



**Metromix Pty Ltd**

ABN: 39 002 886 839

# Teralba Quarry Extensions

## Soil and Land Capability Impact Assessment

Prepared by

**GSS Environmental**

**August 2011**

**Specialist Consultant Studies Compendium  
Volume 2, Part 9**

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**Metromix Pty Ltd**

ABN: 39 002 886 839

# Soil and Land Capability Impact Assessment

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## **EXECUTIVE SUMMARY**

R.W. Corkery & Co. Pty Limited on behalf of Metromix Pty Ltd commissioned GSS Environmental to conduct a soil and land capability assessment for the Teralba Quarry Extensions Project.

This assessment report forms part of an Environmental Assessment for the Project and provides information on the following issues:

- Description of the soil units across the Study Area in accordance with the Australian Soil Classification system;
- Description of the Rural Land Capability classification across the Study Area in accordance with the Rural Land Capability System;
- Description of the Agricultural Suitability classification across the Study Area in accordance with the Agricultural Suitability Classification System;
- Recommendations on soil stripping depths for proposed disturbance areas, including recommendations for topsoil handling, stockpiling and amelioration for reuse in rehabilitation; and
- Description of necessary erosion and sediment control measures to manage in situ and stockpiled soil resources.

The soil and land capability field survey covered an area of 87ha (referred to as the Study Area) and the survey was undertaken at a high intensity scale of 1:25 000. Soil samples were analysed for various physical and chemical soil attributes by a National Association of Testing Authorities accredited laboratory. These analyses included tests for fertility parameters, and dispersion and erodibility attributes.

Results of the analysed data show that three major soil types, and one soil variant, are present in the Study Area. The predominant soil type is a Yellow-Brown Kurosol with the less dominant soil types being Brown Rudosol and Yellow-Brown Tensosol. The Yellow-Brown Kurosol is characterised by a weakly structured acidic, silty-clay loam topsoil overlying a massively structured, strongly acidic, medium clay subsoil. The Brown Rudosol is characterised by a shallow, weakly structured, light sandy clay topsoil overlying bedrock. The Yellow-Brown Tensosol is characterised by a weakly structured, moderately acidic, dark-brown silty-clay loam topsoil that grades into a weakly structured, strongly acidic, brown loam at depth. All Study Area soils are non-sodic to marginally sodic throughout the profile.

Most soil types in the Study Area were found to have suitable topsoil for reuse in rehabilitation works, given appropriate amelioration for acidity. The recommended soil stripping depth ranges from 0.3 - 0.7m for topsoil and nil for subsoil. Amelioration of all stripped topsoil is required to improve their suitability for rehabilitation due to constraints such as moderate acidity and weak soil structure. Amelioration with gypsum and/or lime as well as organic amendments has been recommended.

Land capability classification across the Study Area ranges from Class VI to Class VII land. The area that would be disturbed by the proposed Extensions is mainly covered by Class IV land. This classification indicates that the land is not capable of being regularly cultivated but is suitable for grazing.

Agricultural suitability classification across the Study Area ranges from Class 4 to Class 5 land. The area that would be disturbed by the Project is mainly covered by Class 4 land. This classification indicates that the land must not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented.

The Study Area's post-development landform is expected to be mainly comprised of flat to moderately inclined slopes, and can be restored to land capability Class VI and agricultural suitability Class 4.



## **1. INTRODUCTION**

GSS Environmental (GSSE) was commissioned by R.W. Corkery & Co. Pty Limited (RWC) on behalf of Metromix Pty Ltd (Metromix) to undertake a soil and land capability assessment associated with an application for Project Approval to be submitted to the Department of Planning under Part 3A, Section 75 of the Environmental Planning and Assessment Act 1979.

This soil and land capability assessment report forms part of an *Environmental Assessment* for Teralba Quarry Extensions and includes the methodology used in the assessment, a summary of the results, and a description of the management measures proposed to mitigate the potential soil and land capability impacts of the Teralba Quarry Extensions.

### **1.1 PROJECT DESCRIPTION**

Teralba Quarry is located 2.5km to the east of the Sydney – Newcastle Freeway and is situated approximately 0.4km west of Teralba and 7km north of Toronto. Teralba Quarry is surrounded by four collieries, namely Rhondda Colliery, Newstan Colliery, Stockton Borehole Colliery and Teralba Colliery (**Figure 1.1**).

Products from Teralba Quarry are used for roadbases, fine coarse concrete aggregates, drainage aggregates, and sand and fill products for the civil construction industry throughout Newcastle, the Central Coast and the lower Hunter Valley. The current extraction and processing operations are undertaken in accordance with Development Consent (DA130/42) granted by the former Lake Macquarie Municipal Council in 1964.

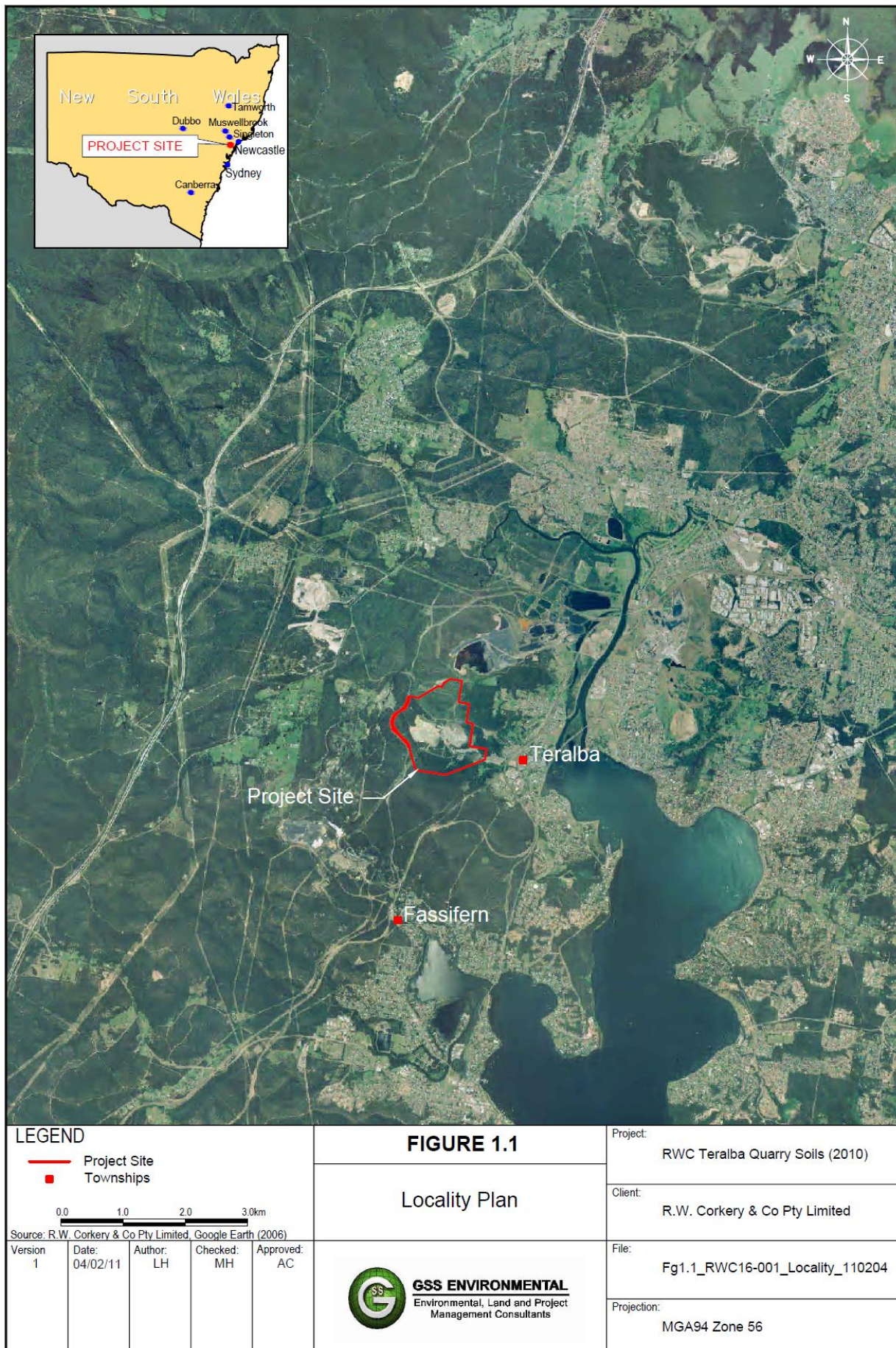
Metromix proposes to extend the current Council approved extraction and processing operation. This will involve additional extraction areas as well as modifying some processing operations. Metromix is seeking a Project Approval that covers both the existing operations as well as the proposed operations such that the quarry site can be managed in accordance with a single project approval.

The area to be covered by the soil and land capability assessment (hereafter referred to as the Study Area) is approximately 87ha and encompasses the following elements (**Figure 1.2**):

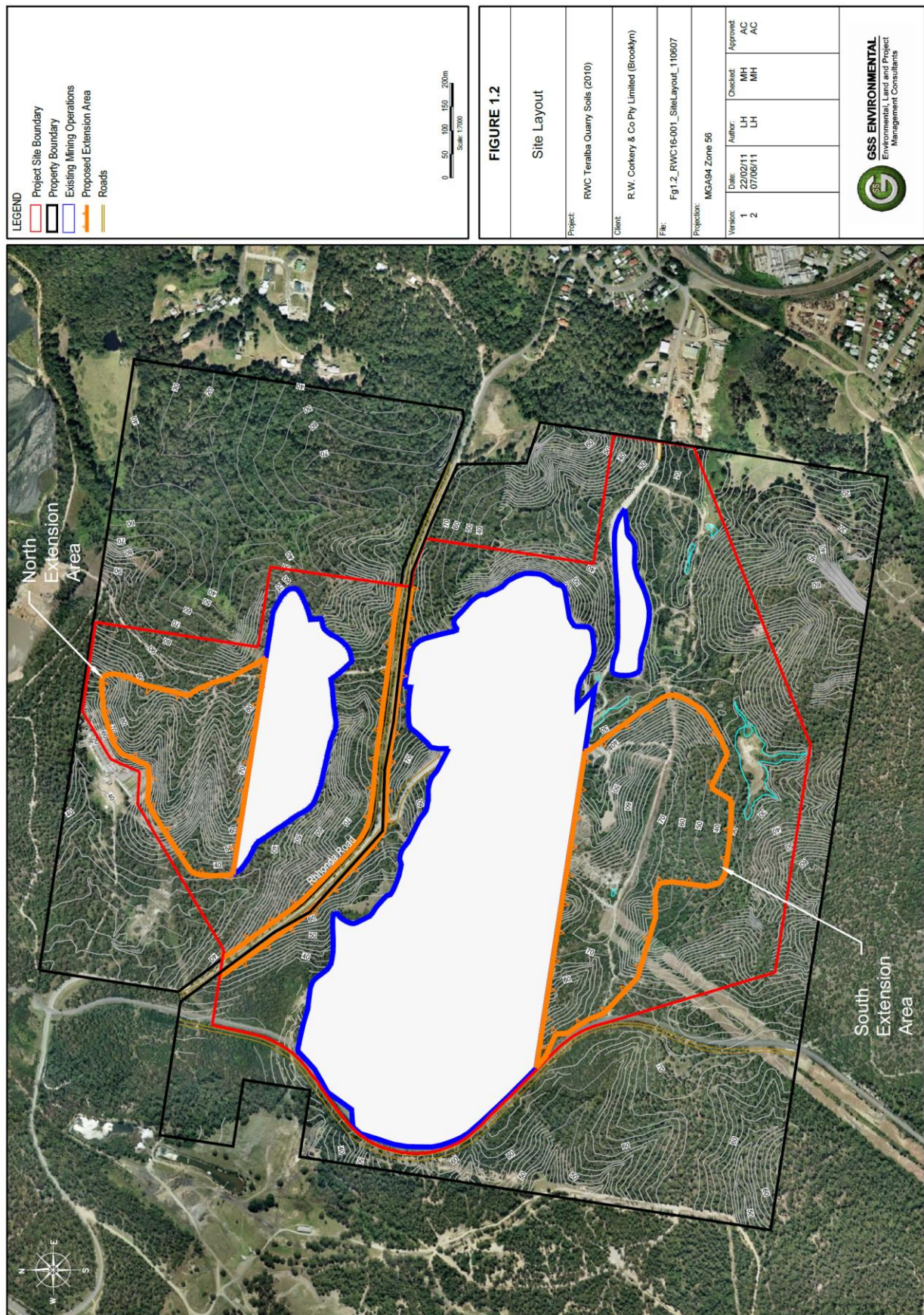
- proposed Northern (9.3ha) and Southern Extensions (16.5 totalling 25.8ha);
- the road reserve for Rhondda Road within which a sub-surface crossing is proposed between the existing Southern Extraction Area and the existing Mid-Pit Extraction Area (2.7ha); and
- an area surrounding the existing extraction areas and proposed extensions of 58.5ha.

