Cleary Bros (Bombo) Pty Ltd

ABN: 28 000 157 808

CLEARY BROS

Albion Park Quarry Extraction Area Stage 7 Extension

Soil and Surface Water Assessment

Prepared by

Strategic Environmental and Engineering Consulting Pty Ltd

SEEC

July 2021

Specialist Consultant Studies Compendium Part 7

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Soil and Surface Water Assessment

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EXECUTIVE SUMMARY

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd has been commissioned by Cleary Bros (Bombo) Pty Ltd to undertake a soil and surface water assessment for the proposed Stage 7 extension of the existing Albion Park Quarry. The Project is classified as State Significant Development.

The Project Area incorporates Stages 1 to 6 of the current extraction area and the proposed Stage 7 extension. Stages 1 to 6 are included in the Application Area as a quantity of rock remains to be extracted in these stages and greater efficiencies would be achieved by extracting the remaining rock concurrently in Stages 5, 6 and 7.

The extraction operations within the Stage 7 area would be undertaken progressively in a general anti-clockwise direction, with previously extracted lands progressively rehabilitated throughout the Project life. The final landform would incorporate five rehabilitation domains based upon the final landform created within the Project Area that include terrace, slope, plains, open water and foreshore domains for the management of surface water as described in the EIS.

No changes are proposed to the existing operations and all existing controls used to conserve soils are expected to be maintained. This includes the stockpiling of topsoil, subsoil and overburden within the existing and proposed extraction area.

The Stage 7 extraction area is located within the Rocklow Creek catchment with runoff from the Project Area generally flowing in a south-easterly direction and eventually draining into the Tasman Sea at Minnamurra. The extraction process would reshape sections of the local watercourse catchments, causing runoff from parts of the former catchments to drain internally to one of three sumps. Peak flows are estimated to decrease by up to 25% in watercourses at the Project Area boundary, and by up to 4% in Rocklow Creek immediately downstream of the Illawarra Railway. The potential decrease to peak flows in these downstream watercourses would be offset by the discharge of runoff captured within the sump(s) following the settlement of fine sediment. This change would reduce peak flow volumes while extending the duration of tail flows following storm events.

Disturbed lands, and lands not yet rehabilitated, would drain to internal sump(s) where sediment-laden water would be treated, if required, prior to reuse on site or release to receiving waters in accordance with the existing Environment Protection License (EPL) 299. Runoff that exceeds the sump volume will be contained within the extraction area with any discharge from the extraction area complying with the limits set out in the EPL.

The current Main dam has sufficient capacity to cater for the additional water required for dust suppression of the extended haul roads. Water captured within the proposed sump(s) may also be used for dust suppression purposes.

1 INTRODUCTION

1.1 PROJECT IDENTIFICATION

Cleary Bros (Bombo) Pty Ltd (Cleary Bros) plans to apply for a new development consent under Part 4, Division 4.7 of the *Environmental Planning and Assessment Act 1979* to extend the existing extraction area within the Albion Park Hard Rock Quarry, located approximately 1km south and west of the Princes Highway at Albion Park (see **Figure 1**) (the Project). The Project is classified as State Significant Development. The Application Area for the Project is detailed in the Environmental Impact Statement (EIS).

1.2 BACKGROUND AND HISTORY

The existing Albion Park Quarry was approved on 21 February 2006 by the Land and Environment Court (DC 10639/2005) and has been modified in 2009, 2015 and most recently in 2017. Cleary Bros is currently extracting hard rock from within Stages 5 and 6 of the Quarry although some minor activities continue in Stages 1 to 4 (see **Figure 1**).

Cleary Bros is proposing to extend the current extraction area beyond Stages 5 and 6 to an area identified as Stage 7 (**Figure 2**). Extraction would be undertaken in the Stage 7 extension area in a similar manner to the existing operations in Stages 5 and 6 with the extracted rock transported through Stages 1 to 6 to the fixed crushing and screening plant to the north of the extraction area. **Figure 2** displays the boundary of the Stage 7 extension area.

Cleary Bros does not intend to modify any operational procedures for the extended extraction area with the annual production limit maintained at 900 000 tonnes per annum (tpa).

1.3 PROJECT FEATURES

The Project Area incorporates Stages 1 to 6 of the current extraction area and the proposed extraction area extension, i.e. Stage 7 – see **Figure 2**. Stages 1 to 6 are included in the Application Area as a quantity of rock remains to be extracted in these stages and greater efficiencies would be achieved by extracting the remaining rock concurrently in Stages 5, 6 and 7. The extraction of Stage 7 would be undertaken in four general stages, namely Stages 7a to 7d. Extraction in Stages 7c and 7d would initially be confined to the western side of both substages (Stage 7c/7d) with extraction concluding in the Eastern Rim (**Figure 3**). Some of the overburden and soil from Stages 7a and 7b would be used for the rehabilitation of Stages 1 to 4. Rehabilitation would occur progressively throughout the Project life. Future rehabilitation would focus on the conservation of all topsoil and as much subsoil as possible for use in long term rehabilitation of the Project Area and initial stabilisation of the areas to be disturbed and backfilled with overburden and/or VENM/ENM during Stage 7. Vegetation would also be progressively established on the elevated final or terminal extraction benches as they are completed.

The final landform would incorporate five rehabilitation domains based upon the final landform created within the Project Area that include terrace, slope, plains, open water and foreshore domains for the management of surface water as described in Section 3.11.5 of the EIS.

Stages 1 to 6 are located wholly within Lot 1 DP858245. Stage 7 is located immediately east of Stages 1 to 6 and extends onto the adjoining Lot 7 DP3709. The internal haul road between the current extraction area and the processing area is located in the northern part of Lot 2 DP858245 but is not within the Project Area.

Both lots within the Application Area are owned by Bridon Pty Ltd, an associated entity of Cleary Bros (Bombo) Pty Ltd.

1.4 PURPOSE OF THIS ASSESSMENT

The purpose of this Assessment is to describe the existing soil resources and surface water features within and surrounding the Project Area and to assess the impacts of the Project upon the soil and water resources within and surrounding the Project Area. This report focuses on the Stage 7 extraction area which has four stages as shown in **Figure 3**.

Table 1 contains key inclusions as part of this assessment.

Table 1 – Key soil and water constraints and opportunities included in this assessment.

Parameter	Key inclusions in this assessment
Soils	• Mapping of the existing soil resources within Stages 1 to 6 and within the proposed Stage 7; • Identifying soil characteristics relevant to re-use of soil resources in the rehabilitation activities; • Estimating potential soil stockpiling volumes; • Identifying potential impacts to soil resources as a result of the Project. • Recommending mitigation or management measures to address soil-related constraints to effective environmental management and rehabilitation.
Water	• A review of previous surface water-related studies undertaken for the existing extraction area. • A description of the existing surface water catchment areas and stormwater flows within the extraction and operational areas of the Project. • A description of the existing surface water environment including: – A description of regional/local surface water catchments. – Catchments, drainage and hydraulic features within the Project Area. – Local variations in surface water quality. • Identifying potential impacts to water resources as a result of the proposed Project. • Recommending mitigation or management measures to address water-related constraints to effective environmental management. • Identifying the licensing requirements applicable under the *Water Management Act 2000.*

1.5 OBJECTIVES

The key objective of this Assessment is to satisfy the surface water and soil-related requirements of the Secretary's Environmental Assessment Requirements (SEARs) for this Project. **Appendix 1** includes the surface water and soil-related SEARs and where each is addressed in this report.

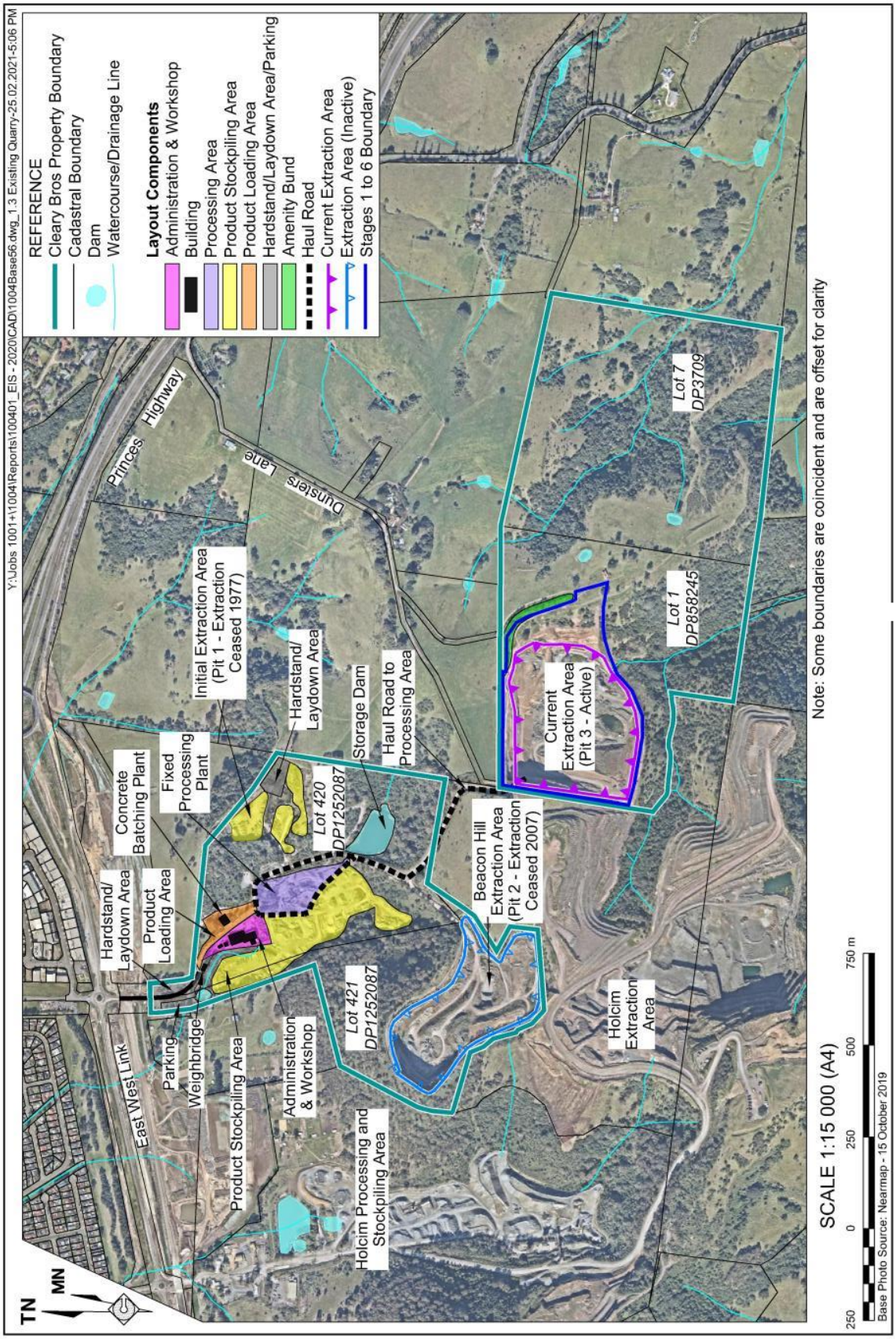


Figure 1 – Existing operations (provided by R.W. Corkery & Co. Pty Limited)

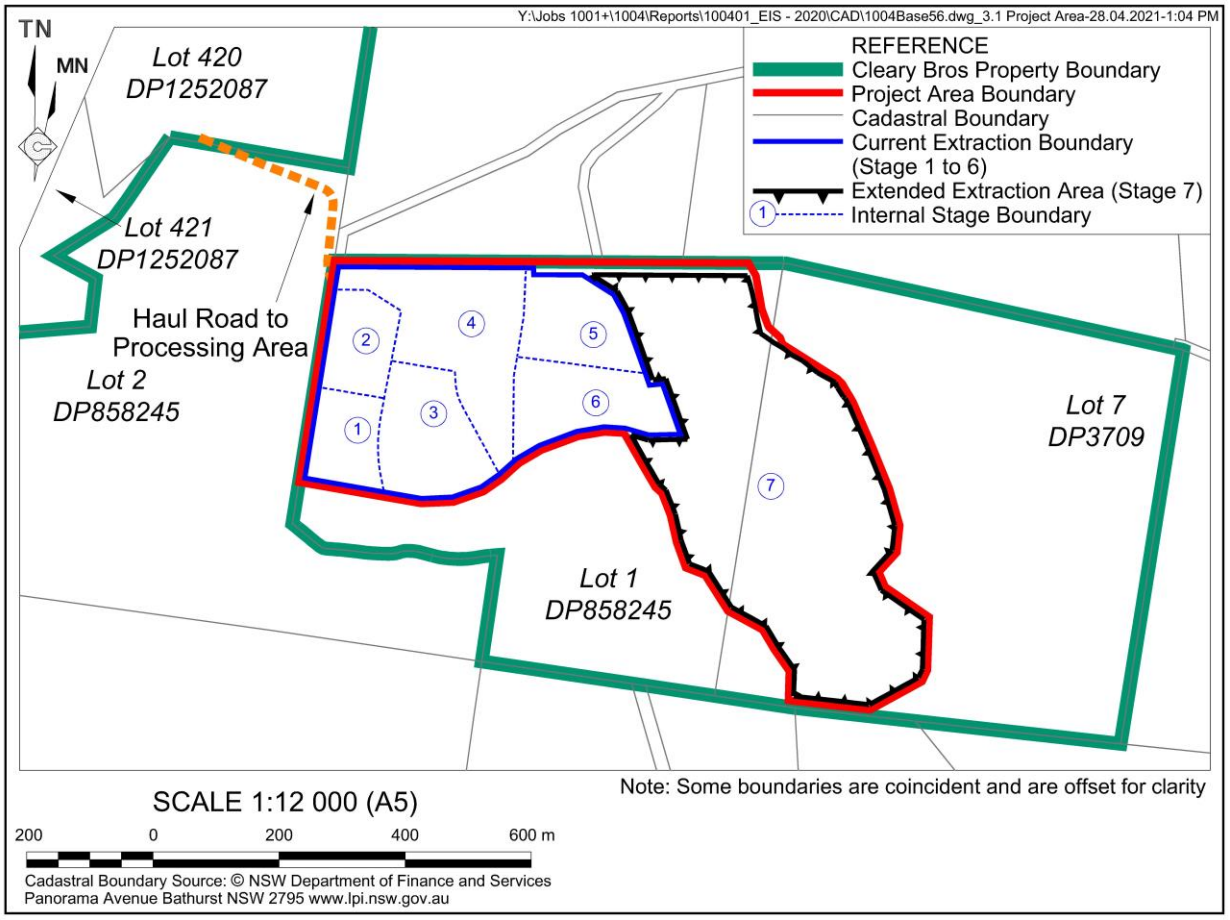


Figure 2 – The Project Area (provided by R.W. Corkery & Co. Pty Limited)

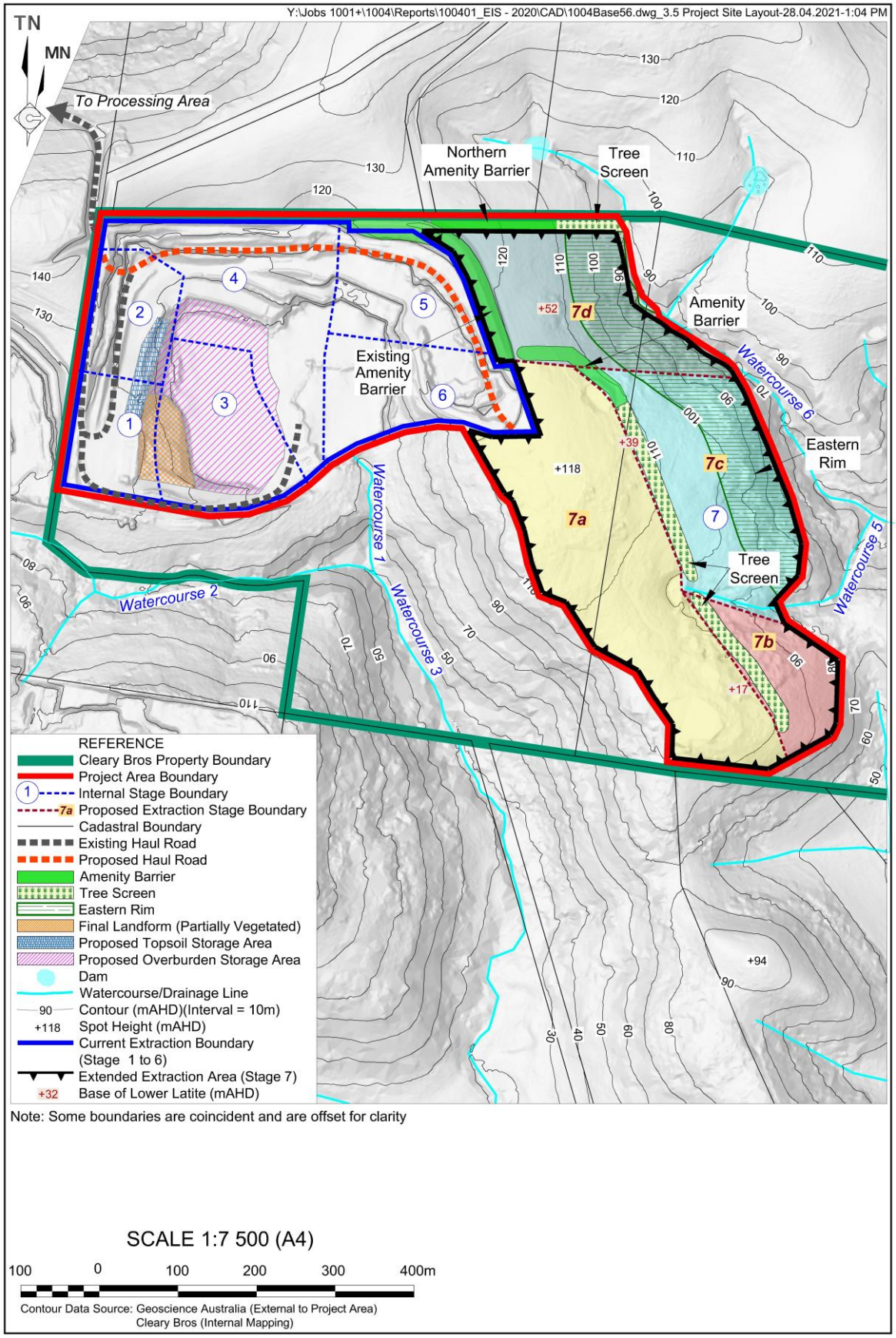


Figure 3 – Indicative extraction area layout (provided by R.W. Corkery & Co. Pty Limited)

2 SOIL CHARACTERISTICS

2.1 EXISTING SOIL RESOURCES

Existing soil resources are limited within the current approved extraction area as shown in **Figure 2**. An existing amenity barrier made from site-derived soil materials lies to the north and east of Stages 5 and 6. These materials would be available for rehabilitation purposes towards the end of the Project life. A stockpile of subsoil that was extracted from Stages 2 and 4 is also located within the footprint of Stage 7 (see Section 2.2.4, Test Pit 10).

