Hy-Tec Industries Pty Limited

ABN: 90 070 100 702

Austen Quarry
Stage 2 Extension Project

Soil and Land Capability Assessment

Prepared by

Strategic Environmental & Engineering Consulting (SEEC) Pty Ltd

September 2014

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Soil and Land Capability Assessment

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EXECUTIVE SUMMARY

Strategic Environmental & Engineering Consulting (SEEC) Pty Ltd have been commissioned by R W Corkery and Company Pty Ltd to prepare this Soil and Land Capability Assessment. If forms part of an Environmental Impact Statement that accompanies an application to extend existing quarry activities at Austen Quarry, via Hartley, NSW.

DLWC/SCA (2002) mapping identifies the quarry operations are on the Mount Walker and Marrangaroo Soil Landscapes. The existing processing area is located on the Marrangaroo Soil Landscape and both the existing and extended (Stage 2) extraction areas and overburden emplacement are located on the Mount Walker Soil Landscape.

SEEC undertook an inspection of the Site in June 2013, taking selected samples for analyses. Soils of the Stage 2 extraction area and the overburden emplacement extensions are shallow and consist primarily of Lithosols (sandy, gravelly soils with minimal profile development). Topsoil and subsoil are not well defined and would be difficult to separate as both are thin and very similar. Rock outcrop is common.

The Land and Soil Capability Class is 6 as a result of significant soil acidity and extensive rock outcropping. Class 6 lands have very severe limitations for a wide range of land uses and few management practices are available to overcome them. Soil fertility is very low and the land is generally suitable only for low productivity grazing (with limitations).

Topsoil and subsoil would be stripped together and used to rehabilitate the Overburden Emplacement. The blended soil would be moderately erodible and so exposed slope lengths on the face of the Overburden Emplacement would be limited by adopting a lift of only 10 m. Soil stability and moisture holding capability may be increased by incorporating organic matter before placement. Fertility and vegetation growing conditions could be improved by using lime and gypsum with slow release fertilizer (e.g. organic fertiliser).

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1. INTRODUCTION

SEEC have been commissioned by R.W. Corkery Pty Ltd on behalf of Hy-Tec Industries Pty Limited to prepare this Soil and Land Capability Assessment. It forms part of an Environmental Impact Statement for the Stage 2 Extension of Austen Quarry, Hartley, NSW. The assessment describes the nature of the soils, their susceptibility to erosion, their quantities and their potential for use in land rehabilitation.

2. PROJECT DESCRIPTION

2.1 GENERAL DESCRIPTION

The Austen Quarry ("the quarry") is located approximately 3.5km south-southwest of the village of Hartley and 10km south of Lithgow (**Figure 1**).

The quarry is located on rural land, owned by the Hartley Pastoral Corporation Pty Ltd (HPC), and is currently operating under Development Consent No. 103/94 (DA 103/94), which approves the despatch of up to 1.1 million tonnes of rhyolite products per year until March 2020. Hy-Tec Industries Pty Limited ("the Applicant") proposes to extend the extraction area and overburden emplacement of the quarry in order to extend the operational life of the quarry (until 2050).

For the purposes of this document reference is made to existing approved components or activities as "Stage 1" and new or extended components or activities as "Stage 2". The location(s) of all components, which together are referred to as the Site (an area of approximately 128ha), are displayed on (**Figure 2**).

It is noted that, should development consent be granted for the Stage 2 Extension Project, the Stage 2 extraction area would incorporate the existing Stage 1 extraction area and likewise, the Stage 2 overburden emplacement would incorporate the Stage 1 overburden emplacement. The following provides a description of the relevant component areas and activities of Stages 1 and 2.

2.2 APPROVED STAGE 1 COMPONENT AREAS

Extraction Area

The approved extraction area covers 12.1ha, however, a ridge on the northern side of the approved limit of extraction has been excised from the area to provide a visual barrier across much of the extraction area for viewers at Hassans Walls. The loading hopper of the primary crushing station is located at the northwestern corner of the Stage 1 extraction area at approximately 750m AHD (the footings are at an elevation of approximately 735m AHD).

Existing Stage 1 Overburden Emplacement

The overburden emplacement covers approximately 6.8ha, and has been developed immediately adjacent to the Stage 1 extraction area. Overburden placement in this area has involved the partial in-filling of the head of a gully between 730m AHD and 780m AHD.

