ABN: 69 107 169 102

Werris Creek Coal Pty Limited

SOILS ASSESSMENT

For

Werris Creek Coal Mine Life of Mine Project

Prepared by:

GSS Environmental

Specialist Consultant Studies Compendium

Volume 2, Part 7

December 2010

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WHITEHAVEN COAL

ABN: 69 107 169 102

Werris Creek Coal Pty Limited

SOILS ASSESSMENT

for

Werris Creek Coal Mine
Life of Mine Project

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December 2010

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Executive Summary

R.W. Corkery & Co. Pty Limited commissioned GSS Environmental (GSSE) to undertake a soil and land capability assessment for the Werris Creek Coal Mine Life of Mine Project (the LOM Project) for inclusion in the Environmental Assessment (EA).

The GSSE soil and land capability assessment report provides:

- a description of the soil and land capability classification across the Study Area in accordance with the Australian Soil Classification System (ASC) and the NSW technical guidelines for assessing land capability;
- recommendations on soil stripping depths for all soil types in the Study Area, including recommendations for topsoil handling, stockpiling and amelioration for reuse in rehabilitation; and
- identification of unfavourable materials, which require specific management and handling practices.

Soil samples were analysed for various physical and chemical soil attributes by a NATA accredited laboratory. Results of the analysed data showed that 3 soil types occurred through the study area. These soils consist of the following:

- Brown Chromosol (73 ha);
- Stoney Brown Chromosol (144 ha); and
- Dark Brown Vertosol (205 ha).

The Brown Chromosol and the Dark Brown Vertosol soil types were recommended for stripping at 0.3 m, whilst the Stoney Brown Chromosol was not recommended for stripping.

Land Capability classification across the Study Area ranges from Class III to Class VI pre-mining and Class III to Class VII post-mining. Agricultural Suitability classes ranged from Class 2 to Class 4 pre-mining and Class 2 to Class 5 post-mining across the entire study area including previously approved and disturbed areas.

There are adequate subsoil and topsoil resources contained in both stockpiled material and in situ soil yet to be stripped, to meet the rehabilitation objectives for the LOM Project.

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1 Introduction

GSS Environmental (GSSE) was commissioned by R.W. Corkery & Co. Pty Limited on behalf of Werris Creek Coal Pty Limited (the "Proponent"), to undertake a Soil and Land Capability Impact Assessment for the Werris Creek Coal Mine Life of Mine Project ("LOM Project").

1.1 BACKGROUND

Werris Creek Coal Pty Limited currently operates the Werris Creek Coal Mine, located approximately 4km south of the town of Werris Creek and 11km north-northwest of Quirindi, within the North West Slopes and Plains of New South Wales, under Development Consent DA 172-7-2004. The Werris Creek Coal Mine is currently operated within Mining Lease (ML) 1563 on land owned by the Proponent and covering an existing approved area of approximately 679ha. A locality plan of the Werris Creek Coal Mine is shown in **Figure 1.**

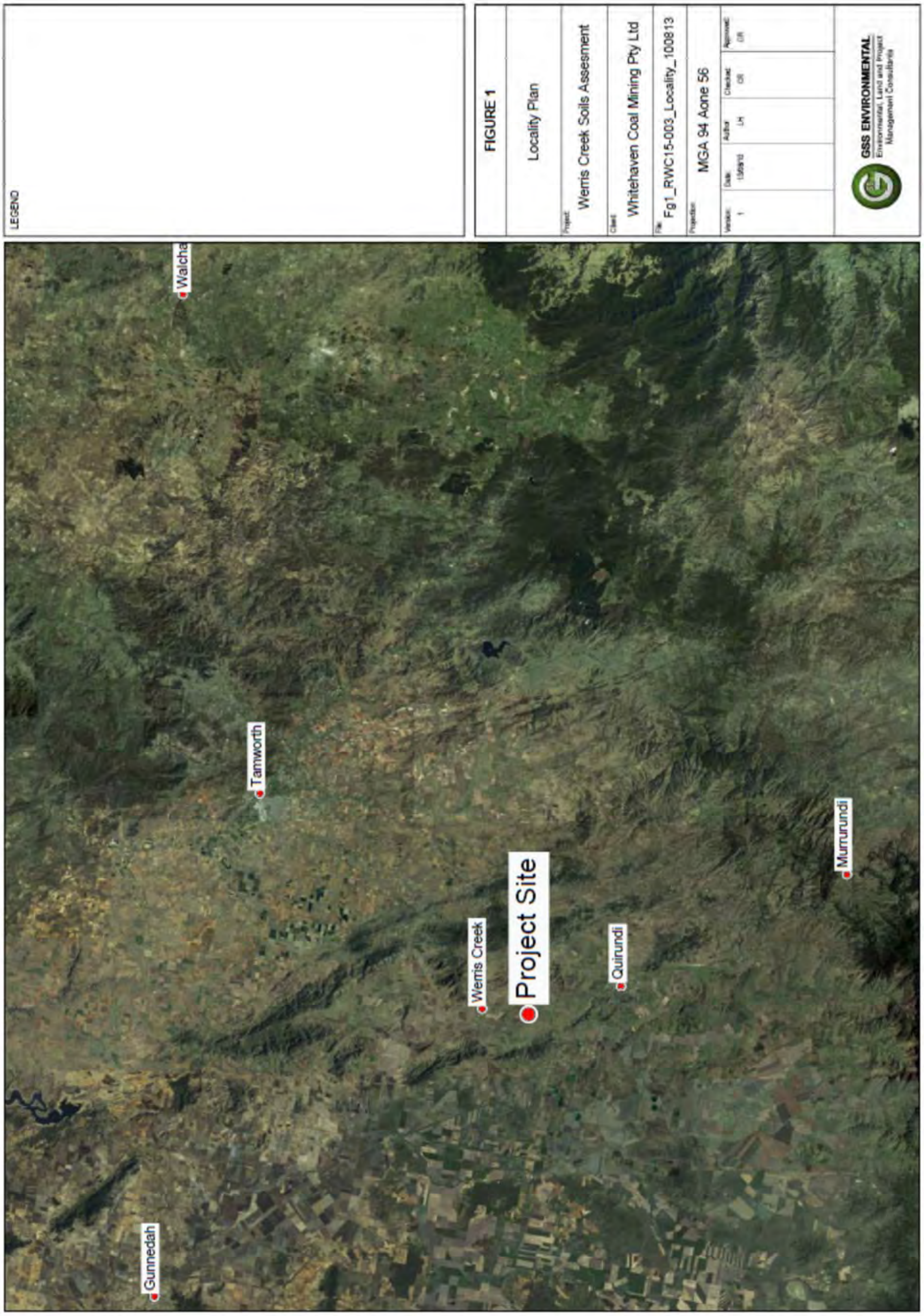
The Werris Creek Coal Mine has operated continuously since April 2005 and in October 2009 an application to modify the limit of open cut mining and overburden emplacement (MOD 5 - the Northern Extension) was approved by the Minister for Planning. The Proponent has undertaken exploration drilling to the north of the approved open cut (within an area covered by Exploration Licence (EL 5993 & EL7422) and confirmed the continuation of the coal seams to the north at depths and strip ratios which would allow for the continuation of open cut mining. On the basis of the continuation of the coal seams, the Proponent has prepared mine designs to extend the mine to the north to the extent of the coal resource. The land on which the further extension of open cut mining operations are to be undertaken is referred to as the "Project Site.

1.2 PROJECT OVERVIEW

Development Consent (DA-172-7-2004) for the Werris Creek Coal Mine was originally granted in February 2005 and construction activities (as defined by DA-172-7-2004) commenced in April 2005. The open cut is mined using traditional haul back methods producing up to 2 million tonnes per annum of coal for the export and domestic markets. The coal is transported either directly by rail from the Werris Creek Rail Siding to the Port of Newcastle or by public road to domestic markets.

On the 6th of October 2009, the Minister for Planning issued a modification to DA 172-4-2004 to enable a small extension to the open cut operations to the north and allow for the dewatering of the underground workings associated with the former Werris Creek Colliery (MOD 5 - the Northern Extension). The proposed modification was made with the understanding that this would allow for a further extension of the mine to the north to fully recover the coal resource within the mining lease (LOM Project). The LOM Project would include:

- production of up to 2.5Mtpa of thermal and Pulverised Coal Injection (PCI) coal for the domestic and international markets;
- open cut mining operations for 24hours a day, 7 days a week;
- an extension to the out-of-pit overburden emplacements;


LEGEND
FIGURE 1
Locality Plan
Werris Creek Soils Assesment
Whitehaven Coal Mining Pty Ltd
Fg1_RWC15-003_Locality_100813
MGA 94 Aone 56
GSS ENVIRONMENTAL
Walcha
Tamworth
Werris Creek
Project Site
Quirundi
Murrurundi
Gunnedah

- the construction of an Acoustic and Visual Amenity Bund extending around north-eastern perimeter of the open cut to attenuate noise impacts and screen the operation visually from Werris Creek;
- relocation of the Coal Processing Area and increase in the size of the ROM stockpile to 200,000 t;
- relocation of the Site Facilities and Administration Area;
- increase the size of the Product Coal Stockpile Area to 250,000 t by extending the pad to the east;
- installation of a second feed point at the Rail Load-out Facility;
- construction of a ‘turn-around’ rail loop off the Werris Creek Rail Siding to the immediate west of the Rail Load-out Facility;
- construction of a new mine entrance off Escott Road (and closing the existing mine entrance off the Werris Creek Road);
- continued dewatering of the old underground workings;
- construction of a new Void Water Dam; and
- possible construction of a conveyor to transport coal from the Coal Processing Area to the Product Coal Stockpile Area.

R. W. Corkery & Co Pty Limited (RWC) has been engaged by Werris Creek Coal Pty Limited (WCC) to undertake an *Environmental Assessment* (EA) of the proposed LOM Project. This EA accompanies an application for Project Approval submitted to the Department of Planning under Part 3A of the *Environmental Planning and Assessment Act 1979.* The following Soil and Land Capability Impact Assessment has been prepared as part of the requirements for the EA and addresses the following Director General’s Requirements as paraphrased in **Table 1**.

