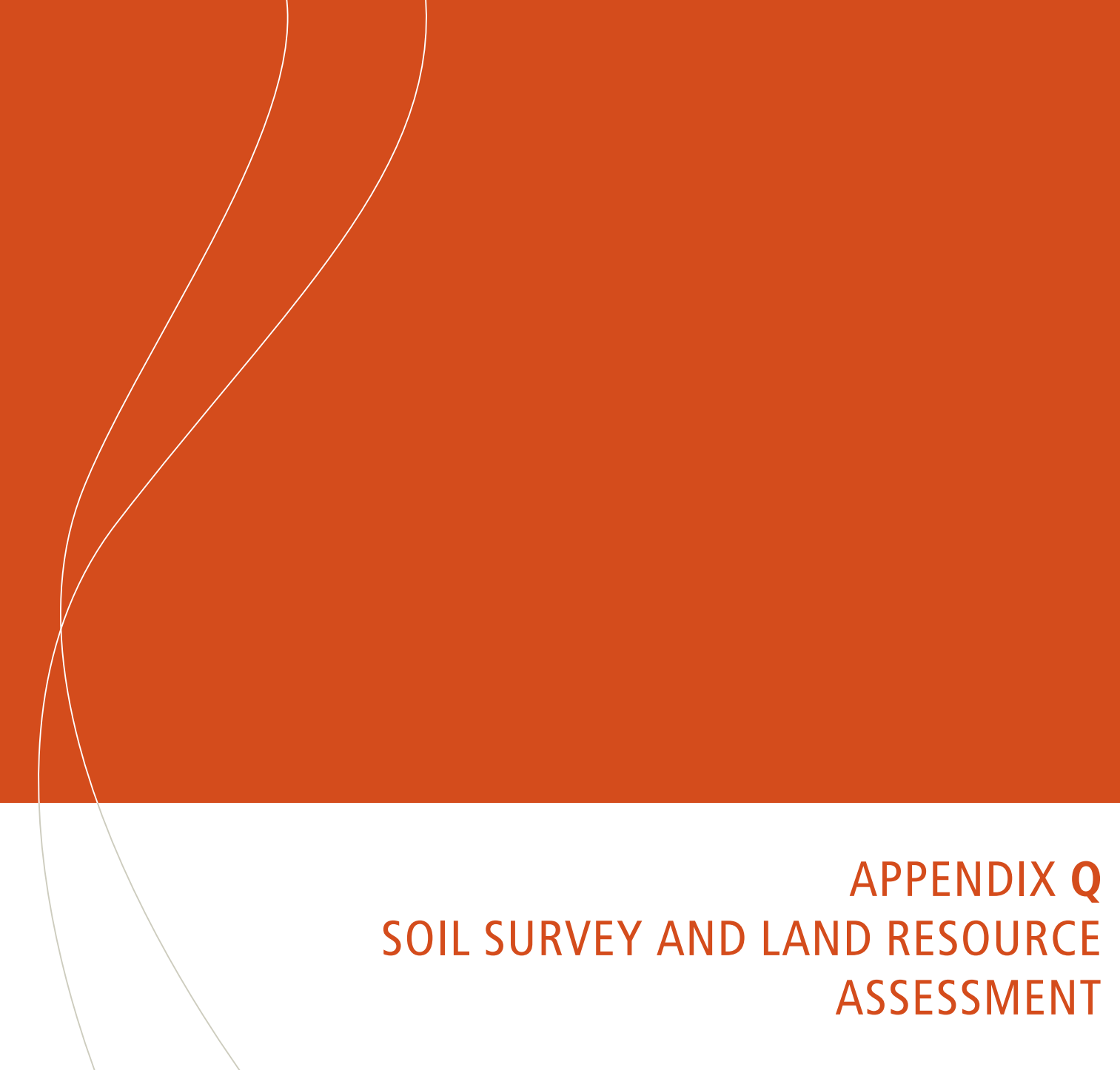




APPENDIX Q SOIL SURVEY AND LAND RESOURCE ASSESSMENT



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Mt Arthur Coal Consolidation Project

Soil Survey and Land Resource Assessment Report

August 2009

HAN02-001 MAC Soils Assessment



GSS ENVIRONMENTAL
Environmental, Land and Project
Management Consultants

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1.0 INTRODUCTION

GSS Environmental (GSSE) was commissioned by Hansen Bailey on behalf of Hunter Valley Energy Coal (HVEC) to undertake a soil, land capability and agricultural suitability assessment for a new Project Approval for the Mt Arthur Coal Consolidation Project under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Mt Arthur Coal currently has approval to extract up to 28 Million tonnes per annum (Mtpa) from the Mt Arthur Coal Complex, of which 8 Mtpa is from underground methods.