Figure 1 – Local Setting

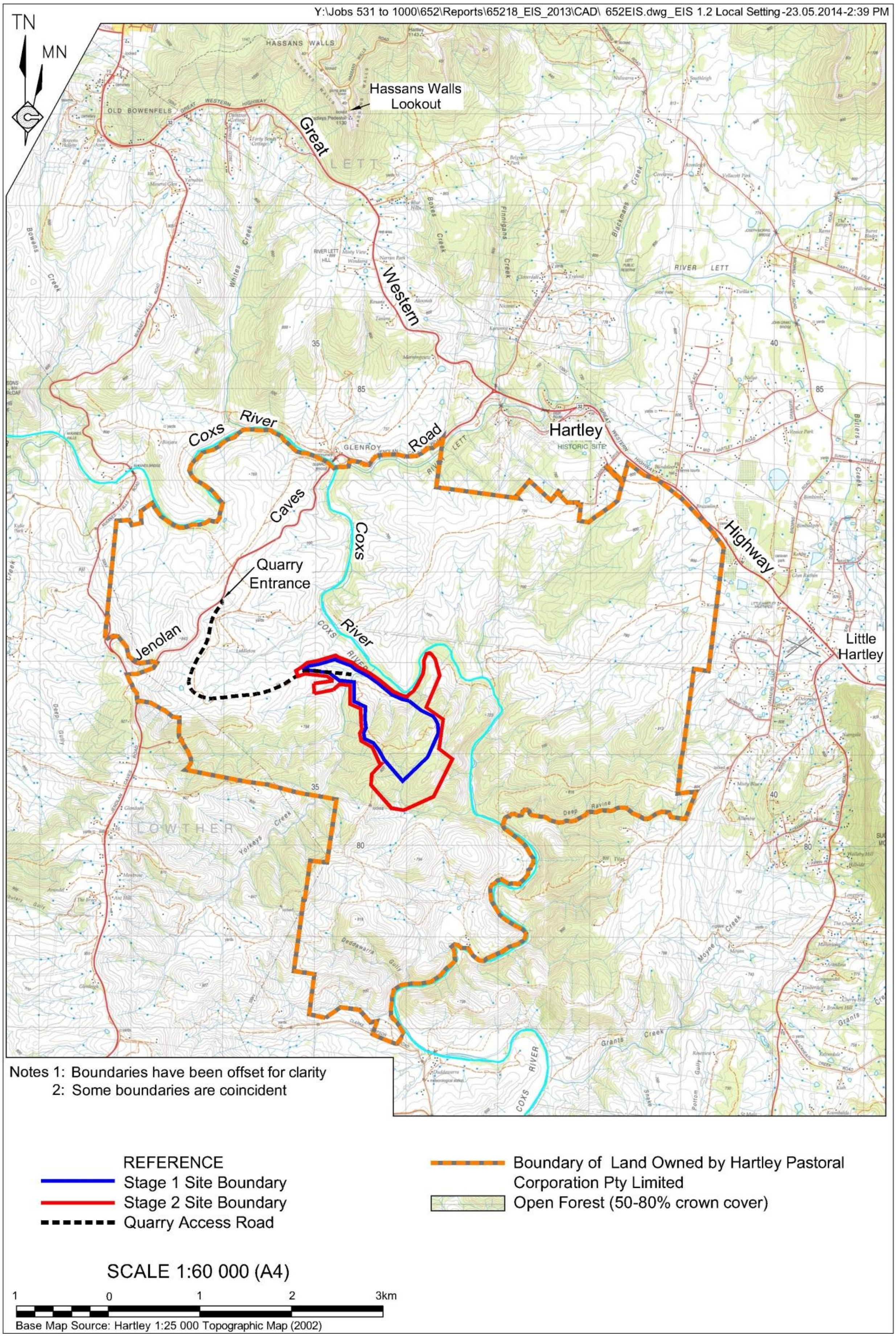
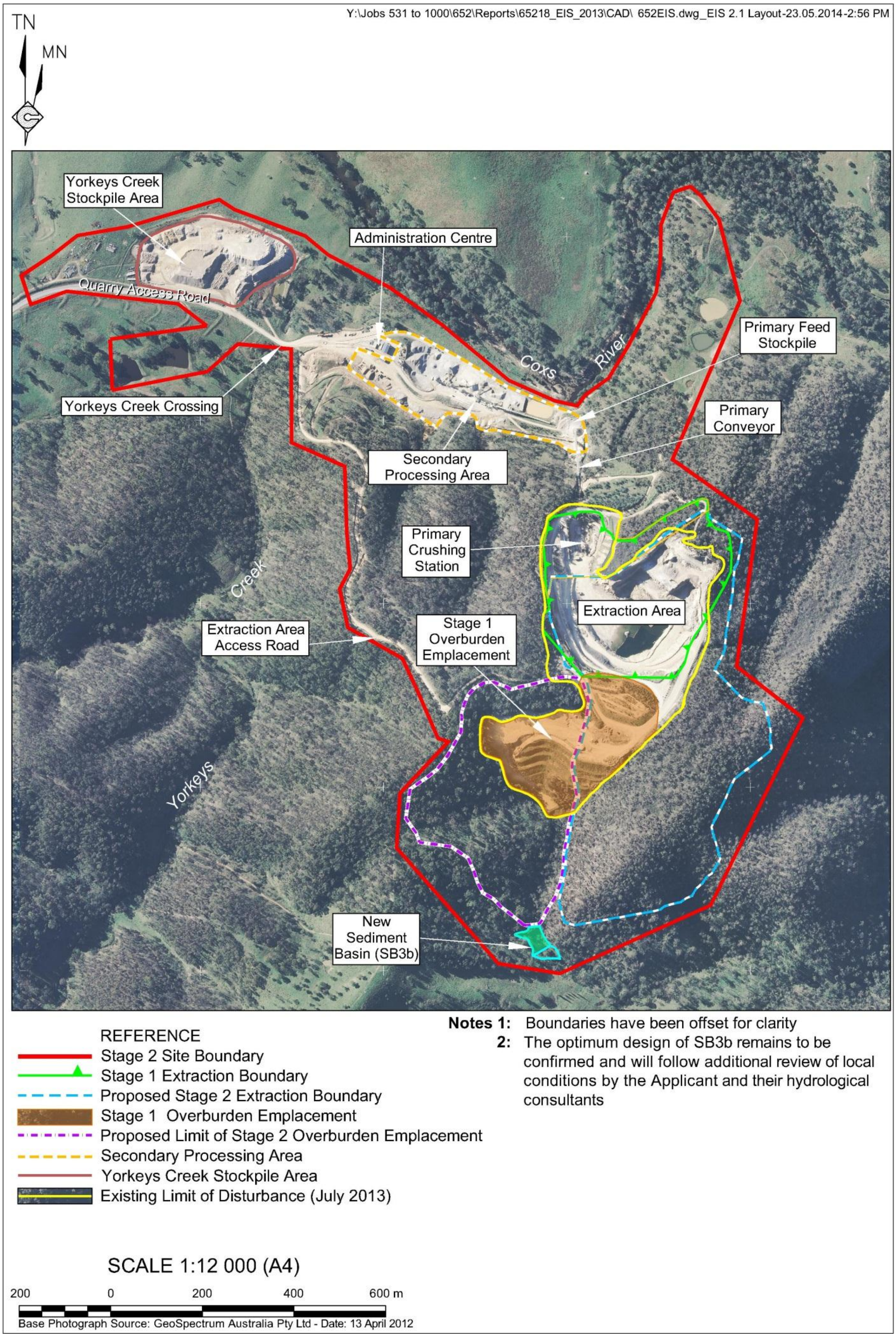


