Sutton Forest Quarries Pty Ltd

ABN 66 158 999 994

Soils Assessment

Specialist Consultant Studies Compendium

Volume 2, Part 10

Prepared by

Strategic Environmental & Engineering Consulting (SEEC) Pty Ltd

February 2018

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Soils Assessment

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* Note: This figure was finalised prior to a late modification to the footprint of the northeastern barrier – the east-west section shown on this figure has been removed – see EIS Figure 2.1.

EXECUTIVE SUMMARY

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd has been commissioned by R.W. Corkery & Co. Pty Limited on behalf of Sutton Forest Quarries Pty Ltd ("the Applicant") to prepare this Soils Assessment for the proposed Sutton Forest Sand Quarry Project ("the Proposal") via Sutton Forest, NSW.

SEEC undertook an inspection of the Site in August 2013, taking selected soil samples for laboratory analyses. For the most part, the soils are coarse grained and of poor fertility. Soil depth is moderate in most areas of the Site but is shallow, or even absent, in parts of the quarry access road corridor.

For the majority of the Site, the Land and Soil Capability Class is Class 5 as a result of significant soil acidity. Class 5 lands are described to have severe limitations for high impact management such as cropping. Fertility is low and Class 5 lands are not prime agricultural lands. There are some management practices available but, agriculturally, the land is best suited to grazing with some limitations and only occasional cropping for pasture improvement. Part of the extraction area has previously been cleared but much of the previously cleared land has been allowed to regenerate.

Topsoil and subsoil should be stripped and stockpiled within the footprint of the extraction area for stockpiling of topsoil and subsoil extracted during the early years of operations when not all topsoil and subsoil stripped can be relocated for rehabilitation purposes.

Soil stability, fertility and moisture holding capability can all be increased by incorporating organic matter before replacement of topsoil. Fertility and vegetation growing conditions could also be improved by using lime, gypsum and slow release organic fertiliser.

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1. INTRODUCTION

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd has been commissioned by R.W. Corkery & Co. Pty Limited on behalf of Sutton Forest Quarries Pty Ltd ("the Applicant") to prepare this Soils Assessment for the proposed Sutton Forest Sand Quarry Project ("the Proposal") via Sutton Forest, NSW.

This report serves to identify specific soils-related constraints and opportunities that might affect the proposed design of the Proposal and its establishment, operation and post-operative rehabilitation. In conducting this assessment, SEEC has:

- conducted a review of existing soil landscape information;
- conducted an extensive field survey of the landforms and soils;
- collected representative soil samples for laboratory testing;
- obtained relevant laboratory test results for specific soil characteristics; and
- analysed the laboratory data to provide recommendations for establishment, operation and rehabilitation.

For the purposes of this document, the Proposal would be undertaken within an area referred to as "the Site" (see **Figure 1**). The Site incorporates the quarry operations area, i.e. the area in which all extraction, processing and related activities would be undertaken. Access between the quarry operations area and the Hume Highway would be via a 1.4km long quarry access road.

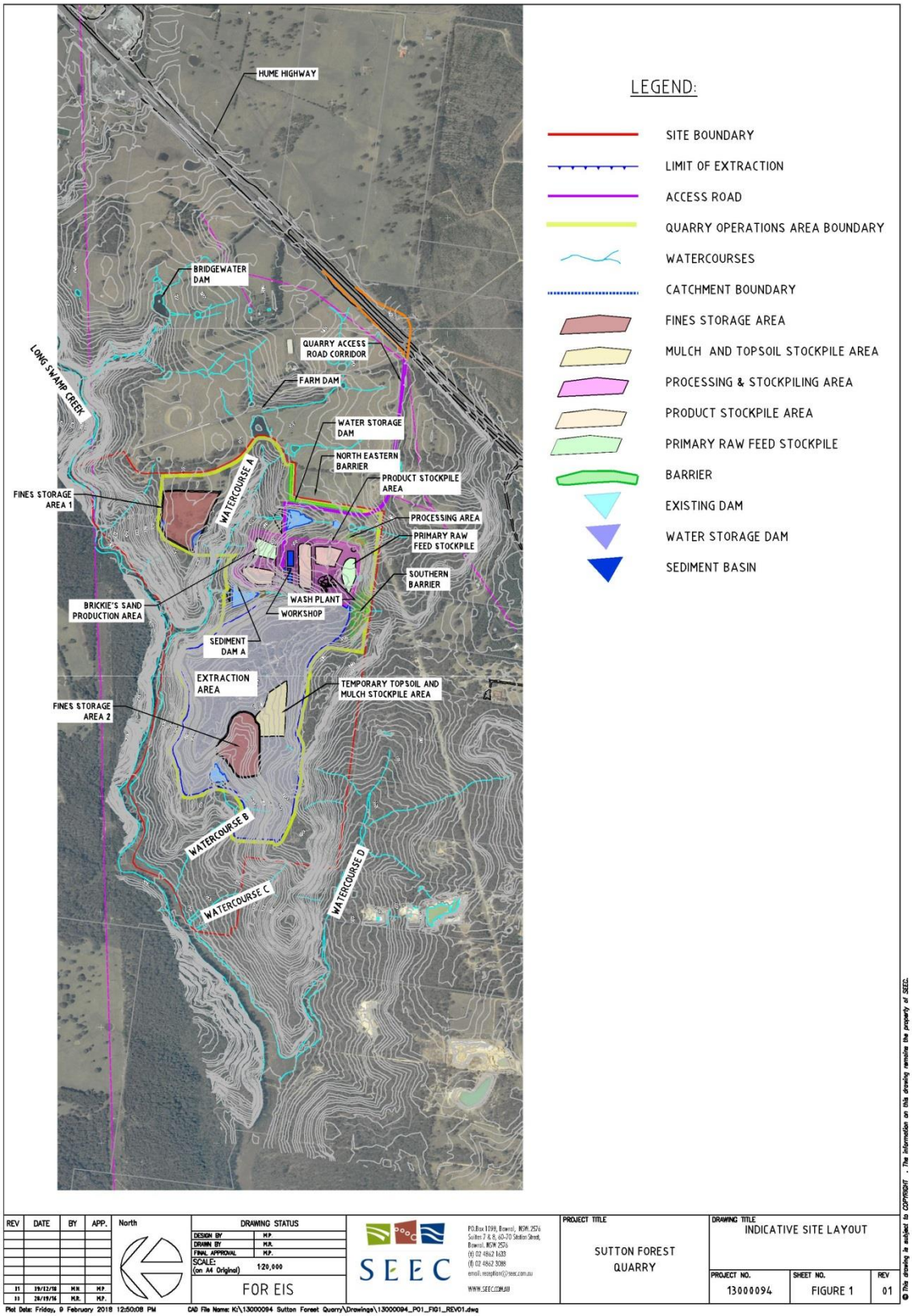

Figure 1 – Site Location and Layout of the Proposal

2. DESCRIPTION OF THE PROPOSAL

The proposed extraction and processing areas, as shown on **Figure 1**, have been defined based upon the occurrence of friable sandstone within the Quarry Operations Area, and taking advantage of the local topography that would provide long term protection to control the propagation of noise to the south and limit the visibility of operational areas from the adjoining properties and the Hume Highway. An estimated 34 million tonnes of friable sandstone has been defined within the proposed extraction area and the footprint of the processing and stockpiling area. This resource is capable of yielding approximately 29 million tonnes of high quality sand products. Negligible overburden is present within the proposed extraction area as the friable sandstone in a number of areas lies directly beneath the soil.

