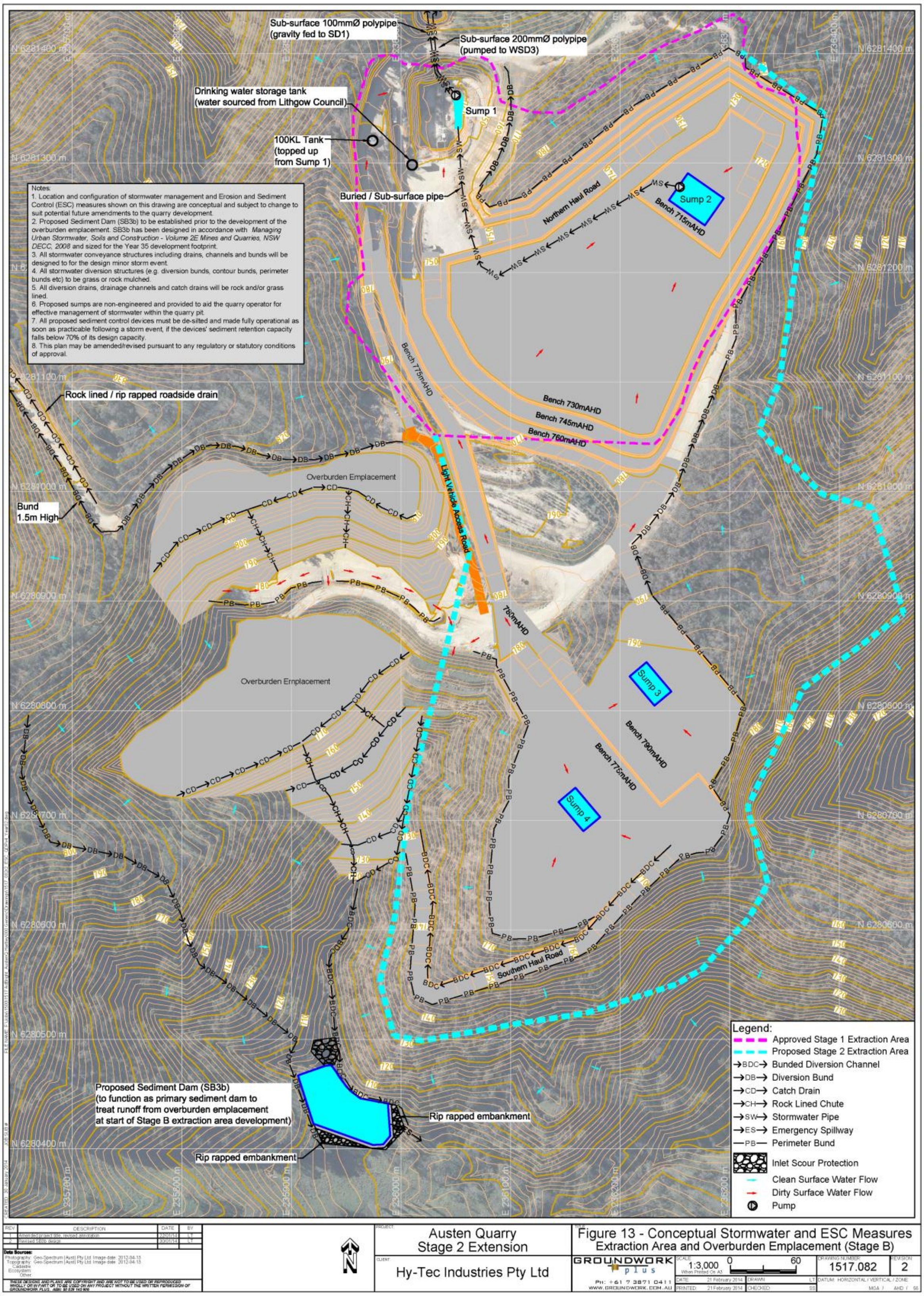
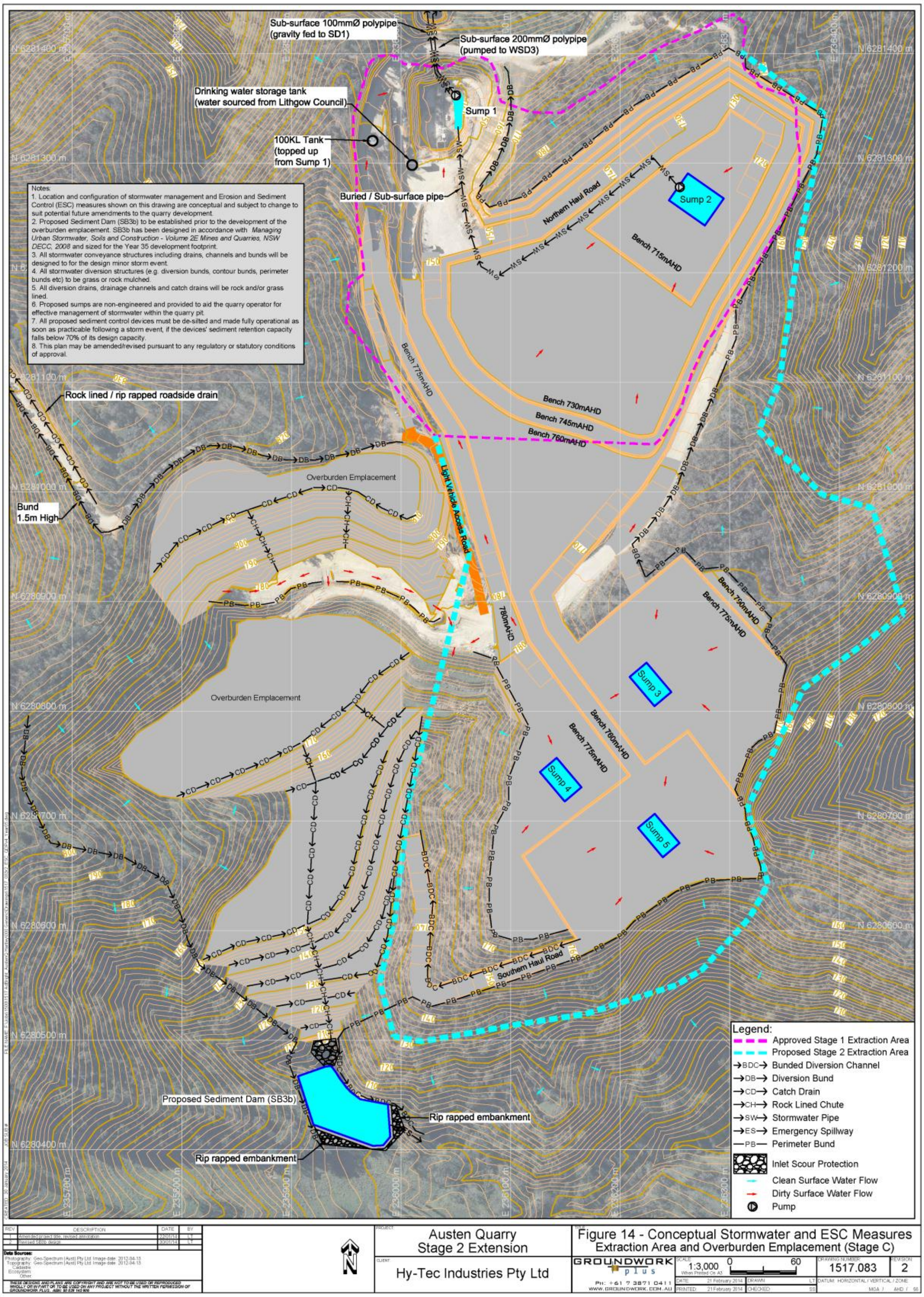

Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Northern Haul Road
Sump 2
Bench 715mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008 and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Rock lined / rip rapped roadside drain
Bench 775mAHD
Bench 730mAHD
Bench 745mAHD
Bench 760mAHD
Bund 1.5m High
Overburden Emplacement
Light Vehicle Access Road
760mAHD
Overburden Emplacement
Sump 3
Bench 790mAHD
Bench 775mAHD
Sump 4
Southern Haul Road
Proposed Sediment Dam (SB3b) (to function as primary sediment dam to treat runoff from overburden emplacement at start of Stage B extraction area development)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
N
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 13 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (Stage B)
GROUNDWORK plus
1:3,000
0 60
1517.082
2
21 February 2014


Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Sump 2
Northern Haul Road
Bench 715mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with *Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008* and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Bench 775mAHD
Rock lined / rip rapped roadside drain
Bench 730mAHD
Bench 745mAHD
Bench 760mAHD
Overburden Emplacement
Bund 1.5m High
Light Vehicle Access Road
780mAHD
Bench 750mAHD
Bench 775mAHD
Sump 3
Overburden Emplacement
Bench 760mAHD
Bench 775mAHD
Sump 4
Sump 5
Southern Haul Road
Proposed Sediment Dam (SB3b)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 14 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (Stage C)
GROUNDWORK plus
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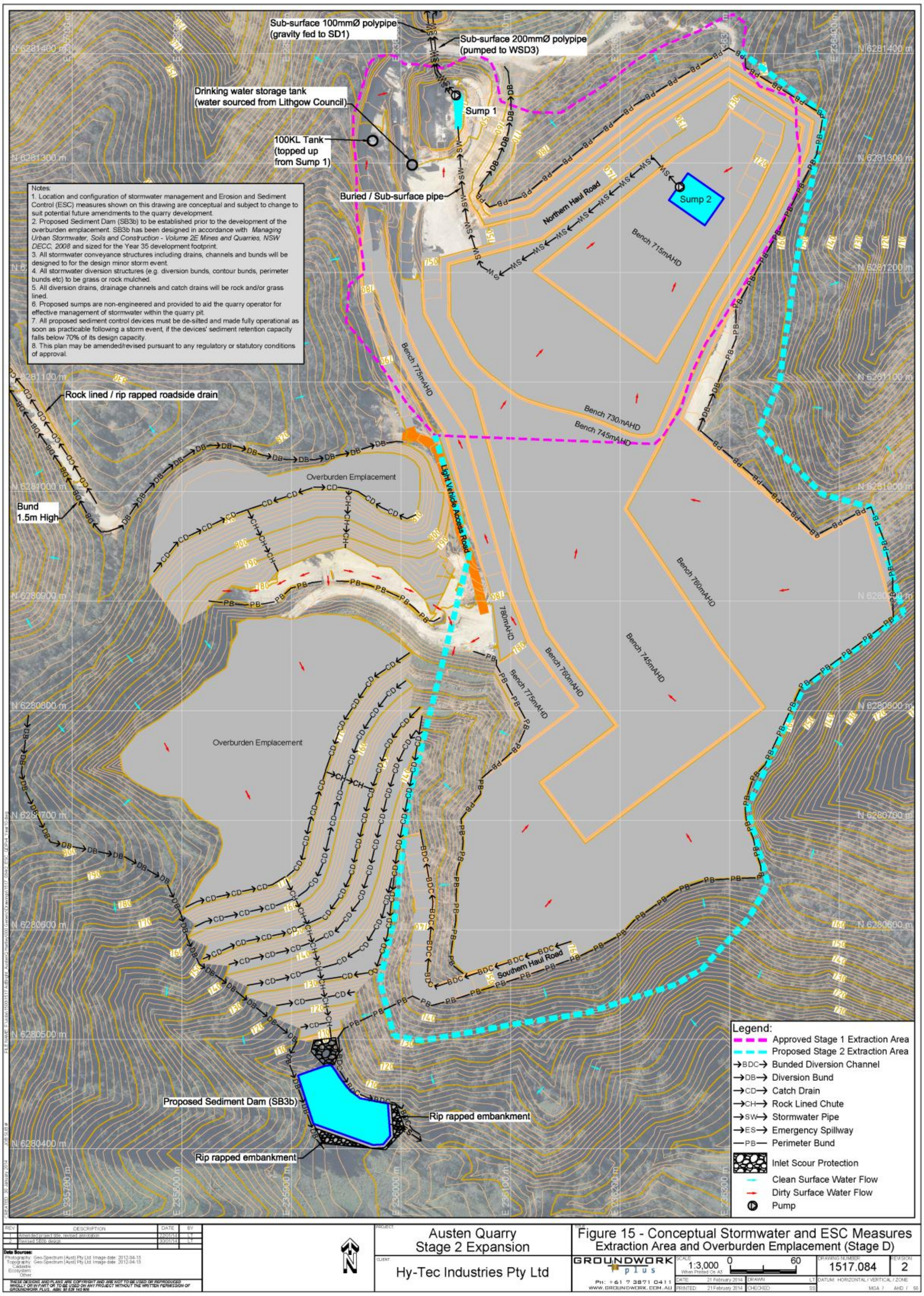
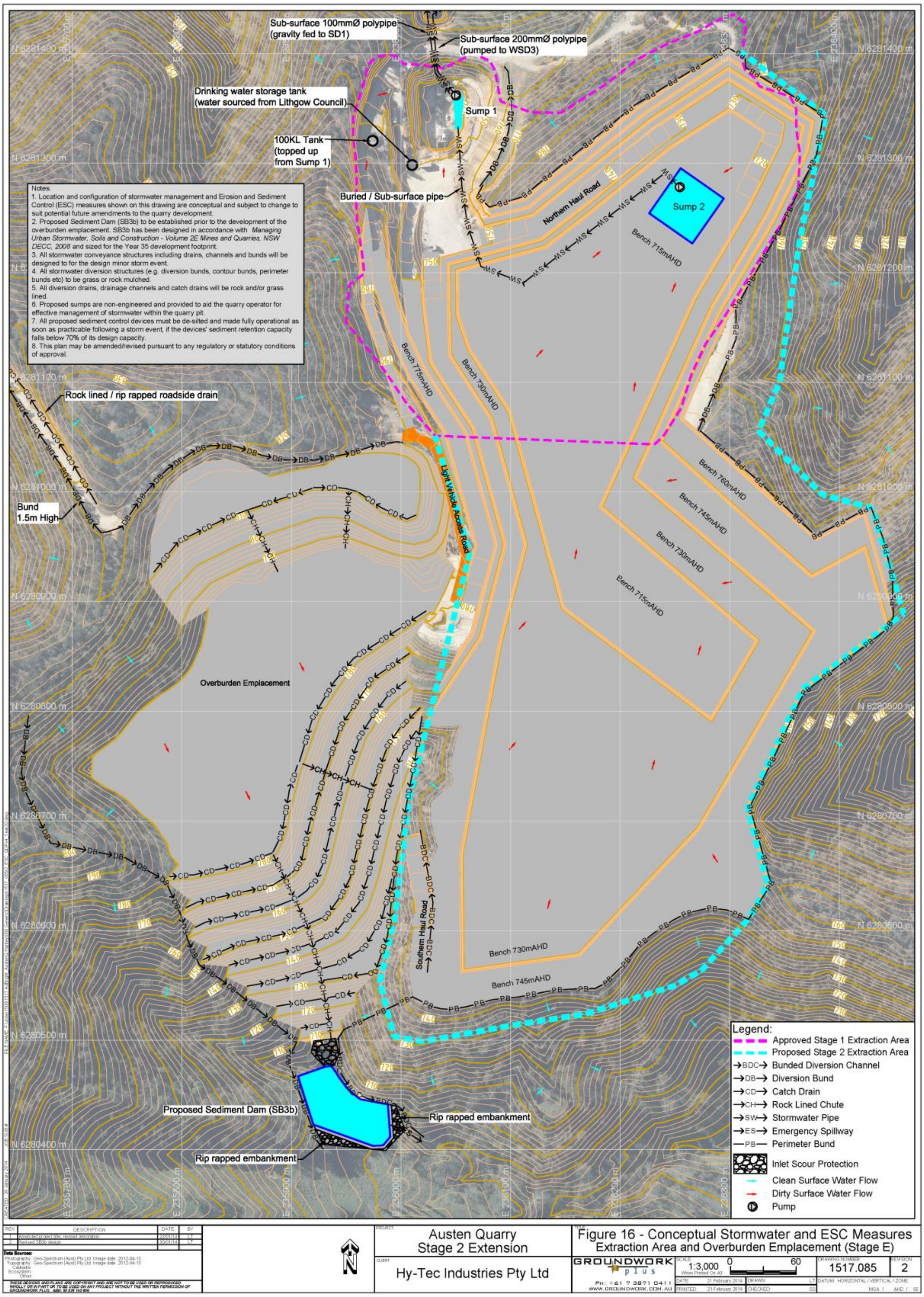
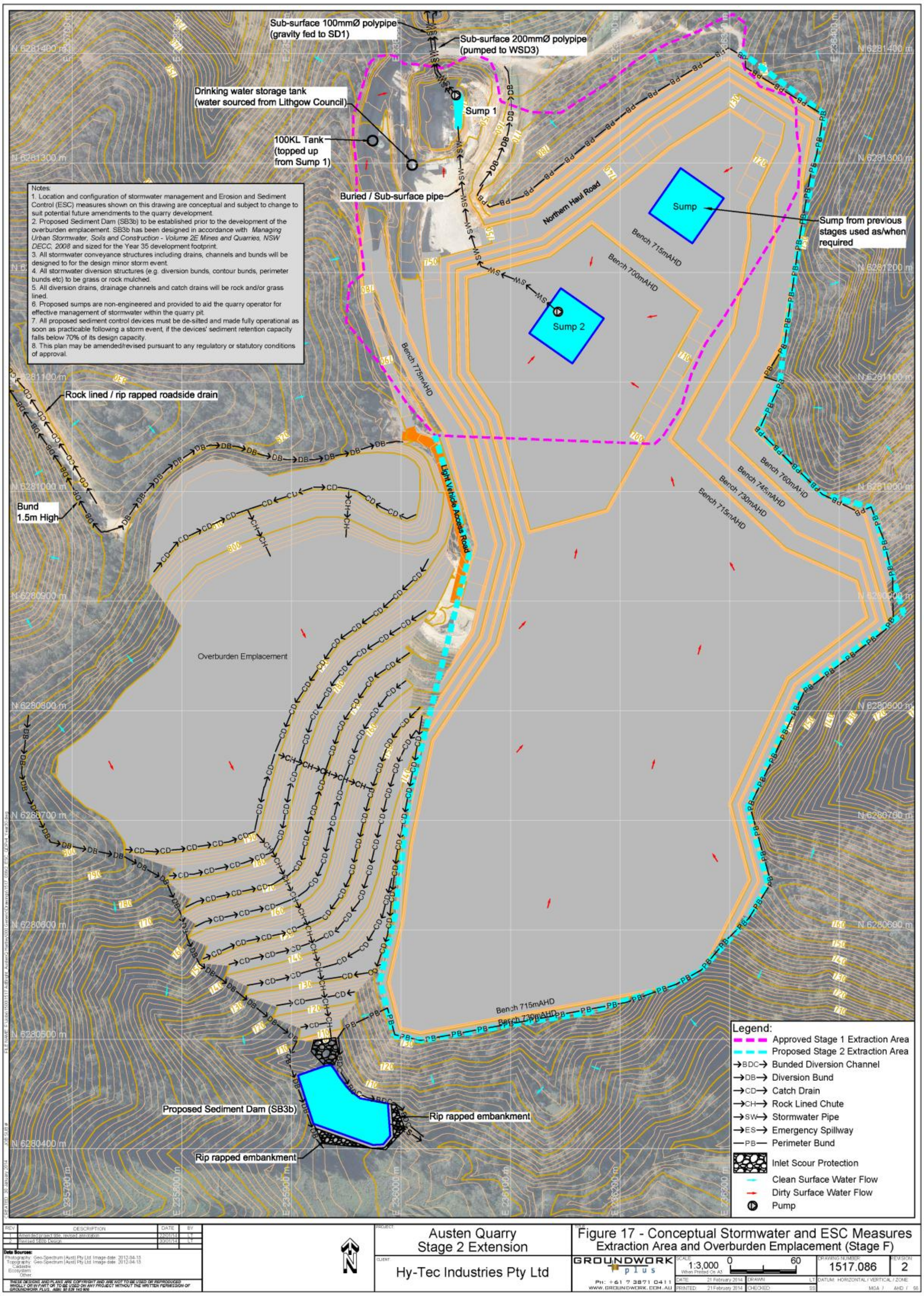
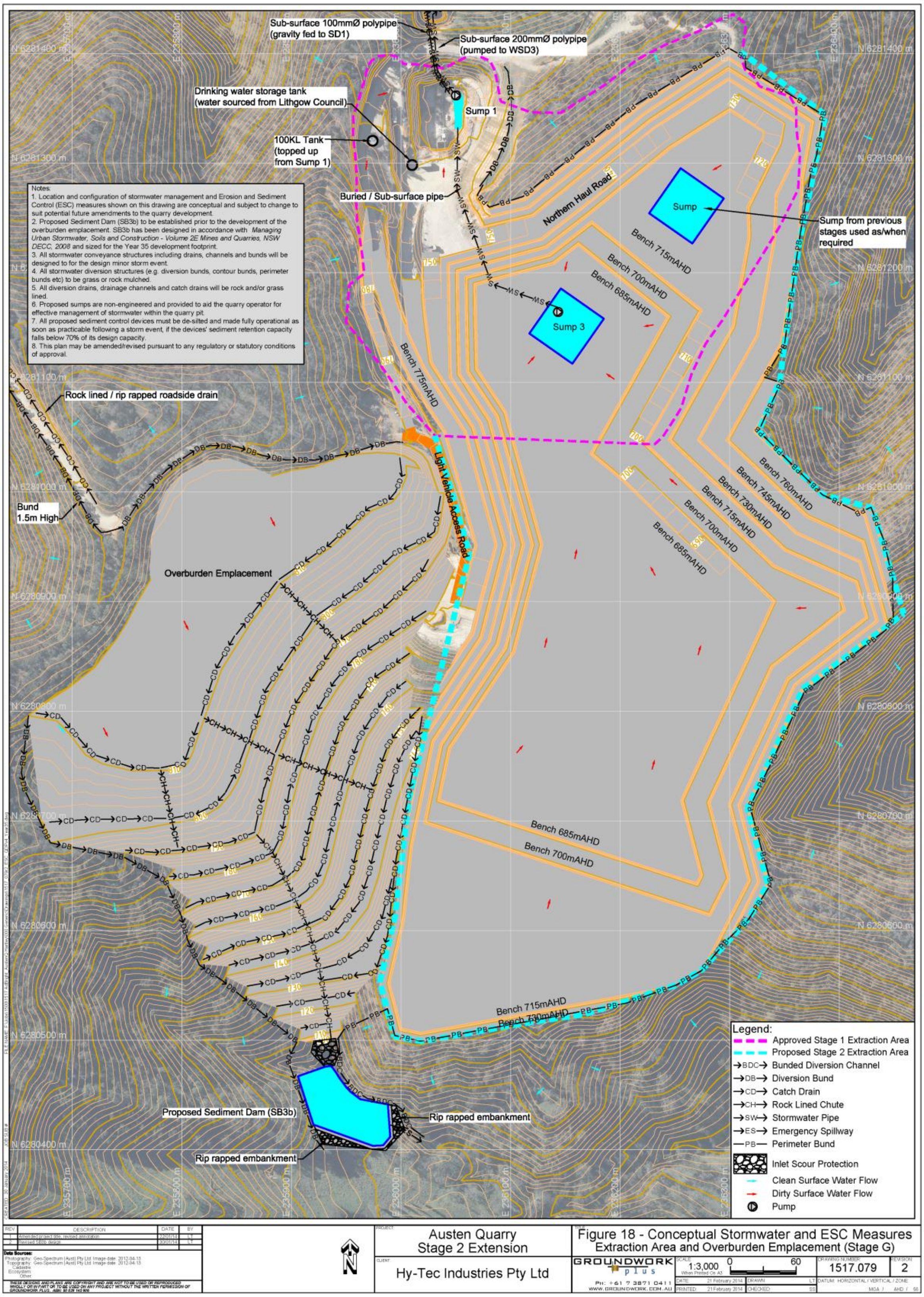

Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Northern Haul Road