2.2 SOILS WITHIN PROPOSED STAGE 7

2.2.1 Soil Landscape Mapping

Soil landscape mapping for this area was conducted by Hazelton (1992) and was accessed via the NSW Government's eSpade online portal. The area covered by the Stage 7 extension is wholly mapped as the Bombo Soil Landscape (**Figure 4**). Key features of the Bombo Soil Landscape are in **Table 2.**

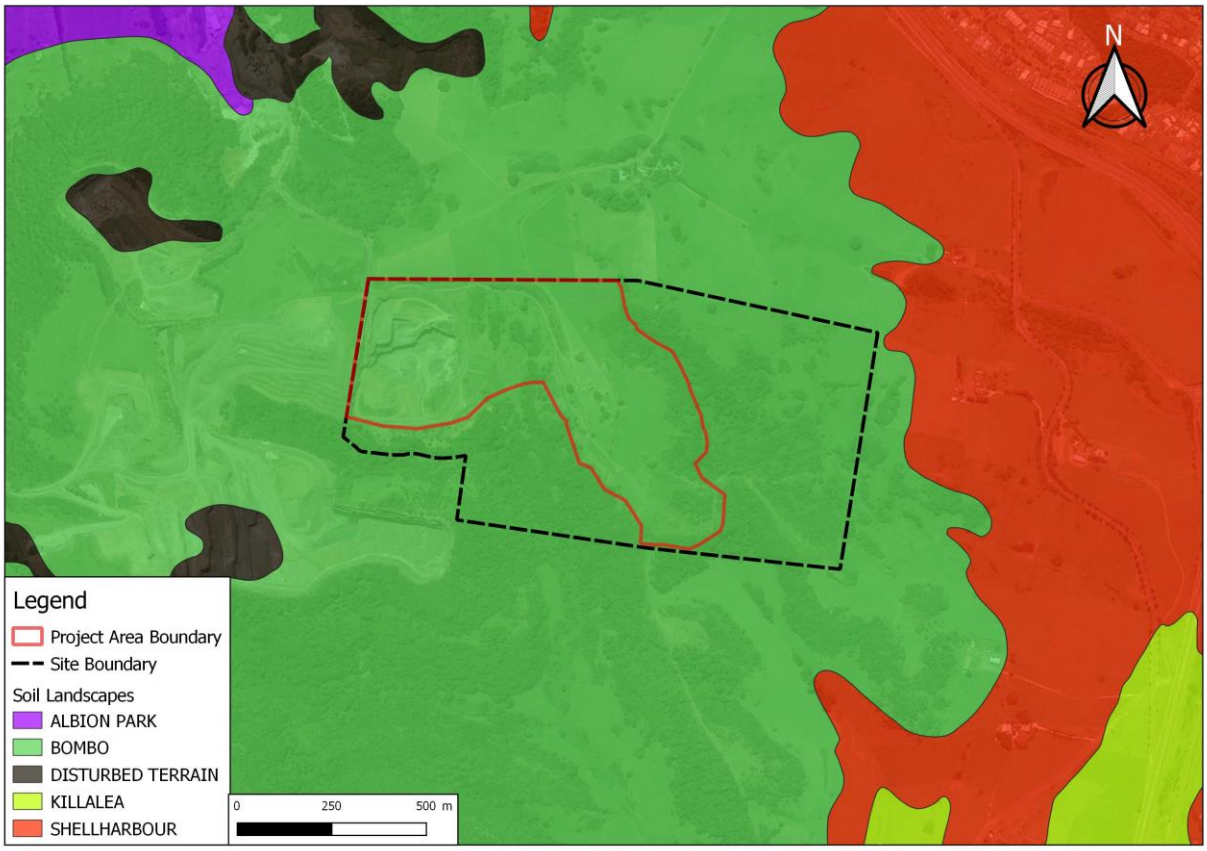


Figure 4 – Soil landscapes in and around the Project Area (from NSW eSpade portal)

Table 2 – Key features of the Bombo Soil Landscape (from Hazelton, 1992)

Feature	Description
Landscape description and geology	Rolling low hills with benched slopes on Bumbo Latite
Typical topography	Slope gradients 15 to 25% with narrow crests and long, convex ridges. Moderately-inclined to steeply-inclined slopes with narrow incised drainage lines and occasional springs.
Soils	Shallow, structured loams associated with rock outcrop and steep slopes. Krasnozems and Red/brown Podzolic Soils (Red and Brown Ferrosols) occur in all other areas.
Soil characteristics	• Highly organic topsoils • Moderate fertility • Potential sodicity/dispersion • Low wet bearing strength (topsoils) • Acidic soils (localised) • High reactivity (shrink/swell potential) (localised).
Landscape characteristics	• Localised steep slopes • Localised mass movement (slumping) hazard • Localised rockfall hazard • Rock outcropping.
Land capability	• High to severe limitations for cultivation. • Low to moderate limitations for grazing. • Inferred Land Capability Class III to VI.

2.2.2 Sampling Density, Pattern and Locations

A series of 12 soil investigation pits (Test pits) were excavated across the area proposed for Stage 7 (**Figure 5**). The frequency and pattern of sampling is in accordance with that recommended in DLWC (2000) for 1:5,000 to 1:10,000 scale surveys (as recommended for quarry developments such as this). The 12 locations selected are representative of the typical landform elements that occur within Stage 7.

2.2.3 Methodology

Test pits were excavated to a depth of 1.5m or until excavation was refused on rock, whichever was shallower. At each test pit, the following details were recorded.

- Landform position.
- GPS location.
- Topographic conditions including slope.

- Apparent soil drainage.
- The soil profile characteristics (see below).
- Soil depth.
- The presence of nearby rock outcrop.
- Vegetation cover type.

The following information was recorded for each soil profile at each test pit:

- Depth of each soil layer.
- Soil colour in each layer.
- Soil texture in each layer.
- Soil structure in each layer.
- The presence of coarse fragments in each layer.
- The presence of mottling in each layer.
- Any other obvious soil properties.

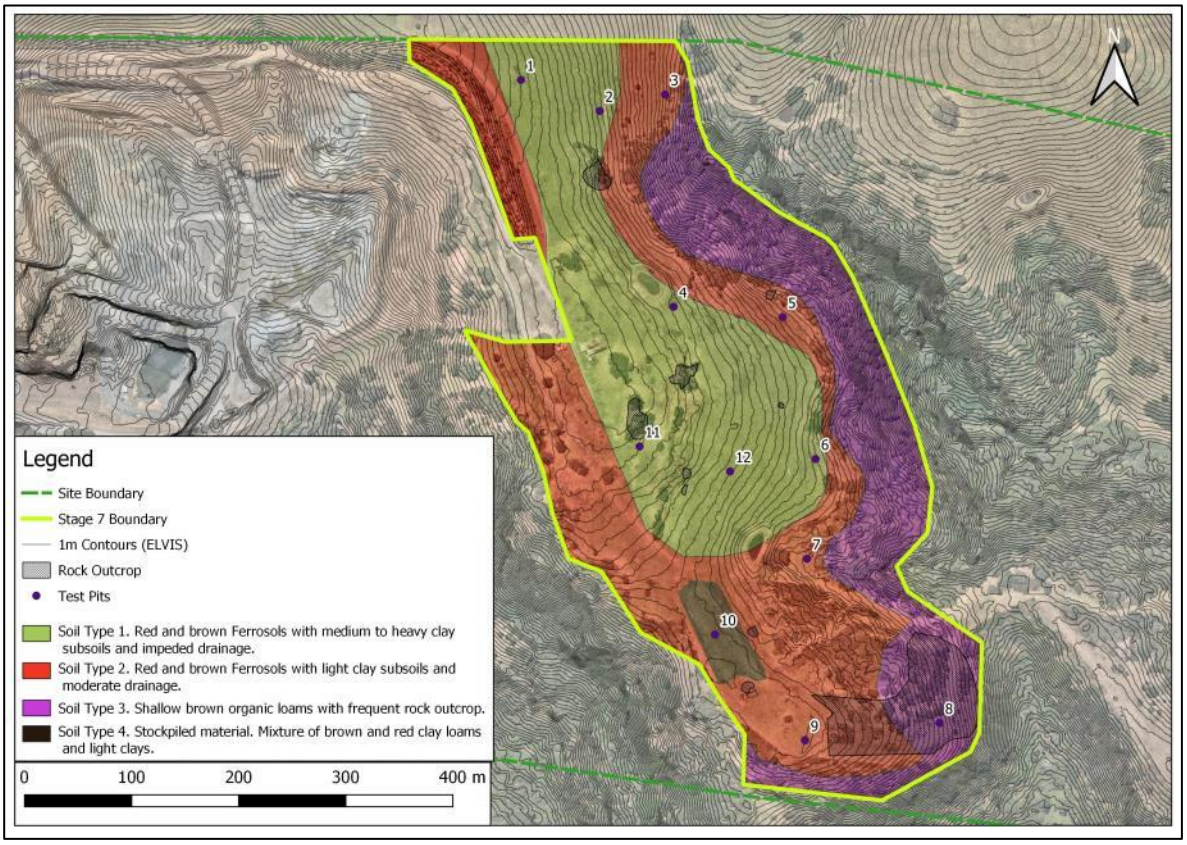


Figure 5 – Soil test pit locations and location of identified soil units within Proposed Stage 7.

2.2.4 Sampling Summary

A summary of the 12 test pit locations is included in **Table 3**. At each test pit, samples of topsoil and subsoil were collected, except in Test Pit 8, where subsoil was absent. Basic chemical and physical testing were undertaken on all samples including Emerson Aggregate Tests (EATs) the results of which are presented in **Table 3.** Representative soil samples were sent for laboratory testing for other analyses, as detailed in Section 2.2.6.

Table 3 – Summary of soil sampling regime.

Test Pit ID	Location	Landform position	Soil conditions	Other Key Features
1	N. - 34.586047 E. 150.824932	Upper slope on ridge	Topsoil: 0 to 250 mm. Well-structured brown clay loam. Subsoil: 250 to 800 mm. Well-structured light brown medium-heavy clay.	Topsoil: pH 7.8, EAT 2. Subsoil: pH 7.8, EAT 1.
2	N. -34.586334 E. 150.825898	Midslope	Topsoil: 0 to 125 mm. Well-structured light brown clay loam. Subsoil: 125 to 900 mm. Well-structured light brown medium clay.	Rock outcrop to south. Topsoil: pH 6.8, EAT 7. Subsoil: pH 5.9, EAT 1.
3	N. -34.586263 E. 150.826488	Lower slope	Topsoil: 0 to 400 mm. Well-structured brown light clay. Subsoil: 400 to 1,000 mm. Well-structured light brown light clay.	Topsoil: pH 6.0, EAT 7. Subsoil: pH. 6.1, EAT 7.
4	N. -34.588021 E. 150.82645	Midslope	Topsoil: 0 to 200 mm. Well-structured brown clay loam. Subsoil: 200 to 800 mm. Well-structured brown light clay.	Topsoil: pH 6.2, EAT 7. Subsoil: pH 6.1, EAT 7.
5	N. -34.588268 E. 150.827733	Midslope	Topsoil: 0 to 150 mm. Well-structured dark brown clay loam. Subsoil: 150 to 1,100 mm Well-structured light brown medium-heavy clay. Mottled below 600 mm.	Small rock outcrop nearby. Topsoil: pH 5.9, EAT 7. Subsoil: pH 6.0, EAT 7.
6	N. -34.589363 E. 150.827781	Midslope	Topsoil: 0 to 150 mm. Moderately-structured brown fine sandy clay loam. Subsoil: 150 to 600 mm. Well-structured brown medium clay. Mottled below 570 mm.	Topsoil: pH 6.3, EAT 7. Subsoil: pH 6.0, EAT 8.
7	N. -34.590101 E. 150.827561	Drainage Depression	Topsoil: 0 to 400 mm. Well-structured dark brown clay loam. Subsoil: 400 to 1,400 mm. Well-structured brown light clay. 30% basalt cobbles.	Large amount of coarse fragments. Topsoil: pH 5.6, EAT 7. Subsoil: pH 5.8, EAT 7.
8	N. -34.591647 E. 150.828972	Lower slope	Topsoil: 0 to 300 mm. Moderately-structured dark brown loam. 15-20 mm ribbon. Subsoil: absent.	High frequency of rock outcrop surrounding test pit. Topsoil: pH 5.4, EAT 7
9	N. -34.591536 E. 150.827604	Upper slope on ridge	Topsoil: 0 to 275 mm. Moderately-structured dark brown light sandy clay loam. Subsoil: 275 to 800 mm. Moderately-structured brown light clay.	Edge of rock outcrop. Topsoil: pH 6.1, EAT 7. Subsoil: pH 5.5, EAT 7.

Test Pit ID	Location	Landform position	Soil conditions	Other Key Features
10	N. -34.590799 E. 150.826831	Existing stockpile	Topsoil: 0 to 200 mm. Brown light clay. Subsoil: 200 to 1,100+ mm. Brown light clay.	Stockpile material. High wood content. Silt fence found at 500 mm. Topsoil: pH 5.9, EAT 1. Subsoil: pH 5.9, EAT 7.
11	N. -34.589386 E. 150.826172	Upper slope on ridge	Topsoil: 0 to 200 Well-structured brown light clay. Subsoil: 200 to 1,000 mm. Well-structured brown medium clay mottled below 600 mm.	Rock outcrop nearby. Topsoil: pH 6.0, EAT 2. Subsoil: pH 6.3, EAT 8.
12	N. -34.589469 E. 150.826815	Midslope	Topsoil: 0 to 200 mm. Well-structured brown clay loam. Subsoil: 200 to 1,000 mm. Well-structured light brown medium-heavy clay.	Downslope of rock outcrop. Topsoil: pH 6.0, EAT 7. Subsoil: pH 6.3, EAT 8.

2.2.5 Soil Units Within Stage 7

Figure 5 displays the four soil units present within Stage 7 based on interpretation of the observed soil conditions described in **Table 3** and landscape conditions. Soil units 1 to 3 occur throughout the Project Area whilst Soil Unit 4 is stockpiled material. A summary of each of the four soil units is provided in **Table 4**.

Table 4 – Summary of identified Soil Units within Stage 7

Soil unit	Description and soil conditions	Key Features
1	Red and brown Ferrosols (Krasnozems) with medium to heavy clay subsoils and slow to impeded drainage.	Topsoil material (0 to 200 mm deep) generally suitable for use for rehabilitation purposes. Subsoils (below 200 mm) not suitable for rehabilitation purposes unless heavily ameliorated to break up clays.
2	Red and brown Ferrosols (Krasnozems) with light clay subsoils and moderate drainage.	Topsoil and subsoil materials (0 to 200 mm deep) generally suitable for use for rehabilitation purposes. Subsoils (below 200 mm) require minor amelioration with gypsum to break up clays.
3	Shallow brown organic loams with frequent rock outcrop.	Topsoil material is 0 to 400 mm deep and generally suitable for use for rehabilitation purposes.
4	Stockpiled material. Mixture of brown and red clay loams and light clays.	All stockpiled material assumed to be generally suitable for use for rehabilitation purposes.

2.2.6 Representative Samples

Field observations and basic field tests were conducted on all soil profile layers from each of the 12 test pits. Based on this initial analysis, representative samples were then sent to a NATA-registered soil laboratory for a suite of further testing. **Table 5** shows the samples that were sent for testing and the suite of tests applied to each.

Table 5 – Laboratory test suite and samples tested

Test Pit ID	Layer	Landscape position	Physical Tests	Chemical Tests
2	Subsoil	Ridgeline	PSA, D%, OC%	Nil.
6	Topsoil	Midslope	Texture, Structure, Permeability Class, Typical Clay content, Potential Infiltration Rate, OC%, OM%	pH, EC, CEC, ESP, Cation ratios, PO_4, NO_3, SO_4, Lime/Gypsum amelioration rate.
9	Topsoil	Upper slope	Texture, Structure, Permeability Class, Typical Clay content, Potential Infiltration Rate, OC%, OM%	pH, EC, CEC, ESP, Cation ratios, PO_4, NO_3, SO_4, Lime/Gypsum amelioration rate.
9	Subsoil	Upper slope	Texture, Structure, Permeability Class, Typical Clay content, Potential Infiltration Rate, OC%, OM%, PSA, D%	pH, EC, CEC, ESP, Cation ratios, PO_4, NO_3, SO_4, Lime/Gypsum amelioration rate.

Key to Abbreviations:

- PSA = Particle Size Analysis
- D% = Dispersion percentage
- OC% = Organic carbon percentage
- OM% = Organic matter percentage
- EC = Electrical conductivity
- CEC = Cation exchange capacity
- ESP = Exchangeable Sodium Percentage
- PO_4 = Phosphorus
- NO_3 = Nitrate
- SO_4 = Sulfate

2.3 LABORATORY TEST RESULTS - SOIL PHYSICAL CHARACTERISTICS

2.3.1 Soil Permeability and Drainage

Hydraulic conductivity is dependent on physical properties such as texture, structure and aggregate stability when wetted (Hazelton and Murphy, 2016). Soil permeability testing indicates that soils within the Project Area are moderately rapid to rapidly drained (**Table 6**).

Table 6 – Soil permeability and drainage

Test Pit ID	Layer	Potential infiltration Rate	Estimated Permeability Class (mm/hr)*
6	Topsoil	Moderately rapid	20-60
9	Topsoil	Rapid	60-120
9	Subsoil	Moderately rapid	20-60

*Adapted from Geeves *et al.* (2007a) as described in Hazelton and Murphy (2016).

2.3.2 Percent Water

The water-holding capacity of a soil is dependent on a range of soil properties including:

- Particle size distribution
- Clay type
- Percentage organic matter
- Bulk density and structure of soil.

Table 7 lists the estimated water-holding capacity values for the three representative samples that were tested for physical soil properties.

Table 7 – Soil water-holding capacity

Test Pit ID	Layer	Est. Field Capacity (% Water)	Est. Permanent Wilting Point (% water)	Est. Plant Available Water (% water)	Est. Plant Available Water (mm/m)
6	Topsoil	28	15	13	130
9	Topsoil	26	12	14	140
9	Subsoil	26	15	11	110

Adapted from Williams *et al*. (1983) as described in Hazelton and Murphy (2016).

2.3.3 Wind Erosion Hazard

Susceptibility to wind erosion is primarily a product of soil particle size and water-holding capacity. **Table 8** contains a summary of the wind erosion potential of those representative samples that were tested for key physical characteristics relating to wind erosion.

Table 8 – Analysis of wind erosion hazard

Test Pit ID	Layer	Texture	Relative fine sand content (%)*	Relative coarse sand content (%)*	Profile drainage**	Wind erodibility rating**
2	Subsoil	Medium Clay	21.72	4.17	Low to Moderate	Low
9	Subsoil	Sandy Clay Loam	38.75	2.72	Moderately Rapid	Medium

* Adapted from Greeves *et al*. (2007b) as described in Hazelton and Murphy (2016).
** Adapted from Wells and King (1989) as described in Hazelton and Murphy (2016).

2.3.4 Dispersion Potential

Dispersion potential is assessed primarily on particle size and the soil's dispersion percentage, although can also be affected by the presence or absence of key cations. An analysis of dispersion potential is presented in **Table 9** for those representative samples that were tested for key physical characteristics relating to dispersion.

Table 9 – Analysis of physical characteristics relating to soil dispersion

Test Pit ID	Layer	Dispersion Percentage (%)	PSA Clay (%)	PSA Silt (%)	Dispersion Significance*	Sediment Type*
2	Subsoil	28.2	54.91	16.57	17.8	Type D (dispersible)
9	Subsoil	9.21	38.75	2.72	3.7	Type F (fine, non-dispersible)

* The percent of the whole soil dispersible is calculated from the mechanically-dispersed PSA and the dispersion percent as follows: (Clay % + Half of the silt %) x Dispersion percent. If this value exceeds 10%, the soil is considered to be "significantly dispersible" – i.e. it is a Type D (dispersible) soil according to Landcom (2004).

2.4 LABORATORY TEST RESULTS - SOIL CHEMICAL CHARACTERISTICS AND FERTILITY

2.4.1 Salinity and pH

The results of electrical conductivity (EC) and pH testing of representative soil samples are included in **Table 10**, along with an analysis of their relative salinity and acidity levels. Testing shows that all three samples are non-saline and are slightly to strongly acidic. Subsoils would benefit from an application of lime to address acidity.