Figure 2 – Existing and Proposed Component Areas



Secondary Processing Area

The secondary processing area encompasses the area from the surge stockpile at the end of the conveyor from the primary crushing station to the site office. This area covers approximately 6.1ha and incorporates three crushers, six screens, 17 conveyors and the air separation unit. Aggregates of various sizes are separated or blended to produce customised products and temporarily stockpiled before transportation to their destination or to the Yorkeys Creek stockpile area.

Yorkeys Creek Stockpile Area

The bulk of the road pavement materials, manufactured sands, select fills, drainage materials and road construction materials are stockpiled within the Yorkeys Creek stockpile area to the northwest of the secondary processing area along the Quarry Access Road. This area covers approximately 4.4ha and is defined by the area between the Quarry Access Road, Yorkeys Creek and the northern boundary of the Application Area.

Quarry Access Road

The sealed private Quarry Access Road from the Jenolan Caves Road to the quarry weighbridge provides the only access to the Site. The road has centre and edge line markings the full length of the road between the intersection with Jenolan Caves Road and the substantial culvert crossing of Yorkeys Creek to the west of the outgoing weighbridge.

Other Areas

The Site also incorporates additional existing infrastructure and services including:

- the on-site road network;
- the administration building, amenities, laboratory and other structures;
- water management structures;
- the hydrocarbon storage area;
- two weighbridges; and
- facilities to house services such as power and communications.

2.3 PROPOSED STAGE 2 COMPONENT AREAS

Proposed Stage 2 Extraction Area

The proposed Stage 2 extraction area would incorporate a lateral extension of and deepening the existing Stage 1 extraction area along an adjacent southwest-northwest trending ridge. The northern side of the ridge within in the existing Stage 1 extraction area would remain as a visual barrier to views from the north. The area of the extension covers approximately 16.1ha and lies immediately to the southeast and east of the Stage 1 extraction area. The combined area of the Stage 1 and Stage 2 extraction areas would be 28.2ha.

Proposed Stage 2 Overburden Emplacement

The proposed overburden emplacement would laterally extend (6.7ha) and increase the elevation of the existing Stage 1 overburden emplacement. In total, the overburden emplacement would cover approximately 13.5ha. The Stage 2 overburden emplacement would continue to in-fill the small valley to the southwest of the Stage 2 extraction area.

Table 1 provides a summary of the approved activities and proposed modifications proposed.

Table 1 – Overview of Proposal Components and Activities

Component or Activity	Approved Stage 1 Operations*	Proposed Stage 2 Operations**
Area	79ha	Covers 103ha (a 30% increase)
Duration of Approval	Approved to March 2020	Approval sought to March 2050 (an increase of 30 years)
Maximum Annual Sales Level	1.1 Million tpa	No Change
Extraction Area	Approximately 12.1ha to an elevation of 730m AHD	Extension of approximately 16.1ha to an elevation of 685m AHD
Overburden Emplacement	Approximately 6.8ha to an elevation of 780m AHD	Extension of approximately 6.7ha to an elevation of 810m AHD
Method of Extraction	Drilling / blasting and load and haul to Primary Crusher	No Change
Mobile Equipment Fleet in Extraction Area	1 x Bulldozer 1 x Excavator (85t) 2 x Haul Trucks (40t) 1 x Water Truck (15 000L)	1 x Bulldozer 1 x Excavator (85t) 3 x Haul Trucks (60t) 1 x Water Truck (15 000L)
Processing Operations	Four Stage Crushing and Screening Plant and air separator - throughput 400tph	No Change
Product Stockpiling surrounding Plant	Stockpile capacity = 80 000t	No Change
Hours of Operating Quarry Operations	Mon-Fri: 6:00am-6:00pm Saturday: 7:00am-3:00pm	Mon-Fri: 6:00am-10:00pm Saturday: 7:00am-3:00pm
Blasting	Mon-Fri: 9:00am-5:00pm	No Change
Yorkeys Creek stockpile area	Area = 4.4ha Capacity = 500 000 tonnes	No Change
Quarry Access Road	3.1km in length sealed	No Change
Maximum Product Transportation	1.1 Million tpa	No Change
Daily Truck Loads to Sydney Customers	Average 125@ Maximum 180#	No Change
Daily Truck Loads to local and Sydney Customers	Average 150^ Maximum 250#	No Change
Loading Product Trucks and Despatch Hours of Operation	Mon-Fri: 5:00am-10:00pm Saturday: 5:00am-3:00pm	No Change