A fixed wash plant and mobile screening plant would be used to process the extracted raw sand to produce high quality sand products meeting nominated Australian Standards and customers' individual specifications. The principal products produced would be various grades of washed concrete sand and mortar (brickie's) sands. The fixed wash plant would be used to produce concrete sand and blended products whereas the mobile screening plant would be used to produce brickie's sand products.

The sand extraction and processing operations have been designed to optimise the recovery of sand whilst satisfying both site and surrounding environmental constraints and progressively backfilling the extraction void with the residual fines from the processing operations together with virgin excavated natural material (VENM) and excavated natural material (ENM) to create a free draining final landform with features that would support the ongoing agricultural and nature conservation land uses.

Figure 1 displays the following principal components of the Proposal.

- An extraction area covering approximately 47ha with its footprint typically between 660m AHD and 700m AHD.
- A processing and stockpiling area covering approximately 12ha incorporating a fixed wash plant involving washing, screening, dewatering and product stockpiling beneath radial and fixed stackers.
- Two mobile brickie's sand plants would ultimately be located within the northern part of the processing and stockpiling area and/or close to the active extraction area.
- A temporary topsoil and mulch stockpile area within the footprint of the extraction area for the storage of topsoil recovered from the early extraction stages and mulched timber from the areas cleared.
- Two fines storage areas to contain fines produced from the sand washing process during the first three stages of extraction.
- Two water storage dams located to the east and west of the processing and stockpiling area to provide water for dust suppression as well as a supplementary supply for the wash plant.
- A diversion drain along the southern boundary of the proposed Quarry Operations Area to divert runoff away from operational areas and capture for reuse in processing and dust suppression.

- The site weighbridge and office would be positioned adjacent to the processing and stockpiling area. One weighbridge would be constructed initially with provision for a second weighbridge, as production ramps up in the future.

The overall operational footprint would be kept as small as practicable and ultimately rehabilitated to provide for ongoing agricultural land uses and long-term nature conservation and wildlife corridor values within the local area.

Access to and from the quarry operations area would be via the quarry access road (**Figure 1)**.

Product despatch would involve the use of truck and dog trailers (tri and quad axle) as well as rigid trucks.

The Applicant proposes to commence production at an initial extraction rate of approximately 250 000tpa (yielding approximately 220 000tpa of sand products) increasing to an average extraction rate of 820 000tpa (yielding approximately 700 000tpa of sand products). The maximum extraction rate proposed is 1Mtpa which would yield approximately 860 000tpa of sand products.

The defined sandstone resource would be extracted in a staged manner, i.e. over eight extraction stages (Stages 0 to 7). The development consent currently being sought would enable extraction of the resource until Year 30. Assuming an average rate of extraction is maintained extraction Stage 5 would be completed by Year 30. The completion of the subsequent extraction stages (Stages 6 and 7) would require an additional development consent beyond Year 30.

The Site would be progressively rehabilitated in a manner that would provide long-term nature conservation and wildlife corridor values of the local area together with some agricultural/horticultural opportunities for the landowner.

3. SOILS INVESTIGATION

3.1 SOIL LANDSCAPE MAPPING

3.1.1 Distribution

SCA/DLWC (2002) mapping (**Figure 2**) identifies that:

- the extraction area (including the topsoil and mulch stockpile and fines storage area 2) lies mostly on the Soapy Flat Soil Landscape with minor occurrences of the Penrose and Nattai Tablelands Soil Landscapes;
- the processing and stockpiling area lies on the Larkin Variant a Soil Landscape and an area of 'disturbed ground';
- the quarry access road lies mostly on the Larkin Variant a Soil Landscape with a minor section on the Soapy Flat Soil Landscape;
- Fines storage area 1 is on the Larkin Variant a Soil Landscape.

Table 1 lists the approximate areas of each soil landscape. The soil landscapes are summarised in Sections 3.1.2 to 3.1.7; all descriptions are from SCA/DLWC (2002).

Table 1 – Soil Landscapes within the Site

Soil Landscape	Site Location	Site Area (ha)
Soapy Flat	extraction area	21.5
	quarry access road	0.27
Penrose	extraction area	4.2
Larkin Variant a	extraction area	0.9
	processing and stockpiling area	7.2
	quarry access road	1.05
	fines storage area 1	5.0
Nattai Tablelands	extraction area	12.7
	processing and stockpiling area	4.74
Disturbed	processing and stockpiling area	0.06
	quarry access road	0.05

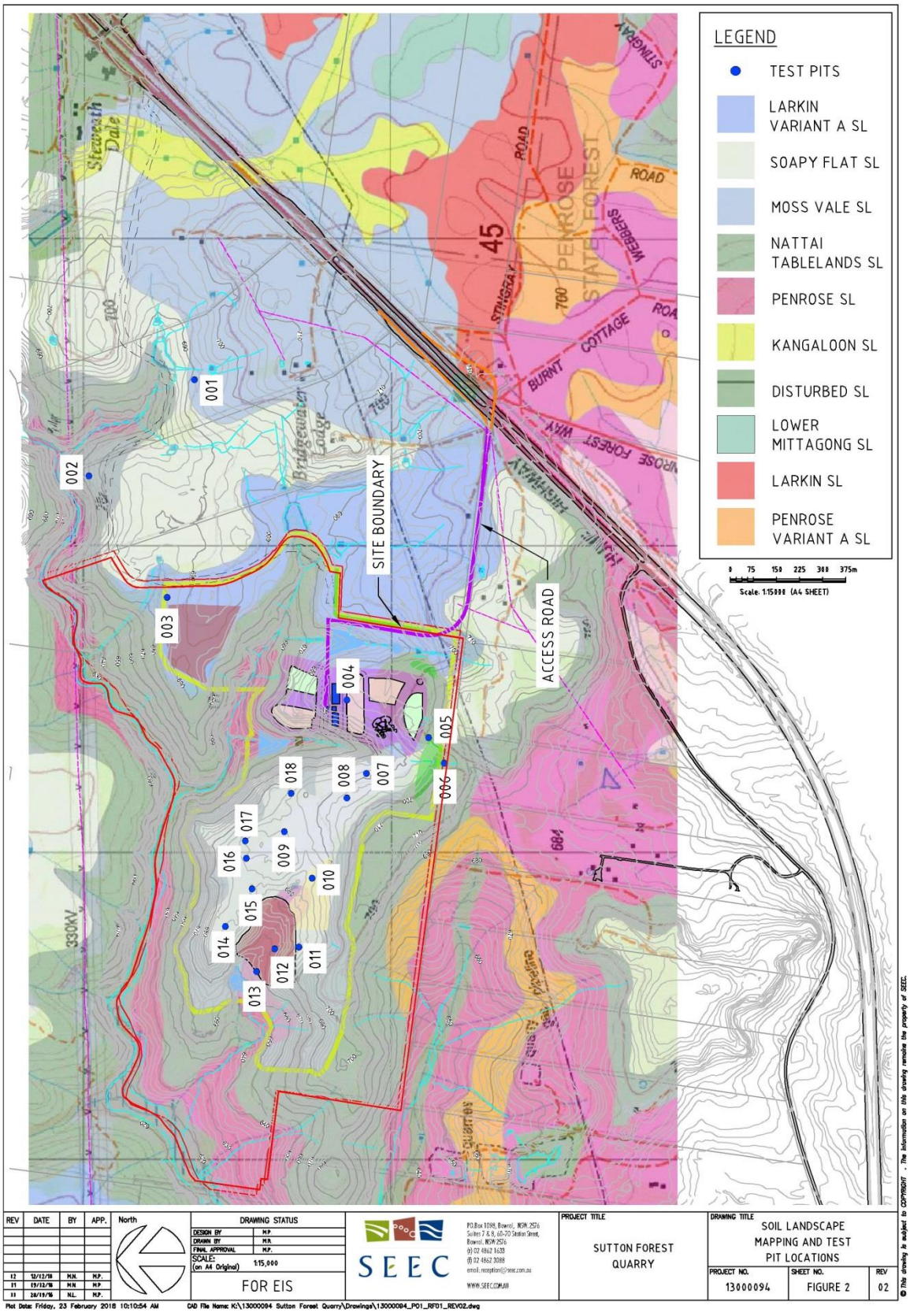

Figure 2 – Soil Landscapes and Locations of Test Pits

3.1.2 Soapy Flat Soil Landscape

This landscape occurs on gently undulating rises to undulating low hills on Hawkesbury Sandstone in the Moss Vale Tablelands. There are four landscape facets[1] comprising:

- imperfectly drained hills: Yellow Kurosols and Chromosols (Yellow Podzolic soils);
- well drained hillslopes and crests: Brown Dermosols (Brown Podzolic soils);
- ridges and footslopes: Orthic Tenosols (Earthy Sands); and
- swampy areas: Hydrosols (Acid Peats).

3.1.3 The Penrose Soil Landscape

This landscape occurs on undulating rises to undulating low hills formed on Hawkesbury Sandstone. There are four landscape facets[1] comprising:

- upper slopes and gentle slopes: Kandosols (Yellow Earths);
- mid-slopes: Orthic Tenosols (Earthy Sands);
- lower slopes: Sodosols (Solodic Soils); and
- poorly drained areas: Grey Kurosols (Grey Podzolic Soils).

3.1.4 The Nattai Tablelands Soil Landscape

This Landscape occurs on undulating to rolling elevated hills on Hawkesbury Sandstone. There are three landscape facets[1] comprising:

- broad crests and inside benches: Yellow Kandosols (Yellow Earths);
- narrow crests and sideslopes: Tenosols (Earthy Sands), Rudosols (Lithosols); and
- soil on shale lenses: yellow Kurosols and Chromosols (Yellow Podzolic Soils).

3.1.5 The Larkin Variant a Soil Landscape

This landscape predominantly occurs as a residual soil derived from lateritic substrate. There are three landscape facets comprising:

- gentle slopes: Ferrosols (Lateritic Red Earths);
- change in slopes and substrate material: Ferrosols (Lateritic Red Podzolic Earths); and
- areas with higher clay content: Ferrosols (Lateritic Krasnozems).

[1] Refer to Glossary of Terms **Section 6**

3.2 SITE INVESTIGATIONS

3.2.1 Introduction

Soils were investigated by excavating 18 test pits across the Site (**Figure 2**)**.** Twelve test pits were excavated within the extraction area and the remaining six test pits were excavated within, or in the proximity of the processing and stockpiling area and the quarry access road. The corresponding soil landscapes are listed in **Table 2**.

Table 2 – Test Pits and Soil Landscapes

Soil Landscape	Test Pit Numbers (TP)
Soapy Flat	1, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18
Penrose	12, 13
Larkin Variant a	3, 4
Nattai Tablelands	2, 5, 6

Access restrictions limited the investigation of the Nattai Tablelands Soil Landscape to one test pit (TP2). The soil depth at TP2 was observed to be 400 mm, which is typical of this soil landscape.

3.2.2 Soil Profiles

The individual soil logs from the various test pits are given in **Appendix 2**. Soil profile investigations demonstrate the accuracy of the soil landscape mapping, with soil profiles being generally consistent with those predicted by the soil landscape mapping. In the extraction area, very sandy, acidic soils (earthy sands) were encountered. The Larkin Variant a Soil Landscape that occurs in the processing and stockpiling area and most of the quarry access road comprises soils with a slightly higher fraction of clay and silt but the soils are still very sandy (sandy clay loam). Soils on the Nattai Tablelands Soil Landscape were visually thin and often absent.

Topsoil depth varies from 0 to approximately 0.2m for all soils across the Site.

3.3 LABORATORY TESTING

Soil samples were sent to NSW Department of Lands' Scone Soil Laboratory for suites of chemical and physical tests (**Table 3**).

As previously noted, access to those areas mapped as the Nattai Tablelands Soil Landscape (SCA/DLWC, 2002) was limited. As a result, only a single test pit (TP2) was excavated on this soil landscape. Where data are presented for the Nattai Tablelands Soil Landscape, they have either been interpreted from typical data for the soil texture described in TP2 or derived from SCA/DLWC (2002).

Sections 3.4 and 3.5 provide the results and interpretation of laboratory testing.

Table 3 – Laboratory Testing Schedule

Test Pit & Layer	Soil Landscape	Soil Type	Physical Tests	Chemical Tests
8 Layer 1	Soapy Flat	Loamy sand	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
8 Layer 2		Sandy loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
8 Layer 3		Sandy clay loam	PSA, D%, EAT, OC%, K	nt
14 Layer 1		Sandy loam	PSA, D%, EAT, OC%, BD	pH, EC, CEC, Exch Cations
14 Layer 2		Sandy loam	PSA, D%, EAT, OC%, BD	pH, EC, CEC, Exch Cations
16 Layer 1		Sandy loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
16 Layer 2		Sandy loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
16 Layer 3		Clayey sand	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
13 Layer 1	Penrose	Loamy sand	PSA, D%, EAT, OC%, K	pH, EC, CEC, Exch Cations
13 Layer 2		Clayey sand	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
3 Layer 1	Larkin Variant a	Sandy loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
3 Layer 2		Sandy loam	PSA, D%, EAT, OC%, BD	pH, EC, CEC, Exch Cations
4 Layer 1		Sandy clay loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
4 Layer 2		Sandy clay loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
4 Layer 3		Sandy clay loam	PSA, D%, EAT, OC%, K, BD	pH, EC, CEC, Exch Cations
4 Layer 4		Loamy sand	PSA, D%, EAT, OC%, BD	nt

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
- K = K-Factor
- BD = Bulk Density
- Exch Cations = Exchangeable cations (Sodium, Potassium, Calcium, Magnesium)
- nt = not tested

3.4 SOIL ERODIBILITY

3.4.1 K-Factors

Table 4 contains the results of K-Factor (Sheet Erosion) analyses derived using the method described in Rosewell (1993) and Rosewell (2005). Soil erodibility (K-factors) range from 0.013 (low) for clayey sand to 0.027 (moderate) for a sandy clay loam. Soils have a low to moderate susceptibility to sheet erosion. For design purposes, the raw results have been consolidated to give the values in **Table 5.**

Table 4 – Soil Erodibility

Test Pit & Layer	Soil Landscape	Soil Type	K-Factor[2]	Relative erodibility
8 Layer 1	Soapy Flat	Loamy sand	0.014	Low
8 Layer 2		Sandy loam	0.023	Moderate
8 Layer 3		Sandy clay Loam	0.024	Moderate
16 Layer 1		Sandy loam	0.025	Moderate
16 Layer 2		Sandy loam	0.019	Low
16 Layer 3		Clayey sand	0.013	Low
13 Layer 1	Penrose	Loamy sand	0.016	Low
13 Layer 2		Clayey sand	0.017	Low
4 Layer 1	Larkin Variant a	Sandy clay loam	0.027	Moderate
4 Layer 2		Loamy sand	0.012	Low
4 Layer 3		Loamy sand	0.01	Low
2 Layer 1[3]	Nattai Tablelands	Sand	0.015	Low
2 Layer 2		Sandy loam	0.03	Moderate

Table 5 – Adopted K-Factors for Design

Soil Landscape	Soil Layer	Adopted K-Factor for Design
Soapy Flat	All layers	0.020
Penrose	All layers	0.017
Larkin Variant a	Topsoil	0.027
	Subsoil	0.012
Nattai Tablelands	Topsoil	0.029
	Subsoil	0.051

[2] Taken from Rosewell, 1993 and Rosewell and Edwards, 1988 (i.e. not site-specific tested)
[3] Derived from field texture

3.4.2 Wind Erosion

Table 6 summarises the soils' susceptibility to wind erosion. Most soils have high susceptibility (Hazelton and Murphy, 2007). This is a reflection of their granular, non-cohesive, nature.