Table 1: Director Generals Requirements Pertaining to Soil and Land Capability

Page 1 of 2

Government Agency	Paraphrased Requirement	Relevant Section of this Assessment
	Soils, Land Capability And Land Use	
Industry & Investment	**Agriculture**	
	From an agricultural perspective the EA should assess and document potential impacts on agricultural enterprises, future productivity and how any adverse impacts would be mitigated.	4.1.2
	I&I NSW recommend the ËA complete a table on Agricultural Land Suitability Classes before and after mining:	4.2.2
	Pre-Mining	
	Comprehensive description of the pre-existing land use and productive capacity of the site providing an objective bench mark of rehabilitation. This should be done using the Department of Natural Resources (DNR) Land Capability assessment and the former Department of Primary Industries (NSW Agriculture) Agricultural Suitability.	4
	An assessment of land use and agricultural operations within the surrounding area and how the operations will fit in the given landscape.	
	Natural resources of significance for agricultural development, including soils, ground and surface waters and any alluvial lands.	3

Table 1: Director Generals Requirements Pertaining to Soil and Land Capability (Cont'd)

Page 2 of 2

Government Agency	Paraphrased Requirement	Relevant Section of this Assessment
	Soils, Land Capability And Land Use (Cont'd)	
	Predicted potential and cumulative environmental and socio-economic impacts on agricultural activities. This should include:	
	- Impacts on surface and ground waters, (flow regime, flow rates, quality and pressure) that might affect other water users (downstream and contiguous aquifer users) and the environment.	N/A to this assessment. Refer surface water and groundwater assessments
	- predicted and possible changes to water use requirements (surface and ground waters).	N/A to this assessment. Refer surface water and groundwater assessments
	- noise, dust, blasting impacts	N/A to this assessment. Refer noise and air quality assessments
	- changes to infrastructure and local roads affecting other users.	N/A to this assessment. Refer traffic and transport assessment
	- The total area to be disturbed, future land capability and the size of all final voids within the combined leases.	4
	- Possible social impact of mining employment on rural labour force	N/A to this assessment. Refer Section 4B of Environmental Assessment
	Potential opportunities for sustainable agricultural production on land under the control of the mining company during and post-mining. The productive use of pasture lands is encouraged.	4.1.2
	The general approaches that would be adopted to ensure the sustainable management of cleared pasture areas and to retain / enhance productivity. Short term, piecemeal grazing leases or merely excluding cattle will not sustain the productive capacity and agricultural potential of the site, or ensure sustainable environmental outcomes.	4.1.2
	What management plans will be developed (& when) for pasture / grazing management.	To be provided in rehabilitation assessment
	Key environmental management and rehabilitation strategies including; ……… - topsoil management and re use strategies and prevention of subsoil constants such as compaction, saline contamination and other forms of contamination	5

1.3 OBJECTIVES

The principal objectives of the assessment undertaken by GSSE are to:

i. assess areas to be disturbed by the LOM Project at a sufficient level of detail to satisfy the requirements of Industry and Investment NSW (I&I - NSW);

ii. assess the pre and post-mining rural land capability and class of the Project Site in accordance with Department of Environment, Climate Change and Water (DECCW) guidelines;

iii. assess the pre and post-mining agricultural suitability of the Project Site in accordance with I&I - NSW guidelines;

iv. assess topsoil resources for mining and infrastructure area rehabilitation including management and mitigation measures;

v. assess suitable post-mining land uses for the LOM Project; and

vi. address all Director General's Requirements relating to soils, land capability and agricultural suitability in this assessment.

2 Existing Environment

2.1 STUDY AREA

The Study Area, which coincides with the Project Site for this Soil and Land Capability Impact Assessment, is shown on **Figure 2**. Hence, the Study Area for this assessment is referred to as the Project Site in this report. Note that as some of the Project Site has already been disturbed by open cut mining activities and soils were only assessed in areas that are currently not disturbed by open cut mining activities.

2.2 GEOLOGY

2.2.1 Regional Geology

ML 1563 is located in the Werrie Basin which extends from the Namoi River near Carroll southwards beneath the Tertiary basalts of the Liverpool Ranges in the Willow Tree – Wallabadah area to Blandford. The Mooki Thrust forms the western boundary of the Werrie Basin while Lower Carboniferous rocks known as the Burundi Series and comprising of a bed of conglomerates over the top of a thin bed of tuffaceous limestones (Pratt, 1996) form the eastern boundary.

2.2.2 Local Geology

The majority of ML 1563 is located within the Werris Creek Coal Measures which comprise pebble and granular conglomerates, sandstones, mudstones and coal originating in a fluvial to deltaic environment. The estimated total thickness of the Werris Creek Coal Measures is 105m (EIS 2004).

The base of the coal measures comprises a sequence of carbonaceous, pelletoidal claystones and mudstone and overlies the Werrie Basalt, a thick sequence of basaltic lavas with intervening palaeosols. The Werrie Basalt overlies Carboniferous conglomerates and sandstones of the Quirindi dome which are exposed along the north-south oriented ridges which dominate the local landform. To the south of ML 1563, the Werrie basalt has been overlain by unconsolidated sediments of the Quaternary period.

2.2.3 Soil Landscape Units

Four (4) soil landscape units underpin the Project Site as delineated by the ‘Soils of the Tamworth 1:100 000 Sheet Report are described below.

2.2.3.1 Narrawolga Soil Landscape

There are three soil profile types within this soil landscape. These are:

- shallow Tenosols (Lithosols) on the crests;
- shallow Tenosols (Earthy Sands) of the midslopes; and
- Brown Sodosols (Solodic Soils) of the lower slopes.

2.2.3.2 Escott Soil Landscape

There is one major soil profile type within this soil landscape, a Brown Sodosol (Soloth).

2.2.3.3 Siphon Soil Landscape

There are five major soil profile types within this soil landscape. These are:

- Red and Brown Chromosols (Red-brown Earths) and Red Ferrosols (Euchrozems) of the upper footslopes;
- Black Vertosols (Black Earths) of the mid footslopes; and
- Grey Vertosols (Grey Clays) of the lower footslopes.

The elevated land within the Project Site comprises of the Narrawolga soil landscape while the area to the southwest, west and northwest of the ridge country comprises of the Escott soil landscape and the area to the east and southeast of the Project Site comprises of the Siphon soil landscape.

2.3 TOPOGRAPHY AND HYDROLOGY

Regionally, the Project Site lies within the Namoi River Basin in an area characterised by the transition from the elevated ranges associated with the Liverpool Ranges to the south, the Great Dividing Range to the east, the Nandewar Range to the north, and open plains to the west. Locally, the Project Site is located within a valley created by two north-south trending ridgelines extending from Werris Creek in the north to Quipolly Creek in the south. Elevations within this area are effectively bounded by the north-south oriented ridgelines and Werris and Quipolly Creeks and range from approximately 340m AHD on the banks of Werris Creek to 670m AHD on Grenfell Hill, 3.5km west of the Project Site. Elevations within the Project Site vary from 360m AHD near the southern extremity of the overburden emplacement to approximately 445m AHD on the top of ”Old Colliery” Hill.

The Project Site is located between two creeks, namely Quipolly Creek in the south and Werris Creek to the north. Werris Creek flows into the Mooki River and then into the Namoi River. Quipolly Creek, controlled by the Quipolly Dam located upstream of Quipolly Creek, flows into Quirindi Creek, the Mooki River and then into the Namoi River.

2.4 VEGETATION

Remnants of two endangered ecological communities (EEC's) occur within the Project Site, namely:

- White Box Yellow Box Blakely's Red Gum Woodland and Derived Native Grasslands; and
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions.

To assist in the development of a biodiversity offset strategy for the LOM Project, ELA (2010) classified vegetation on the Project Site in accordance with 'Biometric Vegetation Types'. The vegetation communities within the Project Site, and a summary of their composition, are as follows.

White Box Grassy Woodland

The majority of tree covered vegetation at the Project Site is grassy woodland dominated by White Box (*Eucalyptus albens*). Tumbledown Gum (*Eucalyptus dealbata*) is co-dominant on the more exposed and erodible soils of the Narrawolga soil landscape, however, these areas are not considered to be sufficiently distinct to warrant classification as a separate vegetation type. The most abundant grass species of the understorey are *Aristida ramosa* (Purple Wiregrass), *Aristida leptopoda* (White Speargrass), *Chloris ventricosa* (Tall Chloris), *Austrostipa aristiglumis* (Plains Grass), *A. scabra* (Speargrass), A. *verticillat*a (Slender Bamboo Grass), *Bothriochloa macra* (Red-leg Grass) and *Dichanthium sericeum* (Queensland Bluegrass).

This vegetation community is considered to meet the classification as an endangered ecological community (EEC) under the NSW TSC Act under the name of “White Box Yellow Box Blakely's Red Gum Woodland”.

Bluegrass – Spear Grass – Redleg Grass Derived Grasslands (White Box Grassy Woodland and Derived Native Grassland)

The most common and widespread vegetation community at across the Project Site is derived grassland dominated by native perennial grasses. The dominant grass species are Red-leg Grass, Queensland Bluegrass, White Speargrass, Plains Grass, Chloris truncata (Windmill Grass) and Austrodanthonia bipartita (Wallaby Grass).

These derived native grassland patches are described as a distinct community, however, this community would previously have formed part of a grassy woodland with White Box forming the dominant overstorey.

Brigalow – Belah Woodland

This community is described as an open forest or woodland up to 25m high with an upper stratum dominated by Brigalow (Acacia harpophylla), often with Belah (Casuarina cristata) on less gilgaied clays. This community occurs as a single remnant of approximately 50 mature Brigalow trees to the west of the current approved open cut area. The community supports only Brigalow in the upper stratum, and only one small shrub was recorded in the understorey, Maireana microphylla (Bluebush). The majority of Brigalow trees present were mature, though regrowth was noted.

The Brigalow – Belah woodland is listed as ‘Endangered’ under the TSC Act as ‘Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains bioregions’, as well as under the EPBC Act as ‘Brigalow (Acacia harpophylla dominant and co-dominant)’.

Cropped and Cultivated Paddocks (Cleared Land)

To the north of Escott Road, an area of the Project Site surrounding the product coal storage area and rail load-out facility has previously been cleared for cultivation and cropping and as such no longer represents a native vegetation community. An area of paddocks to the east of the approved open cut area appears to have also been subject to regular cultivation/cropping.

These areas have been modified from the natural state to the extent that native species are now uncommon and most of the cultivated areas were either cleared at the time of survey or dominated by planted introduced species such as Lucerne (Medicago sativa).

Across the Project Site, ground cover has been invaded by introduced weed and pasture species. Of these, Bathurst Burr [Xanthium spinosum], Paterson's Curse [Echium plantagineum] and Spiny Burrgrass [Cenchrus incertus], all of which are listed as noxious for Liverpool Plains Shire by the NSW Department of Industry were identified during previous field surveys.

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 i and ii (Section 1.3) are discussed in this section.

3.1 SOIL SURVEY METHODOLOGY

3.1.1 Reference Map

An initial soil 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 Project Site.

- 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. Source materials included reports which detail previous soil and land suitability mapping for the Project Site and its surrounds. These reports are listed in date order below.

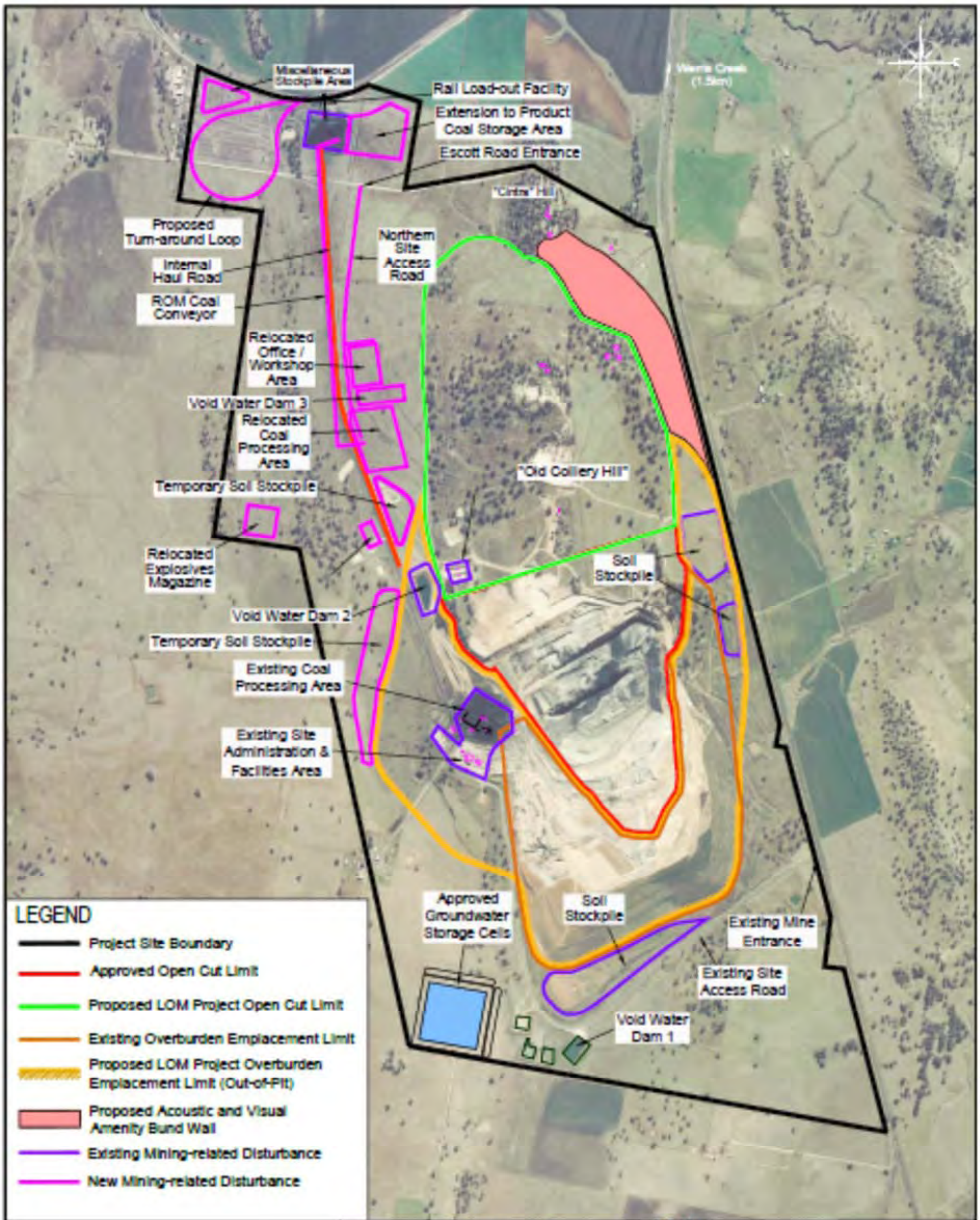
  i. Tamworth Soil Landscapes Map and Report (Banks, 2001).
  A survey of the region (including the areas surveyed in this assessment) was undertaken by Banks (2001) at a scale of 1:100,000. The survey map and report provides a broadscale guide to the soil and landscape distribution in the region and provides a framework for more detailed surveys.