Table 1 – Overview of Proposal Components and Activities (Cont'd)

Component or Activity	Approved Stage 1 Operations	Proposed Stage 2 Operations
On-site Administration and Amenities	Site Office, two weighbridges, workshops, stores and amenities	No Change
Services		
Diesel	Annual Usage* = 0.95 million litres	Annual Usage** = 1.4 million litres
Telecommunications	1 line	No Change
Sewerage	Biocycle Unit (30 persons)	No change
Note * Based upon 750 000tpa. Note ** Based upon 1.1 million tpa.		
@ Current Average = 83 per day. # Current Maximum = 150 per day. ^ Current Average = 87 per day.		
Rehabilitation	Peripheral rehabilitation only during quarry operational life.	Revegetation of terminal extraction benches.
	Temporary measures to ensure erosion and sediment control. Monitoring for the success of revegetation and erosion control. Final landform suitable for passive biodiversity conservation (woodland / forest vegetation) and minor grazing[ø]. Removal of all buildings, infrastructure and stockpiles[ø].	No changes to other components
Note * Based upon 750 000tpa. ** Based upon 1.1 million tpa. [ø] Unless a further stage of operations is approved.		

3. SOIL INVESTIGATION

3.1 SOIL LANDSCAPES

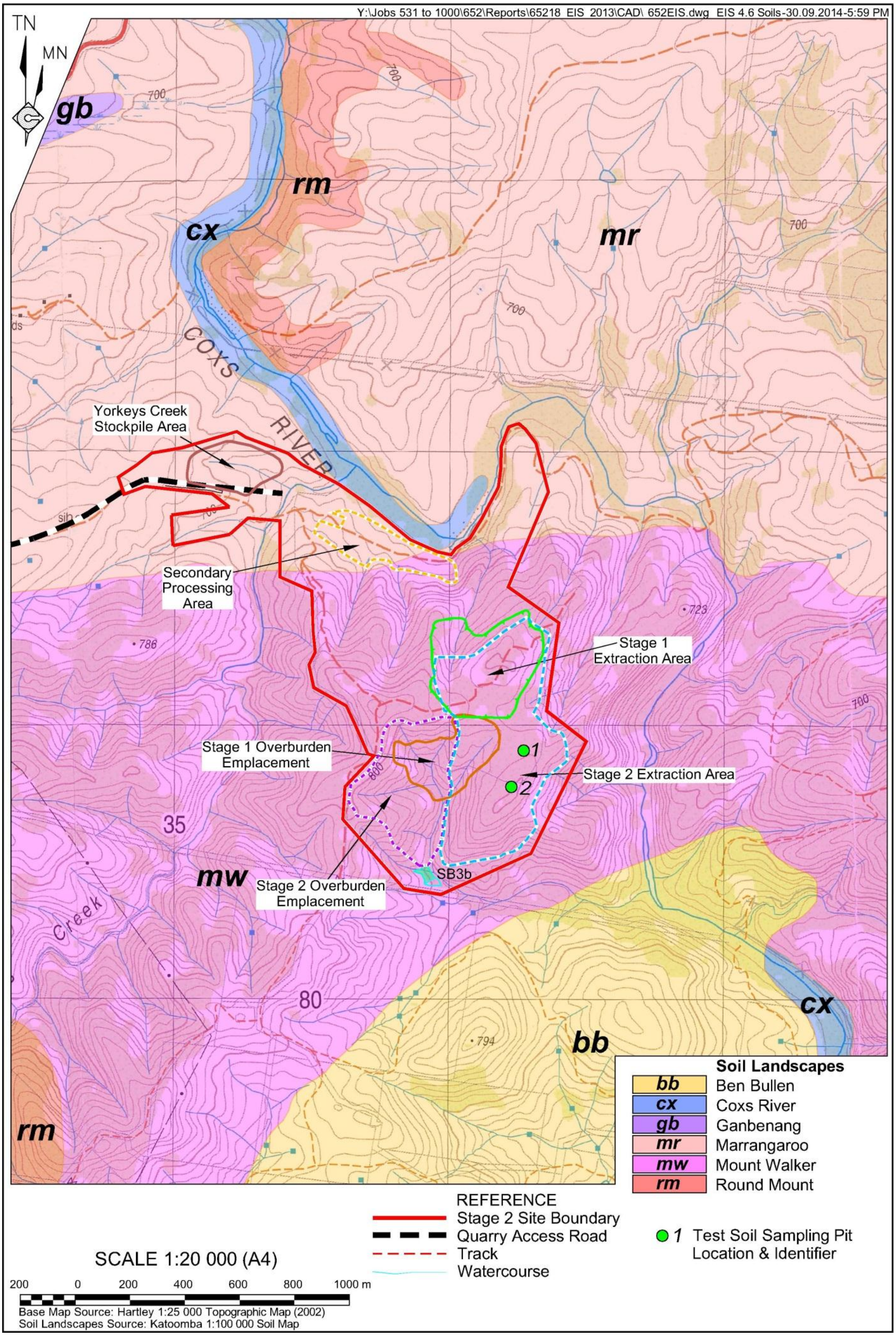
The soil landscape mapping of DLWC/SCA (2002) (**Figure 3**) identifies the Site as occurring over the Mount Walker and Marrangaroo Soil Landscapes. The Secondary Processing Area is located on the Marrangaroo Soil Landscape and both the Stage 1 and 2 extraction areas and overburden emplacement are located on the Mount Walker Soil Landscape.