The actual area of land to be physically disturbed within the Study Area by the proposed operations is approximately 28.5ha and encompasses the following (hereafter referred to as the disturbance area) (**Figure 1.2**):

- proposed Northern and Southern Extensions; and
- proposed 20m wide corridor across Rhondda Road.







## 1.2 ASSESSMENT OBJECTIVES

The major objectives of the soil and land capability assessment undertaken by GSSE were to:

- Objective 1** Classify and determine the soil profile types within the Study Area;
- Objective 2** Provide a description of, and figures showing, the land capability classes within the Study Area;
- Objective 3** Provide a description of, and figures showing, the agricultural suitability classes within the Project Site;
- Objective 4** Provide selective topsoil and subsoil management recommendations; and
- Objective 5** Provide recommendations to mitigate soil erosion and sedimentation associated with the works or soil stockpiles.

This report outlines the methodology and results of the soil and land capability assessment conducted to satisfy the assessment objectives. This includes background research, field assessment and laboratory analysis of soil samples sourced from within the Study Area as well as proposed management measures.

## 1.3 STANDARDS

To satisfy Objective 1 of the soil and land capability assessment, the soil taxonomic classification system used was the Australian Soil Classification (ASC) system. This system is routinely used as the soil classification system in Australia.

To satisfy Objective 2 of the soil and land capability assessment, the relevant guideline applied was *Systems Used to Classify Rural Lands in New South Wales* (Cunningham et al., 1988). This is the guideline approved by the NSW Super-Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

To satisfy Objective 3 of the soil and land capability assessment, the relevant guideline applied was the *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries, 1990). This is the guideline approved by the NSW DITRIS.

To satisfy Objective 4 of the soil and land capability assessment, the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot & Veness, 1981) was utilised to determine which soils throughout the site are suitable for conserving and utilising in the quarry site rehabilitation program. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.

To satisfy Objective 5 of the soil and land capability assessment, the *Managing Urban Stormwater: Soils and Construction Vol. 1* (Landcom, 2004) was used as a basis for recommendations of soil erosion and sedimentation mitigation associated with the proposed works.

## **2. EXISTING ENVIRONMENT**

### **2.1 TOPOGRAPHY AND HYDROLOGY**

The topography of the Study Area is characterised by gently inclined to moderately inclined slopes (41%) with some prominent moderately steep to steep ridgelines that have broad level to gently inclined crests. Gently inclined lower slopes are prominent in the southeastern corner of the Study Area where the site drains in easterly towards Lake Macquarie (**Figure 2.1; Table 2.1**).

The proposed Northern Extension is dominated by steep to very steep slopes forming a north-south orientated ridgeline. The ridgeline has a maximum elevation of 90m and is characterised by incised drainage lines. The proposed Southern Extension is dominated by slopes that are moderately inclined to very steep with broad flat crests. The proposed 20m wide corridor across Rhondda Road follows the crest of an east-west trending ridgeline.

The Study Area contains seven sub-catchments, three of which flow directly eastwards towards Lake Macquarie whilst the remaining four catchments flow to the northwest towards Cockle Creek and in turn to Lake Macquarie.

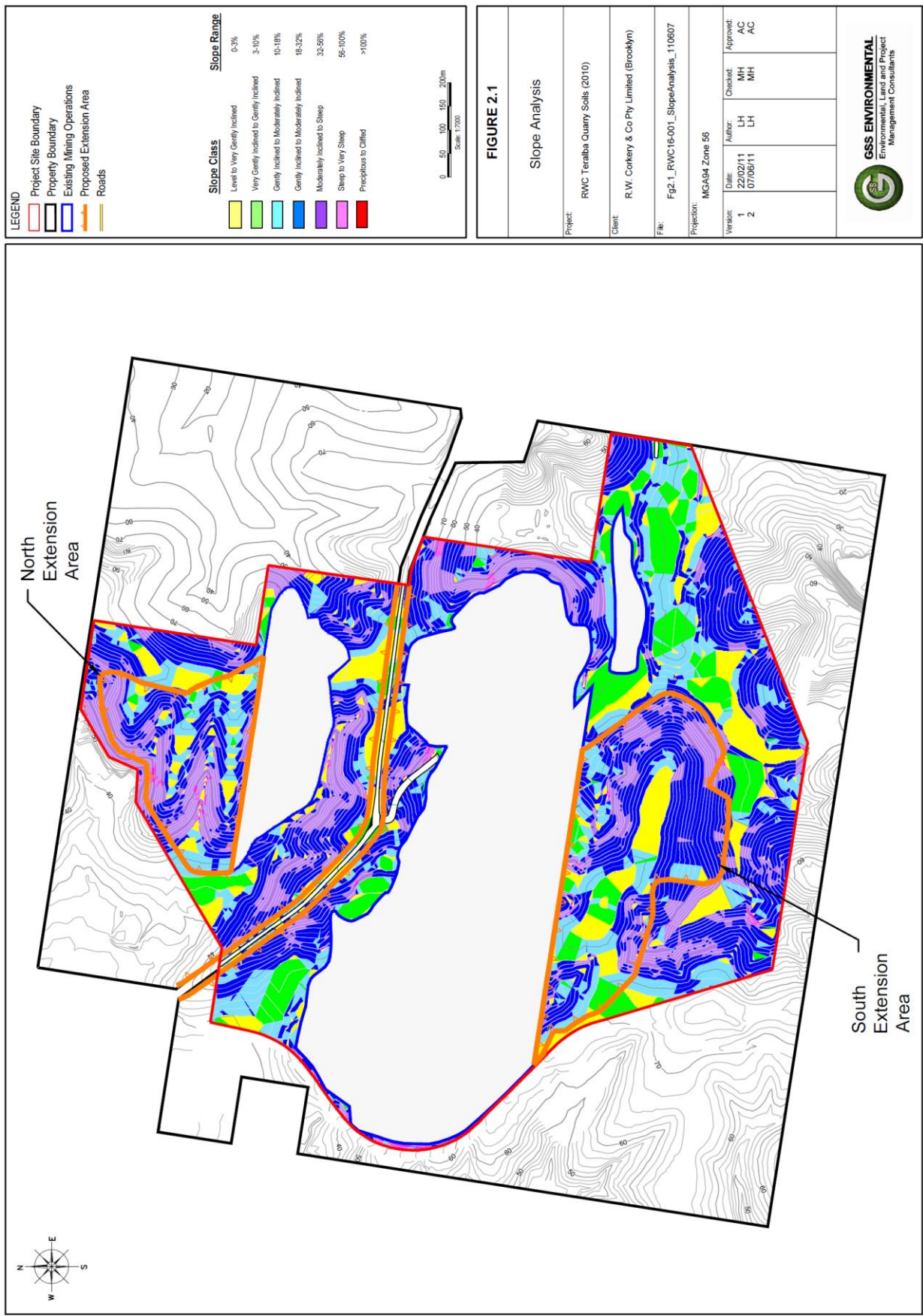
**Table 2.1**  
**Slope Analysis**

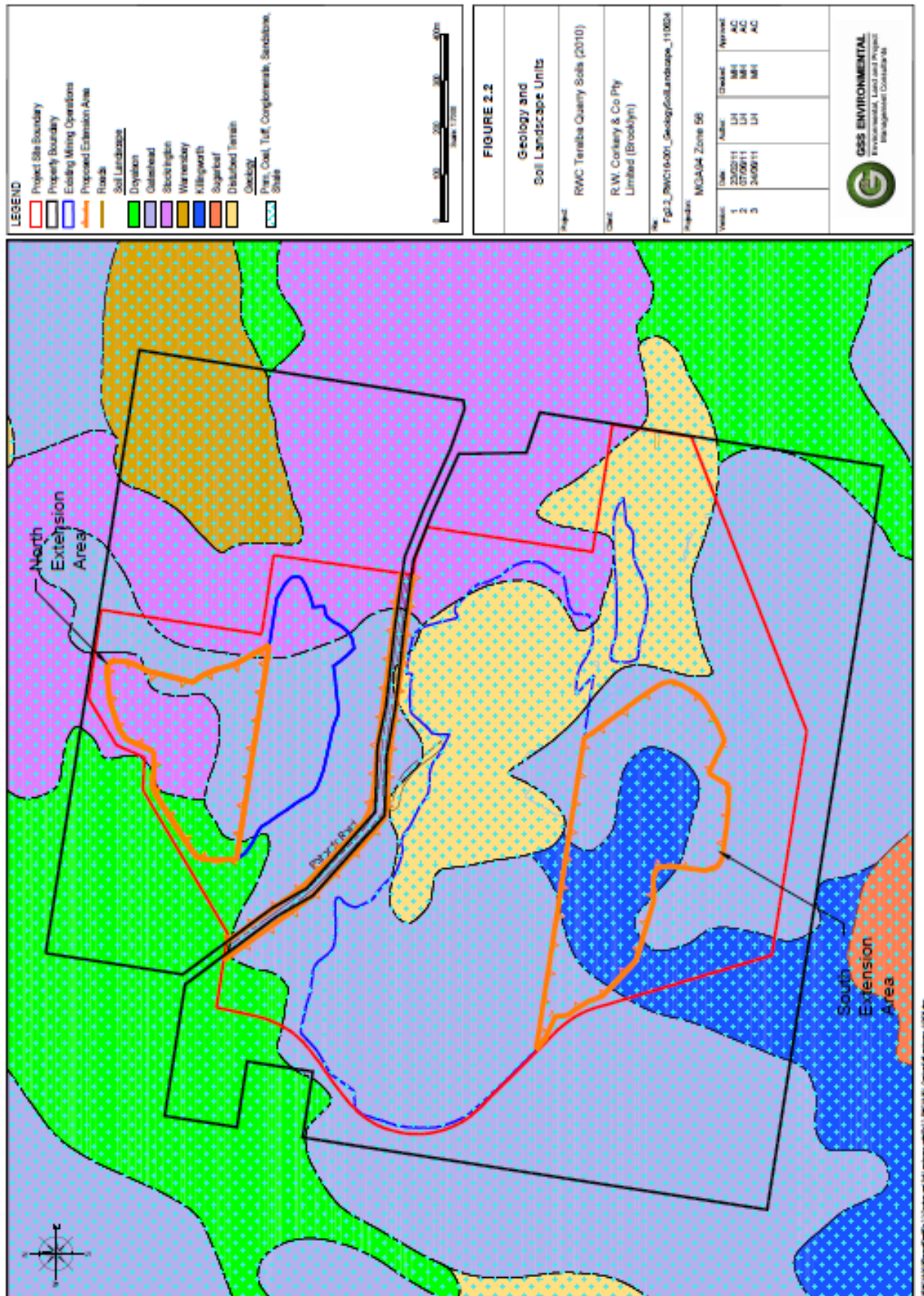
<b>Slope Class</b>	<b>Slope %</b>	<b>ha</b>	<b>% of Study Area</b>
Level to Very Gently Inclined	0-3	11	13
Very Gently Inclined to gently inclined	3-10	9	10
Gently Inclined to Moderately Inclined	10-18	15	17
	18-32	36	41
Moderately Inclined to Steep	32-56	15	17
Steep to Very Steep	56-100	1	1
Precipitous to Cluffed	>100	<1	<1
<b>Total</b>		<b>87</b>	<b>100</b>

### **2.2 GEOLOGY AND SOIL LANDSCAPE UNITS**

The Study Area is underlain by Permian Newcastle Coal Measures which comprise conglomerate, shale, sandstone and tuff. (**Figure 2.2**). Conglomerate interbedded with sandstone is the most widely abundant geological assemblage at the surface of the site.