  ii. Geoff Cunningham Natural Resource Consultants (2004). Proposed Werris Creek Coal Mine Soil and Land Capability Assessment.
  A detailed survey was undertaken in 2004 and describes 24 soil profile sites that assisted with the Soil and Land Capability Assessment for the original Werris Creek Coal Mine Project.

3.1.2 Soil Profiling

Eight soil profiles were assessed at selected sites throughout the LOM Project area to enable soil profile descriptions to be made. Subsurface exposure was undertaken by a 2 tonne excavator, which excavated test pits to 1.2 m deep. The test pit locations were chosen to provide representative profiles of the soil types encountered during the survey. The soil layers were generally distinguished on the basis of changes in texture, structure and colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994). Photographs of soil profile exposures were also taken (refer to **Plates 1** to **6**).

Soil profiles were also observed through the use of surface exposures located in existing track cuttings, gullies and disturbances resulting from dams, mining operations and an existing quarry pit. Soil test pit locations are shown in **Figure 2.**



Version	Date	Author	Checked	Approved		
1	28/07/10	LH	CR	CR	**FIGURE 2** Project Site Layout	Project: Werris Creek Soils Assessment; Client: Whitehaven Coal Mining Pty Ltd; File: Fg2_RWC15-002_SiteLayout_100813.dwg; Projection: MGA 94 Zone 56

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3.1.3 Soil Field Assessment

Soil profiles within the Project Site were assessed generally in accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures (McDonald *et al*, 1998). Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. The system remains the benchmark for land resource assessment in the Australian coal mining industry. A more detailed explanation of the Elliot and Veness procedure is presented in **Appendix 1** to this report. A list of field assessment parameters used in the field study are summarised in **Table 2**.

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

Table 2: Field Assessment Parameters

Descriptor	Application
Physical:	
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

3.1.4 Soil Laboratory Assessment

Soil samples were collected from the exposed soil profiles and subsequently sent to the NSW Land and Property Management Authority Soil Conservation Service Laboratory in Scone, NSW for analysis. Samples were analysed to establish the suitability of surface and near-surface soil horizons as potential growth media and identify high value soils or conversely, soils that may have properties that are deleterious to vegetation establishment. Samples were analysed from the following sites (as shown on **Figure 3**).

- Test Pit 1 – 1/1, 1/2, & 1/3.
- Test Pit 2 – 2/1, 2/2, 2/3 & 2/4.
- Test Pit 4 – 4/1, 4/2 & 4/3.

- Test Pit 5 – 5/1 & 5/2.
- Test Pit 6 – 6/1, 6/2 & 6/3.
- Test Pit 7 – 7/1 & 7/2.

Soil horizons are signified by /1/2/3 in the sample ID, with the surface horizon being /1 and subsoil horizons being /2 and /3. The samples were subsequently analysed in the laboratory for the following parameters.

- Colour.
- Particle Size Analysis.
- Emerson Aggregate Test.
- pH.
- Electrical Conductivity.
- Cation Exchange Capacity (CEC) and Exchangeable Cations.

A description of the significance of each test and typical values for each soil characteristic are included in **Appendix 2**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for recovery and use as a growth medium for the rehabilitation of disturbed areas. Similarly, potentially unfavourable soil material was identified. The soil test results for the soil survey are provided in **Appendix 3**. The selected physical and chemical laboratory analysis parameters and their relevant application are listed in **Table 3**.

Table 3: Laboratory Analysis Parameters

Property	**Application**
Physical:	
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)	Susceptibility to surface sealing under rainfall or irrigation; effect of raindrop impact and slaking; permeability; infiltration; aeration; seedling emergence; correlation with other properties.
Chemical:	
Soil reaction (pH) (1:5, soil: water suspension)	Nutrient availability; nutrient fixation; toxicities (especially Al, Mn); liming; sodicity; correlation with other physical, chemical and biological properties.
Electrical conductivity (EC) (1:5, soil: water suspension)	Appraisal of salinity hazard in soil substrates or groundwater, total soluble salts.
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 the Scone Soil Conservation Service Laboratory for each physical and chemical parameter are provided in **Table 4**.

Table 4: Laboratory Test Methods

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

3.1.5 Soil Type Description

The applicable technical standard adopted by GSSE for the Project Site is the Australian Soil Classification (ASC) system. This standard is routinely used as the soil classification system in Australia. In this naming, soil groups are based on the characteristics and attributes as follows.

- The number of horizons in the profile.
- The colour of various horizons with special emphasis on the surface horizons.
- Texture and structure.
- Relative arrangement and chemical composition.
- Thickness of the horizons.
- Geological origin of the soil material.

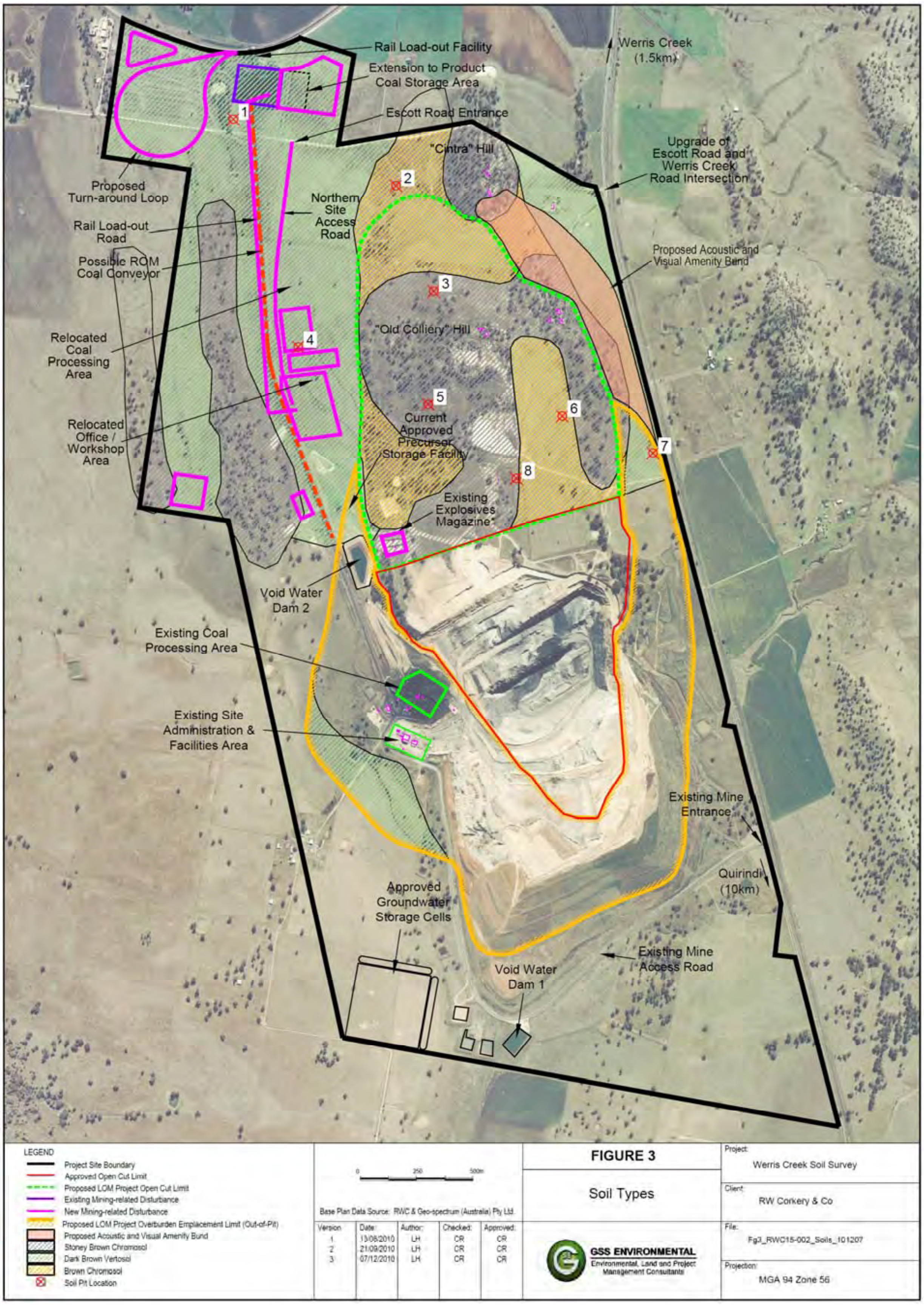
3.2 SOIL SURVEY RESULTS

3.2.1 Soil Types: Summary

The following soil units were identified within areas of the Project Site that are currently undisturbed by open cut mining activities:

- Brown Chromosol (73 ha);
- Stoney Brown Chromosol (144 ha); and
- Dark Brown Vertosol (205 ha).

The distribution of these soils is illustrated in **Figure 3**. Exposed profiles of major soil units are shown in **Plates 1, 3** and **5**. Landscape photos of areas where each soil unit was observed are shown in **Plates 2, 4** and **6**. Profile descriptions for each soil unit are summarised in **Tables 5, 6** and **7**.