Table 10 – Analysis of salinity (EC) and pH

Test Pit ID	Layer	Texture	EC (dS/m)	Multi-plier factor	ECe	Salinity	pH	Condition*
6	Topsoil	Fine Sandy Clay Loam	0.09	8.6	0.774	Non saline	6.34	Slightly acidic
9	Topsoil	Light Sandy Clay Loam	0.1	14	1.4	Non saline	6.12	Slightly acidic
9	Subsoil	Sandy Clay Loam	0.04	9.5	0.38	Non saline	5.45	Strongly acidic

* relative interpretation of pH values from Bruce and Rayment (1982), as described in Hazelton and Murphy (2016).

2.4.2 CEC and Exchangeable Cations

Cation Exchange Capacity (CEC) indicates a soil's ability to hold and exchange cations and is a major controlling factor for soil structural stability and nutrient availability for plant growth. It also influences soil pH and a soil's reaction to fertilizers and ameliorants (Hazelton and Murphy, 2016).

All samples sent to the laboratory for testing were found to have moderate CEC (**Table 11**). This indicates that the soils within Stage 7 have moderate capacity to retain and respond to any nutrients applied (e.g. in fertilizers).

Table 11 contains the results of a comparison of the calcium to magnesium ratios within each sample. All samples were found to be either low in calcium or calcium deficient. Low calcium to magnesium ratios (< 2) can be indicative of clay dispersion in a soil.

Calcium deficiency in these soils also has the potential to limit pasture growth although applications of agricultural lime can be used to address this. As noted above, these soils would respond relatively well to fertilizer applications.

Exchangeable sodium percentage (ESP) can influence or exacerbate the likelihood of dispersion. The ESP levels were all relatively low and all samples are non-sodic (**Table 11**). As such, the most likely cause of dispersion witnessed in the subsoils of Test Pit 9 (refer to **Table 9**) is an excess of magnesium in the soil. That soil would benefit from an application of lime to add calcium and address the strong acidity.

Table 11 – CEC, Calcium and Magnesium analyses

Test Pit ID	Layer	CEC		Ca:Mg Ratio		Exchangeable Sodium Percentage	
		Value (me/100g)	Class	Value (me/100g)	Class	Value (me/100g)	Class
6	Topsoil	12.6	Moderate	1.2	Calcium Low	2.1	Not Sodic
9	Topsoil	23.4	Moderate	1.3	Calcium Low	0.9	Not Sodic
9	Subsoil	15.5	Moderate	0.2	Potential Calcium deficiency	2.6	Not Sodic

Further analysis of cation concentrations is in **Table 12** and **Table 13**. Magnesium values in all three representative samples were high. High magnesium levels do not tend to impact on plant growth but can influence soil structure and dispersion potential.

Potassium values as a percentage of the overall CEC were found to fluctuate across the three representative samples. Given the inherent nutrient status and low fertility of these soils, potassium is unlikely to be a limiting factor for plant growth.

Aluminium was only identified in the subsoil in Test Pit 9, caused by the strong acidity of that sample. Providing soil pH remains between 5.0 and 8.0, the presence or absence of aluminium is not considered to be an issue for plant growth. However, pH outside this range can lead to aluminium becoming soluble and being taken in by plant roots. Most introduced plant species are not adapted to high levels of dissolved aluminium and would experience low germination and growth rates as a result. However, native sclerophyll forest vegetation that is endemic to the local area is unlikely to be so significantly affected by potential aluminium toxicity caused by low pH.

Table 12 – Exchangeable Cation Laboratory Test Results

Test Pit ID	Layer	Aluminium (me/100g)	Calcium (me/100g)	Magnesium (me/100g)	Potassium (me/100g)	Sodium (me/100g)
6	Topsoil	0	5.82	5.04	1.49	0.26
9	Topsoil	0	7.86	5.88	1.74	0.22
9	Subsoil	2.53	0.86	4.66	0.41	0.40

Table 13 – Analysis of Cation Concentrations Relative to CEC

Test Pit ID	Layer	Aluminium		Calcium		Magnesium		Potassium		Sodium	
		% of CEC	Desirable range*	% of CEC	Desirable range*	% of CEC	Desirable range*	% of CEC	Desirable range*	% of CEC	Desirable range*
6	Topsoil	0	<1	46.2	65-80	40	10-20	11.8	3-8	2.1	<1
9	Topsoil	0	<1	33.6	65-80	25.1	10-20	7.4	3-8	0.9	<1
9	Subsoil	16.3	<1	5.5	65-80	30.1	10-20	2.6	3-8	2.6	<1

*Analysis from Agriculture Victoria (2011), described in Hazelton and Murphy (2016).

2.4.3 Base Saturation and Extent of Leaching

Base saturation is determined by the sum of potassium, calcium, magnesium and sodium, expressed as a percentage of the total CEC. It provides an indication of how closely nutrient status approaches potential fertility and the extent of leaching that has occurred of base cations from the soil (Hazelton and Murphy, 2016). **Table 14** lists the results of base saturation analysis for these soils.

Table 14 – Analysis of base saturation and likely extent of nutrient leaching

Test Pit ID	Layer	Base saturation	Rating*	Likely extent of leaching*
6	Topsoil	100%	Very High	Very weakly leached
9	Topsoil	67.09%	High	Weakly leached
9	Subsoil	40.65%	Moderate	Moderately leached

*Analysis from Metson (1961), described in Hazelton and Murphy (2016).

2.4.4 Available Nutrients

Laboratory test results for available nutrients are contained in **Table 15**. All tested samples exhibited a very low availability of nitrate (NO_3), phosphorous, sulfur and calcium indicating they have relatively low fertility.

Levels of Potassium in the two representative topsoil samples were high but were low in the representative subsoil sample. Levels of available magnesium were high in all representative samples. Any addition of fertilizers or ameliorants to these soils should exclude potassium and magnesium.

Table 15 – Available nutrients

Nutrient	Test Pit ID					
	6 (topsoil)		9 (topsoil)		9 (subsoil)	
	Value	Rating*	Value	Rating*	Value	Rating*
Available Nitrate (mg/kg)	1.3	Very low	2.4	Very low	0.43	Very low
Available Phosphorus (mg/kg)	7.53	Very low	6.2	Very low	<5	Very low
Available Potassium (mg/kg)	583	High	681	High	159	Very low
Available Sulfur (mg/kg)	7.8	Very low	8.1	Very low	4.3	Very low
Available Calcium (mg/kg)	1170	Very low	1580	Very low	172	Very low
Available Magnesium (mg/kg)	613	High	714	High	567	High

* Ratings based on Rayment and Lyons (2014) as reported by SESL.

2.4.5 Organic Matter

Test results for organic matter are listed in **Table 16**. All samples have adequate organic matter and do not require any addition of composted material to support vegetation growth.

Table 16 – Test results for Organic Carbon and Organic Matter

Test Pit ID	Layer	Organic Carbon Percentage	Organic Matter Percentage	Rating*
2	Subsoil	1.27	2.18	Moderate
6	Topsoil	4.65	8	Very High
9	Topsoil	6.45	11.1	Very High
9	Subsoil	1.03	1.77	Moderate

*Adapted from Emerson (1991) and Charman and Roper (2000) as described in Hazelton and Murphy (2016).

2.4.6 Lime and Gypsum Application Rates

Optimum pH and calcium content aids with vegetation establishment. **Table 17** provides indicative lime and gypsum application rates for soils to achieve these ideal conditions.

Table 17 – Lime and gypsum application rates

Test Pit ID	Layer	Lime Application Rate (g/sqm)		Gypsum Application rate to achieve 67.5 % exch. Ca (g/sqm)
		To achieve pH 6.0	To neutralise Al	
6	Topsoil	0	Not required	461
9	Topsoil	0	Not required	1,362
9	Subsoil	567	493	852

2.4.7 Nutrient Application Rate

Table 18 shows the required nutrient application rate in grams per square metre (g/sqm) to achieve desirable nutrient concentrations to maximise plant growth and yield. The effective amelioration depths for topsoil and subsoil are 150 mm and 200 mm respectively.

Table 18 – Nutrient application rate for optimal vegetation growing conditions

Test Pit ID	Layer	Effective amelioration depth (mm)	Nitrate (NO3) (g/sqm)	Phosphorus (P) (g/sqm)	Potassium (K) (g/sqm)	Sulfur (S) (g/sqm)	Calcium (Ca) (g/sqm)	Magnesium (Mg) (g/sqm)
6	Topsoil	150	5.7	11.1	No additional	12	138.7	No additional
9	Topsoil	150	5.5	11.4	No additional	12	176.4	No additional
9	Subsoil	200	7.9	15.5	38.6	17	529.8	No additional

2.5 SOIL THICKNESS AND RECOVERABLE SOIL RESOURCES

Table 19 displays the range and average soil depths and estimated quantities of recoverable topsoil and subsoil within each soil unit based upon the data assembled in Sections 2.2 to 2.4.

Table 19 – Soil depth and recoverable quantities

Soil Unit	Topsoil			Subsoil		
	Thickness (m)		Quantity (lcm)	Thickness (m)		Quantity (lcm)
	Range	Average		Range	Average	
1	0 - 0.25	0.15	14,970	0.55 – 0.8	0.6	57,244
2	0 – 0.4	0.25	23,602	0.45 – 1.0	0.7	68,817
3	0 – 0.3	0.1	16,662	-	-	-
4	0 – 0.2	0.1	1,074	0.4 – 2.2	1.6	4,832

lcm = loose cubic metres

Table 20 lists the recoverable quantities of topsoil and subsoil from each of the four stages within Stage 7.

Table 20 – Recoverable soil quantities

Stage	Topsoil (lcm)	Subsoil (lcm)
7a	22 884	65 164
7b	8 048	9 882
7c	15 605	28 486
7d	9 771	27 001
Total	56 308	130 893

Source: R.W. Corkery & Co. Pty Limited

2.6 EXISTING LAND CAPABILITY ASSESSMENT

Based on soil, surface water, geology and topographic conditions, the existing Land Capability varies from Class III to Class VI according to soil properties, incidence of rock outcrop and topography (**Figure 6**).

Class III lands have moderate to high capability. These lands have moderate limitations and are capable of sustaining high-impact land uses such as cultivation or intensive grazing. However, Class III lands require extensive application of intensive, readily available and widely accepted management practices to minimise the risk of land and soil degradation. Class III lands are generally suitable for grazing, urban development, horticulture (orchards), and intensive forestry (OEH, 2012). Within proposed Stage 7, approximately 8.5 ha are mapped as Class III.

Class IV lands have moderate capability, with inherently moderate to high limitations for high-impact land uses such as cropping, intensive grazing or horticulture. Class IV lands are generally suitable for urban development or broad-acre grazing. Class V lands are similar to Class IV but are slightly steeper, necessitating more significant soil conservation techniques to mitigate the erosion hazard when grazed (OEH, 2012). Within proposed Stage 7, approximately 6.4 ha are mapped as Class IV and V.

Class VI lands have low capability, as they have inherent constraints that need to be carefully managed to prevent long-term degradation. These lands are generally suitable for grazing, forestry and nature conservation (OEH, 2012). Within proposed Stage 7, approximately 5.0 ha are mapped as Class VI.

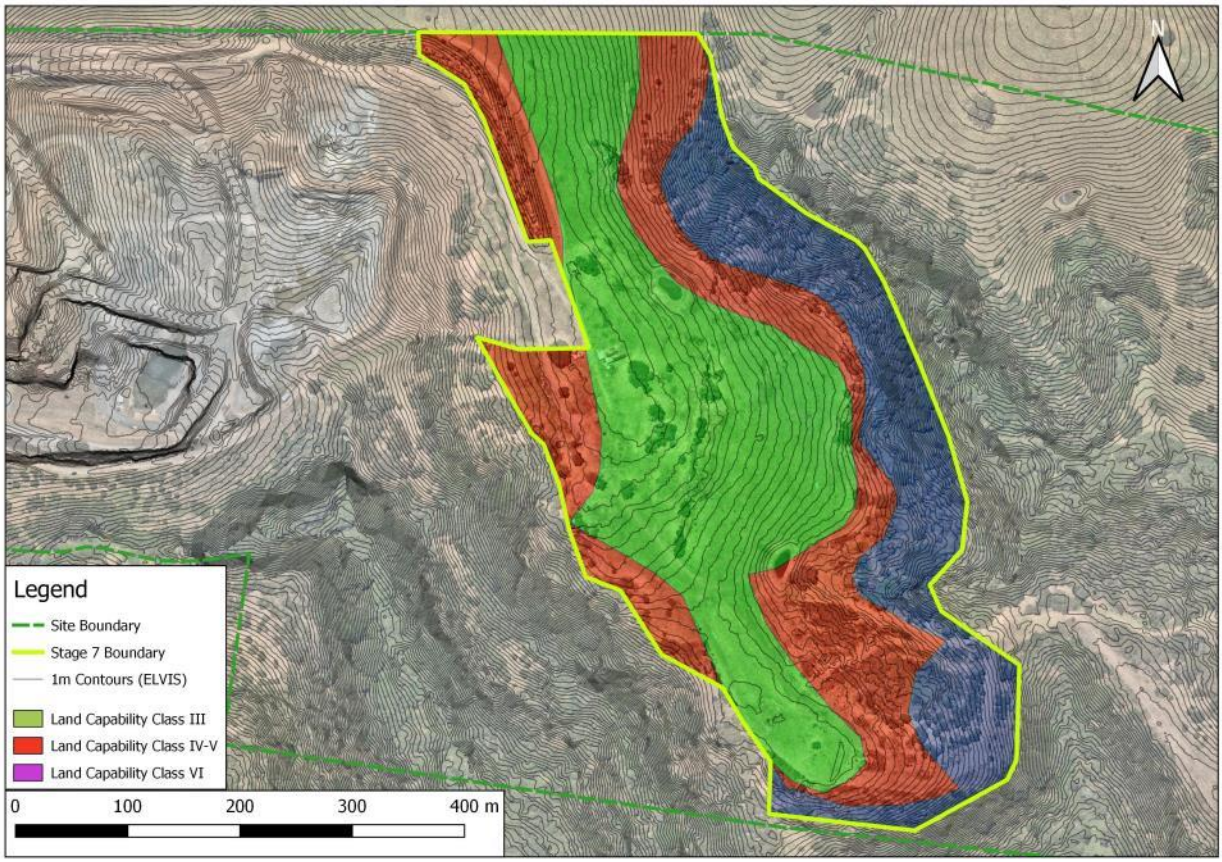


Figure 6 – Existing Land Capability Classes within proposed Stage 7.

3 SURFACE WATER CHARACTERISTICS

3.1 CLIMATE

3.1.1 Rainfall

For the purpose of this assessment, rainfall data have been obtained for the period from 1893-2020 from the Bureau of Meteorology (BoM) Albion Park Post Office Station Number 68000 (5 km north-west of the Project Area) as contained in **Table 21**. These data have been used for the purposes of this report in preference to data from the Cleary Bros on-site weather station data as the onsite station only dates back to 2013 and contains data gaps. The statistics in **Table 21** indicate that rainfall in the area occurs throughout the year with February and March experiencing slightly higher rainfall.

Table 21 – Monthly climate averages for Albion Park Post Office (BoM station 68000)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean (mm)	103.5	125.3	131.5	99.9	91.2	106.8	70.3	68.6	59.3	76.4	84.7	78.7	1098.6
Median	74.1	86.2	85.4	62.8	45.2	61.3	41.5	31.3	38.9	54.8	64.4	60.0	1063.2
10th %ile	24.2	16.3	25.5	15.0	9.1	6.7	6.5	5.6	7.0	10.0	16.1	13.7	654.4
90th %ile	201.5	325.2	331.9	256.8	221.6	276.9	177.6	179.2	137.7	175.0	173.5	185.1	1655.1

The Bureau of Meteorology reports the 2-year, 6-hour rainfall event as 14.3 mm/hr for Albion Park based on the 1987 Intensity Frequency Duration (IFD) methodology. The latest 2016 IFD rainfall intensity for the same event is 13.3 mm/hr, and therefore the slightly more conservative 1987 value was adopted (14.3mm/hr) for soil loss estimates. This translates to a Revised Universal Soil Loss Equation (RUSLE) R-Factor of 4490, which is high.

Winds can be strong at any time of year in this location, sufficient to cause dust rise from exposed areas of soil.

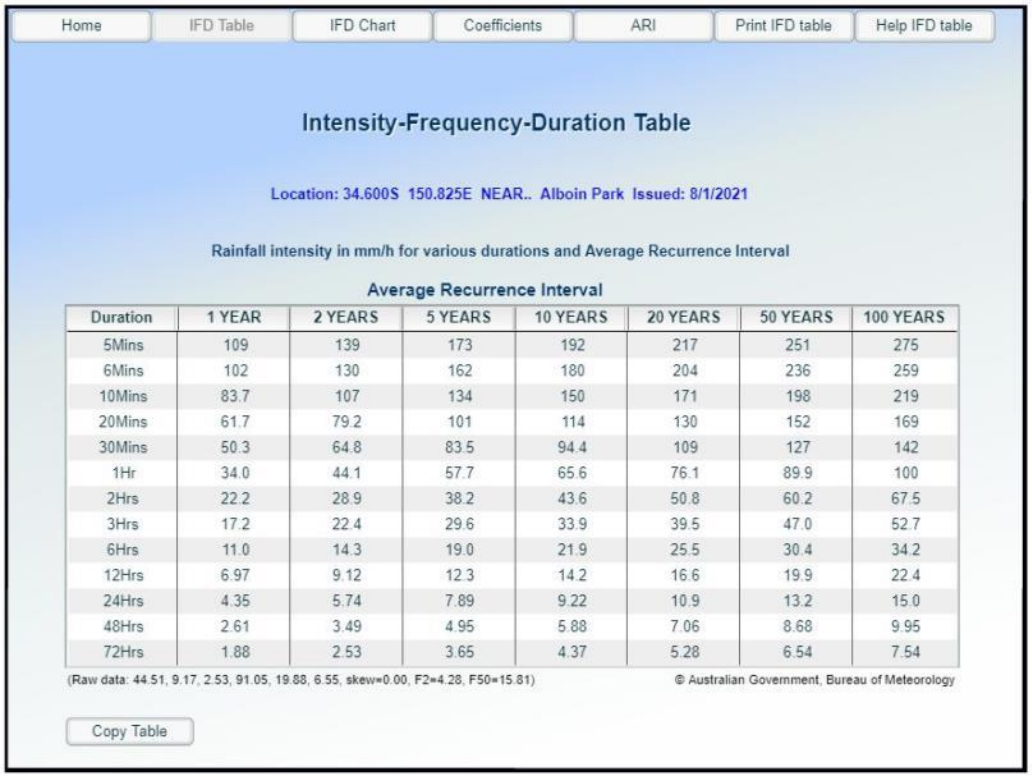
Temperatures are warm enough that frost is unlikely to be an issue for revegetation of disturbed areas. Warm temperatures in summer also translate to relatively high evapotranspiration rates, which could impact on rehabilitation.

3.1.2 Intensity-Frequency-Duration (IFD) Data

The IFD charts and tables for both the 1987 and 2016 data sets as derived from the Bureau of Meteorology are given in **Figure 7** and **Table 22**, **Figure 8** and **Table 23** respectively.