Table 6 – Summary of laboratory Test Results for Susceptibility to Wind Erosion.

Test pit	Soil Landscape	Soil Type	Wind Erodibility index (t/ha)	Wind Erodibility Group*
8 Layer 1	Soapy Flat	Loamy sand	300	2
8 Layer 2		Sandy loam	193	3
14 Layer 1		Sandy loam	193	3
14 Layer 2		Sandy loam	193	3
16 Layer 1		Sandy loam	193	3
16 Layer 2		Sandy loam	193	3
16 Layer 3		Clayey sand	300	2
13 Layer 1	Penrose	Loamy sand	300	2
13 Layer 2		Clayey sand	300	2
3 Layer 1	Larkin Variant a	Sandy loam	193	3
3 Layer 2		Sandy loam	193	3
4 Layer 1		Sandy clay loam	126	5
4 Layer 2		Sandy clay loam	126	5
4 Layer 3		Sandy clay loam	126	5
2 Layer 1	Nattai Tablelands	Sand	300	2
2 Layer 2		Sandy loam	193	3
* The Wind Erodibility Index ranges from 1 to 8 with higher numbers being less susceptible				

3.4.3 Soil Loss and Erosion Hazard

The average annual soil loss was calculated using SOILOSS 5.3 (Rosewell, 2005), which is based on the Revised Universal Soil Loss Equation (RUSLE). For the purposes of this analysis, the following inputs were used (Landcom, 2004).

- R-factor (rainfall factor): 2,040 in Rainfall Zone 7.
- Design K-factors for each soil landscape (from **Table 5**).
- Slope gradients 5%, 10% and 20%, depending on location.
- A slope length of 80m.
- 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 7.** The results show special measures such as timing of works, covering soils during rainfall etc. would only be required if the works are on either the Larkin Variant a or Nattai Tablelands Soil Landscapes and where exposed soils occur on lands sloping more than 20 percent. This would rarely occur but, if it did, special measures for erosion and sediment control as described in Chapter 4 of Landcom (2004) would apply.

Table 7 – Soil Loss Calculations

Layer	Soil Landscape	General Soil Type	K-Factor	Calculated Soil Loss (t/ha/yr) 5% slope	Soil Loss Class 5% slope	Calculated Soil Loss (t/ha/yr) 10% slope	Soil Loss Class 10% slope	Calculated Soil Loss (t/ha/yr) 20% slope	Soil Loss Class 20% slope	Relative Erosion Hazard
All	Soapy Flat	Loamy sand	0.02	63	1	149	1	388	4	Moderate
All	Penrose	Loamy sand	0.017	54	1	127	1	330	3	Low – Moderate
Layer 1	Larkin	Sandy loam	0.027	85	1	201	2	524	5	High
Layer 2		Sandy loam	0.012	38	1	89	1	233	3	Low to Moderate
Layer 3		Sandy loam	0.01	31	1	74	1	194	2	Low
Layer 1	Nattai Tablelands	Sand	0.015	47	1	112	1	291	3	Low to Moderate
Layer 2		Sandy loam	0.03	94	1	223	2	582	5	High

Under the guidelines and recommendations contained in Landcom (2004), construction activities in Rainfall Zone 7 (i.e. this site) 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. This is the case across the Site except where a slope is greater than 20 percent. Given that such slopes are unlikely to occur in the area of disturbance, the standard suite of erosion and sediment controls as described in Landcom (2004) and DECC (2008) can be considered adequate.

3.4.4 Soil Dispersibility

Emerson Aggregate Test (EAT) testing was undertaken to identify potential dispersibility. The results are in **Table 8** (Charman and Murray, 2007).

Table 8 – Emerson Aggregate Test Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	EAT Result	Dispersibility
8 Layer 1	Soapy Flat	Loamy sand	3 (1)	Not Dispersive
8 Layer 2		Sandy loam	5	Not Dispersive
16 Layer 1		Sandy loam	5	Not Dispersive
16 Layer 2		Sandy loam	5	Not Dispersive
16 Layer 3		Clayey sand	5	Not Dispersive
13 Layer 1	Penrose	Loamy sand	3 (1)	Not Dispersive
13 Layer 2		Clayey sand	2 (1)	Dispersive
4 Layer 1	Larkin Variant a	Sandy clay loam	5	Not Dispersive
4 Layer 2		Sandy clay loam	6	Not Dispersive
4 Layer 3		Sandy clay loam	6	Not Dispersive
4 Layer 4		nt	6	Not Dispersive

Further to the EAT results in **Table 8**, an analysis of dispersibility is presented in **Table 9** using the method in Landcom (2004) to identify whether soils are “significantly dispersible”. The results of that analysis indicate the soils are Type C (coarse) and are not considered to be “significantly dispersible”.

Table 9 – Soil Dispersion Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	Dispersion Percentage (%)	PSA Clay %	PSA Silt %	Dispersion significance*	Sediment type
8 Layer 1	Soapy Flat	Loamy sand	12	9	0	1.08	Type C (coarse)
8 Layer 2		Sandy loam	38	9	6	4.56	Type C (coarse)
8 Layer 3		Clayey sand	40	20	6	9.20	Type C (coarse)
16 Layer 1		Sandy loam	29	8	7	3.34	Type C (coarse)
16 Layer 2		Sandy loam	43	10	6	5.59	Type C (coarse)
16 Layer 3		Clayey sand	57	6	4	4.56	Type C (coarse)
13 Layer 1	Penrose	Loamy sand	15	10	3	1.73	Type C (coarse)
13 Layer 2		Clayey sand	38	3	5	2.09	Type C (coarse)
4 Layer 1	Larkin Variant a	Sandy clay loam	17	17	11	3.83	Type C (coarse)
4 Layer 2		Sandy clay loam	17	na	na	na	na
4 Layer 3		Sandy clay loam	14	na	na	na	na
Layer 1	Nattai Tablelands	Sand	-	-	-	-	Type C[4]
Layer 2		Sandy loam	-	-	-	-	Type C[4]

* Note:
The percent of the whole soil dispersible is calculated from (preferably) 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).

[4] Derived from field texture (TP2) using typical values from Landcom (2004).

The Exchangeable Sodium Percentage (ESP) was calculated to determine the sodicity of the soils, which is also representative of potential dispersion (Hazleton and Murphy, 2007) (**Table 10**). Only soils from TP16 were found to be marginally sodic to strongly sodic (Layer 3). All other soils were non-sodic.