Rail Load-out Facility
Extension to Product Coal Storage Area
Escott Road Entrance
Werris Creek (1.5km)
"Cintra" Hill
Upgrade of Escott Road and Werris Creek Road Intersection
Proposed Turn-around Loop
Northern Site Access Road
Rail Load-out Road
Possible ROM Coal Conveyor
Proposed Acoustic and Visual Amenity Bund
Relocated Coal Processing Area
"Old Colliery" Hill
Relocated Office / Workshop Area
Current Approved Precursor Storage Facility
Existing Explosives Magazine
Void Water Dam 2
Existing Coal Processing Area
Existing Site Administration & Facilities Area
Existing Mine Entrance
Quirindi (10km)
Approved Groundwater Storage Cells
Void Water Dam 1
Existing Mine Access Road
1
2
3
4
5
6
7
8
LEGEND
Project Site Boundary
Approved Open Cut Limit
Proposed LOM Project Open Cut Limit
Existing Mining-related Disturbance
New Mining-related Disturbance
Proposed LOM Project Overburden Emplacement Limit (Out-of-Pit)
Proposed Acoustic and Visual Amenity Bund
Stoney Brown Chromosol
Dark Brown Vertosol
Brown Chromosol
Soil Pit Location
0 250 500m
Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd
Version: 1 2 3
Date: 13/08/2010 21/09/2010 07/12/2010
Author: LH LH LH
Checked: CR CR CR
Approved: CR CR CR
FIGURE 3
Soil Types
GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants
Project: Werris Creek Soil Survey
Client: RW Corkery & Co
File: Fg3_RWC15-002_Soils_101207
Projection: MGA 94 Zone 56

3.2.2 Brown Chromosol Soil

Description: Brown Chromosol soils generally consist of light brown to brown loamy sands to loams overlying an abrupt change to yellowish brown to brown clays. The moderately drained upper soil layers range from slightly acidic to neutral, while the poorly drained subsoils range from slightly alkaline to alkaline. The soils are non-saline with moderate fertility characteristics. The soil is non-sodic throughout the profile.

Location: These soils cover 17.19% or 72.50 ha of the areas that are currently undisturbed by open cut mining activities within the Project Site and are found on the upper, mid and waning lower slopes. Representative profile sites include test pits 2 & 6.

Landuse: The land overlying these soils is generally cleared of trees with occasional mature paddock trees and is predominantly used for beef cattle grazing. Numerous graded banks and some farm tracks transect the paddocks, which are dominated by exotic pastures and native grass species.

Management: The top 0.30 m of this soil is suitable for stripping and reuse as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to the limiting factor of high clay content.

Table 5: Brown Chromosol Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.30	Brown (10YR 3/2), moderate consistence loam to sandy loam. A moderate pedality soil (blocky 10-20 mm) with slightly acidic to neutral pH (6.6-7.0), slight dispersion (EAT 3(1)), non-saline (0.02dS/m), roots common to many and nil to <10% stones (<10 mm). Approximate sample depths 0.05–0.10 m and 0.15-0.20 m. Clear and even boundary to Layer 2.
2	0.30 to 0.50	Light brown (7.5YR6/3) to light brownish grey (10YR5/2), weak consistence loam to loamy sand. An apedal single grained to weak pedality soil (blocky <10 mm) with neutral to slightly alkaline pH (7.1-7.5), slight dispersion (EAT 3(2)), non-saline (<0.01dS/m), roots few and <10% stones (<10 mm). Approximate sample depth 0.40-0.45 m. Sharp even boundary to Layer 3.
3	0.50 to 1.20	Yellowish brown (10YR 4/4) to strong brown (7.5YR4/6) with 40% red mottles, strong consistence clay. A massive structured soil with slight to moderately alkaline pH (7.4-8.3), slight dispersion (EAT 3(1)), non-saline (0.03dS/m), no roots and nil stones. Approximate sample depth 0.80 m.

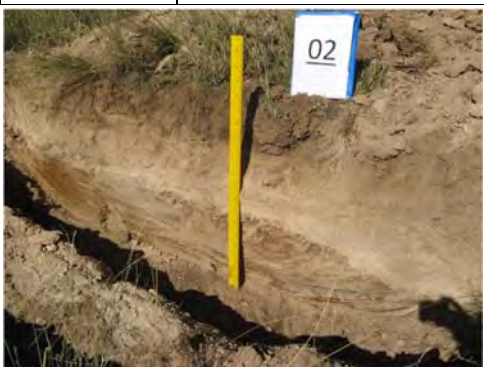


Plate 1 – Brown Chromosol Profile

Plate 2 – Brown Chromosol Landscape

3.2.3 Stoney Brown Chromosol Soil

Description: Stoney Brown Chromosol soils generally consist of stoney brown loamy sands overlying a clear change to light brown stoney clays. These moderately drained soil layers range from slightly alkaline to alkaline at depth. The soils are non-saline with moderate fertility characteristics. The soil is non-sodic throughout the profile.

Location: These soils cover 34.16% or 144.06 ha of the areas that are currently undisturbed by open cut mining activities within the Project Site and are found on upper slopes and crests. Representative profile sites include test pits 3, 5 & 8.

Landuse: The land overlying these soils is generally well vegetated with native grasses. Dense tree stands occupy the ridge trending to moderate density white box trees downslope. An existing quarry is located on the ridge, however majority of the area is used for grazing, with some farm tracks and a disused house present within the area.

Management: This soil is considered unsuitable for stripping and therefore not recommended for reuse as topdressing in rehabilitation. The key limiting factor for this soil is the high stone content throughout the profile. This soil requires only the standard erosion and sediment control measures if disturbed.

Table 6: Stoney Brown Chromosol Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.10	Brown (10YR 3/3), weak consistence loamy sand. A weak to moderate pedality soil (blocky 5-10 mm) with slightly alkaline pH (7.5), slight dispersion (EAT 3(1)), non-saline (0.06dS/m), roots common and 20-50% stones (10–50 mm). Approximate sample depth 0.05–0.10 m. Gradual and even boundary to Layer 2.
2	0.10 to 0.20	Light brown (7.5YR4/4), weak consistence loamy sand. A weak pedality soil (blocky <5 mm) with alkaline pH (8.8), slight dispersion (EAT 3(1)), non-saline (0.06dS/m), roots few and 30-40% stones (10–50 mm). Approximate sample depth 0.10-0.20 m. Clear even boundary to Layer 3.
3	0.20 to 1.20	Yellowish brown with 20% orange mottles, strong consistence clay. A massive structured soil with alkaline pH, slight dispersion, non-saline, no roots and 80% stones (10-100mm). Sample not lab tested due to stone content.

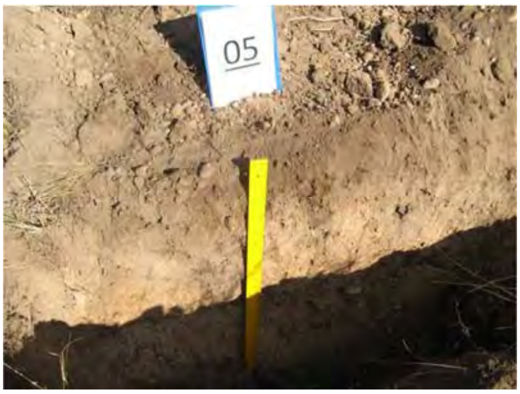


Plate 3 – Stoney Brown Chromosol Profile

Plate 4 – Stoney Brown Chromosol Landscape

3.2.4 Dark Brown Vertosol

Description: Dark Brown Vertosol soils generally consist of well structured dark brown silty clay loam to clay trending to massive brown to dark greyish brown clay. These poorly drained soil layers range from slightly alkaline to strongly alkaline at depth. The soils are non-saline with strong fertility characteristics. The soil is non-sodic throughout the profile.

Location: These soils cover 48.64% or 205.10 ha of the areas that are currently undisturbed by open cut mining activities within the Project Site and are found on lower slopes and plains. Representative profile sites include pits 1, 4 & 7.

Landuse: The land overlying these soils is cleared of trees, however well vegetated with native grasses and exotic pastures. The soil has a history of cultivation and has graded banks on the moderate slopes.

Management: The top 0.30m of soil is considered suitable for stripping and for reuse as topdressing in rehabilitation. The key limiting factor for the lower layers of the soil profile is the high clay content, massive structure and strong alkalinity, whilst in the eastern section of the Project Site, the limiting factor is weathered basalt rock from 0.35 m. This soil requires only the standard erosion and sediment control measures if disturbed.

Table 7: Dark Brown Vertosol Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.30	Brown (7.5YR 3/2) to dark brown (7.5YR2.5/2), moderate consistence silty clay loam to clay. A strong pedality soil (sub angular blocky 10-50 mm) with neutral to slightly alkaline pH (6.6 – 7.9), slight dispersion (EAT 3(1)), non-saline (0.01-0.04dS/m), roots many and stones nil to 5% (<10 mm). Approximate sample depth 0.10–0.20 m. Gradual and even boundary to Layer 2.
2	0.30 to 0.60	Brown (7.5YR3/3) with 10% orange mottles to very dark greyish brown (10YR2/2), strong consistence clay. An apedal massive soil with alkaline pH (8.1 to 9.0), non-dispersive (EAT 4 to 5), non-saline (0.08 to 0.15dS/m), nil roots and nil stones. Approximate sample depth 0.40-0.50 m. Gradual even boundary to Layer 3.
3	0.60 to 1.20	Yellowish brown (10YR4/4) with 10% orange mottles to dark greyish brown (10YR3/3), strong consistence clay. A massive structured soil with alkaline pH (8.4 to 9.2), nil to slight dispersion (5 to 3(1)), non-saline (0.16-0.18), nil roots and nil stones. Approximate sample depth 0.80-0.90 m.

Plate 5 – Dark Brown Vertosol Profile

Plate 6 – Dark Brown Vertosol Landscape

4 Land Assessment

The Project Site has been assessed for both rural land capability and agricultural suitability. The methods and results for both these assessments presented in this section are fulfilling report objectives i, ii and iii (refer Section 1.3).

4.1 LAND CAPABILITY

4.1.1 Land Capability Methodology

The assessment of land capability applied to the Project Site is in accordance with the Department of Environment, Climate Change & Water (DECCW) (formerly the NSW Soil Conservation Service) S*ystems Used to Classify Rural Lands in New South Wales* (Emery 1986 and 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 the three following types of land uses.

- Land suitable for cultivation.
- Land suitable for grazing.
- 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 and 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 8**.

4.1.2 Land Capability Results

Figure 4 shows the distribution of land capability classes for the entire Project Site prior to any disturbance by open cut mining. The information on land capability for the currently disturbed land was taken from the 2004 EIS. The previously approved area of mining has areas of disturbance at the time of writing this report and so whole of Project Site pre-mining values have been used to show the overall Project Site land capability classes, without consideration for current levels of disturbance. **Figure 5** shows the distribution of land capability classes for the entire Project Site at the end of mine life and is based on final landform predictions and meeting the commitments of mine closure obligations as described in Section 4.1.2.2. **Table 9** shows the area of each land capability class pre and post-mining.

Table 8: Rural Land Capability Classes

Class	Land Use	Management Options
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
Special Zonings		
SF	State Forests	Unsuitable for rural production
U	Urban areas	Unsuitable for rural production
M	Mining and quarrying areas	Unsuitable for rural production

Source: Emery KA (1986) Soil Conservation Service of NSW (now known as DECCW)

4.1.2.1 Pre-Mining

The majority of the pre-mining land capability was considered Class III land (567.7 ha), and is located on the lower slopes and flats of the Project Site. Class V land (242.2 ha) was mainly located on the steeper slopes overlying the coal measures. Some Class VI land (97.7 ha) was also present on the ridge tops.

4.1.2.2 Post-Mining

The predicted final landform contours, soil types, and recommended soil depth in rehabilitation, were used to assess the predicted land capability classes of the post-mining land. The post-mining assessment predicts the likely land capability if all stockpiles of subsoil and topsoil were utilised in the rehabilitation program.