Figure 7 – 1987 IFD Chart for the Project Site (From BoM)

Table 22 - 1987 IFD Table for the Project Site (From BoM)



Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	109	139	173	192	217	251	275
6Mins	102	130	162	180	204	236	259
10Mins	83.7	107	134	150	171	198	219
20Mins	61.7	79.2	101	114	130	152	169
30Mins	50.3	64.8	83.5	94.4	109	127	142
1Hr	34.0	44.1	57.7	65.6	76.1	89.9	100
2Hrs	22.2	28.9	38.2	43.6	50.8	60.2	67.5
3Hrs	17.2	22.4	29.6	33.9	39.5	47.0	52.7
6Hrs	11.0	14.3	19.0	21.9	25.5	30.4	34.2
12Hrs	6.97	9.12	12.3	14.2	16.6	19.9	22.4
24Hrs	4.35	5.74	7.89	9.22	10.9	13.2	15.0
48Hrs	2.61	3.49	4.95	5.88	7.06	8.68	9.95
72Hrs	1.88	2.53	3.65	4.37	5.28	6.54	7.54

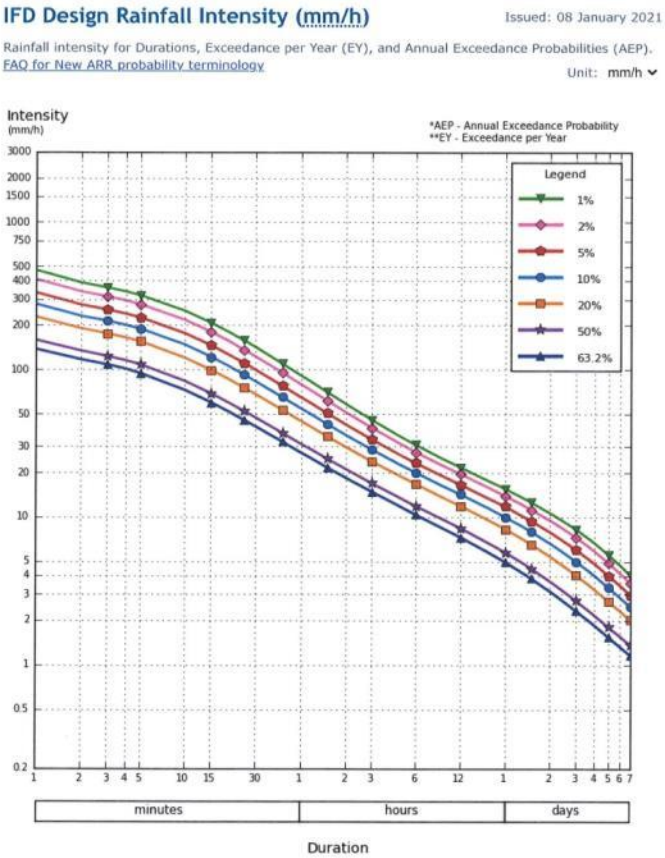


Figure 8 – 2016 IFD Chart for the Project Site (From BoM)

Table 23 – 2016 IFD Table for the Project Site (From BoM)

IFD Design Rainfall Intensity (mm/h)

Issued: 08 January 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	138	159	228	279	333	410	474
2 min	117	134	190	231	275	338	390
3 min	108	123	175	214	254	312	360
4 min	101	115	164	200	238	293	338
5 min	94.3	108	155	189	225	276	319
10 min	72.7	83.6	120	148	176	217	251
15 min	59.9	68.9	99.3	122	146	180	208
20 min	51.5	59.2	85.3	105	125	155	179
25 min	45.5	52.3	75.3	92.5	111	136	158
30 min	41.1	47.2	67.8	83.1	99.3	122	142
45 min	32.5	37.2	53.3	65.1	77.6	95.4	110
1 hour	27.4	31.4	44.8	54.7	64.9	79.5	91.5
1.5 hour	21.7	24.9	35.2	42.8	50.6	61.5	70.5
2 hour	18.5	21.2	29.9	36.1	42.5	51.5	58.7
3 hour	14.9	17.0	23.9	28.8	33.7	40.4	45.8
4.5 hour	12.1	13.8	19.4	23.2	27.0	32.2	36.2
6 hour	10.4	11.9	16.8	20.1	23.3	27.6	31.0
9 hour	8.48	9.75	13.7	16.4	19.1	22.5	25.1
12 hour	7.31	8.43	11.9	14.3	16.6	19.6	21.8
18 hour	5.87	6.79	9.70	11.7	13.6	16.1	17.9
24 hour	4.96	5.77	8.30	10.0	11.8	13.9	15.6

3.1.3 Evaporation

Mean daily pan evaporation for the site (**Table 24**) was also obtained from the Bureau of Meteorology's Station at Albion Park Post Office (Station 68000) based on records from 1970 to 25/11/2020 .The mean annual pan evaporation is 1541mm.

Table 24 – Mean Daily Pan Evaporation (Bureau of Meteorology, Albion Park Post Office).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean daily pan evaporation (mm)	6.30	5.54	4.47	3.36	2.41	2.00	2.22	3.09	4.12	5.02	5.69	6.50

3.2 REGIONAL AND LOCAL CATCHMENT CONDITIONS

The Stage 7 extraction area is located within the Rocklow Creek catchment with runoff from the Project Area generally flowing in a south-easterly direction before joining the Minnamurra River, which drains into the Tasman Sea at Minnamurra. Local catchments in and around the proposed extraction area are shown in **Figure 9** .

The local catchment is generally cleared of trees on the flatter sections and reasonably heavily vegetated on the steeper sections. The exception is the current extraction areas to the west of the Stage 7 extension area. The land to the north towards the Princes Highway and East West Link is mostly cleared grazing land. Further north and east of the Highway is largely urbanised for residential and commercial land uses. The area to the south comprises mainly large areas of grazing land, steep vegetated hillsides and Boral's hard rock quarry and sand extraction area.

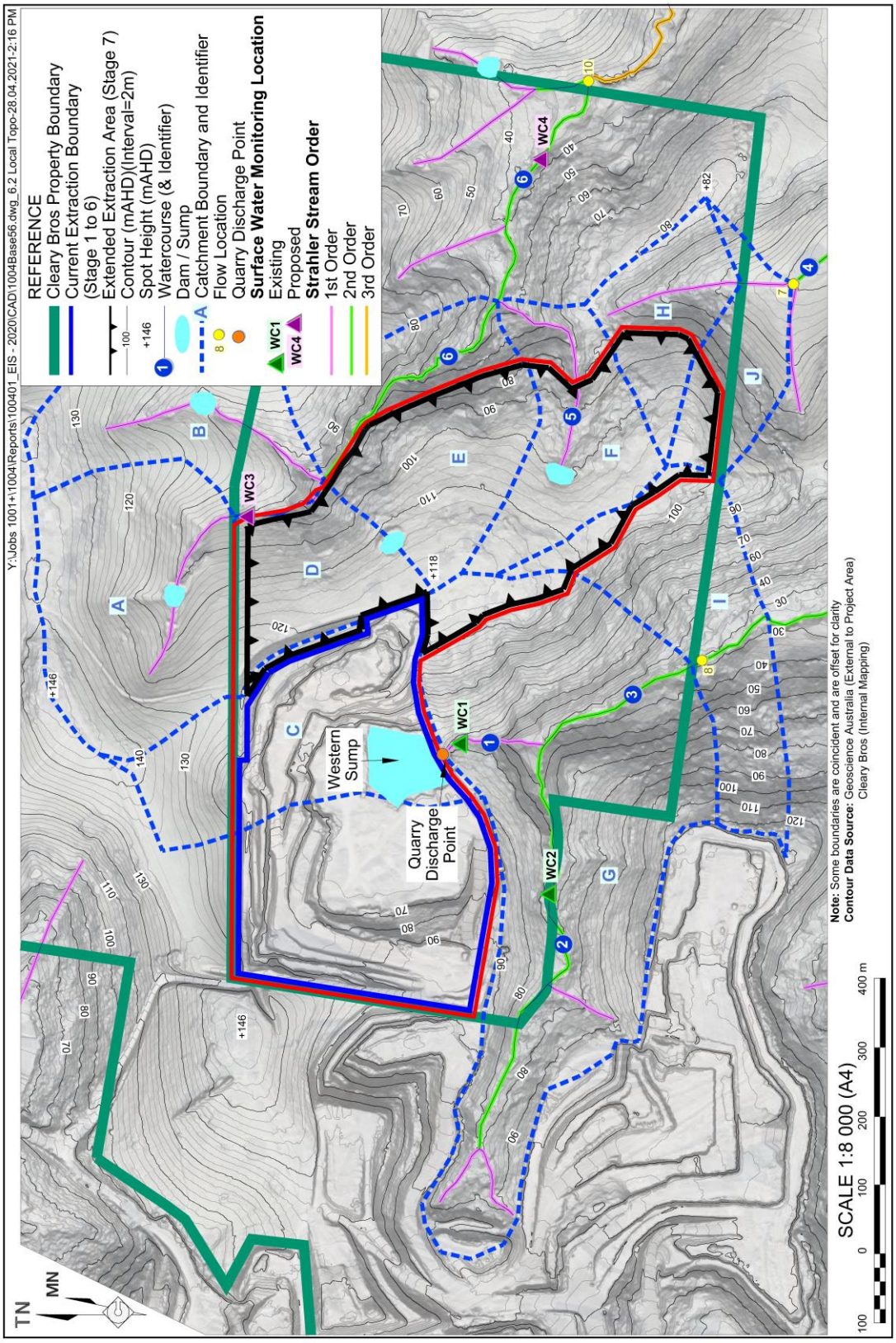


Figure 9 – Local topography and drainage (provided by R.W. Corkery & Co. Pty Limited)

3.3 EXISTING SURFACE WATER INFRASTRUCTURE AND DRAINAGE

The Stage 7 extension would be carried out in four general stages (7a, 7b, 7c and 7d) and is mostly located on a ridge with runoff generally flowing towards the east into an existing gully (Watercourse 6 on **Figure 9**). Elevations range from a maximum of approximately 119m AHD at the crest of the ridge to a minimum of approximately 70m AHD towards the base of the gully. The site varies in slope from around 5% along the ridge to around 33% near the gully.

Figure 10 highlights the Stage 7 extraction area, the adjacent existing watercourses and their Strahler order. **Figure 11** includes these watercourses and the catchments within the Stage 7 extraction area. A first order ephemeral watercourse from a northern catchment (Cat A) passes outside of the north-eastern corner of the Stage 7d area then continues south east where it is joined by another first order watercourse (tributary from the catchment marked Cat B). This second order watercourse (Watercourse 6) then continues in a south–easterly direction and joins a first order ephemeral watercourse (Watercourse 5) that originates within the southern section of Stage 7a and continues through Stage 7c. Watercourse 6 continues in a south–easterly direction towards the Project boundary.

The northern catchments (Cat A and B on **Figure 11**) are mostly cleared of native vegetation with a farm dam on each of the two tributaries of Watercourse 6. Gullies and steeper areas are generally well vegetated with the flatter areas of the site mostly cleared of native vegetation. A house and two farm dams are located near the northern section of proposed Stage 7a.

As the proposed Stage 7 component of the Project area generally occupies a ridgeline, runoff from some small catchments flow downslope via sheet flow to a series of surrounding watercourses. These include a local second order watercourse to the west (Watercourse 3), and first order watercourses to the south (Watercourse 4) and east (Watercourse 6). These watercourses drain in a generally south-easterly direction and ultimately join Rocklow Creek after passing through the former dredge ponds of Boral's Dunmore Sand and Soil site.

The break-up of the existing catchments directing flow towards the various watercourses is shown in **Figure 11**. The northern corner of the Stage 7 extraction area (Stage 7d) has been designed to ensure that it does not intersect with Watercourse 6. The existing catchments draining to Watercourse 6 are shown as Catchments A, B, D and E with Catchments D and E located within the proposed extraction area (**Figure 11**). Catchment C would drain westwards towards the existing sump within the existing Stage 5. Catchments G and I drain westward into Watercourse 3. Catchment F drains to the east into Watercourse 5 and Catchments H and J would drain to the south-east into Watercourse 4.

There is a single 18ML 'Main Dam' located on the Cleary Bros property within the Lake Illawarra Catchment and to the south of the main product stockpile and processing areas (**Figure 9**). Harvested water in the Main Dam is used for various purposes within the Quarry including dust suppression, quarry material processing, and for concrete production.

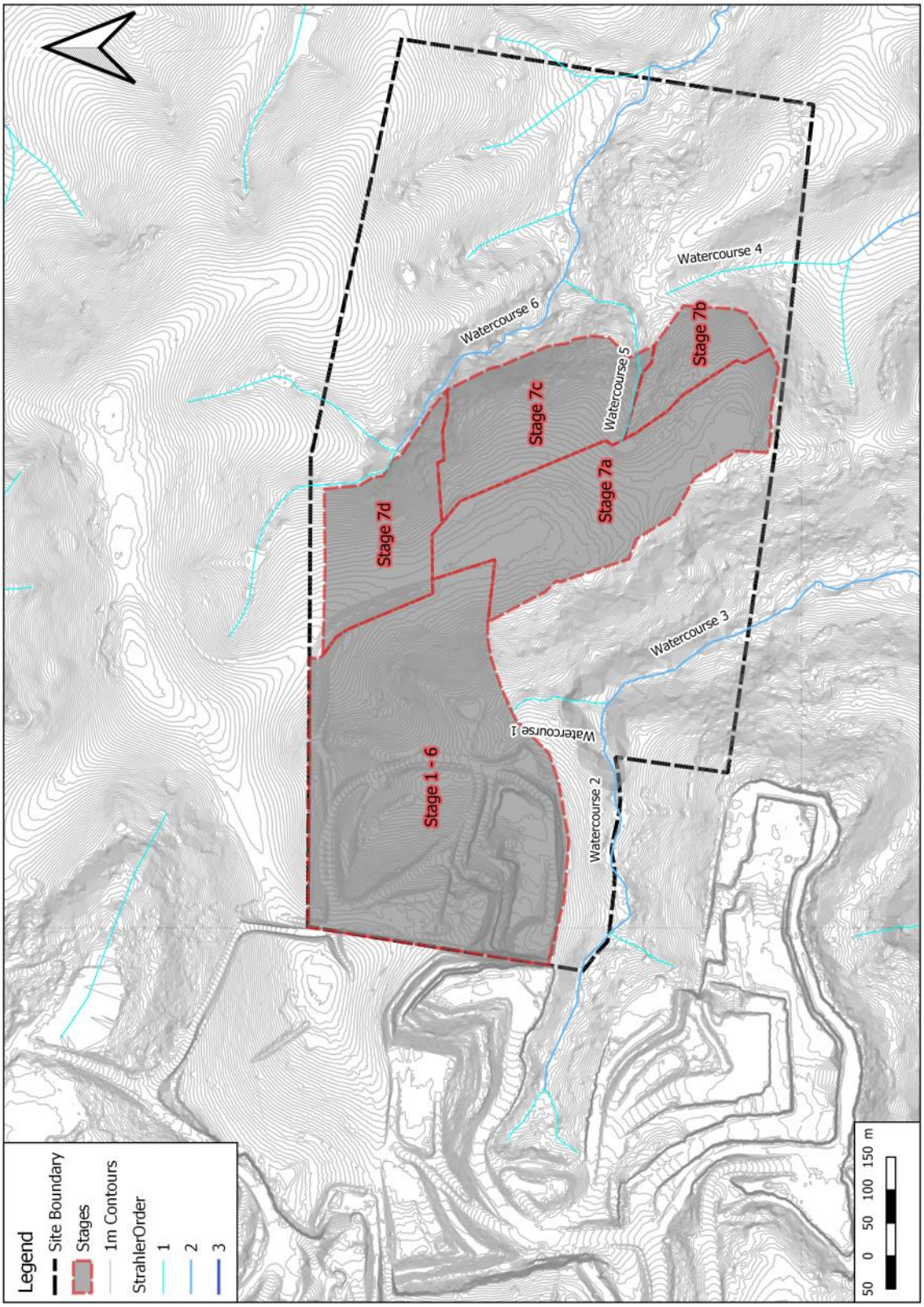


Figure 10 – Stream order in and around the current extraction area and proposed Stage 7.

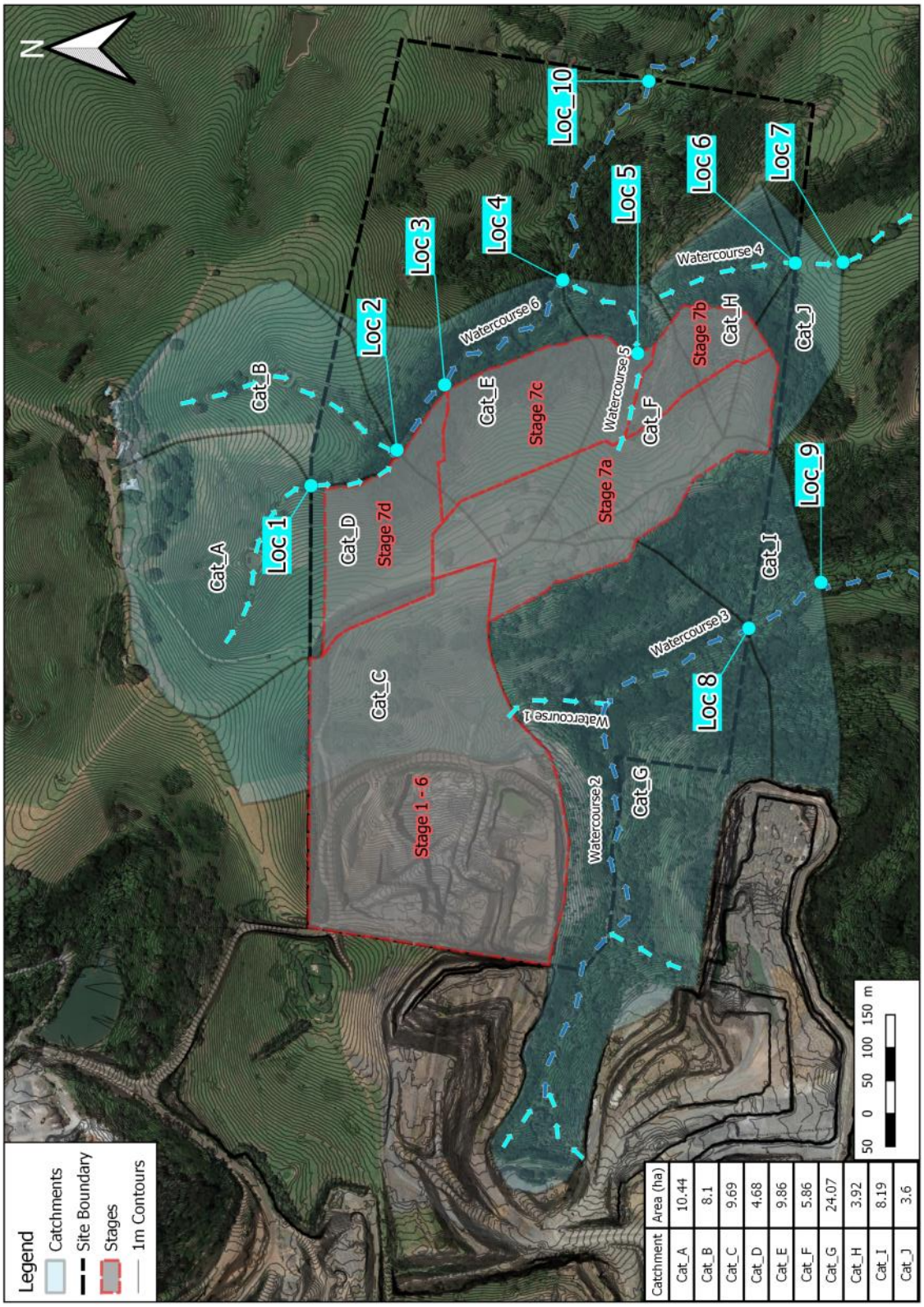


Figure 11 – Existing site catchment areas.

3.4 EXISTING CATCHMENTS

Peak flows from each catchment (**Figure 11**) and at various locations along the main watercourses have been estimated. The predicted peak flows for the various existing sub-catchments as estimated using the Rational Method are shown in **Table 25**.