Table 10 – Exchangeable Sodium Percentage (ESP) Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	Na (me/100g)	CEC	ESP %	Sodicity
8 Layer 1	Soapy Flat	Loamy sand	0.1	3.8	2.6	Non-sodic
8 Layer 2		Sandy loam	0.1	3.6	2.8	Non-sodic
13 Layer 1		Loamy sand	0.2	4	5.0	Non-sodic
13 Layer 2		Clayey sand	0.1	2	5.0	Non-sodic
16 Layer 1		Sandy loam	0.1	0.8	12.5	Marginally sodic to sodic
16 Layer 2		Sandy loam	0.2	2.7	7.4	Marginally sodic to sodic
16 Layer 3		Clayey sand	0.1	0.6	16.7	Strongly sodic
14 Layer 1	Penrose	Sandy loam	0.1	3.1	3.2	Non-sodic
14 Layer 2		Sandy loam	0.2	4.2	4.8	Non-sodic
3 Layer 1	Larkin Variant a	Sandy loam	0.1	3.6	2.8	Non-sodic
3 Layer 2		Sandy loam	0.2	3.7	5.4	Non-sodic
4 Layer 1		Sandy clay loam	0.2	3.8	5.3	Non-sodic
4 Layer 2		Sandy clay loam	0.1	3.1	3.2	Non-sodic
4 Layer 3		Sandy clay loam	0.2	4.1	4.9	Non-sodic

3.5 SOIL CHEMICAL TESTING

3.5.1 Salinity

The results of electrical conductivity testing of representative soil samples are included in **Table 11**, along with an analysis of their salinity levels (Hazleton and Murphy, 2007). Testing shows the soils are not saline.

Table 11 – Electrical Conductivity and Salinity Test Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	EC (dS/m)	Multiplier factor	ECe	Salinity
8 Layer 1	Soapy Flat	Loamy sand	<0.01	23	<2	Non-saline
8 Layer 2		Sandy loam	<0.01	14	<2	Non-saline
13 Layer 1		Loamy sand	<0.01	23	<2	Non-saline
13 Layer 2		Clayey sand	<0.01	23	<2	Non-saline
16 Layer 1		Sandy loam	<0.01	14	<2	Non-saline
16 Layer 2		Sandy loam	<0.01	14	<2	Non-saline
16 Layer 3		Clayey sand	<0.01	23	<2	Non-saline
14 Layer 1	Penrose	Sandy loam	<0.01	14	<2	Non-saline
14 Layer 2		Sandy loam	<0.01	14	<2	Non-saline
3 Layer 1	Larkin Variant a	Sandy loam	<0.01	14	<2	Non-saline
3 Layer 2		Sandy loam	<0.01	14	<2	Non-saline
4 Layer 1		Sandy clay loam	<0.01	9.5	<2	Non-saline
4 Layer 2		Sandy clay loam	<0.01	9.5	<2	Non-saline
4 Layer 3		Sandy clay loam	<0.01	9.5	<2	Non-saline
2 Layer 1	Nattai Tablelands	Sand	-	-	-	Non-saline[5]
2 Layer 2		Sandy loam	-	-	-	Non-saline[5]

[5] As reported in SCA/DLWC (2002)

3.5.2 Cation Exchange Capacity

Cation Exchange Capacity (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 fertilisers and make them available to plants. The results are given in **Table 12** and show all the soils have very low CEC (Hazleton and Murphy, 2007).

Table 12 – Cation Exchange Capacity Test Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	CEC	Classification
8 Layer 1	Soapy Flat	Loamy sand	3.8	Very low
8 Layer 2		Sandy loam	3.6	Very low
13 Layer 1		Loamy sand	4	Very low
13 Layer 2		Clayey sand	2	Very low
16 Layer 1		Sandy loam	0.8	Very low
16 Layer 2		Sandy loam	2.7	Very low
16 Layer 3		Clayey sand	0.6	Very low
14 Layer 1	Penrose	Sandy loam	3.1	Very low
14 Layer 2		Sandy loam	4.2	Very low
3 Layer 1	Larkin Variant a	Sandy loam	3.6	Very low
3 Layer 2		Sandy loam	3.7	Very low
4 Layer 1		Sandy clay loam	3.8	Very low
4 Layer 2		Sandy clay loam	3.1	Very low
4 Layer 3		Sandy clay loam	4.1	Very low

3.5.3 Base Saturation

Base saturation is the percentage of cation exchange capacity that is saturated with potassium, calcium, magnesium and sodium ions. 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 13** shows the results, demonstrating that the soils are significantly leached and there would be opportunity to raise their fertility. However, any efforts to raise fertility should be done by incorporating organic matter and slow release organic fertilisers, otherwise nutrients would likely leach from the soil (as suggested by the low CEC (**Table 12**)).

Table 13 – Base Saturation Test Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	BS%	Classification
8 Layer 1	Soapy Flat	Loamy sand	34	Low
8 Layer 2		Sandy loam	28	Low
13 Layer 1		Loamy sand	33	Low
13 Layer 2		Clayey sand	40	low-mod
16 Layer 1		Sandy loam	75	High
16 Layer 2		Sandy loam	41	Moderate
16 Layer 3		Clayey sand	-	-
14 Layer 1	Penrose	Sandy loam	29	Low
14 Layer 2		Sandy loam	40	low-mod
3 Layer 1	Larkin Variant a	Sandy loam	75	High
3 Layer 2		Sandy loam	43	Moderate
4 Layer 1		Sandy clay loam	50	Moderate
4 Layer 2		Sandy clay loam	42	Moderate
4 Layer 3		Sandy clay loam	46	Moderate

3.5.4 Acidity and Alkalinity

The results of pH testing are shown in **Table 14.** The soils are moderately to strongly acidic across the site (Hazleton and Murphy, 2007).

Table 14 – pH Test Results and Analysis

Test Pit & Layer	Soil Landscape	Soil Type	pH (water)	pH ($CaCl_2$)	Classification
8 Layer 1	Soapy Flat	Loamy sand	5.3	4	Strongly acid
8 Layer 2		Sandy loam	5.7	4.3	Moderately acid
13 Layer 1		Loamy sand	5.5	4.3	Strongly acid
13 Layer 2		Clayey sand	5.6	4.5	Moderately acid
16 Layer 1		Sandy loam	5.3	4.4	Strongly acid
16 Layer 2		Sandy loam	5.8	4.5	Moderately acid
16 Layer 3		Clayey sand	5.7	4.6	Moderately acid
14 Layer 1	Penrose	Sandy loam	5.4	4.3	Strongly acid
14 Layer 2		Sandy loam	6.0	4.6	Moderately acid
3 Layer 1	Larkin Variant a	Sandy loam	6.1	5	Slightly acid
3 Layer 2		Sandy loam	5.7	4.5	Moderately acid
4 Layer 1		Sandy clay loam	5.7	4.6	Moderately acid
4 Layer 2		Sandy clay loam	5.5	4.4	Strongly acid
4 Layer 3		Sandy clay loam	5.8	4.5	Moderately acid
2 Layer 1	Nattai Tablelands	Sand	4.5 to 6.0	-	Moderately to strongly acidic
2 Layer 2		Sandy loam	5.0 to 6.0	-	Moderately to slightly acid

3.5.5 Organic Matter

Organic matter is largely responsible for the physical and chemical fertility of a soil. The results **(Table 15)** show the topsoils have moderate to high organic matter content but the subsoils have very low to extremely low organic matter (Hazelton and Murphy, 2007). An addition of organic material into the soils when using them for rehabilitation works would improve soil structure and the potential cation exchange capacity.