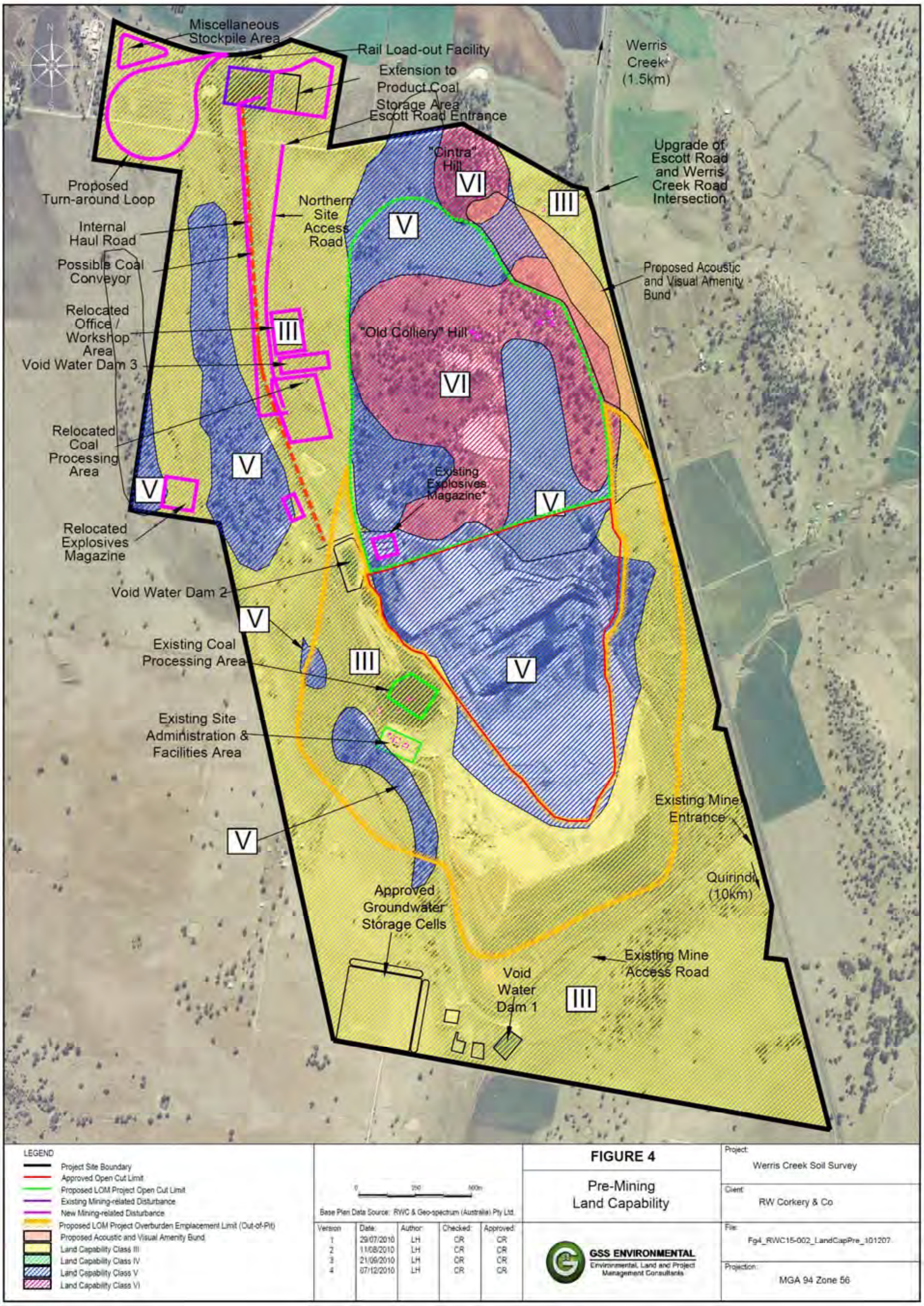


FIGURE 4
Pre-Mining Land Capability

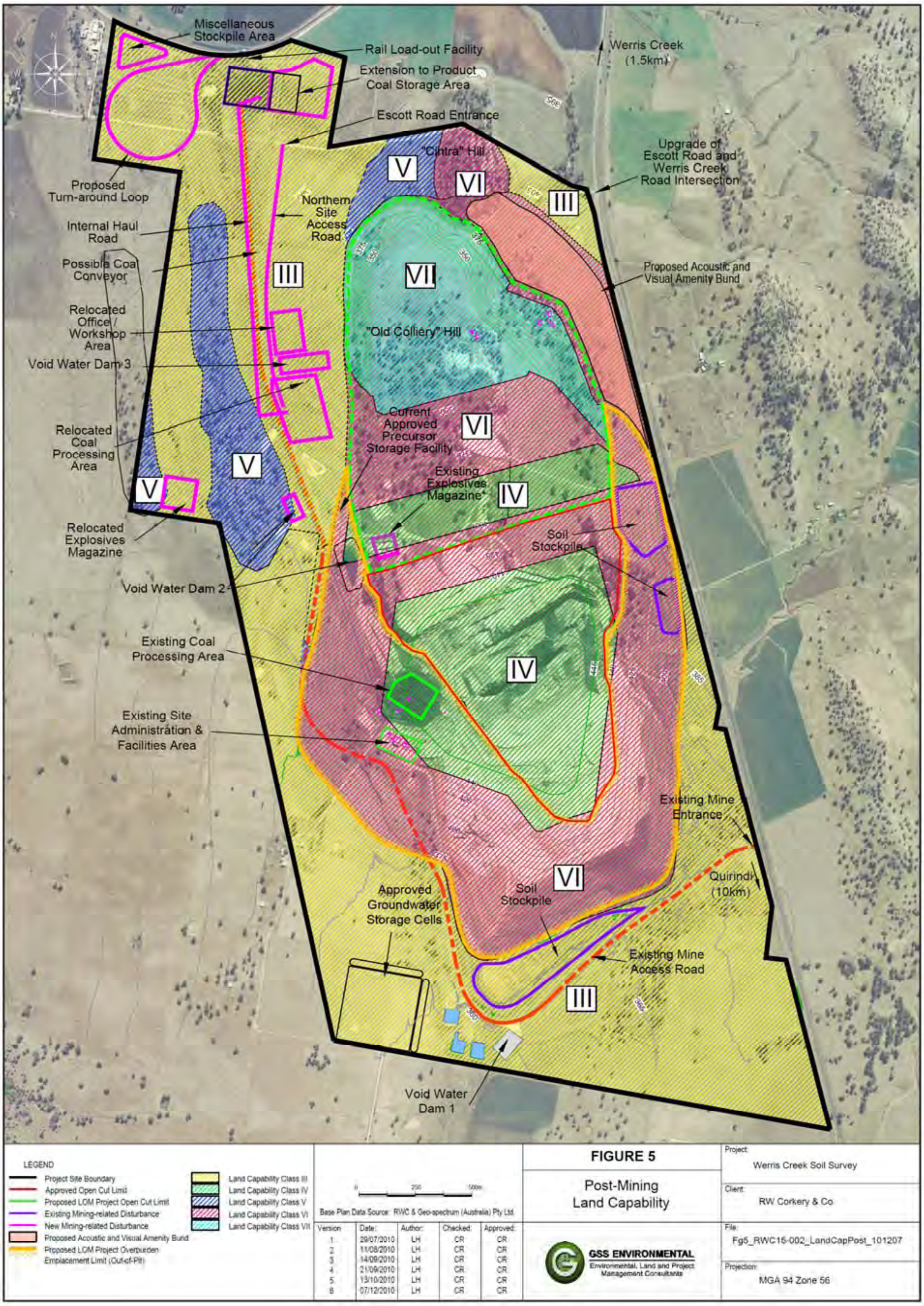

Miscellaneous Stockpile Area
Rail Load-out Facility
Extension to Product Coal Storage Area
Escott Road Entrance
Werris Creek (1.5km)
Upgrade of Escott Road and Werris Creek Road Intersection
"Cintra" Hill
Proposed Turn-around Loop
Internal Haul Road
Possible Coal Conveyor
Northern Site Access Road
Relocated Office / Workshop Area
Void Water Dam 3
"Old Colliery" Hill
Proposed Acoustic and Visual Amenity Bund
Relocated Coal Processing Area
Current Approved Precursor Storage Facility
Existing Explosives Magazine
Relocated Explosives Magazine
Soil Stockpile
Void Water Dam 2
Existing Coal Processing Area
Existing Site Administration & Facilities Area
Existing Mine Entrance
Quirindi (10km)
Approved Groundwater Storage Cells
Soil Stockpile
Existing Mine Access Road
Void Water Dam 1
III
IV
V
VI
VII
LEGEND
Project Site Boundary
Approved Open Cut Limit
Proposed LOM Project Open Cut Limit
Existing Mining-related Disturbance
New Mining-related Disturbance
Proposed Acoustic and Visual Amenity Bund
Proposed LOM Project Overburden Emplacement Limit (Out-of-Pit)
Land Capability Class III
Land Capability Class IV
Land Capability Class V
Land Capability Class VI
Land Capability Class VII
Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd
FIGURE 5
Post-Mining Land Capability
Project: Werris Creek Soil Survey
Client: RW Corkery & Co
File: Fg5_RWC16-002_LandCapPost_101207
Projection: MGA 94 Zone 56
GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants
Version | Date | Author | Checked | Approved
1 | 29/07/2010 | LH | CR | CR
2 | 11/08/2010 | LH | CR | CR
3 | 14/09/2010 | LH | CR | CR
4 | 21/09/2010 | LH | CR | CR
5 | 13/10/2010 | LH | CR | CR
6 | 07/12/2010 | LH | CR | CR

Table 9: Land Capability Classes and Areas for Entire Project Site

Land Capability Pre-Mining			Land Capability Post-Mining		
Land Capability Class	**Area to be Disturbed (ha)**	**Total Area (ha)**	**Land Capability Class**	**Disturbed Area (ha)**	**Total**
III	186.6	567.7	III	25.2	407.6
IV	0.0	0.0	IV	119.5	119.5
V	191.0	242.2	V	0.4	50.2
VI	89.1	97.7	VI	252.4	261.1
VII	0.0	0.0	VII	69.2	69.2
Total	**466.7**	**907.6**	**Total**	**466.7**	**907.6**

NB: An additional 82.6ha has already been disturbed by current approved mining activities therefore the total 'disturbed area' is 549.3 ha.

Post-mining land capability would include Class VI on the (<10 degrees) slopes of the overburden emplacements. The top of the overburden dump and the flat section between the dump and the void is relatively flat and a layer of subsoil would be placed as an intermediate layer between the overburden and the topsoil, which should bring the land capability of the area to Class IV. The steeper slopes of the partially backfilled final void are considered Class VII and should only be used for woodland ecological community. The base of the void would be Class VII.

Although the post-mining land capability is predicted to have capabilities between Class III and Class VII, it is noted that the revegetation plan for the Project Site only requires some Class III land with the rest of the Project Site being established with native vegetation. Areas established with the woodland vegetation would have a range of land capability classes from Class III to Class VII. Given the post-mining land capability classes predicted in the above assessment, there would be no impact on agricultural enterprises in the immediate area. The land would be capable of maintaining current levels agricultural production provided the methodology for reinstating soil material is followed. This assessment only takes into account soil resources and potential of the soil and does not account for potential future land uses or the rehabilitation of specific vegetation species or communities.

4.2 AGRICULTURAL SUITABILITY

4.2.1 Agricultural Suitability Methodology

The agricultural suitability system applied to the Project Site is in accordance with the I&I – NSW's (formerly the NSW Agricultural & Fisheries) *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries, 1988).

The system consists of five (5) 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 and suitable for some grazing activities.

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 10.**

Table 10: Agricultural Suitability Classes

Class	Land Use	Management Options
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. It has a moderate to high suitability for agriculture but edaphic (soil factors) or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.
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. The overall level of production is moderate as a result of edaphic or environmental constraints. Erosion hazard or soil structural breakdown limit the frequency of ground disturbance, and conservation or drainage works may be required.
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. Production may be high seasonally but the overall level of production is low as a result of a number of major constraints, both environmental and edaphic.
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. Agricultural production is very low or zero as a result of severe constraints, including economic factors, which preclude improvement.

Source: NSW Agriculture & Fisheries (1990) (now known as I&I - NSW).