HVEC is applying for a new Project Approval to gain a single, contemporary planning approval for its open cut operations and the mining of additional areas within Mt Arthur Coal's current Mining Leases (ML) (the Project). The Project Application Boundary (EA Boundary) is consistent with the Project Approval area for the Mt Arthur Underground Project (MAU).

The Project continues all aspects of Mt Arthur Coal's current activities and specifically comprises the following:

- Consolidation of all of Mt Arthur Coal's open cut mining related planning approvals into one contemporary Project Approval;
- Extension of the mine footprint to uncover additional coal reserves within the current MLs;
- Increasing the Mt Arthur Coal Complex approved production levels by 8 Mtpa up to 36 Mtpa ROM coal. This will be achieved by;
 - Increasing open cut coal production by up to 8 Mtpa; and
 - Having the flexibility to increase either open cut or underground production by an additional 4 Mtpa if the maximum production from either underground or open cut methods is not being met (total to not exceed 36 Mtpa).
- Relocation of a section of Edderton Road in approximately 2019;
- Upgrading the existing Mt Arthur Coal, Coal Handling and Preparation Plant (CHPP) to wash up to 36 Mtpa of ROM coal and allow the inclusion of an ultra-fine coal circuit to re-process fines and facilitate increased resource recovery and reduced water demand;
- Increasing the approved rail haulage capacity in line with the increased coal production from 19 Mtpa to 27 Mtpa, with the construction of a second rail load out facility and associated conveyor system;
- Modifications to existing infrastructure (such as workshop and bath house), construction of additional ROM coal hoppers and the extension of ROM and product coal stockpiles; and
- A total workforce of approximately 2,600 at peak production, which represents an increase of approximately 1,610 from current staffing levels and an estimated additional 720 positions directly attributable to the Mt Arthur Coal Consolidation Project.

No changes to the mining method or hours of operation are proposed, although a gradual increase in the mobile equipment fleet will be required.

This report is based on a desk top review of Soil and Land Capability Assessments previously undertaken by Dames & Moore (2000) for the Mt Arthur North (MAN) Environmental Impact Statement (EIS), Resource Planning (1993) for the Bayswater No. 3 EIS and additional fieldwork undertaken by GSSE during March 2009. For the remainder of this report the EA Boundary in which the land resource assessment was conducted will be referred to as the "survey area".

1.1 Objectives

A land resources assessment has been undertaken by GSSE to assist Mt Arthur Coal with the post-mining rehabilitation activities. The major objectives of this study were to:

- Assess areas to be disturbed at a sufficient level of detail to satisfy the requirements of the Department of Primary Industries (DPI);
- Assess pre and post mining land capability classification in accordance with Department of Water and Energy (DWE) guidelines;
- Assess pre and post mining agricultural suitability classification in accordance with DPI Agriculture guidelines;
- Assess topsoil resources for mining and infrastructure area rehabilitation and management;
- Provide an assessment to determine whether the survey area soils are suitable for rehabilitation purposes and what treatments, if any, are required to optimise successful rehabilitation; and
- Provide suitable post-mining land use recommendations for the open cut operations.

1.2 Location

The Mt Arthur Coal Complex is located approximately 5 kilometres (km) south-west of Muswellbrook and approximately 130 km north-west of Newcastle in New South Wales and covers an area of approximately 36 km². The site is located on Thomas Mitchell Drive, west of the New England Highway, north-west of the Bayswater and Liddell Power Stations, and west of Drayton Mine and the village of Antiene. A general locality plan showing The Mt Arthur Coal Complex's location within the region is shown in **Figure 1**.