The soil landscapes within the Study Area have been mapped by the Land & Water Conservation incorporating the Soil Conservation Service of NSW at the scale of 1:100 000 by Murphy (1993) and Matthei (1995). The soil landscape units as described by these publications are “areas of land that have recognisable and specific topographies and soils that can be presented on maps and described by concise statements”. The soil landscape units that occur within the Study Area are as follows:

- Gateshead unit is the most common and is present in the Study Area’s north, west and south;
- Stockrington variant unit occurs to the Study Area’s east and north-east;
- Doyalson unit small pocket in the Study Area north-west, and;
- Killingworth unit occurs as a small pocket in the Study Area’s south.

Gateshead soil landscape occurs as undulating to rolling rises on Permian conglomerate, shale and sandstone on the Awaba Hills. Elevation to 130m, local relief is up to 100m and slopes of 5% to 15%. Common soil occurrences of this landscape unit include moderately deep podzols and soloths, with some shallow lithosols. Limitations include, localised steep slopes and shallow soils, high run-on and acid soils of low fertility.

Stockrington variant landscape occurs as side slopes on conglomerates of the Newcastle Coal Measures, Adamstown Subgroup. Elevation to 160m, local relief is up to 180m and presence of steep slopes of 25 ->40% gradients, to benches of 15-20% slope. Common soil occurrences of this landscape unit include moderately deep to deep loams, and deep podzols and soloths. The limitations include steep slopes, mass movement hazard and foundation hazard.

Killingworth landscape occurs as undulant to rolling hills on the Newcastle Coal Measures of the Awaba Hills region. Elevation 50-160m, local relief 30-100m and slopes are 3-20%. Common soil occurrences of this landscape unit include shallow to moderately deep podzols and soloths, and shallow loams and lithosols. Limitations include, foundation hazard (localised), shallow soils (localised), sodic/dispersible soils of low wet strength and very acid soils of low fertility.

Doyalson soil landscape occurs as gently undulating rises on Munmorah Conglomerate. Broad crests and ridges and long, gently inclined slopes. Limitations include high erosion hazard, foundation hazard (localised), high run-on (localised). Common soil occurrences of this landscape unit include shallow to moderately deep podzols and soloths, and shallow lithosols. Limitations include seasonal waterlogging (localised), hard-setting, stony, strongly acid soils of low fertility.

## **2.3 LAND USE**

The Study Area is located in an area of largely uncleared open woodland, consisting of young to mature trees dominated by native vegetation. It is surrounded on three sides by coal mining activities. Located to the east of the site is a private coal haul road, and boundaries to the west are shared with industrial facilities. Lake Macquarie is located further to the southeast of Teralba.



## **2.4 VEGETATION**

The Study Area is dominated by open woodland comprised predominantly of native vegetation. Two vegetation communities have been mapped in the proposed Extension areas and these are the Coastal Foothills Spotted Gum-Ironbark Forest and Coastal Plains Smooth-barked Apple Woodland (NPWS, 2003). The recorded vegetation appears to best fit the map unit profile for Coastal Foothills Spotted Gum-Ironbark Forest and has been identified as a Regionally Significant Habitat by City of Lake Macquarie (2008).

One species of National and State conservation significance is present, namely *Tetratheca juncea*, listed as Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the NSW Threatened Species Conservation Act 1995 (TSC Act) (NPWS, 2003). One regionally significant plant species, *Macrozamia flexuosa*, is also present (NPWS, 2003).

Several noxious weed species are also present in the proposed extension areas. These include *Ageratina adenophora* (Crofton Weed), *Cortaderia selloana* (Pampus Grass) and *Lantana camara* (Lantana) (NPWS, 2003).

## **3. SOIL SURVEY AND ASSESSMENT**

This section outlines the methods used to conduct the soil survey component of the assessment and reports the results. Objectives 1 and 2 are discussed in this section.

### **3.1 SOIL SURVEY METHODOLOGY**

A field survey and a desktop study were undertaken for the proposed extension areas. This process consisted of the following stages.

#### **3.1.1 Reference Mapping**

An initial soil map (reference map) was developed using the following resources and techniques.

- Aerial photographs and topographic maps  
Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils within the Study Area.
- Reference information  
Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included cadastral data, prior and current physiographic, geological, vegetation, and water resources studies.
- Previous reports  
Soil Landscapes of the Newcastle 1:100 000 Sheet (Matthei, 1995); and  
Soil Landscapes of the Gosford-Lake Macquarie 1:100 000 Sheet (Murphy, 1993).

- Stratified observations

Following production of a broad soil map, surface soil exposures, topography and vegetation throughout the potential disturbance areas were visually assessed to verify potential soil types, delineate soil type boundaries and determine preferred locations for targeted subsurface investigations (hereafter referred to as soil pits).

### 3.1.2 Field Survey

#### 3.1.2.1 Scale

The field survey was undertaken at a high intensity scale of 1:25 000. This survey scale enables the production of a detailed map that is suitable for intense land uses such as engineering works (*Guidelines for Surveying Soil and Land Resources* (McKenzie *et al.*, 2008). This survey scale was adopted to offer an adequate dataset of soil types within the Study Area and to assess the potential impact on these soils following the proposed power station development.

#### 3.1.2.2 Survey Type

The field survey undertaken was an integrated survey and is a qualitative survey type. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets (McKenzie *et al.*, 2008). Background reference information derived from sources cited in **Section 3.1.1** were used to predict the distribution of soil attributes in the field. The characteristics evaluated to generate the correlated sets include vegetation type, landform and geology.

The specific type of integrated survey undertaken was a 'free survey'. A free survey is a conventional form of integrated survey and its strength lies in its ability to assess soil and land at medium to detailed-scales (Hewitt *et al.*, 2008). Survey points are irregularly located according to the survey teams' judgement to enable the delineation of soil boundaries. Soil boundaries can be abrupt or gradual, and catena and toposequences are used to aid the description of gradual variation.

#### 3.1.2.3 Survey Observations

To satisfy the 1:25 000 scale in accordance with the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al.*, 2008), the recommended number of observations per unit area required is 0.08 observations per ha. For the Study Area of area 87ha this equates to a total of 7 observations required.

To satisfy the 1:25 000 scale, in accordance with the *Guidelines for Surveying Soil and Land Resources*, (National Committee on Soil and Terrain, 2008) a minimum of 10-30% of these observations are to be Detailed Profile Descriptions (also referred to as Class I observations), 5% are to be Laboratory Assessed (also referred to as Class II observations), and the remainder are to be made up by Minor Class Observations (also referred to as Class IV observations).

The actual observation density utilised for the Study Area totalled three Class I observations, three Class II observations and 10 Class IV observations. This exceeds and satisfies the observation requirements for a 1:25 000 survey scale. **Figure 3.1** illustrates the distribution of these survey observations throughout the Study Area.

#### **3.1.2.4 Detailed Soil Profile Observation**

Across the Study Area three exposed soil profiles were assessed (**Figure 3.1**). A number of factors influenced the frequency of soil profile assessment, not the least being access. Soil profiles were assessed for soil type and distribution, with two to five samples taken from all three profiles for laboratory analysis.

Each soil profile exposure pit was excavated by a backhoe to the required depth and to a suitable size to receive maximum light on the profile exposure from which the samples were removed. Pits were backfilled post analysis.

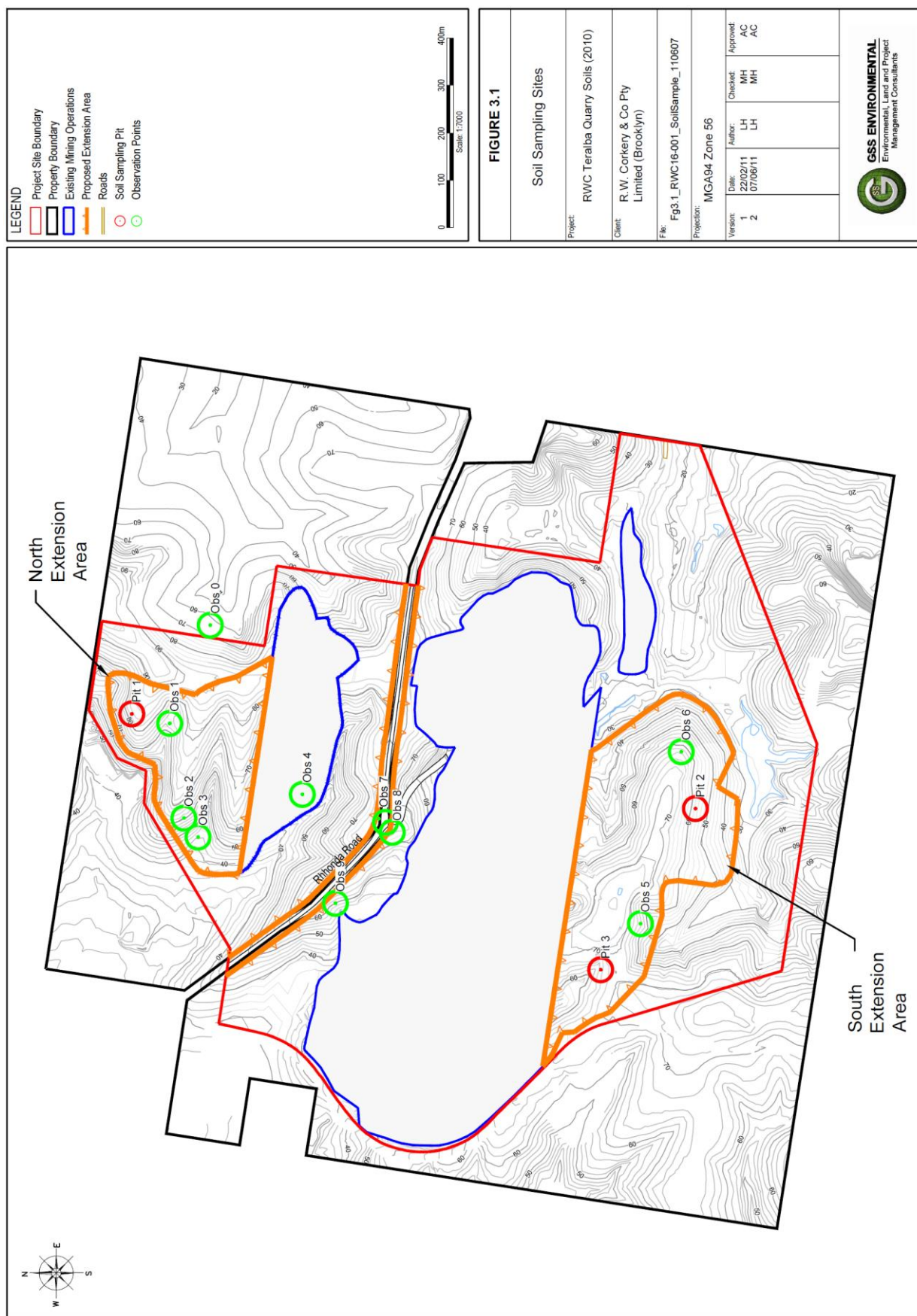
Soil profiles within the Study Area were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* soil classification procedures (National Committee on Soil and Terrain, 2008, 2009). Detailed soil profile descriptions recorded information that covered the parameters as specified in **Table 3.1**. Soil profile logging was undertaken in the field using soil data sheets.