Table 25 – Existing catchment flows (m^3/s)

Catchment	Receiving watercourse	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
A	6	0.91	1.21	1.66	1.99	2.35	2.92	3.33
B	6	0.74	0.99	1.36	1.62	1.92	2.39	2.72
C	1	0.87	1.15	1.58	1.89	2.24	2.79	3.17
D	6	0.47	0.62	0.85	1.02	1.20	1.50	1.70
E	6	0.88	1.17	1.61	1.92	2.28	2.84	3.23
F	5	0.56	0.75	1.03	1.23	1.46	1.82	2.06
G	3	1.79	2.38	3.27	3.91	4.63	5.75	6.52
H	4	0.40	0.54	0.73	0.88	1.04	1.30	1.47
I	3	0.75	1.00	1.37	1.64	1.94	2.42	2.75
J	4	0.38	0.51	0.70	0.83	0.99	1.23	1.39

EY = Exceedances per year
AEP = Annual exceedance probability

Flows within each of the watercourses have been estimated at 10 locations (Loc 1 – Loc 10) as shown in **Figure 11**. The estimated peak flows are shown in **Table 26**. Note that Loc 4 includes the flows from Watercourse 5.

Table 26 – Estimated existing flows in watercourses (m^3/s)

Catchment	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Loc 1	0.91	1.21	1.66	1.99	2.35	2.92	3.33
Loc 2	1.72	2.30	3.16	3.77	4.47	5.55	6.29
Loc 3	1.95	2.61	3.58	4.28	5.06	6.29	7.14
Loc 4	2.63	3.50	4.82	5.76	6.79	8.47	9.61
Loc 5	0.45	0.61	0.83	0.99	1.18	1.47	1.66
Loc 6	0.40	0.54	0.73	0.88	1.04	1.30	1.47
Loc 7	0.69	0.92	1.26	1.51	1.78	2.22	2.52

Catchment	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Loc 8	2.31	3.08	4.24	5.07	5.97	7.45	8.45
Loc 9	2.79	3.72	5.11	6.12	7.21	8.99	10.20
Loc 10	3.80	5.08	6.99	8.37	9.88	12.32	13.97

EY = Exceedances per year
AEP = Annual exceedance probability

3.5 EXISTING SURFACE WATER QUALITY

Ongoing monitoring occurs in the natural watercourses south of the existing extraction area (Stages 1 to 6) in Watercourse 1 (WC1) and Watercourse 2 (WC2) (as shown in **Figure 12** in Section **6.9**) in accordance with the current Quarry Environmental Management Plan for the Stage 1-6 extraction area. Additional samples have been collected by Cleary Bros in the first order watercourse near Stage 7d (Loc 1 on Watercourse 6) however no samples have been able to be collected at the downstream extent of Watercourse 6 (Loc 10). A summary of water quality results from Watercourse 6 at Loc 1 are provided in **Table 27**.

Table 27 – Water quality in Watercourse 6 upstream of the extraction area (Loc 1) (10/2/2021)

Parameter	Value
pH (H unit)	7.4
Electrical Conductivity (µS/cm)	603
Total Dissolved Solids dried at 180ºC (mg/L)	372
Total Suspended Solids dried at 140ºC (mg/L)	<5
Total Alkalinity as CaCO3 (mg/L)	164
Sulfate as SO4 – Turbidimetric (mg/L)	6
Chloride (mg/L)	112
Total Kjeldahl Nitrogen as N (mg/L)	0.9
Total Phosphorus as P (mg/L)	0.15

Based on the results in **Table 27**, the quality of runoff from the Project Area is generally good due to the prevailing vegetation cover with no significant visible areas of erosion. The Project site is currently used for grazing of cattle and therefore water quality in runoff is expected to be worse than if it were un-grazed.

A summary of the water quality monitoring data collected between February 2009 and December 2020 at WC1 and WC2 is presented in **Table 28**.

Table 28 – Summary of water quality in Watercourses 1 and 2 (WC1 and WC2)

Parameter	Location	Minimum	Median	Maximum
Conductivity	WC1	160.0	430.5	1020.0
(µS/cm)	WC2	443.0	1055	2100.0
pH	WC1	6.0	7.4	8.3
(H unit)	WC2	6.9	7.7	8.7
Temperature	WC1	9.3	17.45	29.3
(ºC)	WC2	9.2	18.05	29.1
Turbidity	WC1	2.0	13	5890.0
(NTU)	WC2	0.5	6.3	5040.0
Total Suspended Solids	WC1	2.5	11.5	699.0
(mg/L)	WC2	2.0	11.5	2600.0
Total Dissolved Solids	WC1	135.0	256.5	676.0
(mg/L)	WC2	320.0	682.5	1500.0

4 POTENTIAL SOIL AND SURFACE WATER IMPACTS

4.1 IMPACT SUMMARY

Table 29 lists the potential soil and surface water impacts as a result of the Project.

Table 29 – Potential soil and surface water impacts

Item	Activity	Potential impact(s)
1	Storage and use of potential contaminants or hazardous substances e.g. diesel, oils and explosives	▪ Potential for soil contamination from spills or leaks ▪ Potential for pollutants to wash into watercourses.
2	Clearing of vegetation and topsoil and subsoil stripping	▪ Potential for sediment-laden runoff to wash off site into watercourses. ▪ Damage to protected vegetation ▪ Disturbance of areas outside the Project footprint ▪ Potential for dust to be blown offsite.
3	Earthworks within the Project Area.	▪ Potential for sediment-laden runoff to wash off site into watercourses. ▪ Disturbance of areas outside the Project Area ▪ Potential for dust to be blown off site, impacting neighbours. ▪ Potential for excessive concentration of runoff, leading to or exacerbating downstream erosion.
4	Discharge of water detained on site following rainfall	▪ Potential for stored water to cause localised flooding. ▪ Potential for sediment-laden water to be discharged off site.
5	Stockpiling of overburden and soils	▪ Potential for sediment-laden runoff to wash off site into watercourses. ▪ Potential for dust to be blown off site.
6	Use of plant and equipment	▪ Potential for spills or leaks of fuels, oils and fluids onto soils or into watercourses.

Item	Activity	Potential impact(s)
7	Establishment and use of access tracks	▪ Potential for sediment-laden runoff to wash off site into watercourses. ▪ Damage to protected vegetation ▪ Disturbance of areas outside the Project Area ▪ Potential for dust to be blown off site. ▪ Potential for excessive concentration of runoff, leading to or exacerbating downstream erosion.
8	Blasting	▪ Residual chemicals after blasting e.g. Nitrogen compounds
9	Diversion of drainage lines	▪ Scour of constructed channels, contributing sediment into watercourses.
10	Material extraction and processing	▪ Potential for sediment-laden runoff to wash off site into watercourses. ▪ Potential for dust to be blown off site.
11	Water re-use and pumping	▪ Potential for sediment-laden water to wash off site into watercourses.

4.2 SURFACE WATER QUANTITY

4.2.1 Change To Surface Water Flows

The Project would decrease flows entering Watercourses 1, 3, 4, 5 and 6 as the quarry extraction progressively extends through Stage 7. The catchments draining to these watercourses would decrease in size, as the extraction process would reshape sections of the catchments causing this runoff to drain internally to the quarry sump rather than the existing watercourses. This would progressively decrease peak flows in these downstream catchments. However this would be largely offset by the discharge of runoff captured within the quarry sump(s) following the settlement of fine sediment, resulting in a minimal net deficit of overall flow volumes. This change would reduce peak flow volumes while extending the duration of tail flows following storm events.

The changes in peak flows for each catchment (**Figure 11**) at the full extent of the four Project extraction stages (7a, 7b, 7c and 7d) are described in the following tables. It is noted that Stage 7c and 7d will be extracted in two steps, as per the Eastern Rim concept described in Section 1.3.

Table 30 – Stage 7a catchment flows (m^3/s)

Catchment	Approximate change in peak flows (%)	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
A	0.00%	0.91	1.21	1.66	1.99	2.35	2.92	3.33
B	0.00%	0.74	0.99	1.36	1.62	1.92	2.39	2.72
C	-100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	-11.8%	0.41	0.55	0.75	0.90	1.06	1.33	1.50
E	-10.0%	0.79	1.06	1.45	1.73	2.05	2.56	2.90
F	-42.4%	0.33	0.43	0.59	0.71	0.84	1.05	1.19
G	-3.8%	1.72	2.29	3.15	3.76	4.46	5.53	6.27
H	-6.2%	0.38	0.50	0.69	0.82	0.98	1.22	1.38
I	-10.1%	0.67	0.90	1.23	1.47	1.74	2.18	2.47
J	-19.0%	0.31	0.41	0.56	0.68	0.80	1.00	1.13

EY = Exceedances per year
AEP = Annual exceedance probability

Table 31 – Stage 7b catchment flows (m^3/s)

Catchment	Approximate change in peak flows (%)	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
A	0.0%	0.91	1.21	1.66	1.99	2.35	2.92	3.33
B	0.0%	0.74	0.99	1.36	1.62	1.92	2.39	2.72
C	-100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	-11.8%	0.41	0.55	0.75	0.90	1.06	1.33	1.50
E	-10.0%	0.79	1.06	1.45	1.73	2.05	2.56	2.90
F	-55.9%	0.25	0.33	0.46	0.55	0.65	0.81	0.92
G	-3.8%	1.72	2.29	3.15	3.76	4.46	5.53	6.27
H	-29.9%	0.28	0.38	0.52	0.62	0.73	0.91	1.03
I	-10.1%	0.67	0.90	1.23	1.47	1.74	2.18	2.47
J	-22.4%	0.30	0.39	0.54	0.65	0.77	0.96	1.09

EY = Exceedances per year
AEP = Annual exceedance probability

Table 32 – Stage 7c catchment flows (m^3/s)

Catchment	Approximate change in peak flows (%)	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
A	0.0%	0.91	1.21	1.66	1.99	2.35	2.92	3.33
B	0.0%	0.74	0.99	1.36	1.62	1.92	2.39	2.72
C	-100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	-13.3%	0.40	0.54	0.74	0.88	1.05	1.31	1.48
E	-48.3%	0.46	0.61	0.83	1.00	1.18	1.47	1.67
F	-72.7%	0.15	0.21	0.28	0.34	0.40	0.50	0.57
G	-3.8%	1.72	2.29	3.15	3.76	4.46	5.53	6.27
H	-29.9%	0.28	0.38	0.52	0.62	0.73	0.91	1.03
I	-10.1%	0.67	0.90	1.23	1.47	1.74	2.18	2.47
J	-22.4%	0.30	0.39	0.54	0.65	0.77	0.96	1.09

EY = Exceedances per year
AEP = Annual exceedance probability

Table 33 – Stage 7d catchment flows (m^3/s)

Catchment	Approximate change in peak flows (%)	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
A	0%	0.91	1.21	1.66	1.99	2.35	2.92	3.33
B	0%	0.74	0.99	1.36	1.62	1.92	2.39	2.72
C	-100.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	-82.8%	0.08	0.11	0.15	0.18	0.21	0.26	0.29
E	-52.4%	0.42	0.56	0.77	0.92	1.09	1.36	1.54
F	-72.7%	0.15	0.21	0.28	0.34	0.40	0.50	0.57
G	-3.8%	1.72	2.29	3.15	3.76	4.46	5.53	6.27
H	-29.9%	0.28	0.38	0.52	0.62	0.73	0.91	1.03
I	-10.1%	0.67	0.90	1.23	1.47	1.74	2.18	2.47
J	-22.4%	0.30	0.39	0.54	0.65	0.77	0.96	1.09

EY = Exceedances per year
AEP = Annual exceedance probability

The estimated change in peak flow for each watercourse location during Stage 7d operations is shown in **Table 34**.

Table 34 – Estimated flows in watercourses during Stage 7d operations (m^3/s)

Catchment	Approximate change in peak flows (%)	1 EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Loc 1	0%	0.91	1.21	1.66	1.99	2.35	2.92	3.33
Loc 2	-13.8%	1.48	1.98	2.72	3.25	3.85	4.78	5.42
Loc 3	-18.6%	1.59	2.12	2.92	3.48	4.12	5.12	5.81
Loc 4	-30.7%	1.82	2.43	3.34	3.99	4.72	5.87	6.65
Loc 5	-100.0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loc 6	-29.8%	0.28	0.38	0.52	0.62	0.73	0.91	1.03
Loc 7	-23.4%	0.53	0.70	0.96	1.15	1.37	1.71	1.93
Loc 8	-25.7%	1.72	2.29	3.15	3.76	4.46	5.53	6.27
Loc 9	-23.6%	2.13	2.84	3.91	4.67	5.52	6.87	7.79
Loc 10	-18.0%	3.13	4.17	5.74	6.87	8.10	10.10	11.45

EY = Exceedances per year
AEP = Annual exceedance probability

Flows would remain unchanged at Loc 1 with no loss of catchment area. Flows would be impacted further downstream as the catchment is reduced due to the extraction process. Loc 4 has the largest expected change in flow with a decrease of $0.8m^3/s$ for the 50% AEP design event. This reduction would increase to around $2.9m^3/s$ for the 1% AEP event. This represents a 30.7% reduction in peak flow at this location. Further downstream of the Project Area, additional inflows from other catchments reduces the magnitude of the impact, with peak flows decreasing by around 18% at the Project Area boundary at Loc 10. The flows in Watercourse 3 would decrease by around 25.7% at the Project Area boundary (i.e. at Loc 8). Further downstream, the change in peak flows is expected to reduce to approximately 4% at Rocklow Creek immediately downstream of the Illawarra Railway.

4.2.2 Existing Flow Paths

The upper catchment of Watercourse 5 would be impacted by the Project with the extraction area progressively advancing into the catchment area causing these parts to drain internally to the quarry pit.

No other watercourses are intersected by the proposed extraction areas, with the north-eastern extent of the extraction footprint designed to exclude the 1% AEP level of Watercourse 6.

The existing farm dams within the Project Area would be drained and removed as part of the extraction operations. The small volume of water within the dams would be used on site if possible, or alternatively, tested and discharged off site in accordance with the requirements of the EPL.

4.2.3 Surface Water Demand

The current *Albion Park Quarry Water Management Plan (WMP) (Cardno, 2020)* estimated annual water usage (excluding reticulated potable water) for all existing Quarry-related operations (including haul road dust suppression in Stages 1 to 6) to range from 75 ML/yr to 93 ML/yr depending on the scenario (i.e. wet, dry or average year). The extraction activities within Stage 7 would require increased water usage at each stage for dust suppression of the extended haul road and for dust suppression on the mobile crushing and screening plants. The estimated water usage for dust suppression of the haul roads is summarised in **Table 35** together with the intended annual usage for the mobile crushing and screening plants. Stage 7b has the highest additional water demand for haul road dust suppression of 15.1ML/yr. With the increased water demand for haul road dust suppression, total water requirements would range between 92 ML/yr to 110 ML/yr depending on the scenario, during Stage 7b of operations. The quantity of water required for processing activities in the Project Area would increase from the current level of approximately 1ML/yr to 2ML/yr.

Table 35 – Estimated additional water usage required for Stage 7

Stage	Haul Road Dust Suppression			Water for Processing (ML/yr)	Total
	Approximate Additional Haul Road Length (m)	Water Application Rate L/m^2/hr	Annual Additional Volume for Dust Suppression (ML)		
7a	300 - 600	2	7.6 – 15.1	2	9.6-17.1
7b	600	2	15.1	2	17.1
7c	300	2	7.6	2	9.6
7d	200	2	5	2	7.0
Source: Northstar (*pers. comm*), CB records					

4.2.4 Surface Water Supply

The existing *Albion Park Quarry Water Management Plan (Cardno, 2020)* specifies that the main dam (**Figures 1** and **9**) is the source of water for the current operations described in **Section 6.5.1.** The main dam has a capacity of 18 ML and captures water from local catchment runoff. Its capacity is just below the maximum harvestable right of 18.56ML based on the entire 142.74ha of land owned by Cleary Bros. The estimated water availability for the main dam is summarised in **Table 36**, which has been derived from the catchments shown on Figure A of the Albion Park Quarry Water Management Plan.

Table 36 – Estimated available runoff – Main Storage Dam catchment

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

Source: Albion Park WMP (Cardno, 2020)

Table 36 demonstrates that, even in a dry year, sufficient water is available within the Main Dam through rainfall runoff for the additional Stage 7 water demand of the Project. Water may also be harvested and reused for dust suppression of the haul roads from the Stage 7 extension sump(s) as part of the internal management of sediment-laden stormwater.

4.2.5 Surface Water Balance

A surface water balance was undertaken for each stage of the Project using rainfall data from the Albion Park Post Office Station (Station 68000, years 1892 to 2021) with an average annual rainfall of 1,097mm. **Table 37** shows the estimated pre-development average annual runoff volume for each stage for comparison.

Table 37 – Pre-Development Average Annual Runoff

Source	Catchment Area (m^2)	Runoff Coefficient	Average Annual Runoff (ML)
Stage 7a	81,200	0.4	35.6
Stage 7b	100,800	0.4	44.2
Stage 7c	144,400	0.4	63.3
Stage 7d	192,500	0.4	84.4

The water balance was based on two scenarios. The first is a base case scenario with no harvesting of water from sumps formed within Stage 7. The second is a reuse scenario that allows for the harvesting of water from the Stage 7 extraction area sumps to meet the additional demand for dust suppression of the extended haul road (i.e. the additional water is not sourced from the existing main dam) and for the dust suppression on the mobile crushing and screening plants. This would be undertaken as part of the internal management of stormwater within the extraction area. A summary of the results is shown in **Table 38** and **Table 39** below.

Table 38 shows that during the Stage 7b operations, evaporation from the Stage 7 sump is expected to be approximately 4.7ML/yr. This would increase the maximum supply requirement for Stage 7b to around 20 ML/yr. The water balance indicates that an approximate sump volume of around 10 to 20ML, within an expanded quarry pit capacity of around 350ML would provide sufficient capacity to supply this demand.

Table 38 shows that the average annual runoff volume from each stage is expected to increase as the relatively impervious rock surfaces are exposed during extraction. **Table 39** shows that runoff volumes from each stage would still exceed the existing runoff volumes when evaporation and the additional haul road water and mobile processing plants demands are removed. Following the settling of sediment, surplus runoff from the extraction area that has collected in the sumps will be discharged back to the local watercourses to balance the surface water lost due to the decrease in catchment area. It is expected that the quantity of water discharged may exceed the pre-development runoff throughout the Project life when the extent of exposed rock surface is maximised.

Table 38 – Post Development Average Annual Runoff – Base Case, No Reuse

Source	Catchment Area (m^2)	Runoff coefficient	Average Annual Runoff (ML)	Estimated Sump Area (m^2)	Average Annual Evaporation Loss (ML)	Total Annual Volume (ML)
Stage 7a	81,200	0.7	62.30	3,200	3.37	58.93
Stage 7b	100,800	0.7	77.33	4,000	4.67	72.66
Stage 7c	144,400	0.7	110.78	6,300	7.35	103.43
Stage 7d	192,500	0.7	147.69	7,300	8.20	139.49

Table 39 – Post Development Average Annual Runoff – Reuse for Dust Suppression

Source	Catchment Area (m^2)	Runoff coefficient	Average Annual Runoff (ML)	Estimated Sump Area (m^2)	Average Annual Evaporation Loss (ML)	Additional Average Annual reuse for Dust Suppression (ML)	Total Surplus Annual Volume (ML) Collecting in Sumps
Stage 7a	81,200	0.7	62.30	3,200	3.37	9.60-17.10	41.83-49.33
Stage 7b	100,800	0.7	77.33	4,000	4.67	17.10	55.56
Stage 7c	144,400	0.7	110.78	6,300	7.35	9.60	93.83
Stage 7d	192,500	0.7	147.69	7,300	8.20	7.00	132.49

4.3 WATER ACCESS LICENCE / HARVESTABLE RIGHTS

4.3.1 Harvestable Rights

Under the *Water Management Act 2000 (WM Act)* the Albion Park Quarry has maximum harvestable rights of 18.56ML, based on Cleary Bros total land holding of 142.74 ha. This volume is mostly taken up by the Main Dam which has a capacity of 18ML. The Stage 7 extension area sump(s) would capture and store surface water runoff however additional surface water entitlements would not be required for this activity. Separate to the harvestable right, Clause 21 of the *Water Management (General) Regulation 2018* under the *Water Management Act 2000* provides for several exemptions from the requirement for a Water Access Licence (WAL). These include –

> *Schedule 1 - Excluded Works, Item 3*
>
> *Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, that are located on a minor stream.*
>
> *Schedule 4 – Access Licence Exemptions, Item 12 – Excluded works*
>
> *(1) Any landholder—in relation to the taking of water from or by means of a work referred to in item 1, 2, 3, 4, 6, 7 or 9 in Schedule 1 that is situated on the land, for the purposes and in the circumstances specified in Schedule 1 in respect of the work.*

The Excluded Work Exemption is available for quarrying operations to capture surface water runoff from disturbed areas without the need for a WAL in circumstances where sediment-laden surface water drains into a sump(s) that are *"solely for the capture, containment and recirculation of drainage…. to prevent the contamination of a water source, that are located on a minor stream".*

Separate to this matter, the Groundwater Assessment completed as part of this Project (Jacobs, 2021) has identified that additional groundwater and surface water entitlements would be required due to groundwater inflows into the extraction area.