4.2.2 Agricultural Suitability Results

Figure 6 shows the distribution of agricultural suitability classes for the entire Project Site prior to any mining activities. The information on pre-mining agricultural suitability for the currently disturbed land was taken from the 2004 EIS. **Figure 7** shows the distribution of agricultural suitability classes for the entire Project Site at the end of mine life and is based on final landform predictions and meeting the commitments of mine closure obligations. **Table 11** below shows the area of each agricultural suitability class pre and post-mining.

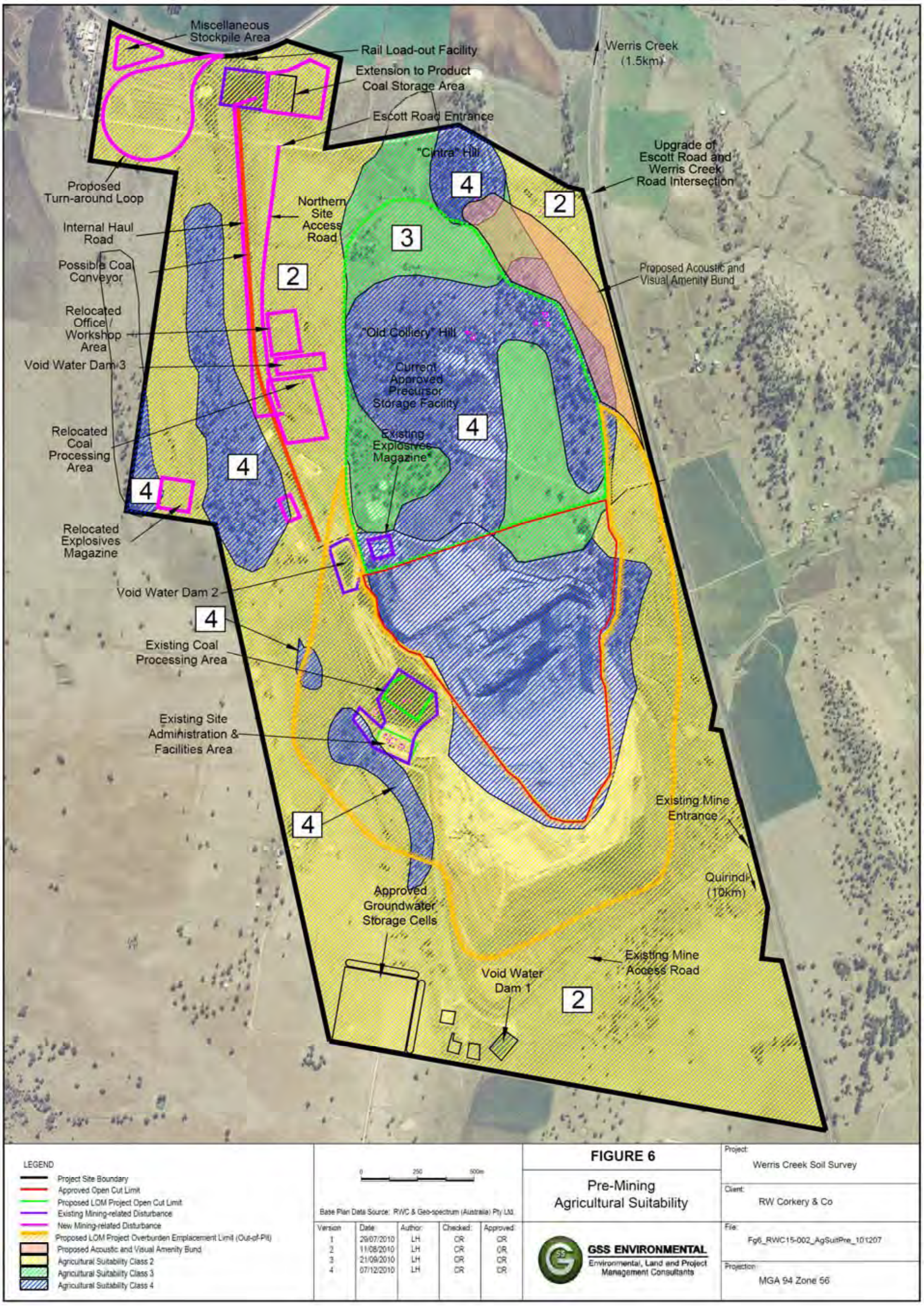


FIGURE 6
Pre-Mining Agricultural Suitability

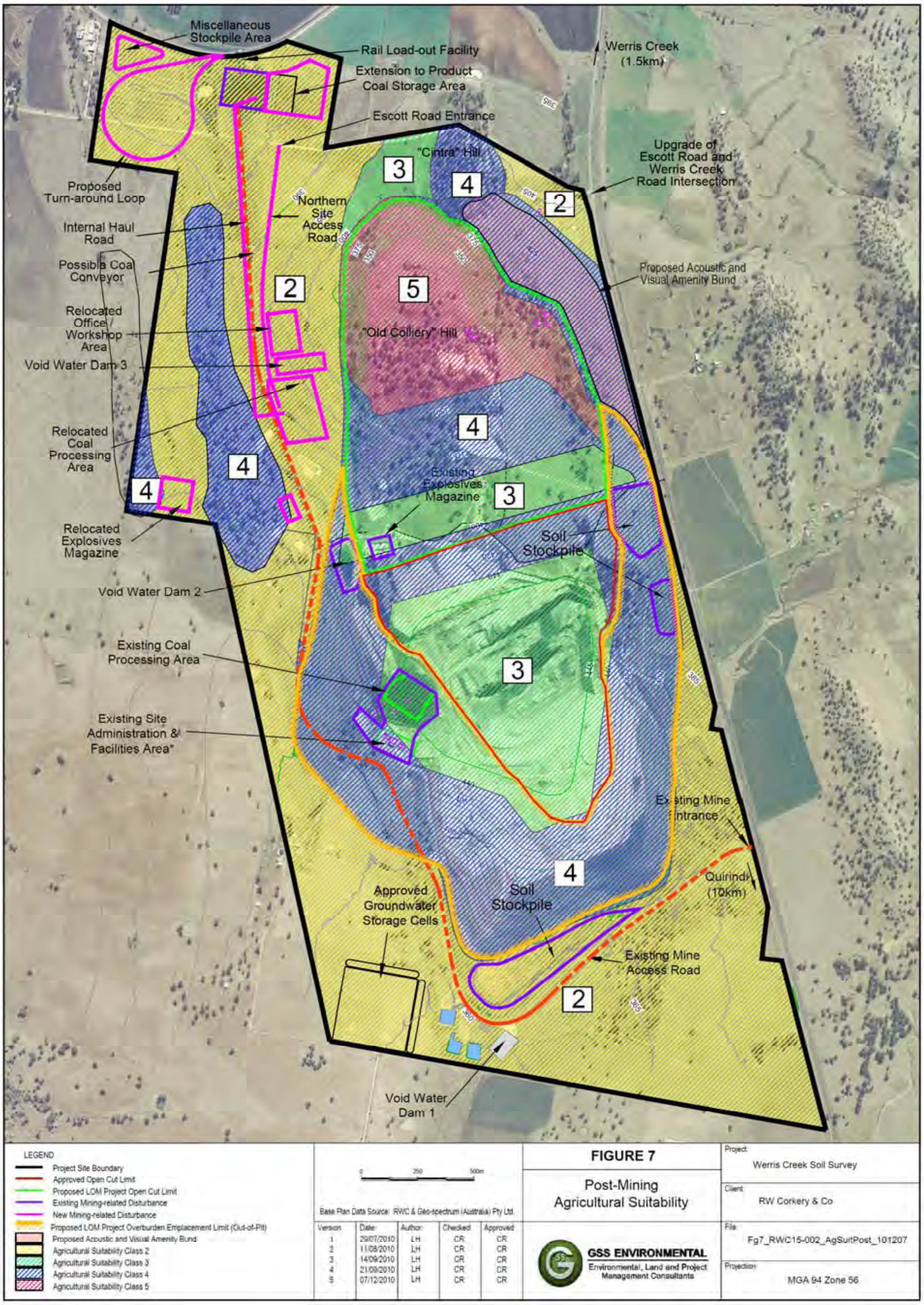


FIGURE 7
Post-Mining Agricultural Suitability

Table 11: Agricultural suitability classes for entire Project Site

Agricultural Suitability Pre-Mining			Agricultural Suitability Post-Mining		
Agricultural Suitability	**Area to be Disturbed (ha)**	**Total Area (ha)**	**Agricultural Suitability**	**Disturbed Area (ha)**	**Total Area (ha)**
2	186.7	567.7	2	25.2	407.6
3	70	80	3	119.5	129.4
4	210	260	4	252.8	301.5
5	0	0	5	69.2	69.2
Total	**466.7**	**907.7**	**Total**	**466.7**	**907.7**

NB: An additional 82.6ha of area has already been disturbed through approved activities, therefore the total 'disturbed area' is 549.3 ha.

4.2.2.1 Pre-Mining

The majority of the pre-mining agricultural suitability of the Project Site was considered Class 2 land, and was located on the lower slopes and flats of the Project Site. Class 4 land was mainly located on the steeper slopes overlying the coal measures. Some Class 3 land was also present on the mid slopes. The area of the land proposed to be disturbed is dominated by Class 4 land and Class 2 land, with a relatively small area of Class 3 land.

4.2.2.2 Post-Mining

The predicted final landform contours, soil types, and recommended soil depth in rehabilitation, were used to assess the predicted agricultural suitability classes of the post-mining land. This assessment predicts the likely agricultural suitability if all stockpiles of subsoil and topsoil were utilised in the rehabilitation program.

Agricultural suitability Class 4 would be on the (<10 degrees) slopes of the overburden emplacements. A minimum of 0.10m subsoil layer is included in the rehabilitated profile. The top of the overburden dump is relatively flat and a layer of subsoil can be placed as an intermediate layer between the overburden and the topsoil which should result in the agricultural suitability of the area being Class 3. The flat bench north of the main overburden emplacement would be rehabilitated to Class 3 land. The steep slopes and base of the final void are considered Class 5 and should only be used for woodland/bushland timbered country.

Although the post-mining agricultural suitability is predicted to have capabilities between Class 2 and Class 5, it is noted that the revegetation plan for the Project Site only requires some Class 2 land, with the rest of the Project Site being established with native woodland vegetation which does not require a specific agricultural suitability class. Therefore areas to be established with native vegetation would be from Classes 2 to 5 leaving the rest of Class 2 land in the infrastructure/rail loop area to be used for agricultural purposes.

5 Soil Management

Soil to be disturbed during the LOM Project, has been assessed to determine its suitability for stripping and re-use for rehabilitation. Furthermore, existing stockpiles of topsoil and subsoil are assumed to be suitable for re-use in rehabilitation. This section provides information on the following key areas related to the management of the topsoil resources on the Project Site.

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

5.1 TOPSOIL ASSESSMENT & BALANCE

5.1.1 Topsoil Assessment Methodology for Stripping

Determination of suitable soil to conserve for later use in mine rehabilitation has been conducted in accordance with Elliott and Veness (1981) and based on extensive industry experience. 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 8** summarises the procedure for the selection of soil material for use as topdressing of areas to be disturbed by the LOM Project and **Table 12** lists the key parameters and corresponding desirable selection criteria.

Table 12: 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 12** were determined during the field assessment.