Global Positioning System recordings were taken for all sites where detailed soil descriptions were made. Vegetation type and land use were also recorded. Soil exposures from excavated pits were photographed during field operations as colour photography of profile sites is a useful adjunct to description of land attributes.

Soil layers at each profile site were also assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. A more detailed explanation of the Elliot & Veness procedure is presented in **Section 4** of this report.

**Table 3.1**  
**Field Assessment Parameters**

<b>Descriptor</b>	<b>Application</b>
Horizon Depth	Weathering characteristics, soil development
Field Colour	Permeability, susceptibility to dispersion /erosion
Field Texture Grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary Distinctness and Shape	Erosional / dispositional status, textural grade
Consistence Force	Structural stability, dispersion, ped formation
Structure Pedality Grade	Soil structure, root penetration, permeability, aeration
Structure Ped & Size	Soil structure, root penetration, permeability, aeration
Stones – Amount & Size	Water holding capacity, weathering status, erosional / depositional character
Roots – Amount & Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms etc	Biological mixing depth



### 3.1.3 Soil Laboratory Assessment

Soil samples from the three soil profile sites were utilised in the laboratory testing programme (refer **Figure 3.2**). Samples were analysed to:

- Classify soil taxonomic classes;
- Determine agricultural and land capacity classes; and
- Determine suitability of soil as topdressing media.

Soil samples of about 1 – 2 kg were collected from each soil layer where appropriate. In total, 10 soil samples were sent to the Department of Lands Scone Research Centre for analysis. Certificate of Analyses for these results are contained in **Appendix 2**. The selected physical and chemical laboratory analysis parameters and their relevant application are listed in **Table 3.2**.

**Table 3.2**  
**Laboratory Analysis Parameters**

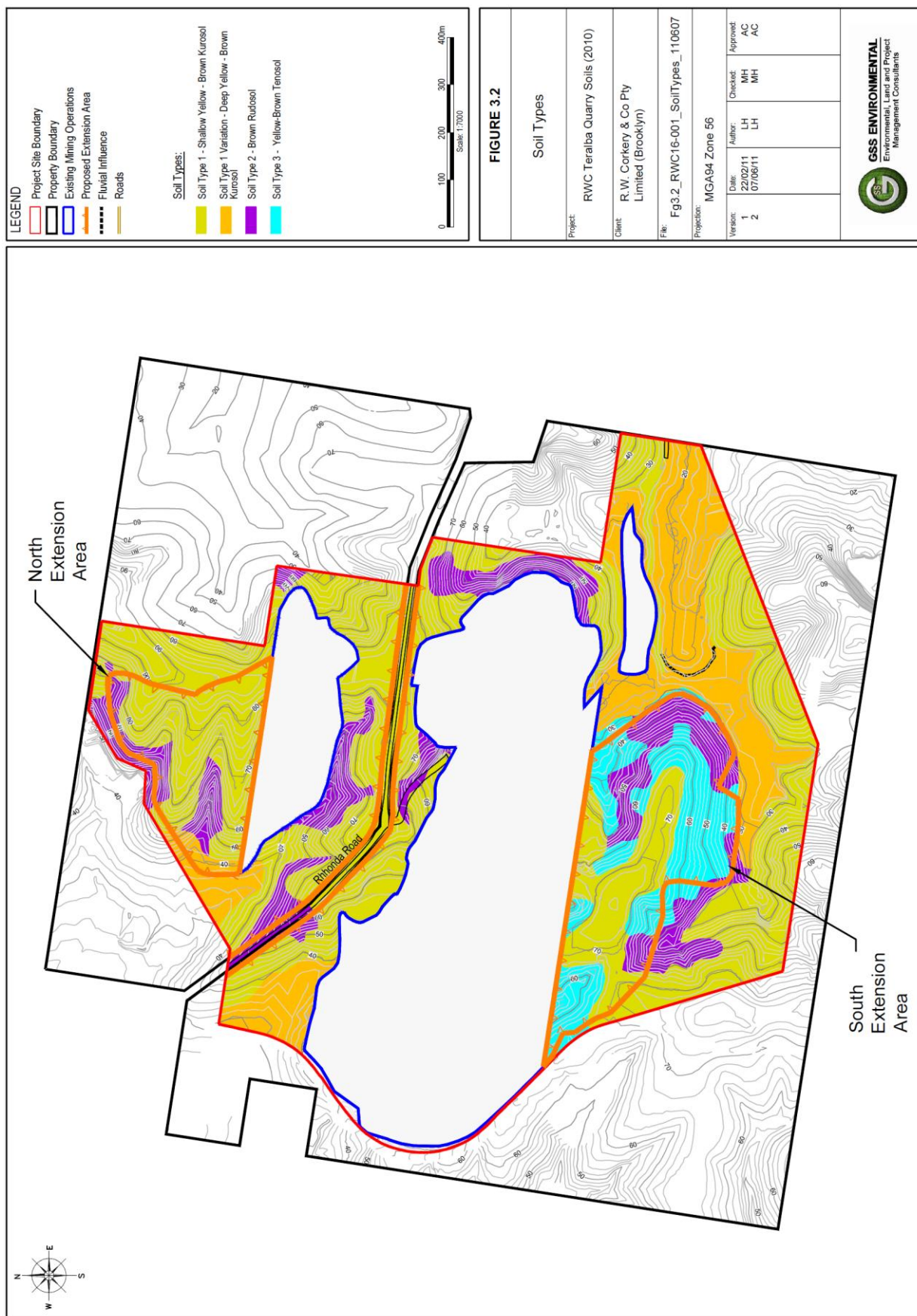
Property	Application
<b>Physical:</b>	
Coarse fragments (>2mm)	Soil workability; root development; droughtiness
Particle-size distribution (<2mm)	Nutrient retention; exchange properties; erodibility; droughtiness; workability; permeability; sealing; drainage; interpretation of most other physical and chemical properties and soil qualities
Aggregate stability (Emerson Aggregate Test (EAT))	Susceptibility to surface sealing under rainfall or irrigation; effect of raindrop impact and slaking; permeability; infiltration; aeration; seedling emergence; correlation with other properties
<b>Chemical:</b>	
Soil reaction (pH)	Nutrient availability; nutrient fixation; toxicities (especially Al, Mn); liming; sodicity; correlation with other physical, chemical and biological properties
Electrical conductivity (EC)	Appraisal of salinity hazard in soil substrates or groundwater, total soluble salts
Cation Exchange Capacity (CEC) and exchangeable cations	Nutrient status; calculation of exchangeable sodium percentage (ESP); assessment of other physical and chemical properties, especially dispersivity, shrink – swell, water movement, aeration

The laboratory methods used by Scone Research Centre for each physical and chemical parameter are provided below in **Table 3.3**.

**Table 3.3**  
**Laboratory Test Methods**

Analyte	Method
Particle Size Analysis (PSA)	Sieve & hydrometer
pH	1:5 soil/water extract
EC	1:5 soil/water extract
Emerson Rating	Emerson Aggregate Test
CEC & exchangeable cations	(AgTU)+ extraction





### 3.1.4 Soil Type Nomenclature

The applicable technical standard adopted by GSSE for the Modification is the Australian Soil Classification (ASC) system. The standard is routinely used as the soil classification system in Australia. A variant of a soil type occurs when there is some dissimilarity, but not enough to create a unique soil type.

## 3.2 SOIL SURVEY RESULTS

Within the Study Area three soil types and one soil variant were identified. **Table 3.4** provides an overview of each soil type and their quantitative distribution within the Study Area, as well as their geological associations. **Figure 3.2** illustrates their spatial distribution. All soil test results are provided in **Appendix 2**.

**Table 3.4**  
**Soil Types**

Soil Type No.	ASC Name	Study Area		Proposed Disturbance Area	
		Area (ha)	Area (%)	Area (ha)	Area (%)
1	Yellow-Brown Kurosols (shallow)	48	55	14.6	51
1-Var	Yellow-Brown Kurosols (deep)	17	19	0.5	2
2	Yellow-Brown Tenosols	14	16	6.0	21
3	Brown Rudosols	8	10	7.4	26
<b>Total</b>		<b>87</b>	<b>100</b>	<b>28.5</b>	<b>100</b>

The physical and chemical characteristics of the soil types are described in **Tables 3.5** to **3.10** and visually presented in **Plates 3.1** to **3.6**.

### 3.2.1 Soil Type 1: Yellow - Brown Kurosols (shallow)

#### Description

Soil Type 1 is a Yellow-Brown Kurosol. Kurosols are characterised by a clear or abrupt textural B horizon in which the major part of the upper 0.2m of the B2 horizon is strongly acidic. Soil Type 1 is mainly associated with Permian sediments characterised by coal, tuff, sandstone, conglomerate and shale.

Soil Type 1 consists of a weakly structured, brown silty loam overlying a yellowish-brown medium clay. The whole soil profile is moderately to strongly acidic, non-saline and slightly dispersive. The subsoil is non-sodic indicating that the clay particles will not tend to disperse when wet. Topsoil Exchangeable Sodium Percent (ESP) was also measured, however, due to the topsoil's very low clay content and associated low Cation Exchange Capacity (CEC) content, this is not relevant indicator for soil aggregate stability.

The topsoil has poor fertility which is characterised by a moderately acidic pH, low CEC, low exchangeable calcium, moderate exchangeable magnesium, and a calcium:magnesium ratio that is calcium deficient. Subsoil fertility is restricted by a strongly acidic pH, however, does exhibit a moderate CEC and high exchangeable magnesium content. Similarly to the topsoil, the subsoil is calcium deficient.

The topsoil has a drainage characteristic of moderate to rapid, while the subsoil drainage is very slow.

### **Location**

These soils cover 55% (48ha) of the Study Area and are associated with moderately inclined slopes as well as level benches and crests. This soil type occurs throughout the Study Area and is the dominant soil type in the proposed Northern Extension.

### **Land Use**

The vegetation overlying these soils is largely open woodland. The vegetation consists of young to mature trees dominated by eucalyptus species. Vegetation communities present are Coastal Foothills Spotted Gum-Ironbark Forest and Coastal Plains Smooth-barked Apple Woodland. Several noxious weed species are also present.



### **Management**

The top 0.50m of soil is suitable for stripping and reuse as a topdressing in rehabilitation. The lower layers are generally unsuitable due to heavy clay content and prohibitive stone content. This soil requires significant amelioration prior to its use to increase soil aggregate stability and lime increase soil pH.

**Table 3.5**  
**Overview – Soil Type 1**

<b>Site Description</b>	
<b>ASC Soil Type</b>	Yellow - Brown Kurosols (shallow)
<b>Soil Overview</b>	Strongly acidic brown silty loam overlying a yellowish-brown medium clay.
<b>Soil Observations</b>	7, 8, 9
<b>Soil Pits Analysed at Laboratory</b>	1
<b>Slope</b>	Moderately inclined slopes (18-32%; 10-18°) with gently inclined slopes on benches and crests.
<b>Major Vegetation Form and Type</b>	Open woodland with eucalyptus species as dominant vegetation type.