4.3.2 Water Sharing Plan

The Project Area falls within the Minnamurra River Management Zone of the Illawarra Rivers Water Source of the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011.* This plan is made under Section 50 of the *Water Management Act 2000 (WM Act).* Water for Stage 7 can be obtained from existing sources within the Project Area or from the Stage 7 extension sump(s) if required, as outlined in **Section 4.3**.

4.4 SURFACE WATER QUALITY

Erosion of exposed soils and crushed rock is expected to be the most significant potential impact to water quality. Clearing, grubbing and all proposed earthworks within Stage 7 would expose soil materials and increase the risk of sediment-laden water leaving the Project Area

unless adequate mitigation measures are in place. The potential water quality impacts of the existing operation as listed in **Table 29** would be applicable to the proposed Stage 7 operations. In particular:

- Sediment-laden water derived from runoff from disturbed areas;
- Fuels, lubricants and hydraulic fluids, used in the various plant and equipment involved in the extraction of quarry products.

With the exception of rehabilitated, previously backfilled areas, all these surfaces would be potential sources of sediment-laden runoff and so would be captured within the sump(s) at the base of the extraction area. Previously backfilled areas that are not yet stabilised[1] would also be sources of sediment.

[1] In accordance with Landcom (2004), “stabilised” lands are defined as those lands with at least 70% permanent vegetation cover or equivalent permanent rock pitching.

5 SOIL MANAGEMENT

5.1 EXISTING OPERATIONS

No changes are proposed for the existing operations and all existing controls used to conserve soils are expected to be maintained. This includes stockpiling topsoil, subsoil and overburden in Stages 1 to 4 where it has been progressively stabilised.

5.2 STAGE 7

An assessment of the soils within Stage 7 (detailed in **Section 2** of this report) identified no significant constraints to the use of these soils for revegetation purposes. Minor amelioration and fertilization of topsoils is recommended to ensure appropriate growing conditions, but this is not unusual and is not expected to be a significant constraint to the use of all topsoil resources within proposed Stage 7.

Some of the subsoils within proposed Stage 7 present an opportunity to be used as a material suitable for rehabilitation purposes, providing they are adequately ameliorated to break up clay, neutralized with lime to address strong acidity, and are fertilized as noted above for topsoils.

Soil stripping and management is to be undertaken progressively within each stage as shown in the Stage Surface Water Management Plans attached in **Appendix 2**. Topsoil is to be conserved as much as practicable for use in rehabilitation. Excessive compaction of topsoil is to be avoided. All stockpiles would need to be on relatively (<10% slope) flat ground and include temporary ground cover with downstream sediment controls in place until stockpiles are stabilised with ground cover.

Topsoil and subsoil would be progressively stripped within each stage and either stockpiled or used to construct amenity barriers, as required. Sediment fencing would be established prior to stripping as shown in the Staged Surface Water Management Plans attached in **Appendix 2**.

6 SURFACE WATER MANAGEMENT

6.1 WATER DIVERSION

Run-on-water to the Project Area from external lands is not of concern as there are no upstream catchments that drain through the Stage 7 extraction areas.

An existing amenity barrier has been constructed along the northern and eastern sides of Stages 5 and 6. This barrier directs upstream clean water catchment flows into the existing low point on the northern side of Stages 5 as it cannot be diverted around the extraction area due to the prevailing topography. This existing amenity barrier is to be extended to the east along the northern extent of Stage 7 prior to commencing extraction in Stage 7a. This section of the amenity barrier is not required for the diversion of surface water as it is located along an existing ridge line. The amenity barrier constructed on the northern and parts of the eastern side of Stage 7a would be removed as extraction proceeds to the northern section of Stage 7c. Sediment-laden water is to be directed to appropriate treatment structures (sumps) as described in Section 6.5.2.

6.2 CHANGE TO SURFACE WATER FLOWS

The Project would reduce the catchment areas draining to local watercourses. This would occur progressively throughout the Project development. The expected change in peak flows at the maximum extent of each stage (7a to 7d) is described in Section 4.2.1. Peak flows would be decreased during storm events, which would reduce flood levels and velocities in the downstream watercourses. However, lower post-rainfall flows could increase due to dewatering of the quarry sump following rainfall events. There may also be some recharge of groundwater from surface runoff in the sump(s), however this is likely to be minor due to the low hydraulic conductivity of the underlying latite (Jacobs, 2021). Excess water would be returned to the natural waterways to limit the change in catchment flow volumes, however some water may be retained and utilised on site for dust suppression.

6.3 EXISTING FLOW PATHS

The existing Watercourse 6 to the northeast of Stage 7d would be maintained to allow clean water to bypass the extraction area. Flows within Watercourse 6 at this location (Loc 3) are estimated to be around 7.14m^3/s for the 1% AEP storm event. The predicted flow depth and width would vary along the watercourse based on slope, vegetation thickness and gully width. An initial check of flow depth within the gully indicates that it could reach 1.1m which would limit flow width to around 10m. A minimum cross-sectional area of 10.2m^2 (including freeboard) would be retained for Watercourse 6 beyond the Stage 7d boundary to minimise the risk that these clean water flows are directed into the extraction area.

All other flows are expected to drain away to local watercourses until the extraction process creates a low spot and collects sediment-laden runoff. External flows should not be allowed to concentrate outside of the defined watercourses as the resultant increased velocities would increase the risk of erosion.

6.4 SURFACE WATER DEMAND

Modelling suggests that the additional surface water demand for dust suppression on the Stage 7 haul roads can be met via the surplus water available in the Main Dam. Runoff collected from the Stage 7 extraction area could also be used as required as discussed previously in Section 4.3.

6.5 WATER STORAGES

6.5.1 Existing Water Storages

The existing 18ML 'Main Dam' would continue to harvest water for various purposes within the Albion Park Quarry such as dust suppression, processing activities, and concrete batching. The Main Dam would be used to supply water for dust suppression within Stage 7, and may also be supplemented by water harvested from the Stage 7 sumps as part of the management of stormwater drainage described in Section 4.3.

6.5.2 Proposed Water Storages

It is not proposed to install any new water harvesting dams for the Project. Based on the WMP (Cardno, 2020), there is currently a surplus of water for the existing extraction rates and these would not increase.

The existing Western Sump and ultimately a number of sumps would be maintained within the Project Area with their locations changing throughout the Project life. These sumps would collect surface runoff, any groundwater inflows and sediments. The sumps would be modified/relocated as required as part of the progressive works. The water collected within the sumps would be released (after treatment to settle out sediment) to the adjoining watercourses. Some water from the sumps would also be used for on-site purposes such as dust suppression as described in Section 4.3.

6.6 EROSION CONTROL

6.6.1 General Requirements

Landcom (2004) and DECC (2008) nominates a range of general requirements to guide soil management following soil disturbance. Throughout the Project life, disturbed land surfaces that are not to be re-worked within 20 days, and which drain towards surrounding watercourses, would require erosion control. There are two such scenarios that might trigger this:

- Land surfaces that have reached their final profile such as the amenity barriers; or
- Land surfaces that have reached a temporary profile which would remain un-worked for more than 20 days, even though they might be re-worked later, and may include areas around the perimeter of the extraction area.

Land surfaces that have reached their final profile need to be stabilised to achieve a C-Factor of 0.1 (equivalent to 60% grass cover) within 20 days of completion and also need to achieve a C-Factor of 0.05 (equivalent to 70% grass cover) within 60 days of completion.

Land surfaces that have reached a temporary profile which would remain un-worked for more than 20 days (even though they might be re-worked later) need to be temporarily stabilised with suitable ground cover to achieve a C-Factor of 0.15 (equivalent to 50% grass cover). There are numerous cost-effective ways to achieve this which include (but are not limited to):

- Vegetative cover such as grass.
- Hydraulic soil binders (e.g. Vital Bon-Matt P47 or equivalent) applied at the manufacturer's recommended rates.
- Wood Chip Mulch at minimum 27 tonnes/hectare.
- Gravel/rock pitching.
- Hydro-mulching or Bonded Fibre Matrix at manufacturer's recommended rates.

Disturbed lands that drain to sumps within the extraction area would not need stabilising, as runoff from these areas would be captured and only discharged in accordance with Environment Protection Licence (EPL) 299 limits.

Until a land surface that drains to an external watercourse is stabilised, sediment controls such as a vegetated buffer and/or sediment fencing would need to be employed.

Monitoring of BOM forecasts for expected significant rainfall events would be undertaken on a daily basis. This would assist in planning soil stripping activities. It may also be necessary to restrict activities in part or all of the Project Area with temporary erosion control measures put in place, as required.

Once a sump's catchment is permanently stabilised (i.e. the full catchment draining to the sump has achieved at least 70% permanent ground cover or other effective stabilisation) it may be decommissioned.

6.6.2 Soil Stockpile Areas

As previously discussed in Section 2.1, a proportion of stripped topsoil, subsoil and overburden from proposed Stage 7a would be used to construct the amenity barriers displayed on **Figure** 3. The proposed barriers would be revegetated with grasses and fast-growing native species to establish a vegetation screen. The location of the proposed amenity barriers are shown on the Staged Surface Water Management Plans attached in **Appendix 2**.

Any topsoil, subsoil and/or overburden in excess of that required for construction of amenity barriers would be stockpiled within Stages 1 to 4. In later years, overburden would be placed in completed areas within Stage 7 and covered with subsoil and topsoil and then vegetated.

6.7 SEDIMENT CONTROL

6.7.1 Design Criteria

The Project would not add any potential new types of pollutants, although the sources of potential pollution might change, particularly with regard to sediment-laden water. This would necessitate modification to the Site's erosion and sediment control structures over time for each stage of the development and is discussed in further detail in this section and in Section 6.6.

Sediment structures are to be designed generally in accordance with the Blue Book (Landcom, 2004).

6.7.2 Stage 7 Extraction Areas

The extraction area would generally move anticlockwise (Stages 7a to 7d) with time (**Appendix 2**). At all times, the extraction area would be internally draining, with the sump relocated as required as the extraction progresses. No direct discharge would occur from the extraction area to receiving waters unless complying with the limits set out in EPL 299.

Stormwater runoff captured in the sumps would be reused on site for dust suppression and/or treated as required to meet the contaminant limits of EPL 299 and discharged to surface waters at the licenced discharge point(s).

6.7.3 Processing Areas

Primary crushing and screening would be undertaken close to the location of each blast with the bulk of the extracted and primary-crushed rock then transported by haul trucks to the fixed processing plant north of the Project Area. Water management practices in this area would remain unchanged.

Processing of some extracted rock would be periodically undertaken within the Project Area on a campaign basis using mobile crushing and screening equipment.

Runoff from the areas where the mobile plant would be located would drain to the active sump(s) within the extraction area (refer to Section 6.7.2 and **Appendix 2**). Any discharge to receiving waters would be in accordance with EPL 299.

6.7.4 The Haul Road

The existing internal haul road between the current extraction area and the fixed processing plant would continue to be used throughout the Project life. This haul road enters the current extraction area from the northwest and descends southwards along the toe of the western face of Stages 1 and 2. The existing internal road through Stages 5 and 6 would be relocated as required and would ultimately extend into Stage 7. All runoff from these internal roads would drain to the active sump(s) within the extraction area.

6.7.5 Discharge Points

There are four existing licenced discharge points under EPL 299 however only one is relevant to the Project Area (EPA ID 6) (see **Appendix 2** plans) as summarised in **Table 40** below. Any releases from the Project Area would initially be at this location and potentially from additional approved points on the perimeter of Stage 7 later on in the Project life. All discharges would be subject to water quality testing before release in accordance with an updated *Water Management Plan.*

Table 40 – Surface water quality limits (EPL No. 299)

EPA ID	Location	Analyte	Units	EPL Limit	Frequency
6	Quarry Extension Discharge (DP2)	pH	pH units	6.5 – 8.5	Daily during discharge
		Turbidity	NTU	32.2	

(Source: Cardno, 2020)

6.8 STORAGE OF HAZARDOUS MATERIAL

No hazardous materials i.e. bulk fuels, lubricants and hydraulic fluids would be stored within the Project Area. Spill kits would be carried on the refuelling truck with additional spill response material available at the Quarry's administration area.

6.9 SURFACE WATER MONITORING

6.9.1 Monitoring and Maintenance

As part of the Water Management Plan, a Monitoring and Maintenance program would be included to ensure the Plan is operational and functioning, as required. Additional surface water monitoring locations would be required and are shown in addition to the existing surface water monitoring locations in **Figure 12.** The existing frequency of water quality monitoring (biannually) would be maintained.

Inspections of soil and water management structures is recommended:

- At least weekly; and
- Prior to forecast rainfall of 10 mm/day or more; and
- If safe to do so, after rainfall of 5 mm/day or more.

Inspections are to be conducted to:

- Verify that all surface water management structures are in place as required for the specific stage of the Project (e.g. diversion and drainage structures, sumps etc.);
- Verify that erosion and sediment control structures such as sediment sumps do not require any maintenance works; and
- Verify that sediment-laden runoff from operational areas of the Project Area are draining internally to sumps, or are subject to the designed sediment control structures.

Regular inspection is to include recording the condition of all surface water management measures and any maintenance, improvement or modifications required to ensure the Project Area remains compliant with the conditions of EPL 299.

In the event that regular water quality monitoring or inspections determines actual or potential pollution as a result of an incident (i.e. actual or potential harm to the environment), the Quarry Manager or their representative would follow the Pollution Incident Response Management Plan (PIRMP) for the Quarry and take immediate steps to address or mitigate the potential for harm.

6.9.2 Testing Locations, Parameters and De-Watering

Surface water monitoring would be undertaken at the locations shown in **Figure 12**. These locations would be reviewed annually to ensure they are appropriate for the activities underway within the Project Area. The analytes for testing are listed in **Table 41**. Surface runoff detained in the sump(s) would be treated (if necessary) to meet the target water quality documented in EPL 299 before being released to receiving waters ("conditional discharges"). Water discharges would be highly dependent on rainfall, consistent with historical discharges of captured surface water from the active extraction area.

Due to the design of the extraction area and nature of the resource, no uncontrolled overflows of water would occur from the sump(s) to receiving waters. All discharges would occur at the licenced discharge point(s). Only sheet flow from stabilised amenity barriers would be able to flow from the Project Area.

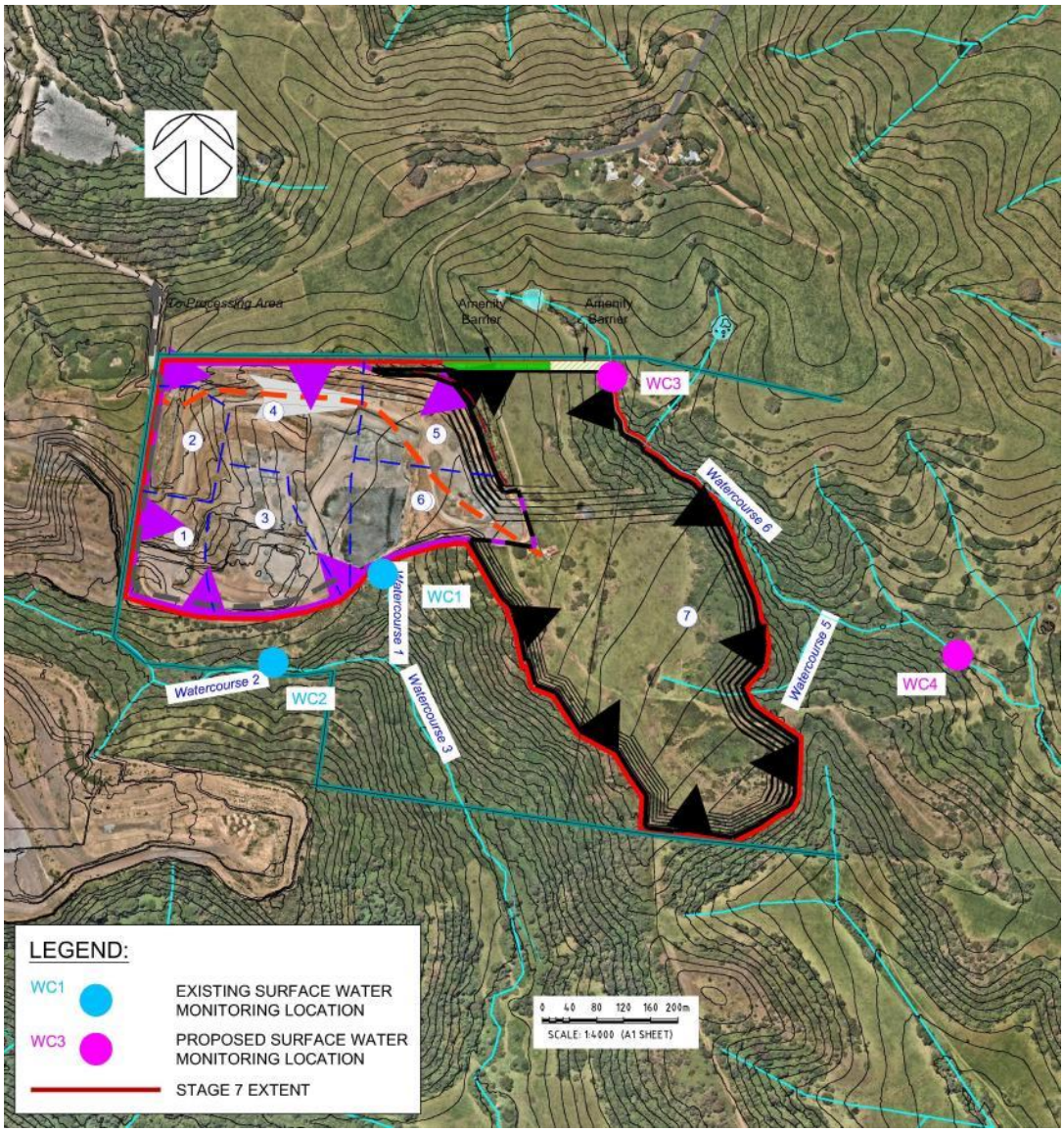


Figure 12 – Surface water monitoring locations (Albion Park Quarry – QEMP).

Table 41 – Existing ground and surface water testing parameters (Albion Park Quarry – QEMP)

Method	Sample Site	Frequency	Analytes
Field Measurement	WC1, WC2, WC3, WC4	Biannual	Electrical conductivity, pH, temperature
Laboratory Testing	WC1, WC2, WC3, WC4	Biannual	Turbidity, Total Dissolved Solids, Total Suspended Solids, Sodium, Potassium, Calcium, Alkalinity, Sulphate, Chloride, Oil & Grease, Dissolved Copper, Dissolved Iron

6.9.3 Environment Protection Licence

As previously discussed in Section 6.7.5**,** any discharges from the Project Area would need to satisfy the conditional requirements of EPL 299 issued by the NSW EPA - refer to **Table 40**.