Sump 2
Bench 715mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008 and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Rock lined / rip rapped roadside drain
Bench 775mAHD
Bench 730mAHD
Bench 745mAHD
Overburden Emplacement
Bund 1.5m High
Light Vehicle Access Road
Bench 760mAHD
Bench 745mAHD
780mAHD
Bench 775mAHD
Bench 760mAHD
Overburden Emplacement
Southern Haul Road
Proposed Sediment Dam (SB3b)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
Austen Quarry Stage 2 Expansion
Hy-Tec Industries Pty Ltd
Figure 15 - Conceptual Stormwater and ESC Measures Extraction Area and Overburden Emplacement (Stage D)
GROUNDWORK plus
1:3,000
1517.084
2
21 February 2014


Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Northern Haul Road
Sump 2
Bench 715mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with *Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008* and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Bench 775mAHD
Bench 730mAHD
Rock lined / rip rapped roadside drain
Bund 1.5m High
Light Vehicle Access Road
Bench 760mAHD
Bench 745mAHD
Bench 730mAHD
Bench 715mAHD
Overburden Emplacement
Southern Haul Road
Bench 730mAHD
Bench 745mAHD
Proposed Sediment Dam (SB3b)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
PROJECT: Austen Quarry Stage 2 Extension
CLIENT: Hy-Tec Industries Pty Ltd
Figure 16 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (Stage E)
GROUNDWORK plus
PH: +61 7 3871 0411
WWW.GROUNDWORK.COM.AU
SCALE 1:3,000 When Printed On A3
0 60
DRAWING NUMBER 1517.085
REVISION 2
DATE 21 February 2014
PRINTED 21 February 2014
DRAWN LT
CHECKED SS
DATUM: HORIZONTAL / VERTICAL / ZONE MGA / AHD / 56


Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Northern Haul Road
Sump
Sump from previous stages used as/when required
Sump 2
Bench 715mAHD
Bench 700mAHD