Site Description	
	
<b>Plate 3.1 – Landscape (Pit 1)</b>	<b>Plate 3.2 – Profile (Pit 1)</b>

**Table 3.6**  
**Morphological Soil Type 1**

Layer	Horizon	Depth (cm)	Description (Pit 1)
1	A1	0 – 20	Very dark greyish brown (10 YR 3/2) silty loam with firm consistence and weak pedality. Peds are sub angular and approximately 10mm in size. There is a 10% coarse fragment content of size 6 – 20 cm and abundant fine roots. Boundary is clear and even. Moderately acid pH, non-saline, and slightly dispersive.
2	A2	20 - 50	Brown (10 YR 5/3) silty loam with weak to moderate consistence force and weak pedality. Peds are sub angular and approximately 5mm in size. There is a 10% coarse fragment content of size 6 - 60cm and few fine to medium roots. Boundary is clear and wavy. Strongly acid pH, non-saline, and slightly dispersive.
3	B21	50 - 70	Strong brown (7.5 YR 7/4) medium clay with moderate consistence and massive pedality. There is a 10% coarse fragment content of size 6 - 60cm and few medium roots. Boundary is clear and wavy Strongly acid pH, non-saline and slightly dispersive.
4	B22	70 - 100	Light yellowish-brown (10 YR 6/4) medium clay with massive pedality. There is a 50% coarse fragment content of size 6 - 60cm and few roots. Boundary is gradual and broken. Strongly acid pH, non-saline, and slightly dispersive.
5	B23	100 - 120	90% coarse fragment content of size 20 – 60cm; occurs within a matrix of heavy clay.

### **3.2.2 Soil Type 1 Variation: Yellow-Brown Kurosols (deep)**

#### **Description**

A variation of the already described Yellow–Brown Kurosols (Soil Type 1) exists within the Study Area. This variant termed Soil Type 1-Var occurs where a greater amount of topsoil can accumulate, which occurs predominately on the lower slopes. This soil type is mainly associated with Permian sediments characterised by coal, tuff, sandstone, conglomerate and shale.

Soil Type 1-Var consists of the descriptive traits of the Brown–Yellow Kurosol, however, has a deeper and more developed profile. This deeper profile is due to colluvial (from topographical inclines) and fluvial (from minor drainage geomorphology) accumulation of material. This soil type in the south-eastern corner of the Study Area has in particular been influenced by fluvial processes associated with Lake Macquarie.

The soil is comprised of a higher level of deposited material leading to a deeper soil profile, higher fertility characteristics as compared to Soil Type 1.

#### **Location**

This variation covers 20% or 17ha, is present throughout much of the Study Area. It forms only a minor portion of the western edge of the proposed Northern Extension Area and is absent from the proposed Southern Extension Area. It occurs on slopes that are very gently inclined to moderately inclined (0-18%; 0-10°).

#### **Land Use**

The land overlying these soils is largely open woodland. The vegetation consists of young to mature trees dominated by eucalyptus species. The vegetation community present is the Coastal Plains Smooth-Barked Apple Woodland. Several noxious weed species are also present.

#### **Management**

The top 0.70m of soil is suitable for stripping and reuse as a topdressing in rehabilitation. The lower layers are generally unsuitable due to heavy clay content and high acidity. This soil requires some amelioration prior to its use to increase soil aggregate stability and liming to raise soil pH.

This soil type was surveyed using mapping observations (Class IV observation) and as such a detailed profile description (Class I observation) and associated laboratory analysis (Class II observation) are not provided here. This is appropriate as it is a variation of Soil Type 1.

### **3.2.3 Soil Type 2: Brown Rudosols**

#### **Description**

Soil Type 2 is a Brown Rudosols. Rudosol soils are shallow soils that show minimal profile development and are dominated by the presence of weathering rock and rock fragments. Soil Type 2 is mainly associated with Permian sediments, which are characterised by coal, tuff, sandstone, conglomerate and shale.

Soil Type 2 consists of a weakly structured, light sandy clay topsoil that displays minimal pedological development. This skeletal soil is discontinuous throughout the Study Area and rock outcrops are a common feature. Fertility is generally low due to strong soil acidity, absence of organic matter and shallow topsoil.

Drainage is moderate to rapid due to the poorly developed structure of the soil and the abundance of gravels and decomposing bedrock (Matthei, 1995).

### **Location**

These soils cover 16% or 14ha of the Study Area and occur on steep to very steeply inclines slopes of the site, where natural erosion is sufficiently rapid to ensure that only a thin cover of soil is maintained. This soil type occurs in both the Proposed Northern and Southern Extension Areas to a limited extent.

### **Land Use**



The land overlying these soils is largely uncleared open woodland with occasional rock outcrops. The vegetation consists of young to mature trees dominated by eucalyptus species. Vegetation communities present are Coastal Foothills Spotted Gum-Ironbark Forest and Coastal Plains Smooth-barked Apple Woodland. Several noxious weed species are also present. This soil type is mainly associated with Permian sediments characterised by coal, tuff, sandstone, conglomerate and shale.

### **Management**

The soil is not suitable for stripping due to its weak textural structure, shallow topsoil and high presence of rock outcrops.

**Table 3.7**  
**Overview Soil Type 2**

<b>Site Description</b>	
<b>ASC Soil Type</b>	Brown Rudosols
<b>Soil Overview</b>	Shallow brown soil overlying bedrock
<b>Soil Observation</b>	0, 4, 2
<b>Slope</b>	Steep to very steep inclined slopes (32–56%; 18-30°)
<b>Major Vegetation Form and Type</b>	Open woodland with eucalyptus species as dominant vegetation type.

Site Description	
	
<b>Plate 3.3 – Landscape – Rock Outcrop (Obs 3)</b>	<b>Plate 3.4 – Topsoil (Obs 3)</b>

**Table 3.8**  
**Morphological Soil Type 2**

Layer	Horizon	Depth (cm)	Description (Matthei 1993 with observations)
1	A1	<50	Very dark brown (7.5 YR 2.5/2) light sandy clay with weak consistence and weak pedality grade. Peds are sub angular - blocky at <50mm. There are few fine - medium roots, and few to many gravel sized, sub-rounded conglomerate fragments.
2	A2		Dull yellowish brown (10 YR 6/4) sandy clay loam with weak consistence force and massive pedality grade. Peds are sub angular blocky at 20 - 50mm. There are few small roots, and sub-rounded gravel sized conglomerate pebbles are common.

### 3.2.4 Soil Type 3: Yellow – Brown Tenosol

#### Description

Soil Type 3 is a Yellow–Brown Tenosol, Tenosols have greater soil profile development than Rudosols, but less development than Kurosols.

Soil Type 3 consists of a weakly structured, dark brown silty loam overlying a brown loam that has weak pedologic organisation. These layers overlie a lower horizon dominated by gravels with strong saprolite presence. The soil profile ranges from moderately to strongly acidic and is non-saline. The topsoil is slightly dispersive, with the subsoil being moderately to highly dispersive. The ESP was also measured, however, due to the topsoil's very low clay content and associated low CEC content, this is not relevant indicator for soil aggregate stability.

Fertility is minimal throughout the poorly developed profile due to a very low CEC. Fertility is restricted by a strongly acidic pH and an overall deficiency in calcium indicated by the calcium/magnesium ratio. This soil type has a moderate-rapid drainage characteristic throughout the profile.

### **Location**

These soils cover 9% or 8ha of the Study Area and are found on the mid to lower slopes with moderate to steep inclines. They exist in the southern regions of the Study Area and extensively within the proposed Southern Extension. This soil type does not occur in the proposed Northern Extension.

### **Land Use**

The land overlying these soils is largely uncleared open woodland. The vegetation consists of young to mature trees dominated by eucalyptus species. Vegetation communities present are Coastal Foothills Spotted Gum-Ironbark Forest and Coastal Plains Smooth-barked Apple Woodland. Several noxious weed species are also present.



### **Management**

The top 0.30m of soil is suitable for stripping and reuse as topdressing material in rehabilitation. This soil is constrained by poor structure, prohibitive subsoil stone content, and high acidity. This soil requires some amelioration prior to its use to increase soil aggregate stability and liming to increase its pH.

**Table 3.9**  
**Overview Soil Type 3**

<b>Site Description</b>	
<b>ASC Soil Type</b>	Yellow–Brown Tenosol
<b>Soil Overview</b>	Brown weakly structured gradational soil.
<b>Soil Observation</b>	5, 6
<b>Soil Pits Analysed at Laboratory</b>	2, 3
<b>Slope</b>	Moderate to steep inclined slopes (18–32%; 10-18°)
<b>Major Vegetation Form and Type</b>	Open woodland with eucalyptus species as dominant vegetation type.



Site Description	
	
<b>Plate 3.5 – Landscape (Pit 2)</b>	<b>Plate 3.6 – Profile (Pit 2)</b>

**Table 3.10**  
**Morphological Soil Type 3**

Layer	Horizon	Depth (cm)	Description (Pit 2)
1	A1	0 – 5	Dark brown (7.5 YR 3/2) silty loam with moderate consistence force and weak pedality. Peds are 5mm and have crumb structure. There is an abundance of fine - medium roots and coarse fragment content of <1cm at 10% presence. Boundary is abrupt and even. Moderately acid pH, non-saline and slightly dispersive.
2	B2	5 – 30	Strong brown (7.5 YR 5/6) silty loam with very weak consistence and very weak pedality grade. Peds are sub angular at approximately 5mm. There are few medium roots and coarse fragments of 4 - 6cm at 20% presence. Boundary is abrupt and wavy. Strongly acid pH, non-saline and high to moderately dispersive.
3	C	30 – 80	Strong brown (7.5 YR 5/6) horizon of stones of 4 – 6cm at 90%. There are few medium roots. Boundary is diffuse. Moderately acid pH, high to moderately dispersive.
4	C / R	80 – 120	Stone layer of 1 – 6cm at 95% presence. Few medium roots.

## 4. LAND ASSESSMENT

The proposed Northern and Southern Extensions have been assessed for both rural land capability and agricultural suitability. The methods and results for these assessments are presented in this section fulfilling report objectives 2 and 3.

## **4.1 LAND CAPABILITY AND AGRICULTURAL SUITABILITY RELATIONSHIP**

In NSW, rural lands are currently being mapped according to two different land classification systems. The first of these was developed by the former Soil Conservation Service of NSW and classifies land into eight classes (I-VIII) known as land capability classes. The second system used by the former NSW Department of Agriculture classifies land into five classes (1-5) known as agricultural suitability classes. These systems are connected with the latter to an extent dependent on the former. A brief overview of their relationship to each other is discussed here with further detail provided in **Sections 4.2** and **4.3** respectively.

The aim of the land capability classification system is to delineate the various classes of rural lands on the basis of their capability to remain stable under particular land uses. This system classifies the land in terms of its inherent physical characteristics or physical constraints and denotes measures needed to protect the land from soil erosion and other forms of land degradation. It therefore considers the optimum use of land rather than the maximum use. The land capability classification system does not imply any aspect of agricultural suitability which can involve connection to markets, availability of water and other facilities. The agricultural suitability classification system aims to satisfy these agricultural suitability aspects.

The agricultural suitability system uses the land capability assessment as a basis and then incorporates other specific factors such as closeness to markets, cultural factors, land location and adverse market demand to determine the appropriate agricultural suitability class. Consequently, a site's agricultural suitability classification may change over time due to market forces and changes to site-specific infrastructure. In contrast, the land capability of a site generally will not change, however, some change may occur in conjunction with improvements in agricultural farming methodology that reduce erosion risk.