The soil landscape mapping describes the Mount Walker Soil Landscape occurring on steep to very steep hills with narrow, rounded crests on the Lambie Group Metasediments. It comprises of yellow earths, Lithosols[1], Leached Loams, red and yellow Podzolic[2] soils and Soloths[3]. There are four soil facets:

- Crests: Yellow earths and Lithosols.
- Upper to mid slopes: Lithosols and Yellow Earths.
- Midslope leached loams: leached loams and yellow Podzolic soils.
- Mid to lower slopes: Yellow Podzolic soils and Soloths.

[1] Shallow soils showing minimal profile development and dominated by the presence of weathering rock and rock fragments.
[2] A type of acidic soil with strong texture contrast.
[3] Soils that are acidic throughout the profile, have a strong texture contrast and have an upper leached horizon.

Figure 3 – Soil Landscapes and Test Pit Locations



The soil landscape mapping describes the Marrangaroo Soil Landscape occurring on rolling hills and narrow flat to rounded convex crests on Carboniferous granite. It comprises of yellow Podzolic soils, earthy sands, siliceous sands, Lithosols, Minimal Prairie Soils, Alluvial Soils and yellow Solodic soils. There are four soil facets:

- Lower slopes: yellow Podzolic soils.
- Crests and side slopes: Earthy Sands and Siliceous Sands.
- Shallow soils/areas near rock outcrop: Earthy Sands, Lithosols and Siliceous Sands.
- Swampy drainage depressions: minimal Prairie Soils, Alluvial Soils and yellow Solodic soils.

For the purpose of this assessment is no work proposed on the Marrangaroo Soil Landscape and so it is not discussed further.

3.2 SITE SPECIFIC INVESTIGATION

SEEC staff (Mark Passfield (Director) and Nick Longden (Scientific Engineer)) visited the site on 18th June 2013. Soils were investigated within the proposed Stage 2 Extraction Area by hand-digging two test pits and using other exposures of batters formed by excavations for drill rig platforms (**Figure 4**).

Figure 4 –Typical Exposed Soil Profile at Drill Site

The investigation showed the soils conform to the expectations of the soil landscape mapping for the Mount Walker Soil Landscape. Very gravelly, quartz-rich, shallow, soil (Lithosol) was encountered over the proposed extraction area. The topsoil is thin (50-100 mm) and poorly defined. It consists of sandy loam with a small (10%) portion of coarse fragments derived from the parent rock. The subsoil consists of fine sandy loam to fine sandy clay loam with variable gravel content (10 to 60 percent) of the parent material (angular quartzite and schists). Occasionally there are thicker pockets of finer soil but, equally, there are localised areas where bedrock is exposed. Depth to bedrock is consistently less than 1.0 m and averages about 600mm.

Although no specific subsurface investigations were done in the Stage 2 Overburden Area, the soils were observed to be similar to those in the Extraction Area and the area lies on the same soil landscape and has the same general topography and vegetation as the Extraction Area. Therefore, soils here may be managed in the same manner.

3.3 LABORATORY TESTING

Soil samples from TP1 and TP2 were sent to NSW Dept. Lands' Scone Soil Laboratory for suites of chemical and mechanical tests (**Table 2**).

Table 2 – Laboratory tests summary

Test Pit	Soil Type	Physical Tests	Chemical Tests
1 Topsoil	Lithosol	PSA, D%, EAT, OC%	pH, EC, CEC, Exch Cations
1 Subsoil	Lithosol	PSA, D%, EAT, OC%	pH, EC, CEC, Exch Cations
2 Topsoil	Lithosol	PSA, D%, EAT, OC%	pH, EC, CEC, Exch Cations
2 Subsoil	Lithosol	PSA, D%, EAT, OC%	pH, EC, CEC, Exch Cations

Key to Abbreviations:

- PSA = Particle size analysis
- D% = Dispersion percentage
- EAT = Emerson aggregate test
- OC% = Organic carbon percentage
- EC = Electrical conductivity
- CEC = Cation exchange capacity
- Exch Cations = Exchangeable cations (Sodium, Potassium, Calcium, Magnesium)

Sections 3.4 to 3.8 provide an interpretation of the results.

3.4 SOIL ERODIBILITY

3.4.1 K-Factor (Sheet Erosion)

Table 3 contains the results of K-Factor analyses on the four soil samples, derived using the method described in Rosewell (1993). Soil erodibility (K-factor) ranges from 0.023 (moderate) to 0.048 (high). Therefore, despite the gravely nature of the soils in the works area, they are moderately to highly erodible. For the purpose of design, it is recommended that the highest K-Factors be adopted (0.034 for topsoil and 0.048 for subsoil).