Bench 775mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008 and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Rock lined / rip rapped roadside drain
Bund 1.5m High
Light Vehicle Access Road
Overburden Emplacement
Bench 760mAHD
Bench 745mAHD
Bench 730mAHD
Bench 715mAHD
Bench 715mAHD
Bench 730mAHD
Proposed Sediment Dam (SB3b)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
Austen Quarry
Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 17 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (Stage F)
GROUNDWORK plus
1:3,000
1517.086
2


Sub-surface 100mmØ polypipe (gravity fed to SD1)
Sub-surface 200mmØ polypipe (pumped to WSD3)
Drinking water storage tank (water sourced from Lithgow Council)
Sump 1
100KL Tank (topped up from Sump 1)
Buried / Sub-surface pipe
Northern Haul Road
Sump
Sump from previous stages used as/when required
Bench 715mAHD
Bench 700mAHD
Bench 685mAHD
Sump 3
Bench 775mAHD
Notes:
1. Location and configuration of stormwater management and Erosion and Sediment Control (ESC) measures shown on this drawing are conceptual and subject to change to suit potential future amendments to the quarry development.
2. Proposed Sediment Dam (SB3b) to be established prior to the development of the overburden emplacement. SB3b has been designed in accordance with Managing Urban Stormwater, Soils and Construction - Volume 2E Mines and Quarries, NSW DECC, 2008 and sized for the Year 35 development footprint.
3. All stormwater conveyance structures including drains, channels and bunds will be designed to for the design minor storm event.
4. All stormwater diversion structures (e.g. diversion bunds, contour bunds, perimeter bunds etc) to be grass or rock mulched.
5. All diversion drains, drainage channels and catch drains will be rock and/or grass lined.
6. Proposed sumps are non-engineered and provided to aid the quarry operator for effective management of stormwater within the quarry pit.
7. All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.
8. This plan may be amended/revised pursuant to any regulatory or statutory conditions of approval.
Rock lined / rip rapped roadside drain
Bund 1.5m High
Light Vehicle Access Road
Overburden Emplacement
Bench 760mAHD
Bench 745mAHD
Bench 730mAHD
Bench 715mAHD
Bench 700mAHD
Bench 685mAHD
Bench 685mAHD
Bench 700mAHD
Bench 715mAHD
Bench 730mAHD
Proposed Sediment Dam (SB3b)
Rip rapped embankment
Rip rapped embankment
Legend:
Approved Stage 1 Extraction Area
Proposed Stage 2 Extraction Area
BDC Bunded Diversion Channel
DB Diversion Bund
CD Catch Drain
CH Rock Lined Chute
SW Stormwater Pipe
ES Emergency Spillway
PB Perimeter Bund
Inlet Scour Protection
Clean Surface Water Flow
Dirty Surface Water Flow
Pump
Austen Quarry Stage 2 Extension
Hy-Tec Industries Pty Ltd
Figure 18 - Conceptual Stormwater and ESC Measures
Extraction Area and Overburden Emplacement (Stage G)
GROUNDWORK plus
1:3,000
1517.079
2