## **4.2 LAND CAPABILITY**

### **4.2.1 Land Capability Methodology**

The land capability system applied to the Study Area is in accordance with NSW DTIRIS and is administered by the NSW Department of Planning & Infrastructure (DPI). This system was introduced by the former Soil Conservation Service of NSW and the relevant guideline is titled *Systems Used to Classify Rural Lands in New South Wales* (Cunningham et al., 1988).

This system classifies the land on its potential for sustainable agricultural use if developed, rather than its current land use, and includes three types of land uses:

- land suitable for cultivation;
- land suitable for grazing; and
- land not suitable for rural production.

The system consists of eight classes, which classify the land based on the severity of long-term limitations. Limitations are the result of the interaction between physical resources and a specific land use. A range of factors are used to assess this interaction. These factors include climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses.

The principal limitation recognised by these capability classifications is the stability of the soil mantle and classes are ranked on their increasing soil erosion hazard and decreasing versatility of use. A description of the eight land capability classes is provided in **Table 4.1** and a spatial distribution included in **Figure 4.1**.

**Table 4.1**  
**Rural Land Capacity Classes**

<b>Class</b>	<b>Land Use</b>	<b>Management Options</b>
I	Regular Cultivation	No erosion control requirements
II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works
III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways
IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks
VI	Grazing only	Managed to ensure ground cover is maintained
VII	Unsuitable for rural production	Green timber maintained to control erosion
VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
Source: Cunningham et al., 1988		

#### **4.2.2 Pre – Mining Land Capability Results**

The relevant Land Capability Classes for the Study Area are displayed in **Table 4.2**

##### **Class VI Land**

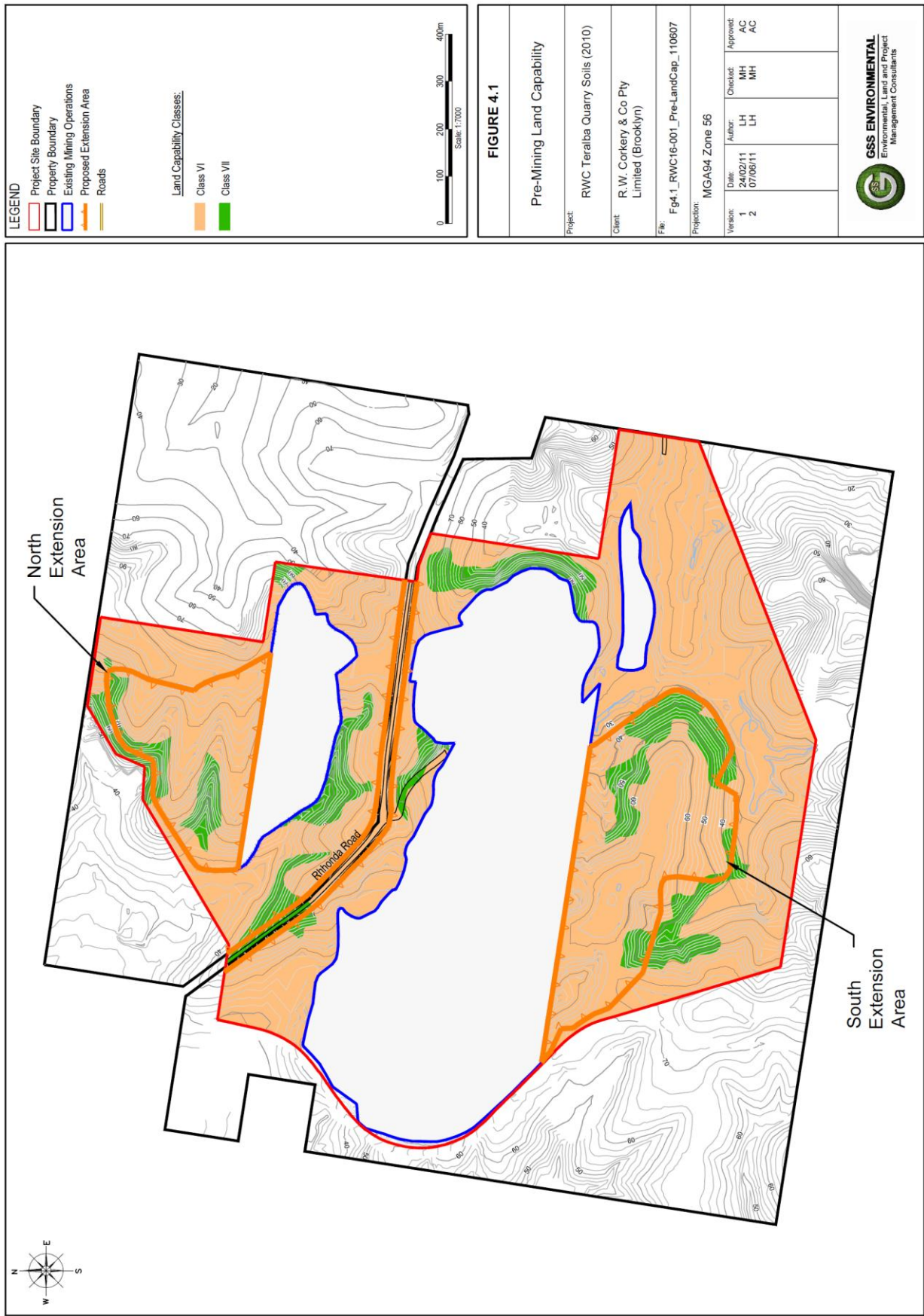
Class VI land consists of Soil Types 1 (Shallow Yellow–Brown Kurosol), 1-Var (Deep Yellow–Brown Kurosol), and 3 (Yellow–Brown Tenosol). This classification indicates that this land must not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented.

The primary constraint of Soil Type 1 is its clayey subsoils, strongly acidic profile, high stone presence, and association with moderately inclined slopes. Soil Type 1-Var is constrained by a weak topsoil texture, heavy subsoil clay content and impeded soil profile drainage. Soil Type 3 is constrained by a high stone presence and a strongly to very strongly acidic soil solum pH.

##### **Class VII Land**

Class VII land consists of Soil Type 2 (Brown Rudosol). This classification indicates that the land is not suitable for cropping or grazing due to severe limitations and is land best protected by green timber. Soil Type 2 is constrained by steep slopes, a shallow/skeletal soil and abundant rocky outcrop exposures.





**Table 4.2**  
**Land Capability Summary**

Class	Soil Type #	Study Area		Proposed Disturbance Area		Main Limitations
		Area (ha)	Area (%)	Area (ha)	Area (%)	
VI	1, 1-Var, 3	73	84	22.5	79	Heavy sub-soil clay content, or stony subsoil; moderate - high acidity, high topsoil permeability; and low available water holding capacity.
VII	2	14	16	6.0	21	High presence of rock outcrops; High erodibility; and Steep slopes.
<b>Total</b>		<b>87</b>	<b>100</b>	<b>28.5</b>	<b>100</b>	

### 4.2.3 Post – Mining Land Capability Results

The post-mining landform will typically be slopes of 0-18% (0-10°). The post-mining land capability of this landform is Class VI. This class indicate that the land will be capable of sustaining light grazing if good soil management practices are employed.

## 4.3 AGRICULTURAL SUITABILITY

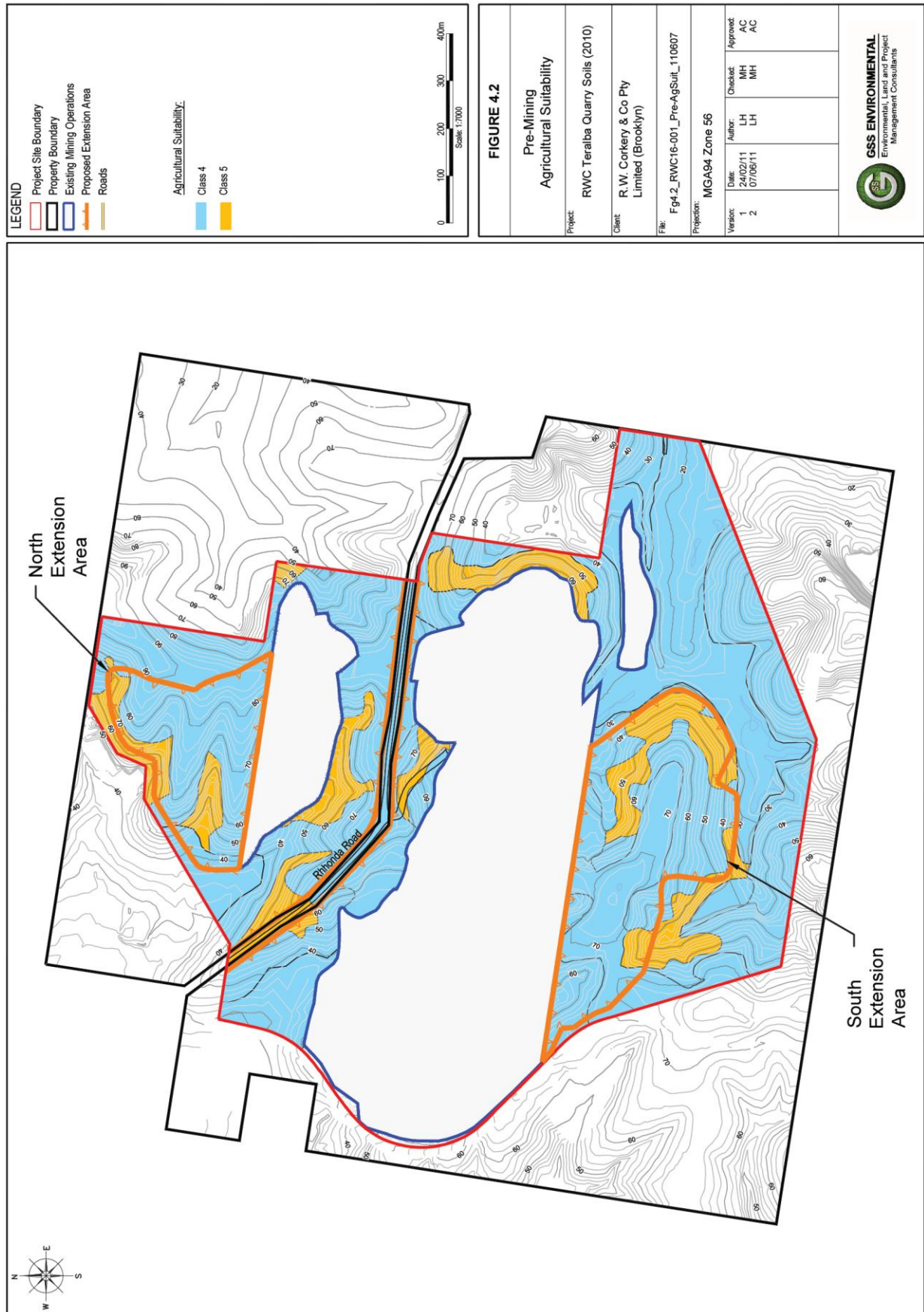
### 4.3.1 Agricultural Suitability Methodology

The agricultural suitability system applied to the Study Area is in accordance with NSW DTIRIS, specifically the NSW DPI. This system was introduced by the former NSW Agricultural & Fisheries and the relevant guideline is titled the *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries, 1990).

The system consists of five classes, providing a ranking of rural lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits. Class 1 ranks the land as most suitable for agricultural activities and Class 5 the least suitable. Classes 1 to 3 are generally considered suitable for a wide variety of agricultural production, whereas, Classes 4 and 5 are unsuitable for cropping however are suitable for some grazing activities

The main soil properties and other landform characteristics considered significant for the land suitability assessment are topsoil texture, topsoil pH, solum depth, external and internal drainage, topsoil stoniness and slope as well as bio-physical factors such as elevation, rainfall and temperature.

The overall suitability classification for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations. A description of each Agricultural Suitability Class is provided in **Table 4.3** and a spatial distribution included in **Figure 4.2**.