Table 15 – Organic Matter Test Results and Analysis

Test Pit& Layer	Soil Landscape	Soil Type	Organic Matter (g/100g)	Rating
8 Layer 1	Soapy Flat	Loamy sand	2.22	High
8 Layer 2		Sandy loam	0.58	Very low
8 Layer 3		Sandy clay loam	0.16	Extremely low
13 Layer 1		Loamy sand	2.40	High
13 Layer 2		Clayey sand	0.24	Extremely low
16 Layer 1		Sandy loam	1.16	Moderate
16 Layer 2		Sandy loam	0.26	Extremely low
16 Layer 3		Clayey sand	0.09	Extremely low
4 Layer 1	Larkin Variant a	Sandy clay loam	1.57	Moderate
4 Layer 2		Sandy clay loam	0.52	Very low
4 Layer 3		Sandy clay loam	0.14	Extremely low
4 Layer 4		Loamy sand	0.07	Extremely low

3.6 SOIL STRUCTURE

Field investigation of the soils in the extraction area and the processing and stockpiling area showed they are generally massive with apedal structure. This is to be expected because of their sandy texture. Where the silt and clay content is a little higher (i.e. loamy), a weak structure was observed.

3.7 SOIL DRAINAGE

Soils in the extraction area, the processing and stockpiling area and much of the quarry access road corridor have high surface infiltration rates and so soil drainage is rapid because of the sandy texture. Four of the primary soil landscapes are estimated to belong to Hydrological Group B (Landcom (2004), these being the Larkin Variant a, Soapy Flat, Nattai Tablelands and Penrose Soil Landscapes. Surface runoff would be low to moderate and is estimated to be no more than 8 percent of mean annual rainfall (SEEC, 2018).

3.8 LAND AND SOIL CAPABILITY ASSESSMENT

The Site's Land and Soil Capability (LSC) is assessed by considering its biophysical features and individual hazards (OEH, 2012) (**Table 16**). For all lands the most limiting hazard is acidification so almost all the soils across the Site have an LSC Class 5. Class 5 lands are described to have severe limitations for high impact management such as cropping. There are some management practices available but the land is best suited to grazing with some limitations and only occasional cropping for pasture improvement. Fertility is low. Class 5 lands are not prime agricultural land. Therefore, there would be little, if any, impact on existing or potential agricultural activities.

Table 16 – LSC Hazard Assessments

Hazard	Description	LSC Class Rating
Water erosion (Slope Class)	The site has slopes >3<10%	Class 3
Wind erosion	Surface soil is sandy loam and loamy sand with 10-20% clay. Mean annual rainfall is > 500mm Exposure is high (crest)	Class 2 - 3
Soil structure decline	Surface soil is sandy loam and loamy sand with 10-20% clay.	Class 3
Soil acidification	Surface soils are sandy loam and loamy sand. pH ($CaCl_2$) is generally 4.0 to 4.7 Mean annual rainfall is about 900 mm	Class 5
Salinity	Recharge potential is high. Discharge potential is low. Soils are not saline.	Class 1
Water logging	Soils are rapidly drained and well drained	Class 1
Shallow soil and rockiness	Soil depth is >100cm. Bedrock exposure is localised	Class 2
Mass movement	Mean annual rainfall is about 900 mm No mass movement present	Class 1
The most limiting hazard is soil acidification – Class 5		

3.9 SOILS SUMMARY

The soils in the extraction area, processing and stockpiling area and the proposed Quarry access road:

- are moderately erodible;
- are Type C (coarse) for the purpose of sediment basin design[6];
- are infertile;
- are not dispersive;
- are non-sodic;

[6] Although site-specific soil variations and adopted water quality targets might necessitate an alternative design.

- are strongly acidic;
- have very low CEC;
- are not saturated with cations;
- are highly permeable;
- have a low water-holding capacity; and
- are prone to acidification.

The land and soil capability class is Class 5 (severe limitations to agricultural production); the lands are not prime agricultural land.

4. RECOMMENDATIONS

4.1 SOIL STRIPPING

4.1.1 Extraction Area

Soils in the extraction area mainly represent the Soapy Flat Soil Landscape with minor occurrences of the Penrose and Nattai Tablelands Soil Landscapes. The soils of the Soapy Flat Soil Landscape generally have a thin (200 mm) but well-defined, topsoil layer (A-Horizon) that has a relatively high organic content. The B1 horizon varies from about 300mm to 500 mm in thickness.

The Penrose and Nattai Tablelands Soil Landscapes have an overall shallower total soil thickness, significantly so in the case of the Nattai Tablelands. However, the A1 horizon is a similar thickness (150 to 200mm).

The A and B of each of these landscape horizons are sufficiently dissimilar to require separation, so topsoil stripping is recommended to no more than 200mm depth. Topsoil should be stockpiled separately in low (less than 2m high) stockpiles. Weeds are not expected to be problematic in the natural soil, but to prevent their potential proliferation stockpiles should be immediately vegetated with appropriate grass cover. While some of the subsoil material below 200mm might be suitable for extraction, significant quantities of loamy subsoil will also require stripping and stockpiling. Average stripping depths for subsoil vary between 500mm and 800mm below existing ground level. Subsoil should be stockpiled separately in stockpiles up to 4m high.

4.1.2 The Quarry Access Road

The quarry access road would predominantly be on the Larkin Variant “a” Soil Landscape with a minor occurrence on the Soapy Flat Soil Landscape. Both soil landscapes have a well-defined topsoil layer that would be stripped separately to the subsoil. Both topsoils are about 200mm thick but the subsoil thickness varies. The A and B horizons are sufficiently dissimilar to require separation, so topsoil stripping would be done to no more than 200mm depth.

Any subsoil stripped within the footprint of the quarry access road (i.e. subsoil not targeted for extraction) would be stockpiled separately to topsoil. Topsoil would either be stored temporary stockpiles or used to stabilise roadside batters. Weeds might be more problematic in the natural soil but to prevent their potential proliferation they would be sprayed prior to land clearing and stockpiles would be immediately vegetated with appropriate grass cover. Any subsoil recovered would be stockpiled and covered with topsoil.

4.1.3 Soil Volumes

4.1.3.1 Extraction Area

The extraction would be undertaken in a number of Stages (**Figure 3**). Stages 0, 1 and 2 combined would cover an area of approximately 30ha and soil stripped from them would need to be stockpiled until Stage 3 commences, at which time progressive backfill with filter cake residue and oversized material would occur.