6.10 ON-SITE WASTEWATER MANAGEMENT

Wastewater within the extraction area would continue to be managed through the use of portable toilets associated with the remote crib hut located within the Project Area. These portable toilets would continue to be serviced regularly with no discharge within the Project Area.

6.11 FINAL LANDFORM

6.11.1 General Description

The final landform is described in **Section 3.11** of the Environmental Impact Statement.

As extraction activities and backfilling progress with each stage, a new sump would be developed for that stage. At the end of the Project, the remaining three sumps would remain as dams within the final landform plan. Five rehabilitation domains have been defined based upon the final landform created within the Project Area. (**Figure 13** and **Figure 14**). These are summarised in **Table 42.**

Once the final landform is progressively completed through placement of the backfill, the following activities would be undertaken to achieve stabilisation and revegetation:

- Contour and shape the final landform so that all surface water runoff is controlled in a manner that minimises the risk of erosion of the substrate materials placed;
- Placement of subsoil and topsoil on the profiled landform; and
- Planting of natural vegetation in line with the Rehabilitation Management Plan.

Ongoing post-extraction rehabilitation activities would occur in accordance with an updated *Albion Park Quarry Rehabilitation Management Plan (RMP).*

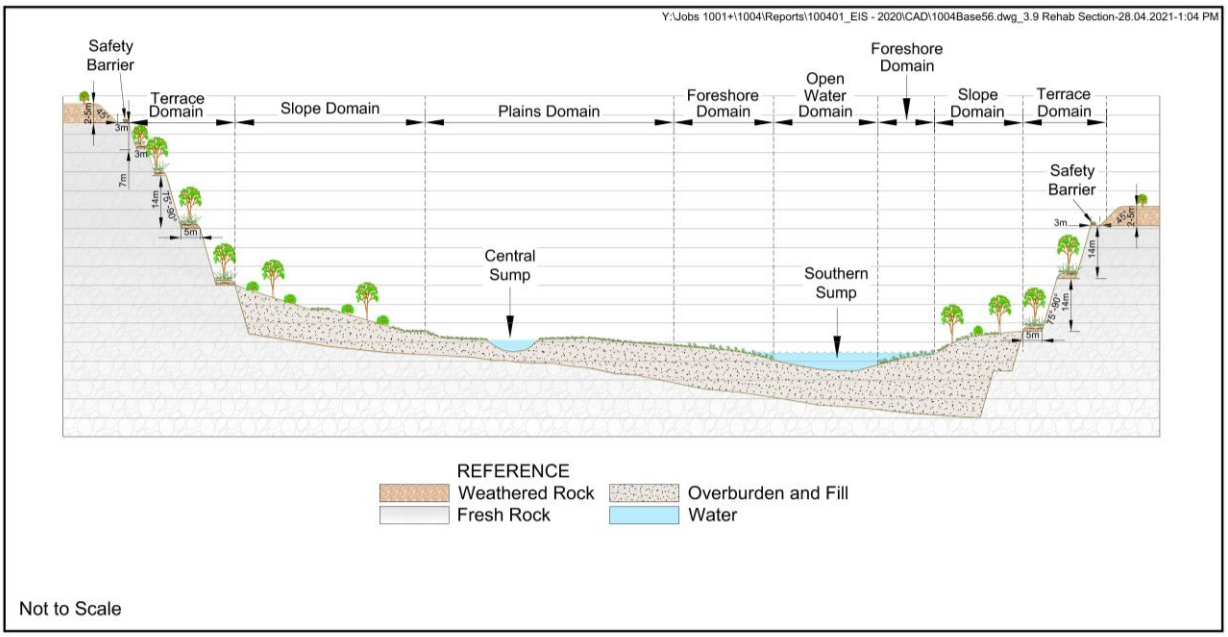


Figure 13 – Final landform domains schematic (provided by R.W. Corkery & Co. Pty Ltd).

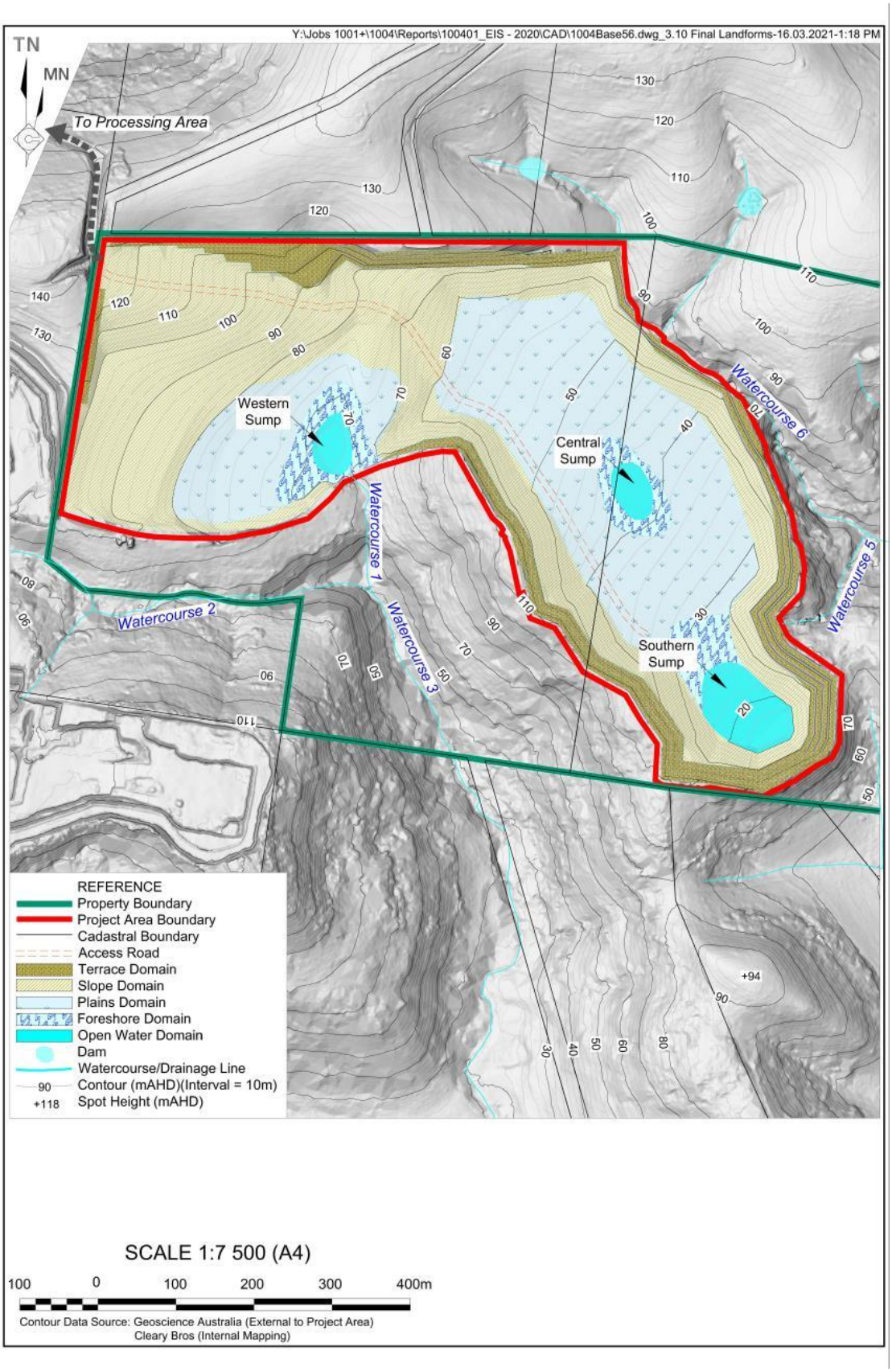


Figure 14 – Indicative final landform (provided by R.W. Corkery & Co. Pty Ltd).

Table 42 – Final landform domains and Land Capability Class

Domain	Estimated area (ha) within the final landform	Description	Land Capability Class
Terrace Domain	4.5 ha	Steeper terminal faces of the extraction area with up to 14m benches, 5m berms and face angles of between 75º and 90º. Overburden and other suitable materials would be placed on the berms to provide a growth medium with water holding capacity for local trees and shrubs.	VIII
Slope Domain	16.0 ha	The intermediate slope between the Terrace and Plain Domains with variable slopes of between 5° and 18° formed from overburden or other suitable back fill materials. Final slopes would be revegetated with trees and shrubs. Pasture species would be established on the lower more gentle slopes grading to the Plains domain.	V to VI
Plains Domain	12.0 ha	Overburden or other suitable backfill would be placed on the floor of the extraction area to a variable depth with a gentle slope. The final profiled Plains Domain would incorporate a series of retained dams which would provide ongoing use for sediment control and stock watering.	IV
Foreshore Domain	2.0 ha	The area between the Plains Domain and the Open Water Domain would be a low-gradient transitional area comprising wetland and water-loving vegetation.	VII
Open Water Domain	1.5 ha	Due to the generally southerly dip of latite resource and the surrounding topography within the Project Area, extraction would create a low point at the southern end of Stage 7 which would form a permanent or semi-permanent water feature collecting surface water running from much of the extraction area.	VIII

6.11.2 Land Capability

Table 42 also includes an assessment of the Land Capability Class for each final landform domain. Note that the assigned Land Capability Classes for each domain assume that topsoil is placed and the area revegetated.

Class IV lands have moderate capability, with inherently moderate to high limitations for high-impact land uses such as cropping, intensive grazing or horticulture. Class V lands are similar

to Class IV but are slightly steeper, necessitating more significant soil conservation techniques to mitigate the erosion hazard when grazed.

Class VI lands have low capability as they have significant inherent constraints that need to be carefully managed to prevent long-term degradation. These lands are generally suitable for grazing, forestry and nature conservation.

Class VII lands have very low capability, with severe limitations that restrict most land uses. These lands should remain vegetated and undisturbed.

Class VIII lands are incapable of sustaining any land use apart from nature conservation (OEH, 2012).

As noted in **Table 42** and shown on **Figure 14**, more than 75% of the proposed final landform comprises the Slopes and Plains domains, with corresponding land capability from IV to VI.

7 SURFACE WATER IMPACT ASSESSMENT

The Project includes the use or generation of potential pollutants as noted in **Section 4** of this report. Without adequate management and/or mitigation measures, there is the potential for undue offsite pollution, primarily as a result of sediment-laden runoff leaving the Project Area.

A series of management measures are detailed in Section 6 to mitigate or manage the potential for undue off-site pollution. Provided these measures are adopted and implemented, the surface water impacts are expected to be minimal. The proposed works would convey sediment-laden water internally to the on-site sumps that would allow treatment prior to discharge. Controlled discharges of treated water from the sumps would be undertaken only after rainfall events and would be in accordance with EPL 299.

Peak flows in local watercourses would be reduced during the extraction process. The reduction would be a gradual process as the extraction footprint progressively increases. At the full extent of the Project, flows are expected to decrease by up to 25.7% at the Property boundary within Watercourse 3 and 18.0% within Watercourse 6. This impact would lessen further downstream of the extraction area as additional catchment areas drain into the watercourses. It is expected that the peak flows will reduce by approximately 4% within Rocklow Creek immediately downstream of the Illawarra Railway. The impacts of these reduced peak flows downstream from the Project Area are assessed to be minimal given the nature of the use of the water on downstream properties (i.e. small volume online water storages for stock harvesting and dredging operations).

Runoff collected from the extraction areas in the sumps within the Project Area would be reused on site and/or discharged back to the local watercourses following the settlement of any fines, resulting in no adverse impacts in overall flow volumes given changes to overall flow volumes would be negligible or potentially marginally greater than pre-development flows.

8 REFERENCES

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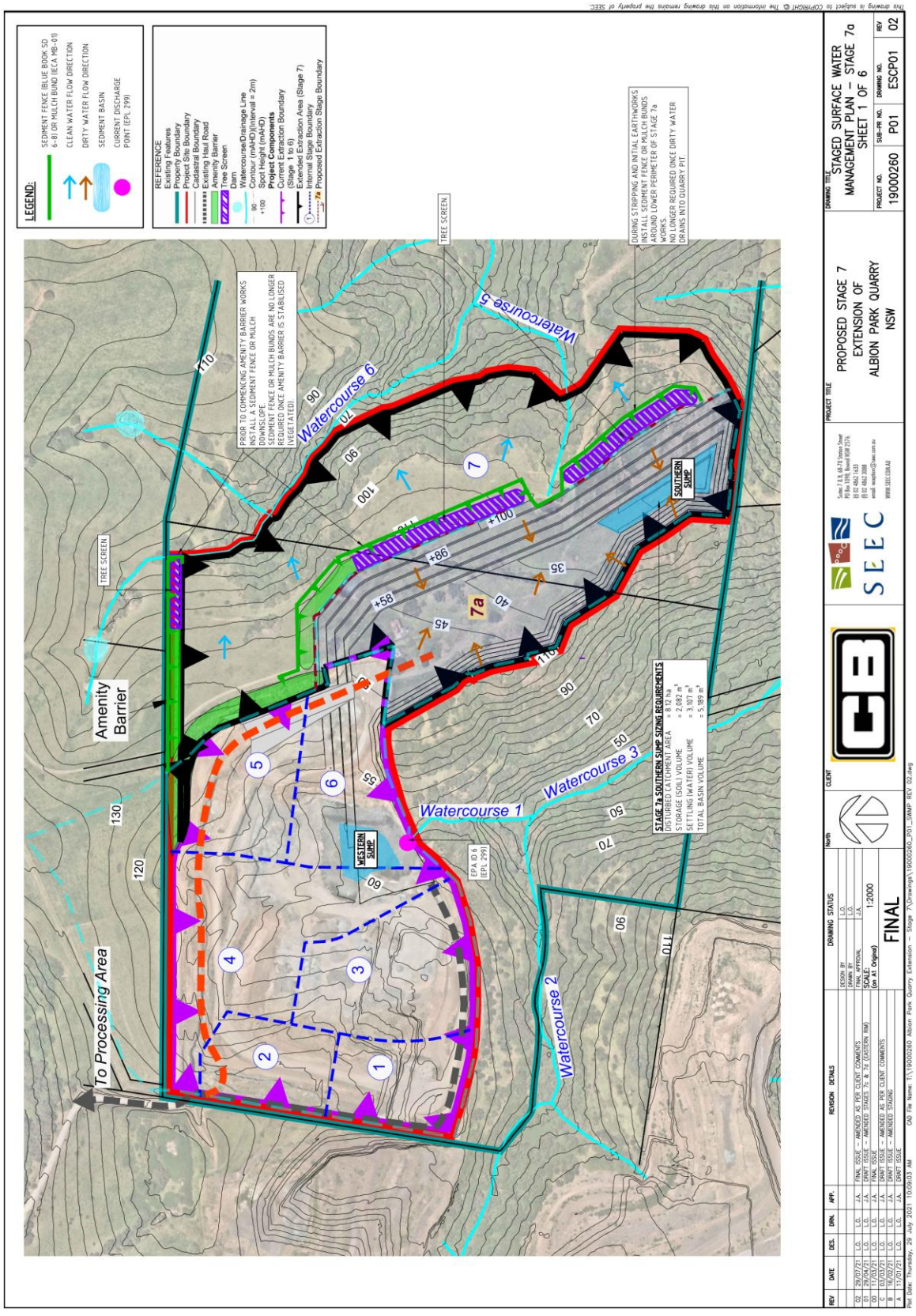
Office of Environment and Heritage (OEH) (2012). The land and soil capability assessment scheme; Second Approximation. NSW Office of Environment and Heritage (OEH), Sydney.

9 APPENDICES

9.1 APPENDIX 1 – SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Government Agency	Paraphrased Requirement	Relevant Section(s)
WATER		
DPIE – SSD 10369	Including: - A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	4.1.3, 4.1.4, 4.1.5
	- Identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*;	4.2
	- Demonstration that water from the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	4.1.4, 4.1.5
	- A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	4.1.4, 4.1.5
	- An assessment of the likely impacts on the quality and quantity of existing surface and ground water resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives;	4.1, 4.2
	- An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users; and	3.5, 4
	- A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and ground water impacts.	6
LAND RESOURCES		
DPIE – SSD 10369	Including a detailed assessment of: - potential impacts on soils and land capability (including potential erosion and land contamination);	2.6, 4