**Table 4.3**  
**Agricultural Suitability Classes**

<b>Class</b>	<b>Land Use</b>	<b>Management Options</b>
1	Highly productive land suited to both row and field crops.	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.
2	Highly productive land suited to both row and field crops.	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation.
3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation.	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture.
4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage.
5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land unsuitable for agriculture or at best suited only to light grazing.
Source: NSW Agriculture & Fisheries (1990)		

### **4.3.2 Agricultural Suitability Results**

The relevant Agriculture Suitability Classes for the Study Area are displayed in **Table 4.4**

#### **Class 4 Land**

The main agricultural suitability class covering the Study Area is Class 4. Class 4 land consists of Soil Types 1 (Shallow Yellow–Brown Kurosol), 1-Var (Deep Yellow-Brown Kurosol), and 3 (Yellow-Brown Tenosol).

This classification indicates that this land must not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented. Pasture selection is to be based on native grasses or improved pastures established using minimum tillage techniques.

A major constraint for both Soil Types 1 and 1-Var is weak topsoil texture, acidic soil profile and low fertility characteristics. Soil Type 3 is additionally constrained by a high subsoil stone presence. The cultivation of these soils for agriculture, which involves removal of the protective vegetative cover present, will facilitate erosion processes and these processes typically take the form of wind erosion where unconsolidated, loose soils are easily transported.

#### **Class 5 Land**

Class 5 land consists of Soil Type 2 (Brown Rudosol). This class of land is best managed by the presence of light green timber due to its highly erodible soils and steep slopes. Partial clearing for grazing can occur, however, significant stands of trees are required to maintain soil cover. This soil type is severely constrained by its steep slopes.

**Table 4.4**  
**Agricultural Suitability Class Summary**

Class	Soil Type #	Study Area		Proposed Disturbance Area		Main Limitations
		Area (ha)	Area (%)	Area (ha)	Area (%)	
4	1	73	84	22.5	79	Poor topsoil structure; Heavy sub-soil clay content, Moderate - high acidity; and Moderately inclined slopes.
4	1-Var					Poor topsoil structure; Heavy sub-soil clay content, Moderate – high acidity, and Low fertility.
4	3					Poor topsoil structure; Moderate – high acidity, High presence of stones; and Low fertility.
5	2	14	16	6.0	21	Rock outcrops; Minimal soil development; Moderate – high acidity.
Total		87	100	28.5	100	

#### **4.3.3 Post – Mining Agricultural Suitability**

The post-mining landform will typically be slopes of 0-18% (0-10°). The post-mining land capability of this landform is Class 4. This class indicate that the land will be capable of sustaining light grazing if good soil management practices are employed.

## **5. DISTURBANCE MANAGEMENT**

Soil to be disturbed due to the modification has been assessed to determine its suitability for stripping and re-use on rehabilitation sites. This assessment is an integral process for successful rehabilitation of the Study Area. This report provides information on the following key areas related to the management of the Study Area's topsoil resources:

- Topsoil stripping assessment which provides a topsoil stripping depth map indicating recommended stripping depths for topsoil salvage and re-use as topdressing in rehabilitation; and
- Topsoil management for soil that is stripped, stored and used as a topdressing material for rehabilitation.

## 5.1 TOPSOIL STRIPPING ASSESSMENT

### 5.1.1 Topsoil Stripping Methodology

Determination of suitable soil to conserve for later use in rehabilitation has been conducted in accordance with Elliott & Veness (1981). The approach remains the benchmark for land resource assessment in the Australian mining industry. This procedure involves assessing soils based on a range of physical and chemical parameters. **Figure 5.1** summarises the procedure for the selection of soil material for use as topdressing of areas disturbed by the Modification and **Table 5.1** lists the key parameters and corresponding desirable selection criteria.

**Table 5.1**  
**Topsoil Stripping Suitability Criteria**

Parameter	Desirable criteria
Structure Grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10cm
Force to Disrupt Peds	≤ 3 force
Texture	Finer than a Fine Sandy Loam
Gravel & Sand Content	<60%
pH	4.5 to 8.4
Salt Content	<1.5 dS/m

Gravel and sand content, pH and salinity were determined for all samples using the laboratory test results. Texture was determined in the field and cross referenced with laboratory results, specifically particle size analysis. All other physical parameters outlined in **Table 5.1** were determined during the field assessment.

Structural grade is significant in terms of the soil's capability to facilitate water relations and aeration. Good permeability and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade and depends on the proportion of coarse peds in the soil surface. Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils, without pores, are considered unsuitable as topdressing materials.

The shearing test is used as a measure of the soil's ability to maintain structure grade. Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the excavation, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.



Procedure for the selection of material for use in topdressing of disturbed areas

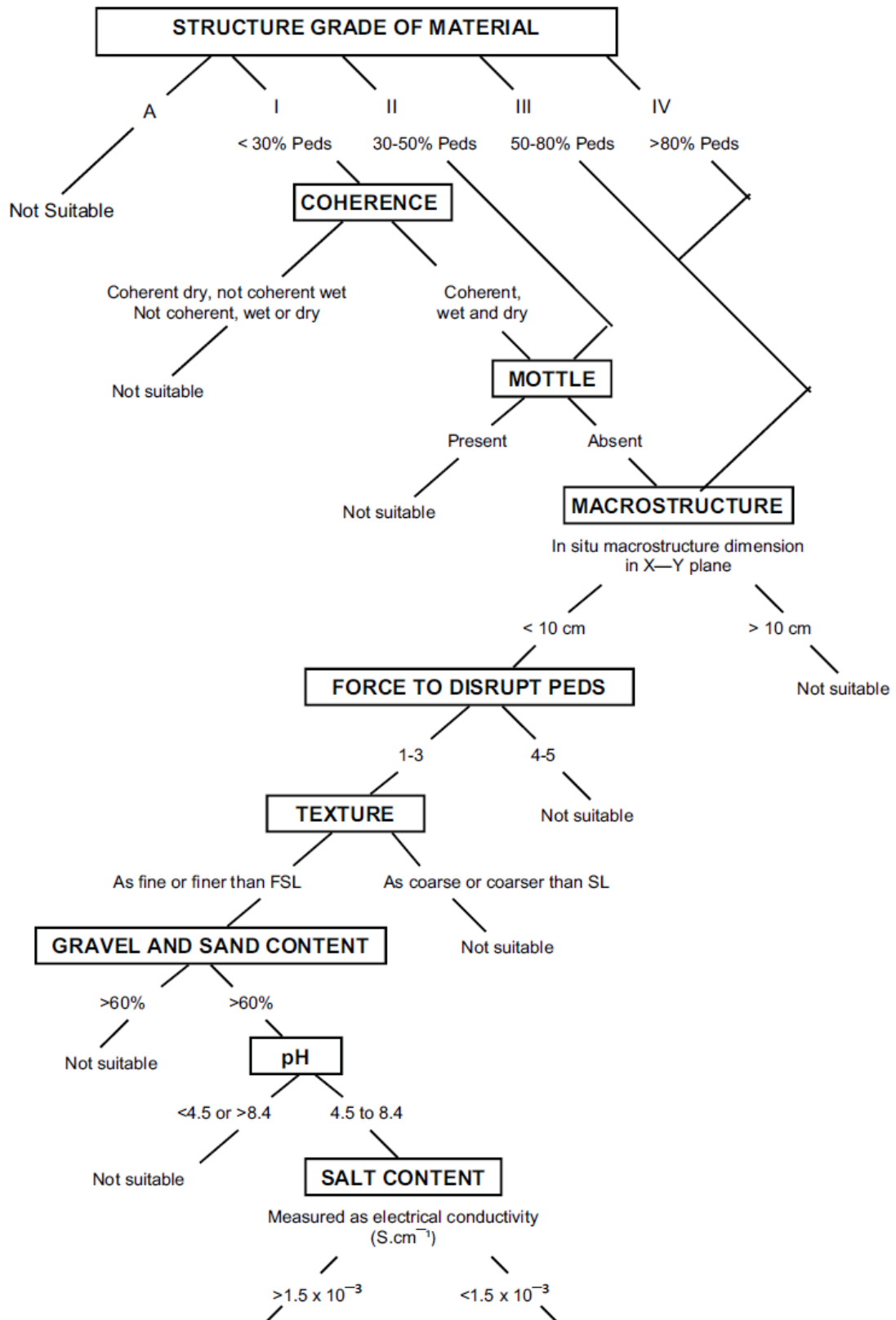


Figure 5.1: Selection of Topdressing Material for Rehabilitation (Source: Elliot and Veness, 1981)

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeability's, however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

### 5.1.2 Topsoil Stripping Depths

The land that the proposed extension will disturb includes the proposed Northern Extension, the proposed Southern Extension, and the proposed 20m wide corridor across Rhondda Road. These disturbance areas are covered by a combination of all the soil types as described in this report. **Table 5.2** summarises the recommended stripping depths by soil type.

**Table 5.2**  
**Stripping Depth for each Soil Type**

Soil Type	ASC	Average Recommended Soil Stripping Depth (m)		Main Limitations
		Topsoil	Subsoil	
1	Shallow Yellow – Brown Kurosol	0.5	Nil	Moderate to strongly acidic soil;
1-Var	Deep Yellow – Brown Kurosol	0.7	Nil	Weak topsoil structure and clayey subsoil texture.
2	Brown Rudosol	Nil	Nil	Shallow topsoil overlying bedrock.
3	Yellow – Brown Tenosol	0.3	Nil	Weak topsoil structure; High presence of stones in subsoil; Very strongly acidic subsoil

The topsoil for Soil Type 1 (Shallow Yellow–Brown Kurosol) and Soil Type 1-Var (Deep Yellow–Brown Subsoil) are considered to be marginally suitable for reuse in post-mining rehabilitation activities. The constraining factors for these soil types include a weak topsoil structure, moderate to strong acidity throughout the profile as well as a slight tendency to disperse when wet. The subsoil is not recommended for stripping due to constraints of medium clayey texture which is an unsuitable characteristic for topdressing media due to the resulting poor aeration, infiltration and inferior structural characteristics.

Soil Type 1 and Soil Type 1-Var are therefore recommended to be stripped to an average depth of 0.5m and 0.7m respectively. Minimal handling procedures are to be employed to limit destabilisation of any organically bound aggregates. In addition, this soil type will require amelioration practices such as the addition of organic amendments (e.g. biosolids) as well as a liming agent to improve pH prior to re-use.



Soil Type 3 (Yellow–Brown Tenosols) is identified as containing marginally suitable material for rehabilitation works. This is due to significant constraints associated with weak soil development, high subsoil stone content, high tendency to disperse when wet and low pH. Soil Type 3 is therefore recommended to be stripped an average depth of 0.3m to salvage the richer organic soil. The subsoil is of weak pedologic organisation and is not appropriate for re-use.

The topsoil for Soil Type 2 (Brown Rudosols) is not considered suitable for stripping and reuse in post-mining rehabilitation activities due to steep slopes, shallow profile and abundant presence of rocky outcrops.

### 5.1.3 Topdressing Suitability Volume

The topsoil volumes discussed in this section have been generated from the recommended stripping depths of each soil type by disturbance element. The estimated total volume of topdressing material available for reuse from the Study Area is 88 380 m<sup>3</sup> (**Table 5.3**).