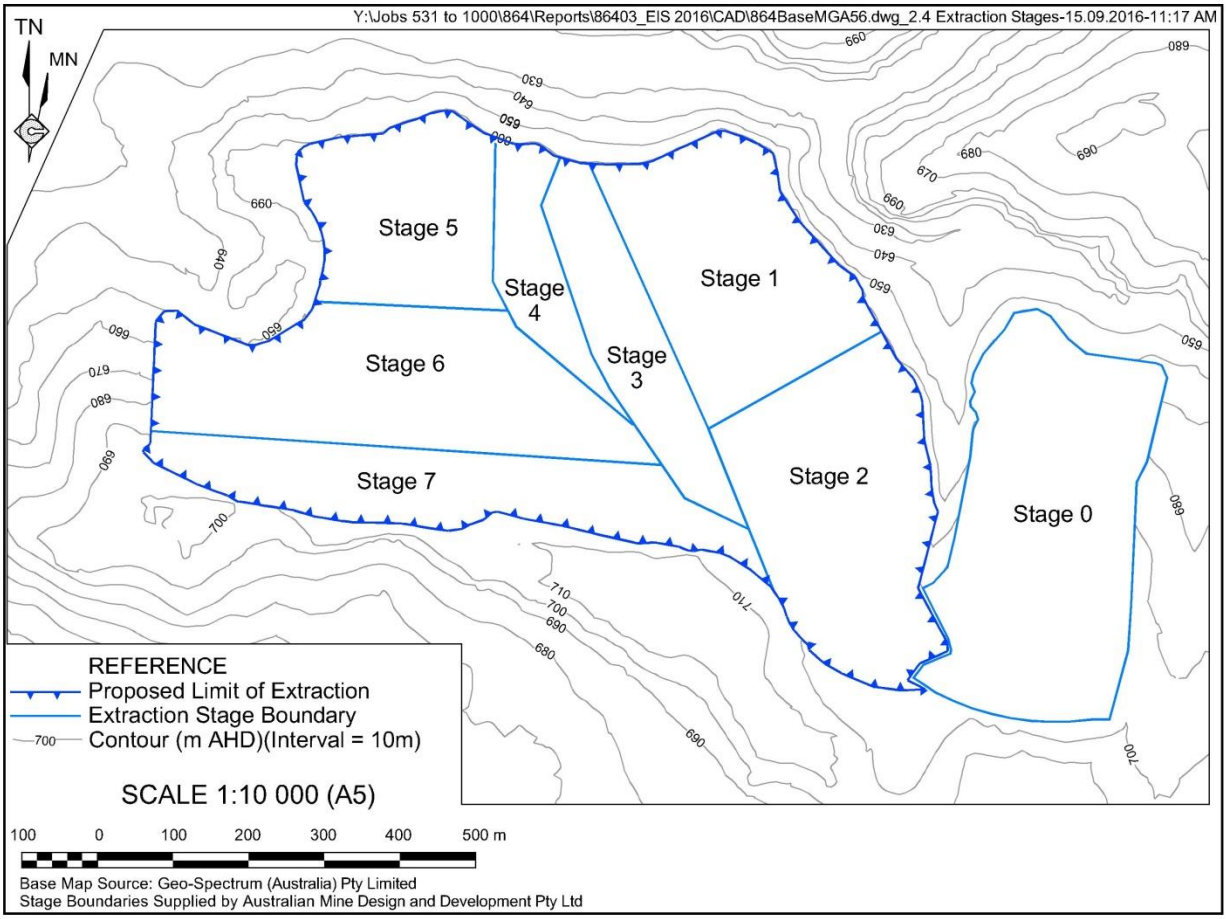

Figure 3 – Indicative Extraction Stages

Assuming:

- a topsoil depth of 200mm;
- a maximum topsoil stockpile height of 2m;
- a subsoil depth of 500mm; and
- a maximum subsoil stockpile height of 10m

About 4.5ha[7] of land would be required for temporary topsoil stockpiles and approximately 2.5ha[8] would be required for subsoil stockpiles. The Applicant has identified an area for soil stockpiling located within the footprint of the extraction area (**Figure 1**).

4.1.3.2 Quarry Access Road

The quarry access road would be approximately 1.4km in length from The Hume Highway to the weighbridge with an average 10m width of disturbance. It would be constructed largely at ground level with little cut and fill. Some topsoil would be used to rehabilitate roadside batters (where in soil) but the bulk will be stored in the temporary topsoil stockpiles. Based on the

[7] 300,000m^2 x 0.2m = 60,000m^3/2m = 30,000m^2 plus side slopes and access.
[8] 300,000m^2 x 0.5m = 150,000m^3/10 = 15,000m^2 plus side slopes and access.

preliminary road design, on average about 10m of land within the road corridor would require stripping. Therefore, the approximate volume of stripped topsoil would be 2,740m^3.

There would be only a minor volume of subsoil produced. This material would be transferred to the quarry operations area for use in the construction of the noise amenity barriers along with any excess topsoil.

4.2 SOIL RE-USE

4.2.1 Soil Handling and Replacement

Soil would be handled when moist only (not too dry or too wet). That would not be difficult for most of the soils present because of their sandy texture. Subsoil and topsoil would be replaced in their correct stratigraphic order, in their correct relative thicknesses, and in a method that ensures the two are keyed together (there must be no compacted, smooth, surface between the two).

4.2.2 Fertiliser Use

The soils are not close to their base saturation levels (**Table 13**) but they have low CEC (**Table 12**). There would be an opportunity to use fertilisers but they should preferably be slow release organic types (e.g. Dynamic Lifter or similar). Organic matter would also improve moisture retention and raise CEC if incorporated into the topsoil. Organic matter may be sourced from composted, mulched, cleared vegetation or from off site. A re-vegetation contractor would be able to advise further.

5. REFERENCES

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6. GLOSSARY OF SOIL TERMS

- Chromosols: Soils with strong texture contrast between A horizons and B horizons. The latter are not strongly acid and are not sodic.
- Ferrosols: Soils with B2 horizons which are high in free iron oxide, and which lack strong texture contrast between A and B horizons.
- Kandosols: soils which lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout.
- Lateritic and Krasnozems: deep, friable red clay soils, often strongly acidic and found mainly on the volcanic substrate.
- Lithosols: A subgroup of Rudosols – containing a high percentage of parent material.
- Podzolic soils: Soils with B horizons dominated by the accumulation of compounds of organic matter, aluminium and/or iron.
- Rudosols: Soil with negligible (rudimentary) pedologic organisation apart from (a) minimal development of an Al horizon or (b) the presence of less than 10% of B horizon material.
- Sodosols: Soils with strong texture contrast between A horizons and sodic B horizons which are not strongly acid.
- Tenosols: soils with generally only weak pedologic organisation apart from the A horizons.
- VENM/ENM: Virgin excavated natural material/excavated natural material

APPENDICES

APPENDIX 1 – COVERAGE OF DIRECTOR-GENERAL'S REQUIREMENTS AND ISSUES RAISED BY OTHER GOVERNMENT AGENCIES

Table 17 – Coverage of Soil and Land Capability-related Agency Requirements

Paraphrased Requirement/Issue	Relevant Section(s)
DIRECTOR-GENERAL'S REQUIREMENTS	
SOIL AND WATER	
The EIS must address the following specific issues: Land Resources - including a detailed assessment of the potential impacts on: • soils and land capability (including land contamination).	3.8
• a detailed description of the measures that would be implemented to avoid and/or minimise the potential impacts of the project on agricultural resources and/or enterprises.	3.8
ISSUES RAISED BY OTHER GOVERNMENT AGENCIES	
None Provided	

APPENDIX 2 – TEST PIT LOGS

SEEC

ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	14/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 1

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm brown sandy clay loam	M		
				200-800mm orange sandy clay loam	M		
				800-1100mm white and orange clayey sand	W		
		1.0 m					Water seeping into the trench at 1100mm
				1100-1300mm+ white dense sand/weathered rock			
				Note: Test Pit 001 terminated at 1300mm in layer 4.			
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations

This log must be read with the accompanying report by SEEC

Rev 1, 09/12

SEEC

ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	14/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 2