9.2 APPENDIX 2 – INDICATIVE STAGED SURFACE WATER MANAGEMENT PLANS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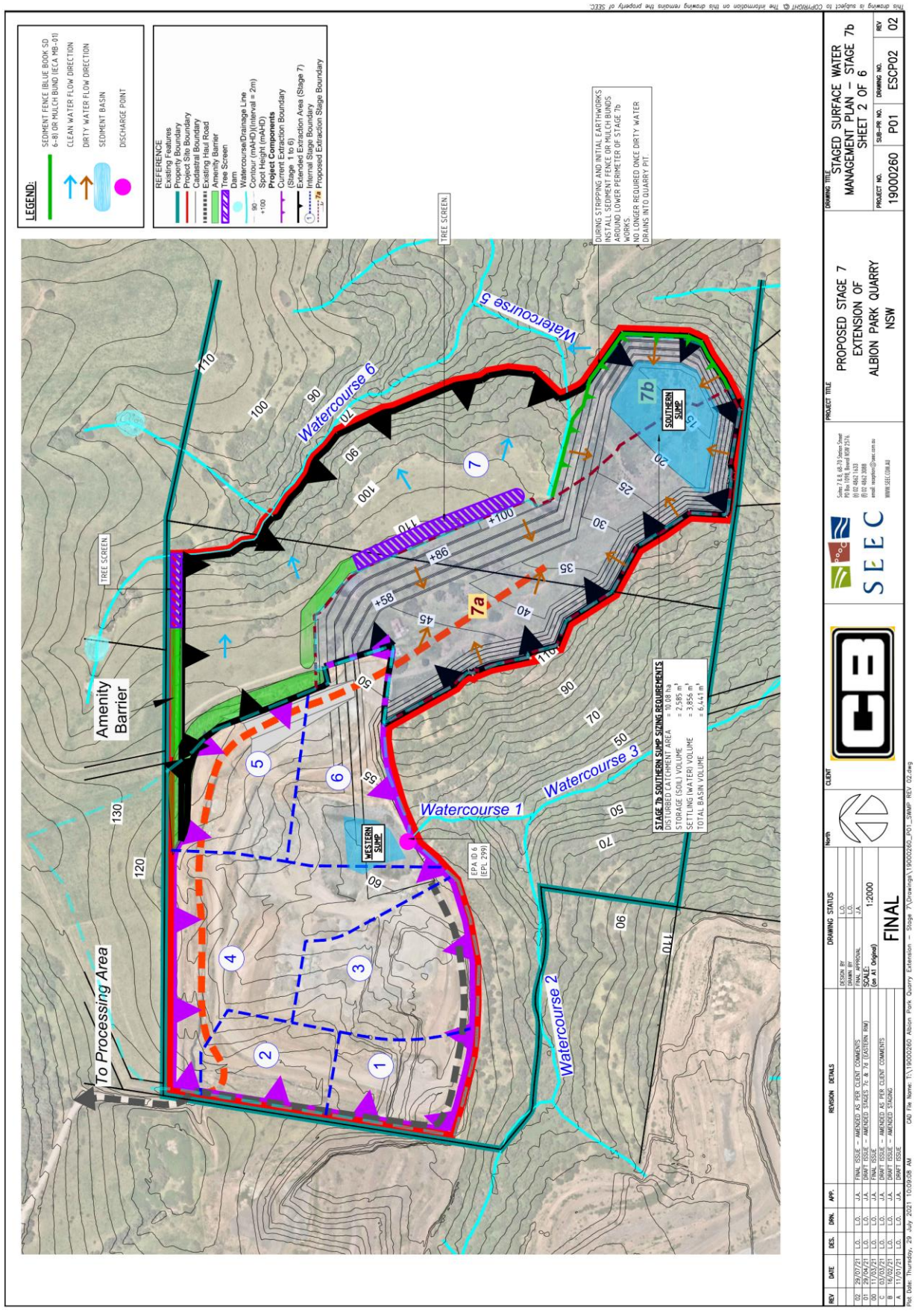
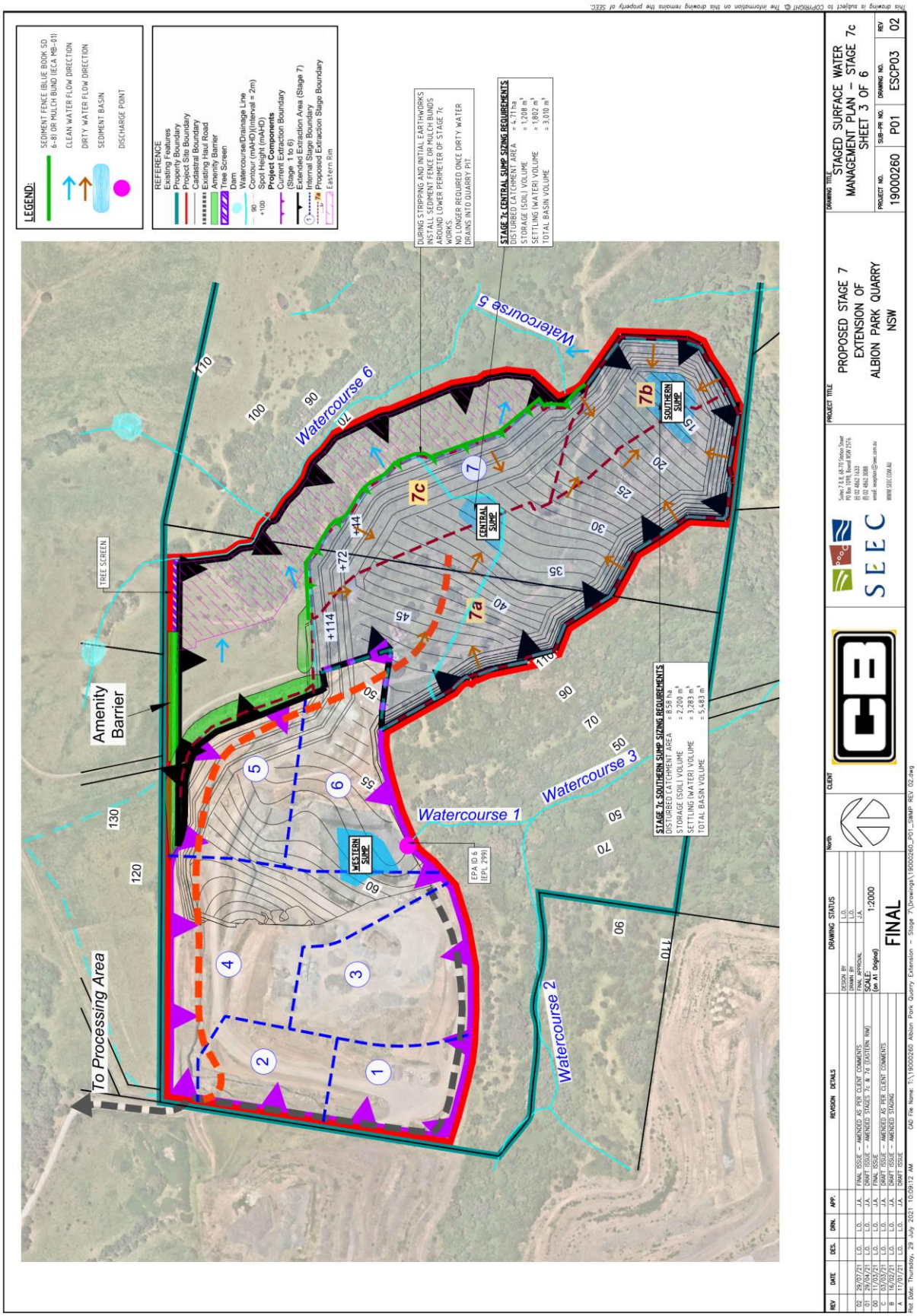
CLEAN WATER FLOW DIRECTION
DIRTY WATER FLOW DIRECTION
SEDIMENT BASIN
CURRENT DISCHARGE POINT (EPL 299)
REFERENCE:
Existing Features
Property Boundary
Project Site Boundary
Cadastral Boundary
Existing Haul Road
Amenity Barrier
Tree Screen
Dam
Watercourse/Drainage Line
Contour (mAHD)(Interval = 2m)
Spot Height (mAHD)
Project Components
Current Extraction Boundary
Stage 7 Boundary
Extended Extraction Area (Stage 7)
Proposed Extraction Stage Boundary
Internal Stage Boundary
PRIOR TO COMMENCING AMENITY BARRIER WORKS INSTALL A SEDIMENT FENCE OR MULCH DOWNSLOPE
SEDIMENT FENCE OR MULCH BUNDS ARE NO LONGER REQUIRED ONCE AMENITY BARRIER IS STABILISED VEGETATED
DURING STRIPPING AND INITIAL EARTHWORKS INSTALL SEDIMENT FENCE OR MULCH BUNDS AROUND LOWER PERIMETER OF STAGE 7a WORKS.
NO LONGER REQUIRED ONCE DIRTY WATER DRAINS INTO QUARRY PIT.
STAGE 7a SOUTHERN SUMP SIZING REQUIREMENTS
DISTURBED CATCHMENT AREA = 8.72 ha
STORAGE (SOIL) VOLUME = 2,062 m³
SETTLING (WATER) VOLUME = 3,107 m³
TOTAL BASIN VOLUME = 5,169 m³
Watercourse 1
Watercourse 2
Watercourse 3
Watercourse 5
Watercourse 6
Amenity Barrier
TREE SCREEN
To Processing Area
WESTERN SUMP
SOUTHERN SUMP
EPA ID 6 (EPL 299)
PROPOSED STAGE 7 EXTENSION OF ALBION PARK QUARRY NSW
STAGED SURFACE WATER MANAGEMENT PLAN – STAGE 7a SHEET 1 OF 6
PROJECT NO. 19000260
SUB-PR NO. P01
DRAWING NO. ESCP01
REV 02
DRAWING STATUS
FINAL
1:2000
(on A1 Original)
CLIENT
SEEC

Cleary Bros (Bombo) Pty Ltd
Albion Park Quarry Extraction Area Stage 7 Extension

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SEDIMENT FENCE (BLUE BOOK SD 6-8) OR MULCH BUND (IECA MB-01)
CLEAN WATER FLOW DIRECTION
DIRTY WATER FLOW DIRECTION
SEDIMENT BASIN
DISCHARGE POINT
REFERENCE
Existing Features
Property Boundary
Project Site Boundary
Cadastral Boundary
Existing Haul Road
Amenity Barrier
Tree Screen
Dam
Watercourse/Drainage Line
Contour (mAHD)(Interval = 2m)
Spot Height (mAHD)
Project Components
Current Extraction Boundary (Stage 1 to 6)
Extent of Extraction Area (Stage 7)
Internal Stage Boundary
Proposed Extraction Stage Boundary
Eastern Rim
DURING STRIPPING AND INITIAL EARTHWORKS INSTALL SEDIMENT FENCE OR MULCH BUNDS AROUND LOWER PERIMETER OF STAGE 7c
NO DISCHARGE
NO LONGER REQUIRED ONCE DIRTY WATER DRAINS INTO QUARRY PIT
STAGE 7c CENTRAL SUMP SIZING REQUIREMENTS
DISTURBED CATCHMENT AREA = 4.71ha
STORAGE (SOIL) VOLUME = 1,208 m³
SETTLING (WATER) VOLUME = 1,802 m³
TOTAL BASIN VOLUME = 3,010 m³
STAGE 7c SOUTHERN SUMP SIZING REQUIREMENTS
DISTURBED CATCHMENT AREA = 8.58 ha
STORAGE (SOIL) VOLUME = 2,200 m³
SETTLING (WATER) VOLUME = 3,283 m³
TOTAL BASIN VOLUME = 5,483 m³
Watercourse 5
Watercourse 6
Watercourse 3
Watercourse 1
Watercourse 2
Amenity Barrier
TREE SCREEN
To Processing Area
CENTRAL SUMP
SOUTHERN SUMP
WESTERN SUMP
EPA ID 6 (EPL 299)
7a
7b
7c
1
2
3
4
5
6
7
DRAWING TITLE
STAGED SURFACE WATER MANAGEMENT PLAN – STAGE 7c SHEET 3 OF 6
PROJECT NO. 19000260
SUB-PR NO. P01
DRAWING NO. ESCP03
REV 02
PROJECT TITLE
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SEEC
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CLIENT
North
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01 29/04/21 L.O. J.A. DRAFT ISSUE – AMENDED STAGES 7c & 7d (EASTERN RIM)
C 03/03/21 L.O. J.A. DRAFT ISSUE – AMENDED AS PER CLIENT COMMENTS
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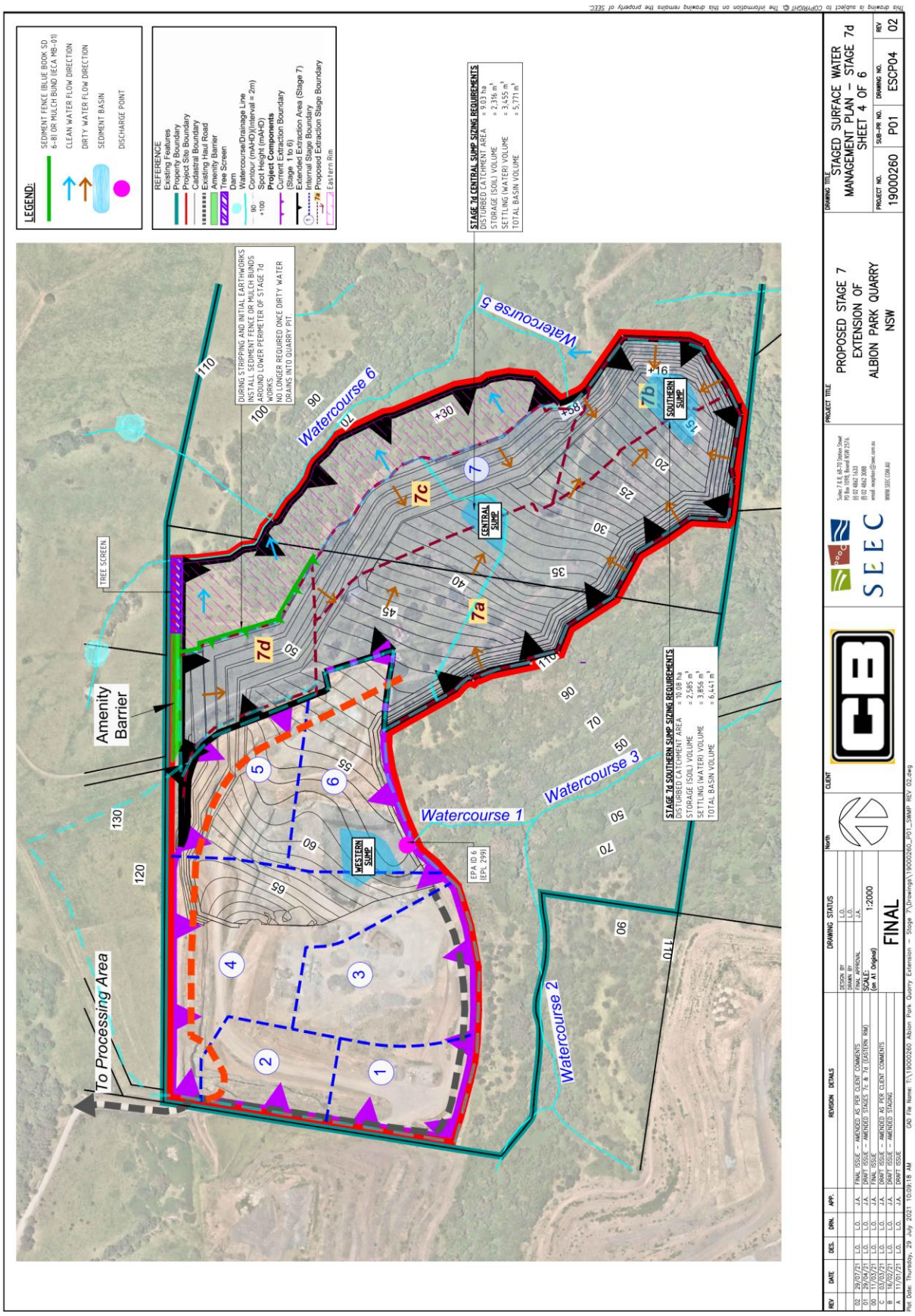
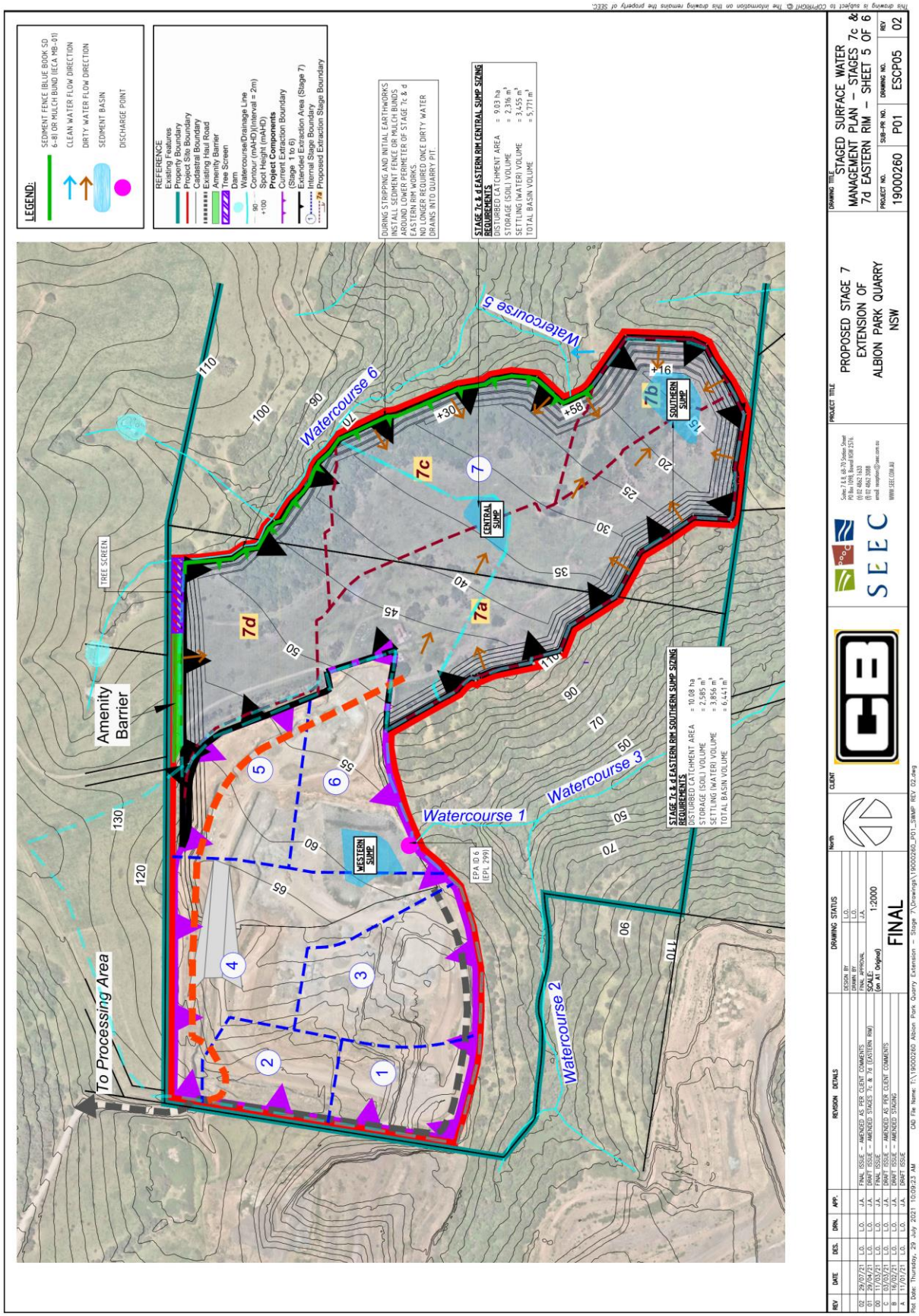
Albion Park Quarry Extraction Area Stage 7 Extension

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DIRTY WATER FLOW DIRECTION
SEDIMENT BASIN
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Existing Features
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Project Site Boundary
Cadastral Boundary
Existing Haul Road
Amenity Barrier
Tree Screen
Dam
Watercourse/Drainage Line
Contour (mAHD)(Interval = 2m)
Spot Height (mAHD)
Project Components
Current Extraction Boundary (Stage 1 to 6)
Extended Extraction Area (Stage 7)
Internal Stage Boundary
Proposed Extraction Stage Boundary
DURING STRIPPING AND INITIAL EARTHWORKS INSTALL SEDIMENT FENCE OR MULCH BUNDS AROUND LOWER PERIMETER OF STAGE 7c & d EASTERN RIM WORKS
NO LONGER REQUIRED ONCE DIRTY WATER DRAINS INTO QUARRY PIT
STAGE 7c & d EASTERN RIM CENTRAL SUMP SIZING REQUIREMENTS
DISTURBED CATCHMENT AREA = 9.03 ha
STORAGE (SOIL) VOLUME = 2,316 m³
SETTLING (WATER) VOLUME = 3,455 m³
TOTAL BASIN VOLUME = 5,771 m³
STAGE 7c & 7d EASTERN RIM SOUTHERN SUMP SIZING REQUIREMENTS
DISTURBED CATCHMENT AREA = 10.08 Ha
STORAGE (SOIL) VOLUME = 2,585 m³
SETTLING (WATER) VOLUME = 3,856 m³
TOTAL BASIN VOLUME = 6,441 m³
Watercourse 5
Watercourse 6
Watercourse 3
Watercourse 1
Watercourse 2
To Processing Area
Amenity Barrier
TREE SCREEN
WESTERN SUMP
CENTRAL SUMP
SOUTHERN SUMP
EPA 0.6 [EPL 299]
7a
7b
7c
7d
1
2
3
4
5
6
7
PROPOSED STAGE 7 EXTENSION OF ALBION PARK QUARRY NSW
STAGED SURFACE WATER MANAGEMENT PLAN – STAGES 7c & 7d EASTERN RIM – SHEET 5 OF 6
PROJECT NO. 19000260
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SEDIMENT BASIN AND SPILLWAY SIZING REQUIREMENTS

Sump	Stage	Disturbed Catchment (ha)	Catchment Soil Loss (t/yr)	Sediment Storage Volume (m^3)	Settling Volume (m^3)	Total Basin Volume (m^3)
Southern	7a	8.12	5,416	2,082	3,107	5,189
	7b	10.08	6,723.4	2,585	3,856	6,441
	7c	8.58	5,722.9	2,200	3,283	5,483
	7d	10.08	6,723.4	2,585	3,856	6,441
Central	7c	4.71	3,141.6	1,208	1,802	3,010
	7d	9.03	6,023.0	2,316	3,455	5,771
Western	Ex. Stage	20.86	13,913.6	5,350	7,981	13,331

Note:

- Sediment basin is to be constructed in accordance with engineering and geotechnical specifications to be structurally sound and geotechnically stable and set out in accodance with Blue Book Standard Drawing SD 6-4.

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
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FINAL APPROVAL J.A.
SCALE: (on A1 Original) 1:2000
FINAL

North

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PROJECT TITLE
PROPOSED STAGE 7 EXTENSION OF ALBION PARK QUARRY NSW

DRAWING TITLE
STAGED SURFACE WATER MANAGEMENT PLAN – BASIN SIZING TBALE – SHEET 6 OF 6

PROJECT NO.	SUB–PR NO.	DRAWING NO.	REV
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