Table 3 – Soil Erodibility (from Rosewell, 1993)

Test Pit	Soil Type	K-Factor	Relative erodibility
1 Topsoil	Lithosol	0.034	Moderate
1 Subsoil	Lithosol	0.048	High
2 Topsoil	Lithosol	0.025	Moderate
2 Subsoil	Lithosol	0.023	Moderate

3.4.2 Wind Erosion

Table 4 summarises the key laboratory test results as they relate to the susceptibility of Site soils to wind erosion. The soils have a moderate susceptibility to wind erosion.

Table 4 – Summary of laboratory test results for susceptibility to wind erosion

(Hazelton and Murphy, 2007).

Test pit	Soil Type	Soil texture	Wind erodibility index (t/ha)
1 Topsoil	Lithosol	Fine sandy loam	193
1 Subsoil	Lithosol	Fine sandy clay loam	126
2 Topsoil	Lithosol	Sandy loam	193
2 Subsoil	Lithosol	Sandy loam	193

3.4.3 Soil Loss and Erosion Hazard

The annual soil loss was calculated using the Revised Universal Soil Loss Equation (RUSLE) (Landcom, 2004). The following inputs were used:

- R-factor (rainfall factor): 1550
- Rainfall Zone 7.
- Mean K-factors for each soil layer (from **Table 3**).
- A slope length of 80 m.
- A rill:interill ratio of 3:1.
- P-factor (Conservation practice) of 1.3 (i.e. assuming no specific conservation practices).
- C-factor (Ground cover factor) of 1.0 (i.e. assuming bare soils).

The results of this analysis are contained in **Table 5**. Under the guidelines and recommendations contained in Landcom (2004), construction activities in Rainfall Zone 7 can occur at any time of year using the standard suite of Best Management Practices (BMPs) for erosion and sediment control if the Soil Loss Class is 4 or less.

However, in this case, most soil works would be associated with the Overburden Emplacement and so the Soil Loss Class would be Class 5 (high). This means, either not undertaking these works during the period December to February inclusive or, if that is unavoidable, employing additional practices to reduce the erosion risk. Such practices would include immediately applying adequate ground cover **(Section 5.3.1**) or reducing the slope length to half by using mulch berms, organic wattles etc.

Table 5 – Soil Loss Calculations Using the RUSLE

Soil Type	Mean K-factor (from Table 5)	Typical Slope Gradient	Assumed Slope Length	Calculated Soil Loss (t/ha/yr)	Soil Loss Class (from Landcom, 2004)
Topsoil	0.034	10%	80	192	Class 2 Low
Topsoil	0.034	20%	80	502	Class 5 High
Topsoil	0.034	50%	22[4]	436	Class 4 Moderate
Subsoil	0.048	10%	80	271	Class 3 Low-moderate
Subsoil	0.048	20%	80	708	Class 5 High
Subsoil	0.048	50%	22[4]	616	Class 5 High

3.4.4 Soil Dispersibility

Emerson Aggregate Test (EAT) testing was done to identify potential dispersibility. The results are in **Table 6**.

Table 6 – Emerson Aggregate Test Results and Analysis (Hazelton and Murphy, 2007)

Test pit	Soil Type	EAT Result	Dispersibility
1 Topsoil	Lithosol	8	Not dispersible
1 Subsoil	Lithosol	5	Not dispersible
2 Topsoil	Lithosol	8	Not dispersible
2 Subsoil	Lithosol	8	Not dispersible

[4] The proposed slope length of each lift at the Overburden Emplacement

Further to the EAT results in **Table 6**, an analysis of dispersibility is presented in **Table 7** using the method in Landcom (2004) to identify whether soils are "significantly dispersible". Under this protocol soil from Test Pit 1 was found to be Type D - significantly dispersible. Soils in Test Pit 2 were classified as Type C - coarse.

Table 7 – Soil dispersion laboratory results and analysis

Test Pit	Layer	Dispersion Percentage (%)	PSA Clay %	PSA Silt %	Dispersion significance*	Sediment type
1 Topsoil	Lithosol	78	12	17	16	Type D (dispersible)
1 Subsoil	Lithosol	44	15	17	10.3	Type D (dispersible)
2 Topsoil	Lithosol	71	1	13	5.3	Type C (coarse)
2 Subsoil	Lithosol	55	4	10	5	Type C (coarse)

* Note: 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).

Finally the Exchangeable Sodium Percentage (ESP) was calculated to determine the sodicity of the soils (which can also reflect potential dispersion) (**Table 8**). All soils are non-sodic (Hazleton and Murphy, 2007)

Table 8 – Exchangeable Sodium Percentage (ESP)

Test Pit	Layer	Na (me/100g)	CEC	ESP %	Sodicity
1 Topsoil	Lithosol	0.3	5.6	5.4	Non-sodic
1 Subsoil	Lithosol	0.2	4.3	4.7	Non-sodic
2 Topsoil	Lithosol	0.1	4.0	2.5	Non-sodic
2 Subsoil	Lithosol	0.1	2.5	4	Non-sodic

3.5 ANALYSIS OF CHEMICAL TEST RESULTS

3.5.1 Salinity

The results of electrical conductivity testing of representative soil samples are included in **Table 9**, along with an analysis of their salinity levels. Testing shows the soils are non-saline (Hazelton and Murphy, 2007).