**Table 5.3**  
**Topsoil Volumes**

Disturbance Area	Soil Type #	Average Recommended Soil Stripping Depth (m)	Area (ha)	Total Volume (m3)
Proposed Northern Extension	1	0.5	6.9	34 500
	1-Var	0.7	0.5	3 500
	2	Not recommended	1.9	0
	3	0.3	0	0
<b>Subtotal</b>			<b>9.3</b>	<b>38 000</b>
Proposed Southern Extension	1	0.5	5.5	27 500
	1-Var	0.7	0	0
	2	Not recommended	3.6	0
	3	0.3	7.4	22 200
<b>Subtotal</b>			<b>16.5</b>	<b>49700</b>
Proposed 20m wide corridor across Rhondda Road	1	0.5	2.1	10 500
	1-Var	0.7	0	0
	2	Not recommended	0.6	0
	3	0.3	0	0
<b>Subtotal</b>			<b>2.7</b>	<b>10 500</b>
<b>Total</b>			<b>28.5</b>	<b>98 200</b>
<b>Total Volume with 10% handling loss (approximately)</b>				<b>88 380</b>

#### 5.1.4 Soil Management

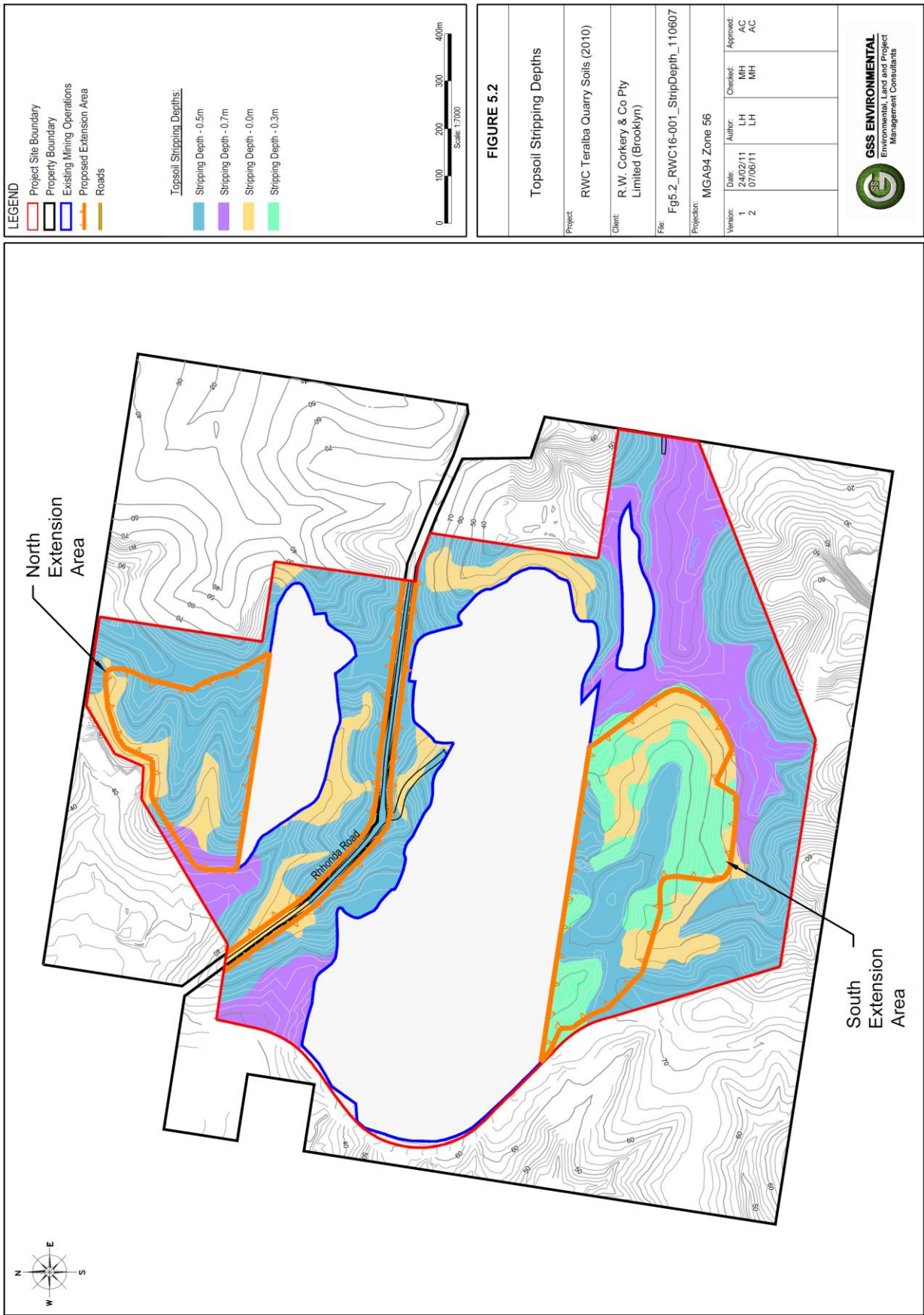
Where topsoil stripping and transportation is required, the following topsoil handling techniques are recommended to prevent excessive soil deterioration, note these techniques equally apply to subsoil management:

- Strip material to the depths stated in **Tables 5.2 - 5.3**, subject to further investigation as required.
- Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if quarrying sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Grading or pushing soil into windrows with graders or dozers for later collection for loading into rear dump trucks by front-end loaders, are examples of preferential less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by overburden trucks may be placed directly into storage.
- The surface of soil stockpiles should be left in as coarsely structured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of 3m. Clayey soils should be stored in lower stockpiles for shorter periods of time compared to coarser textured sandy soils.
- If long-term stockpiling is planned (i.e. greater than 12 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward will provide sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.
- Prior to re-spreading stockpiled topsoil onto reshaped overburden (particularly onto designated tree seeding areas), an assessment of weed infestation on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and / or “scalping” of weed species prior to topsoil spreading.
- An inventory of available soil should be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.
- Topsoil should be spread to a minimum depth range of 0.1m (steep slopes) to 0.2m (flatter areas). Soil respreading on steep slopes at depths exceeding 0.1m can be deleterious because of the “sponge” effect which can cause slippage of the topsoil from the slope. Flat areas should be topsoiled at a nominal depth of 0.2m. Specific topsoil respreading depths for different post mining landform elements will be specified in the Landscape Management Plan.

### **5.1.5 Topsoil Re-spreading and Revegetation**

Where practical, suitable topsoil should be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil should be spread to a nominal depth of 100 mm on all re-graded overburden/substrate. Topsoil should be spread, treated with fertiliser and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion.

The surface of the placed topsoil would be lightly contour ripped (after topsoil spreading) to create a “key” between the soil and the underlying overburden/substrate. Ripping should be undertaken on the contour. Ripping would be undertaken whenever practicable when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified during seeding to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tynded plough or disc harrow.



## **6. REFERENCES**

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# Appendices

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Appendix 1    Glossary

Appendix 2    Certificate of Analysis

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# Appendix 1

## Glossary

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## GLOSSARY

## APPENDIX 1



**Teralba Quarry**  
**Soil and Land Capability Assessment**

**Appendix 1**

Term	Definition
Soil Classification	The systematic arrangement of soils into groups or categories on the basis of similarities and differences in their characteristics.
Soil Coherence	The degree to which soil material is held together at different moisture levels. If two-thirds or more of the soil material, whether composed of peds or not, remain united at a given moisture level, then the soil is described as coherent.
Soil Consistence	The resistance of soil material to deformation or rupture.
Soil Erodibility	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents.
Soil Horizon	A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, biological properties such as colour structure, texture, consistency, kinds and number of organisms present, degrees of acidity or alkalinity.
Soil Profile	A vertical section of the soil through all its horizons.
Soil Salinity	The amount of soluble salts in a soil. The convention measure of soil salinity is the electrical conductivity of a saturation extract.
Soil Structure	Refers to the way soil particles are arranged and bound together to form aggregates or peds.
Soil Texture	The relative proportions of the various soil separates in a soil as described by the classes of soil texture. It is the general coarseness or fineness of soil material as it affects the behaviour of a moist ball (bolus) when pressed between the thumb and forefinger.
Solum	The upper part of a soil profile above the parent material, in which current processes of soil formation are active. The solum consists of either the A and B horizons or the A horizon alone when no B is present.
Structure Pedality Grade	Is the degree of development and distinction of ped.
Structure Ped and Size	Refers to the distinctness, size and shape of peds.
Subsoil	Refers to B soil horizon
Topsoil	Refers to A1 and A2 soil horizons.

1 Definitions have been sourced from: Charman and Murphy, 1991; Peverill et al., 1999; Mckensie et al., 2004; NCST, 2009.

# **Appendix 2**

## **Certificate of Analysis**

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## Certificate of Analysis



## Appendix 2





**SOIL TEST REPORT**

Page 1 of 3

**Scone Research Centre**

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**REPORT NO:** SCO10/399R1

**REPORT TO:** Adele Calandra  
GSS Environmental  
PO Box 907  
Hamilton NSW 2303

**REPORT ON:** Ten soil samples

**PRELIMINARY RESULTS**

**ISSUED:** Not issued

**REPORT STATUS:** Final

**DATE REPORTED:** 19 January 2011

**METHODS:** Information on test procedures can be obtained from Scone  
Research Centre

**TESTING CARRIED OUT ON SAMPLE AS RECEIVED**  
**THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL**

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A handwritten signature in black ink that reads "SR Young".

SR Young  
(Laboratory Manager)

**SOIL CONSERVATION SERVICE**  
**Stone Research Service Centre**

Report No: SCO10/399R1  
Client Reference: Adele Calandra  
GSS Environmental  
PO Box 907  
Hamilton NSW 2303

Lab No	Method Sample Id	P7B/2 Particle Size Analysis (%)					P9B/2 EAT	C1A/4 EC (dS/m)	C2A/3 pH	C2B/3 pH (CaCl <sub>2</sub> )
		clay	silt	f sand	c sand	gravel				
1	1-1	4	13	14	18	51	3(1)	0.05	5.6	4.5
2	1-2	8	13	16	16	47	3(1)	<0.01	5.5	4.3
3	1-3	43	15	11	14	17	5	0.04	5.2	4.0
4	1-4	43	11	16	13	17	5	0.05	5.2	4.0
5	2-1	6	17	19	28	30	3(1)	0.02	5.9	4.9
6	2-2	8	14	11	23	44	2(1)	0.01	5.4	4.3
7	2-3	6	6	4	20	64	2(1)	0.01	5.6	4.3
8	3-1	11	7	11	16	55	3(1)	0.03	5.1	4.0
9	3-2	12	10	14	20	44	5	0.02	5.0	4.0
10	3-4	7	13	22	30	28	3(1)	0.02	5.0	4.1

*SR Young*

**SOIL CONSERVATION SERVICE**  
**Scone Research Service Centre**

SCO10/399R1  
Adele Calandra  
GSS Environmental  
PO Box 907  
Hamilton NSW 2303

Report No:  
Client Reference:

Lab No	Method Sample Id	C5A/3 CEC & exchangeable cations (me/100g)					Colour	
		CEC	Na	K	Ca	Mg	Al	
1	1-1	9.0	0.6	0.4	3.2	2.1	1.0	10YR5/2
2	1-2	6.0	0.4	0.3	0.9	1.4	1.1	10YR7/2
3	1-3	17.3	0.9	0.3	0.8	6.6	5.5	7.5YR7/4
4	1-4	20.6	1.1	0.3	0.8	8.5	6.2	10YR8/2
5	2-1	9.4	0.5	0.4	4.8	1.8	0.5	7.5YR6/2
6	2-2	6.0	0.3	0.4	1.4	1.1	1.1	7.5YR7/3
7	2-3	8.5	0.6	0.4	1.7	3.3	1.0	7.5YR7/3
8	3-1	11.5	0.6	0.3	0.8	3.3	4.4	10YR7/3
9	3-2	9.0	0.6	0.3	0.9	1.9	3.8	10YR7/2
10	3-4	8.0	0.4	0.5	2.3	1.2	2.1	10YR5/2

*SR Young*

END OF TEST REPORT

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