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-250mm brown sandy loam	MM		
				250-400mm orange coarse sand/weathered rock	MM		
				400-500mm+ rock/very dense sand			
				Note: Test Pit 002 terminated at 500mm in rock/very dense sand.			
		1.0 m					
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments	Consistency / Strength			
N	natural exposure	HP	hand penetrometer		VS	very soft	Fb	friable
A	hand auger	DCP	dynamic cone penetrometer		S	soft	VL	very loose
ES	shovel	O	other		F	firm	L	loose
EB	backhoe				St	stiff	MD	med. dense
ED	bulldozer	**Moisture Condition**			VSt	very stiff	D	dense
EG	grader	D	dry		H	hard	VD	very dense
G	gully	MM	moderately moist		The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations			
C	core sample	M	moist					
O	other	W	wet					

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ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	14/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 3

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm brown sandy clay loam	MM		
				200-1000mm orange brown sandy clay loam	MM		
		1.0 m		1000-1400mm light brown/pale sandy clay loam	MM		
				1400-1700mm white and orange sandy clay loam into weathered rock at 1400mm	M		
		2.0 m		Note: Test Pit 003 teminated at 1700mm in weathered rock.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations

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ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 4

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-250mm brown sandy clay loam	MM		
				250-600mm brown orange sandy clay loam	MM		
				600-1200mm orange yellow clayey sand	MM		
		1.0 m					
				1200-2300mm+ white and yellow loamy sand	MM		
		2.0 m					
				Note: Test Pit 004 terminated at 2300mm in layer 4.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations

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ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 5

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey brown loamy sand	D		
				200-400mm brown loamy sand	MM		
				400-850mm+ orange brown coarse loamy sand	MM		
		1.0 m		Note: Test Pit 005 terminated at 850mm in layer 3.			
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations

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ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 6

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-250mm grey brown loamy sand	D		
				250-1150mm+ orange sandy clay loam	MM		
		1.0 m					
				Note: Test Pit 006 terminated at 1150mm in layer 2.			
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations

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ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 7

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey brown loamy sand	D		
				200-500mm brown loamy sand	MM		
				500-1950mm+ orange brown coarse loamy sand	MM		
		1.0 m					
		2.0 m		Note: Test Pit 007 terminated at 1950mm in layer 3.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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ENGINEERING LOG - EXCAVATIONS

		Project Number:	13000094
Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 8

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey loamy sand	D		
				200-500mm brown loamy sand	M		
				500-1100mm yellow brown sandy clay loam	M		
		1.0 m					
				1100mm+ weathered rock			
				Note: Test Pit 008 terminated at 1100mm in weathered rock.			
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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ENGINEERING LOG - EXCAVATIONS

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Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 9

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-300mm brown sandy loam	MM		
				300-1100mm yellow orange sandy clay loam	MM		
		1.0 m					
				1100-1700mm+ orange dense sand	MM		
		2.0 m		Note: Test Pit 009 terminated at 1700mm in layer 3. Too stiff to continue digging.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 10

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey brown loamy sand	D		
				200-800mm brown sandy loam	MM		Depth of layer varied between 800mm and 1100mm
		1.0 m		800-1800mm orange brown dense sand	MM		
		2.0 m		1800-2100mm+ white and orange dense sand	MM		
				Note: Test Pit 010 terminated at 2100mm in layer 4.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 11

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey loamy sand	MM		
				200-750mm dark brown sandy loam	MM		
				750-2000mm+ orange sandy loam	MM		
		1.0 m					
		2.0 m		Note: Test Pit 011 terminated at 2000mm in layer 3.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments	Consistency / Strength			
N	natural exposure	HP	hand penetrometer		VS	very soft	Fb	friable
A	hand auger	DCP	dynamic cone penetrometer		S	soft	VL	very loose
ES	shovel	O	other		F	firm	L	loose
EB	backhoe				St	stiff	MD	med. dense
ED	bulldozer	**Moisture Condition**			VSt	very stiff	D	dense
EG	grader	D	dry		H	hard	VD	very dense
G	gully	MM	moderately moist					
C	core sample	M	moist		The classification symbols and soil descriptions are based on the Unified Soil Classification System (Corps of Engineers, 1953) and AS 1726:1993, Geotechnical Site Investigations			
O	other	W	wet					

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Client	Sutton Forest Quarry Pty Ltd	Date excavated	14/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 12

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey brown loamy sand	D		
				200-750mm brown loamy sand	MM		
				750-2000mm+ orange clayey sand	MM		
		1.0 m					
		2.0 m		Note: Test Pit 012 terminated at 2000mm in layer 3.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments	Consistency / Strength			
N	natural exposure	HP	hand penetrometer		VS	very soft	Fb	friable
A	hand auger	DCP	dynamic cone penetrometer		S	soft	VL	very loose
ES	shovel	O	other		F	firm	L	loose
EB	backhoe				St	stiff	MD	med. dense
ED	bulldozer	**Moisture Condition**			VSt	very stiff	D	dense
EG	grader	D	dry		H	hard	VD	very dense
G	gully	MM	moderately moist					
C	core sample	M	moist					
O	other	W	wet					

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Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 13

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm brown sandy loam	D		
				200-450mm+ yellow dense sand	MM		
				Note: Test Pit 013 terminated at 450mm in layer 2. too stiff to continue digging.			
		1.0 m					
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 14

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm brown sandy clay loam	D		
				200-550mm red brown sandy clay loam	MM		
				550-1900mm+ orange brown sandy loam	MM		
		1.0 m					
		2.0 m		Note: Test Pit 014 terminated at 1900mm in layer 3.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Client	Sutton Forest Quarry Pty Ltd	Date excavated	13/08/2013
Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 15

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm light brown sandy clay loam	D		
				200-400mm brown sandy clay loam	MM		Depth of layer varied between 400mm and 800mm
				400-1650mm+ white and orange dense sand	MM		
		1.0 m					
		2.0 m		Note: Test Pit 015 terminated at 1650mm in layer 3. Too stiff to continue digging.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 16

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-300mm grey brown sandy loam	D		
				300-650mm orange brown sandy clay loam	MM		
				650-1450mm orange loamy sand	MM		
		1.0 m					
				1450mm+ white dense sand/weathered rock.			
				Not: Test Pit 016 terminated at 1450mm in layer 4/weathered rock.			
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 17

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm brown sandy loam	D		
				200-650mm+ yellow dense sand	MM		
				Note: Test Pit 017 terminated at 650mm in layer 2. Too stiff to continue digging.			
		1.0 m					
		2.0 m					
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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Project	Sutton Forest Quarry	Logged By	NL
Location	Sutton Forest	Slope %	

Excavation Dimensions — Test Pit No. 18

Method	Sampling	Depth (m)	Layer Change	Description	Moisture	Consistency /Strength	Remarks
EB				0-200mm grey brown sandy loam	D		
				200-600mm brown sandy loam	MM		
				600-1800mm+ white and orange dense sand	MM		
		1.0 m					
		2.0 m		Note: Test Pit 018 terminated at 1800mm in layer 3.			
		3.0 m					
		4.0 m					

Key

Method		Sampling / Testing		Comments
N	natural exposure	HP	hand penetrometer	
A	hand auger	DCP	dynamic cone penetrometer	
ES	shovel	O	other	
EB	backhoe			
ED	bulldozer	**Moisture Condition**		
EG	grader	D	dry	
G	gully	MM	moderately moist	
C	core sample	M	moist	
O	other	W	wet	

Consistency / Strength			
VS	very soft	Fb	friable
S	soft	VL	very loose
F	firm	L	loose
St	stiff	MD	med. dense
VSt	very stiff	D	dense
H	hard	VD	very dense

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