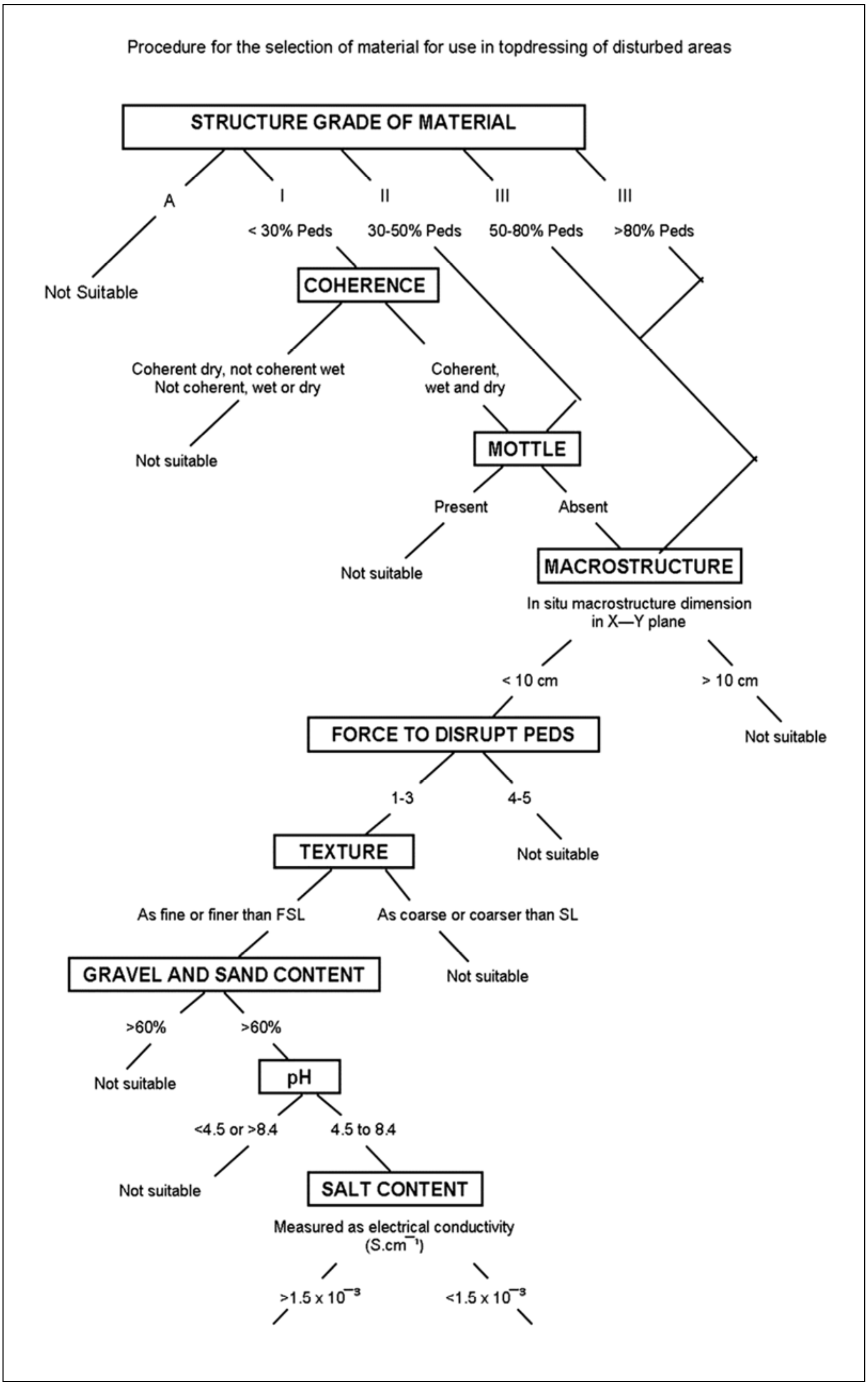


Figure 8 – Procedure for the Selection of Soil Material for use as Topdressing

Structural grade is significant in terms of the soil's capability to facilitate water flow and aeration. Good permeability and adequate aeration are essential for the germination and establishment of vegetation. 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 generally 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 generally considered unsuitable for revegetation, where structure grade is weak 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 would restrict the establishment of vegetation.

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 generally 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, 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 generally unsuitable for revegetation purposes.

5.1.2 Topsoil Stripping Recommendations

Table 13 lists the recommended stripping depths, proposed disturbance area and calculated volumes of available topsoil for each soil type. **Figure 9** provides the spatial distribution of the recommended stripping depths according to soil type. Stripping depth for subsoil are not given as it is recommended for each of the soils present that subsoil is not suitable for rehabilitation purposes and therefore is not required to be stripped.

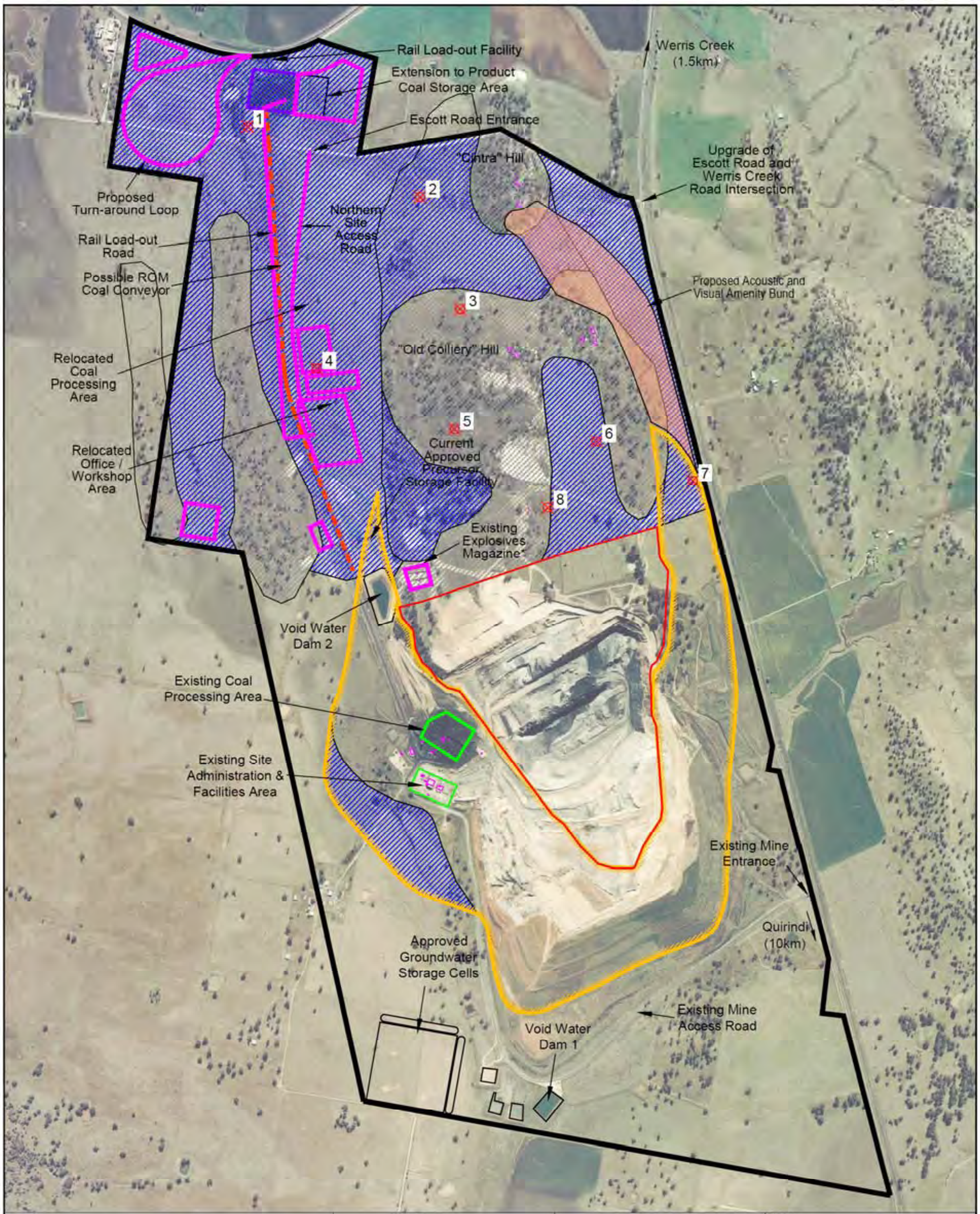
The total volume of suitable topdressing available from the proposed new disturbance areas for the LOM Project, allowing for a 10% handling loss, is calculated to be 374,409 m^3.

5.1.3 Soil Balance

The Werris Creek Coal Mine has previously stockpiled both subsoil and topsoil in large amounts in preparation for reuse in rehabilitation. **Table 14** below lists the volume of material (topsoil or subsoil) contained within each stockpile. These values have been added to the stripping volumes calculated in Section 5.1.2 above to obtain a total volume of available topsoil as well as a current volume of stripped subsoil. The final landform design was used to calculate the area and volume of soil required to rehabilitate all disturbed areas, and hence determine if the LOM Project would have an overall deficit or surplus of topdressing material available for rehabilitation.

Table 13: Topsoil Stripping Volumes

Soil Type		Brown Chromosol	Stoney Brown Chromosol	Dark Brown Vertosol	Total Area
Recommended Stripping Depth (m)		0.3	0	0.3	
Disturbance Areas (ha)	Noise and Visual Bund	3.07	4.26	11.56	18.89
	Main Pit	62.55	95.11	22.59	180.25
	South west dump extension	0	0	15.2	15.2
	Northern site access road	0	0	1.43	1.43
	Extension of Product Coal Stockpile Area	0	0	8.67	8.67
	Proposed Turn around Loop	0	0	1.53	1.53
	Miscellaneous Stockpile Area	0	0	1.85	1.85
	Relocated Coal processing Area	0	0	5.5	5.5
	Relocated Office/Workshop Area	0	0	2.3	2.3
	Relocated Precursor Storage Facility	0	0	1.02	1.02
	Void Water Dam 3	0	0	1.4	1.4
Total Extension Disturbance Area (ha)		65.62	99.37	73.05	238.04
Volume of Topdressing Available (m^3)		196,860	0	219,150	416,010
Total Volume with 10% handling Loss (m^3)		177,174	0	197,235	374,409



LEGEND
- Project Site Boundary
- Approved Open Cut Limit
- Proposed LOM Project Open Cut Limit
- Existing Mining-related Disturbance
- New Mining-related Disturbance
- Proposed LOM Project Overburden Emplacement Limit (Out-of-Pit)
- Proposed Acoustic and Visual Amenity Bund
- Stripping Depth - Nil
- Stripping Depth - 0.3
- Soil Pit Location

0 250 500m

Base Plan Data Source: RWC & Geo-spectrum (Australia) Pty Ltd.

Version	Date:	Author:	Checked:	Approved:
1	21/09/2010	LH	CR	CR
2	07/12/2010	LH	CR	CR

FIGURE 9

Soil Stripping Depth

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Werris Creek Soil Survey
Client: RW Corkery & Co
File: Fg9_RWC15-002_StripDepth_101207
Projection: MGA 94 Zone 56

Table 14: Current stockpile volumes (m3)

Subsoil Stockpiles		Topsoil Stockpiles	
4	67,700	1	3,250
7	1,500	2	3,280
8	3,900	3	12,680
9	34,650	10	10,280
11	518,030	12	55,540
16	14,300	13	18,200
18	39,460	14	33,990
25	36,360	17	6,030
34	139,670	19	9,870
Total	**855,570**	30	1,900
		31	530
		32	1,300
		33	150,530
		Total	**307,380**

As shown in **Table 14** above, there is approximately 855,570 m^3 of subsoil and 307,380 m^3 of topsoil currently stockpiled on site for reuse in rehabilitation. These volumes are to be added to the available stripping material from **Table 13** to calculate the total volume of material potentially available for salvage and reuse in rehabilitation. Furthermore, the volume of material, both topsoil and subsoil, required to meet the rehabilitation and land capability objectives is calculated in **Table 15** below.