Table 9 – Electrical Conductivity and Salinity

Test Pit	Soil Type	EC (dS/m)	Soil texture	Multiplier factor	ECe	Salinity
1 Topsoil	Lithosol	0.06	Fine sandy loam	14	0.84	Non-saline
1 Subsoil	Lithosol	<0.01	Fine sandy clay loam	9.5	<0.095	Non-saline
2 Topsoil	Lithosol	0.01	Sandy loam	14	0.14	Non-saline
2 Subsoil	Lithosol	0.01	Sandy loam	14	0.14	Non-saline

3.5.2 Cation Exchange Capacity (CEC).

CEC is the capacity of the soil to hold and exchange cations. It is a major controlling agent of the soil's structure, nutrient availability for plant growth and its ability to hold onto nutrients in fertilizers. The results are given in **Table** 10 **10** and show that, in general, the soils have very low CEC (Hazleton and Murphy, 2007).

Table 10 – Cation Exchange Capacities

Test Pit	Soil Type	CEC	Classification
1 Topsoil	Lithosol	5.6	Very low
1 Subsoil	Lithosol	4.3	Very low
2 Topsoil	Lithosol	4.0	Very low
2 Subsoil	Lithosol	2.5	Very low

3.5.3 Base Saturation

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, 2007). **Table 11** shows the results of base saturation analysis showing that:

- Despite their relative infertility, nutrient status is moderate in all samples, and
- Some leaching of nutrients has occurred.

Table 11 – Base Saturations

Test Pit	Soil Type	BS%	Classification
1 Topsoil	Lithosol	51.8	Moderate
1 Subsoil	Lithosol	48.8	Moderate
2 Topsoil	Lithosol	42.5	Moderate
2 Subsoil	Lithosol	57.1	Moderate

3.5.4 pH

The results of pH testing are shown in **Table 12**. The soils are moderate to very strongly acidic (Hazelton and Murphy, 2007).

Table 12 – pH Testing

Test Pit	Soil Type	pH	Classification
1 Topsoil	Lithosol	4.6	Very strongly acid
1 Subsoil	Lithosol	5.6	Moderately acid
2 Topsoil	Lithosol	4.9	Very strongly acid
2 Subsoil	Lithosol	5.1	Strongly acid

3.5.5 Organic Matter

Organic matter is largely responsible for the physical and chemical fertility of a soil. The results (**Table 13**) show that the topsoil across the site has very high organic matter content (Hazelton and Murphy, 2007).

3.6 SOIL STRUCTURE

The topsoils are massive with little structure. The subsoils have a poor to moderate structure. Stripping the subsoils could damage their structure if it was carried out when they were too wet or too dry.

Table 13 – Organic Matter Results and Analysis

Test Pit	Soil Type	Organic Matter (g/100g)	Rating
1 Topsoil	Lithosol	3.34	Very high
1 Subsoil	Lithosol	0.47	Very low
2 Topsoil	Lithosol	3.72	Very high
2 Subsoil	Lithosol	1.21	Moderate

3.7 SOIL DRAINAGE AND WATER HOLDING CAPACITY

The soils are permeable due to their high gravel and sand content. However, that permeability would be affected by shallow bedrock. Therefore, they are classified as Hydrological Group D (Landcom, 2004). Considering that up to two thirds of the soil mass can consist of rock fragments, the water-holding capacity of the soils is not high.

3.8 SOILS SUMMARY

The soils in the proposed extraction area are/have:

- Shallow and gravely
- Infertile
- Poorly structured
- Have low available water holding capacity
- Type D (dispersive) for the purpose of sediment basin design
- Non-sodic
- Strongly acidic
- Very low CEC
- Not saturated with cations
- Highly erodible (topsoil) or moderately erodible (subsoil)
- Are high in organic matter (topsoil)
- Hydrological Group D
- Poor seedbed conditions
- Prone to surface sealing under compaction.

4. LAND AND SOIL CAPABILITY ASSESSMENT

Following the guidelines of OEH (2012), the most limiting constraints are Soil Acidification and Rocky Outcrop. The soils are Lithosols and have:

- A sandy loam surface texture;
- Metamorphic rock as their parent material;
- A very low pH (**Table 12**);
- A shallow depth (often less than 0.5m); and
- Up to 20% rock outcrop (SCA/DLWC, 2002).

The buffering capacity of the soils is very low (OEH, 2012) and, in addition, the site has a mean annual rainfall more than 900mm[5]. For both Soil Acidification and Rocky outcrop, the Land and Soil Capability is Class 6. Class 6 lands have very severe limitations for a wide range of land uses and few management practices are available to overcome them. Soil fertility is very low and the land is suitable only for low productivity grazing (with limitations).

5. RECOMMENDATIONS

5.1 SOIL STRIPPING

Topsoil is thin, about 50 to 100mm and it will be difficult to separately strip it from the thin subsoil underneath. However, the two layers are sufficiently similar to allow them to be stripped together and blended before re-use providing adequate amelioration and fertilising occurs. The act of stripping, moving and stockpiling or respreading should be enough to blend the soils. Furthermore, too much effort could destroy the limited structure the subsoil has. We understand this method has been used in the past at this site, with generally good results on rehabilitated lands.