The Proponent has a commitment to reinstate 37ha of Class III land within the mine footprint. This area is planned for reinstatement over the Rail Load-out Facility following closure and equates to approximately 66ha of land. Class III land is considered suitable for cultivation, however the land requires erosion protection structures and strict conservation management techniques to be employed for sustainable agriculture. The estimated rooting depth of cereal crops suitable for the Werris Creek region is approximately 0.6 m. Therefore, allowing for a buffer of 0.1 m, the minimum recommended depth of soil would be 0.7 m. GSSE recommends using 0.5 m of subsoil material with 0.2 m topdressing in Class III areas.

Table 15: Topsoil Balance

		Subsoil (m3)	Topsoil (m3)
Currently Stockpiled Material		855,570	307,380
Proposed material to be stripped in disturbance area		0	374,409
Total material Available		**855,570**	**681,789**
Material calculated to be used in rehabilitation to result in Land Capability Classes	LC III (25.2 ha) SS 0.5m TS 0.2m	126,000	50,400
	LC IV (119.5 ha) TS 0.2m	0	239,000
	LC VI (252.43ha) SS 0.2 TS 0.15m (NB 37.13 ha has already been rehabilitated and not included in calculations)	504,860	322,950
	LC VII (69.20ha) TS 0.1m	0	69,200
Total material Required		**630,860**	**612,250**
Deficit or Surplus		**+224,710**	**+69,539**

Table 15 summaries the best utilisation of existing subsoil stockpiles to rehabilitate the land to the highest possible land capability classes. The surplus of both topsoil and subsoil resulting from the calculations in the above table, may be saved until nearing the end of mine life, where a reassessment can be made to determine the best use and distribution of this material in the rehabilitation and mine closure program.

5.2 TOPDRESSING MANAGEMENT

Where topsoil stripping and transportation is required, the following topsoil handling techniques are recommended to prevent excessive soil deterioration. Note that this also applies to subsoil stripping if required.

- Strip material to the depths stated in **Table 13**, 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 mining 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 by open bowl scrapers, or 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 haul trucks may be placed directly into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil.
- 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 3 m. 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 3 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 provides sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species would not persist in the rehabilitation areas but would 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 continue to be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.
- Topsoil should be spread to a minimum depth range of 0.1 m (steep slopes) to 0.2 m (flatter areas). Soil respreading on steep slopes at depths exceeding 0.2 m can be deleterious because of the “sponge” effect which can cause slippage of the topsoil from the slope. Therefore, in the event that subsoil is spread below the topsoil, it should be keyed into the overburden to minimise the chance of slipping. Flat areas should be topsoiled at a nominal depth of 0.2 m. Specific topsoil respreading depths for different post-mining landform elements should be specified in a Topsoil Management Plan.

5.2.1 Topdressing Respreading and Seedbed Preparation

Where possible, suitable topsoil should be re-spread directly onto reshaped areas at depths as stated in Section 5.1 above. 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.

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be lightly contour ripped (after topsoil spreading) to create a "key" between the soil and the spoil. Ripping should be undertaken on the contour and the tynes lifted for approximately 2 m every 200 m to reduce the potential for channelised erosion. Best results would be obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified prior to, or during seeding, to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

5.3 EROSION AND SEDIMENT CONTROL

5.3.1 Erosion and Sediment Control

The rehabilitation strategies and concepts proposed below have been formulated according to results of industry-wide research and experience. The main objective of regrading the landform is to produce slope angles, lengths and shapes that are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising the risk of erosion and sedimentation. Final slope gradient should not exceed 17%, or approximately 10°, except if associated with the void where slopes may be up to 18°.

The most significant means of controlling surface flow on disturbed areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that would cause erosion. As the slope angle increases, the banks or furrows should be spaced closer together until a point is reached where they are no longer effective.

Contour ripping across the grade is by far the most common form of structural erosion control on mine sites, as it simultaneously provides some measure of erosion protection and cultivates the surface in readiness for sowing. Graded banks are essentially a much larger version of contour furrows, with a proportionately greater capacity to store runoff and/or drain it to some chosen discharge point. The banks are constructed away from the true contour, at a designed gradient (0.5% to 1%) so that they drain water from one part of a slope to another; for example, towards a watercourse or a sediment control dam. Eventually, runoff that has been intercepted and diverted must be disposed of down slope. The use of engineered waterways using erosion blankets, ground-cover vegetation and/or rip rap is recommended to safely dispose of runoff downslope.

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff prior to off-site release. Sediment control dams are responsible for improving water quality throughout the Project Site and, through the provision of semi-permanent water storages, enhance the ecological diversity of the area.

5.3.2 Erosion Potential

The following tests were undertaken on all soil samples to gain an indication of any soil types or layers with potentially high erodibility characteristics.

- Emmerson Aggregate Test.
- Exchangeable Sodium Percentage (ESP).

The results of the Emerson Aggregate Test for all topsoil samples were Class 3(1) which means some slaking, no dispersion of original ped, however, dispersion occurs when remoulded at water content equal to field capacity and immediately immersed in water. Furthermore, there is slight milkiness, immediately adjacent to the aggregate. In the general context of erosion on mine sites, Class 3(1) is considered slightly dispersive. The subsoils were also tested and results included 3(1), 3(2), 4 & 5. The Classes 4 and 5 are generally considered non dispersive, whilst 3(1) and 3(2) are both considered slightly dispersive, with 3(2) having obvious milkiness, but less than 50% of the aggregate affected.

The ESP results are congruent with the EAT results in that ESP ranged from 0.58% to 1.02% in the topsoil, which indicates nil to very low sodicity and 0.80% to 6.76% in the subsoils. In general terms an ESP result above 6 is considered sodic. There was only one result above 6, which was found in the subsoil of the Dark Brown Vertosol at site 4, approximately 0.8 m deep. The amount of organic material within the vertosols generally protects this moderately sodic soil from physically dispersing, however care should be taken to ensure surface runoff water is captured in sedimentation dams from this subsoil when it is exposed. It is not recommended that this or other subsoils (not currently stockpiled) be salvaged and used in rehabilitation.

6 Conclusions

In conclusion, there were three soil types identified in the proposed extension area during the soil survey, namely:

- Brown Chromosol (80 ha);
- Stoney Brown Chromosol (134 ha); and
- Dark Brown Vertosol (188 ha).

The Brown Chromosol and Dark Brown Vertosol are suitable for stripping to 0.3m for re-use in rehabilitation, whilst the Stoney Brown Chromosol was unsuitable due to high stone content throughout the profile.

The rehabilitation scenario provided in Section 4 utilises all available subsoil and topsoil stockpiled on site to achieve the highest quality land capability classes on site. The areas for each land capability class for this scenario are presented in **Table 9**. There is adequate subsoil resources (855,570 m^3) currently stockpiled on site to satisfy the rehabilitation objectives. No further subsoil is recommended for stripping. There is 307,380 m^3 of topsoil stockpiled onsite. There would be adequate topsoil resources to fulfil rehabilitation objectives provided both stockpiled and in-situ materials are utilised in the rehabilitation program, furthermore the in-situ material must be stripped at the recommended depths to ensure adequate resources.

Land Capability classification across the Project Site ranges from Class III to Class VI pre-mining and Class III to Class VII post-mining. Agricultural Suitability classes ranged from Class 2 to Class 4 pre-mining and Class 2 to Class 5 post-mining.

There is adequate subsoil and topsoil resources contained in both stockpiled material and in situ soil yet to be stripped, to meet the rehabilitation objectives for the site, provided soil is stripped according to recommendations in the above sections.

7 References

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NSW Agriculture and Fisheries (1990). *Agricultural Suitability Maps – Uses and Limitations*. Agfact AC.9 Second Edition.

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Appendix 1: Field Assessment Procedure

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) 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.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils 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 extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

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.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; 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.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as the Hunter Valley.

Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.

Appendix 2: Soil Information

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1 - very dispersible soils with a high tunnel erosion susceptibility.

Class 2 - moderately dispersible soils with some degree of tunnel erosion susceptibility.

Class 3 - slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.

Class 4-6 - more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.

Class 7-8 - highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected
(4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (*d*S/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

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Appendix 3: Soil Test Results

Land and Property Management Authority

Soil Conservation Service

SOIL TEST REPORT

Page 1 of 5

Scone Research Centre

REPORT NO: SCO10/139R2

REPORT TO: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

REPORT ON: Eighteen soil samples

PRELIMINARY RESULTS ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 2 June 2010

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

SR Young

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666, Fax: 02 6545 2520

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO10/139R2
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH
1	1-1	35	32	20	12	1	3(1)	0.03	6.8
2	1-2	62	14	11	13	<1	5	0.08	8.1
3	1-3	58	12	13	16	1	5	0.18	8.4
4	2-1	13	10	25	43	9	3(1)	0.02	6.6
5	2-2	9	12	23	48	8	3(1)	0.01	7.0
6	2-3	9	11	25	50	5	3(1)	<0.01	7.5
7	2-4	41	8	13	33	5	3(1)	0.03	7.4
8	4-1	53	13	16	16	2	3(1)	0.04	7.9
9	4-2	49	14	13	20	4	4	0.15	9.0
10	4-3	31	14	25	27	3	3(1)	0.16	9.2

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SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO10/139R2
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH
11	5-1	9	10	18	37	26	3(1)	0.06	7.5
12	5-2	8	11	15	37	29	3(1)	0.06	8.8
13	6-1	20	16	23	40	1	3(1)	0.02	6.7
14	6-2	19	17	20	38	6	3(1)	0.01	6.9
15	6-3	17	12	22	42	7	3(2)	<0.01	7.1
16	6-4	49	6	13	31	1	3(1)	0.03	8.3
17	7-1	48	13	18	18	3	3(1)	0.01	6.6
18	7-2	65	17	11	6	1	5	0.01	7.5

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SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO10/139R2
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C5A/3 CEC & exchangeable cations (me/100g)					Colour	
	Sample Id	CEC	Na	K	Ca	Mg	Dry	Moist
1	1-1	34.2	0.2	1.9	20.8	5.5	7.5YR3/2	7.5YR2.5/2
2	1-2	45.2	1.3	0.2	31.2	9.1	10YR3/2	10YR2/2
3	1-3	42.2	1.6	0.1	29.7	8.8	10YR4/2	10YR3/3
4	2-1	10.6	0.1	0.8	5.6	0.6	7.5YR4/3	7.5YR3/3
5	2-2	13.0	0.2	1.3	8.0	0.8	10YR5/4	10YR3/4
6	2-3	8.9	0.2	0.7	4.8	0.4	7.5YR6/3	7.5YR4/4
7	2-4	25.7	0.5	0.9	14.7	6.4	7.5YR5/6	7.5YR4/6
8	4-1	39.2	0.4	0.7	20.7	10.9	7.5YR4/2	7.5YR3/2
9	4-2	39.3	1.6	0.2	25.1	12.6	7.5YR4/3	7.5YR3/3
10	4-3	28.1	1.9	0.2	13.8	10.0	10YR5/4	10YR4/4

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SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO10/139R2
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C5A/3 CEC & exchangeable cations (me/100g)					Colour	
	Sample Id	CEC	Na	K	Ca	Mg	Dry	Moist
11	5-1	13.9	0.1	1.4	7.8	1.4	10YR5/3	10YR3/3
12	5-2	12.4	0.1	0.6	8.9	0.5	7.5YR6/3	7.5YR4/4
13	6-1	13.0	0.1	1.1	6.9	1.9	7.5YR5/2	7.5YR3/2
14	6-2	13.3	0.2	0.8	7.6	1.8	7.5YR5/2	7.5YR3/2
15	6-3	8.1	0.2	0.4	4.4	1.5	10YR6/2	10YR5/2
16	6-4	25.4	0.4	0.7	13.1	16.3	10YR5/4	10YR4/4
17	7-1	34.5	0.3	1.0	20.5	6.4	7.5YR3/3	7.5YR2.5/3
18	7-2	50.2	0.5	0.1	39.3	11.4	7.5YR4/2	7.5YR3/2

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END OF TEST REPORT

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