Soils would be stripped from both the remaining area of the Stage 1 extraction area (1.5ha), the Stage 2 extraction area (16.1ha) and overburden area extension (6.7ha). The soil, all of which occurs on the same soil landscape and is considered a single soil unit, would be stripped in stages in conjunction with disturbance within these areas. Assuming an average soil depth of 600mm, the total soil resource available for stripping is estimated to be 145,000m^3 (although in reality, the volume is likely to be slightly more as the plan areas used to make this estimation will underestimate the actual surface areas which can be quite steep). If possible, soil previously placed over the Stage 1 overburden emplacement as part of the quarry rehabilitation program should also be recovered, although it is noted that the broken nature of the underlying rock may make this difficult.

5.2 STOCKPILING

Soil would be stockpiled in long stockpiles no more than 2m in height and with a maximum side slope of 2H:1V. Stockpiles would be immediately planted with a mix of sterile annual crops (e.g. Japanese Millet, Oats) and with native grasses. Weeds would be controlled so that when the soil is used, the surface vegetation of the stockpiles could be incorporated into the soil as organic matter.

[5] It is 950 mm

5.3 SOIL REUSE

5.3.1 Placement

Most of the soil would be re-used to rehabilitate the overburden area. Here it is proposed to form a benched slope with individual slope gradients of 2H:1V (50%). Assuming a K-Factor 0.048 and an R-Factor of 1,550, Landcom (2004) gives the maximum permissible slope length (i.e. the slope length between benches) as 25m. This equates to the proposed maximum vertical lift of 10m.

If soils are not to be re-worked within 20 days, adequate ground cover would be applied to reduce the C-Factor to 0.15 (50% ground cover). This would be achieved by either the use of soil binder, mulch (natural or hydro-mulch) or other suitable means.

Once the final landform surface is achieved, adequate ground cover would be applied to reduce the C-Factor to 0.1 (60% ground cover). This would be achieved by either the use of mulch (natural or hydro-mulch) or other suitable means. Seeding or planting would also be done with the aim of achieving a C-factor of 0.05 (70% ground cover) within 60 days.

5.3.2 Revegetation

Following stabilisation, the landform would be revegetated, using both tubestock planting and direct seeding techniques, to create native open forest and grassy woodland communities. Noting the microclimate conditions likely to be created within the retained void (increased shading, restricted drainage and reduced evaporation), species would be carefully selected and likely include those capable of tolerating increased shade, damper and possible cooler conditions.

The species to be used as part of this revegetation program would vary dependent on the final landform, i.e. hill top, slopes or drainage line / riparian zone, however, the objective would be to create open forest and grassy woodland communities equivalent to those disturbed and/or occurring on the Site structured approximately as follows.

- Canopy (tree height of 10m to 25m): 10% - 20% Project Foliage Cover (PFC).
- Mid-storey (tree height 3m to 10m): 5% PFC.
- Lower stratum (shrub layer of 1m to 3m): 10% - 20% PFC.
- Grassy ground cover: 55% - 65% PFC.

An indicative list of species that would be used during rehabilitation planting and seeding programs is provided in Section 2.13.5.4 of the EIS.

5.3.3 Fertiliser Use and Amelioration

The soils have very low CEC, but they are not saturated. Therefore, we do not recommend the use of chemical fertilisers unless they are slow-release. The best option to increase fertility would be to use slow-release fertiliser in conjunction with incorporating organic matter. Using organic matter would increase the CEC of the soil so it could retain nutrients for longer.

Organic matter may be sourced from composting of cleared vegetation or from off-site (e.g. compost blankets, sewage treatment plant waste, manure). If sourced from offsite care would be taken to ensure it is pH neutral. Incorporating organic matter would also reduce the soil's susceptibility to water repellence and increase its ability to hold moisture.

The applicant would revegetate using local native species adapted to the strongly acidic soils. However, there could be scope to improve plant growth by increasing pH slightly using a mixture of lime and gypsum. If used, these could be incorporated into the stripping and stockpiling process. Soil acidity affects the soil's CEC and hence its suitability as a growing medium. Increasing the pH would improve the soils, however, it is noted that any modification of soil pH should ensure that revegetation remains consistent with the objective to reinstate the vegetation communities and species of the local setting.

6. CONCLUSION

The Land and Soil Capability for this site is Class 6. The site has very severe limitations for a wide range of land uses and few management practices are available to overcome them. Soil fertility is very low and the land is suitable only for low productivity grazing (with limitations). We conclude the proposed expansion would not detrimentally affect this classification; re-instated soil and landform(s) would have the same classification.

Soils are shallow (<600 mm) and rocky. For the purpose of their management we conclude the topsoil and subsoil are sufficiently similar for them to be treated as a single unit. Given the severe limitations posed by the soils' properties, they are best suited to re-vegetation using endemic local species to re-create create an open forest and grassy woodland community.

During stripping and replacement the exposed soils would be prone to erosion and their erodibility is moderate to high, particularly given the existing and proposed steep slopes. Prompt rehabilitation would be important. The soils are classified as dispersive for the purpose of soil and water management (Landcom, 2004) and so wet-type sediment basins (Type D) would be required if the receiving catchment is external to the excavation(s).

The total soil resource available for stripping is estimated to be 145,000m^3 (although in reality, the volume is likely to be slightly more as the plan areas used to make this estimation will underestimate the actual surface areas which can be quite steep).

7. REFERENCES

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