The survey area includes additional areas of disturbance within existing MLs, including an area west of Edderton Road (refer to **Figures 2, 3 & 4**).

1.3 Geology

The stratigraphy of the survey area as mapped by the Hunter Coal Field Regional Geology Map – (Geological Series-Sheet 9033 – 1987) comprises Middle to Late Permian sedimentary sequences, overlain in part by Quaternary alluvium and Cainozoic alluvial and colluvial deposits. Three (3) Palaeozoic units have been mapped and are described below. The units are listed in descending order (oldest to youngest) as follows:

- Saltwater Formation (Ps) – This unit is the lowermost unit of the Late Permian Wittingham Coal Measures. It comprises sandstone and siltstone with minor coaly bands, which outcrop in a narrow north-south trending belt.
- Vane Subgroup (Pv) – This unit also belongs to the Late Permian Wittingham Coal Measures and comprises coal seams, siltstone, lithic sandstone, shale and conglomerate, which outcrops in a north to north-west trending belt.
- Jerry's Plains Subgroup (Pj) – This unit is the upper most member of the Late Permian Wittingham Coal Measures. It comprises coal seams, claystone, tuff, siltstone and conglomerate, which outcrop in a north-west trending belt.

Unconformably overlying these Palaeozoic rocks are relatively thin deposits of unconsolidated Cainozoic alluvial/colluvial deposits, which occur as:

- Unnamed Quaternary deposits (Qa) – This unit comprises Quaternary clay, silt, sand and gravel deposited in point bar, levee and overbank environments.
- The deposits are of limited extent and occur in places along the north-western boundary of the survey area, on the floodplain of the Hunter River to the north of the survey area. Narrow alluvial tracts have also been mapped along the drainage flats of intermittent streams within the survey area.
- A second Cainozoic unit, not mapped by the regional geological surveys, but identifiable within the survey area, comprises Cainozoic (Cz) slope wash deposits. This unit comprises alluvial and colluvial deposits of gravel, sand, silt and clay, occupying gently inclined outwash slopes and footslopes, typically along lower slopes bordering drainage lines.

1.4 Topography

The terrain within the survey area comprises mainly of undulating to rolling low hilly lands with broadly rounded crestal areas and moderately inclined dissection slopes, up to approximately 10% slope gradient. Steeper, higher hilly lands occur in the southern and south-western sectors and also in the central north-western sectors of the site. These hilly lands have mostly narrow rounded ridge crests and moderately steep to steep hill and ridge slopes, mostly in the range of 10% to 20% slope gradient. Locally steeper slopes (>20%) occur on the dissected middle lower slopes in the vicinity of Mount Arthur.

1.5 Vegetation

The survey area has been used for grazing prior to the land being utilised for mining, resulting in the majority of the area being classified as 'Pastoral Grassland' (MAN EIS, URS 2000). This community consists of a mixture of native and introduced pasture grasses between 0.1 metre (m) and 1 m in height, interspersed with a variety of widespread native forbs and exotic weed species. Common and widespread grasses include Spear Grass (*Stipa aristiglumis*), Wallaby Grasses, (*Danthonia* spp.), Red Grass (*Bothriochloa macra*), Bluegrasses (*Dichelachne micrantha*, *Dichanthium sericeum*), Barley (*Hordeum leporinum*) and Oats (*Avena barbata*). These grass lands are widespread and exhibit considerable local variation in structure and composition in response to varied grazing pressure, in some places consisting of a stunted grassland and prostrate forb layer of less than 0.1 m in height.

The survey area also contains areas of *Eucalyptus crebra*/*E. albens*/*E. moluccana* Woodland-Open Forest. Structurally this community consists of an open forest to woodland community characterised by the presence of Narrow-leaved Ironbark (*Eucalyptus crebra*) and/or White Box hybrids (*Eucalyptus albens*) as the dominant canopy species to a height of 10 to 15 m. Additional canopy species which occasionally occur include Gum-topped Box (*Eucalyptus moluccana*), Slaty Gum (*Eucalyptus dawsonii*) and Kurrajong (*Brachychiton populneus*). The shrub layer has been heavily cleared and is typically sparse to absent, while the groundcover layer is dominated by a mixture of exotic and native grasses and widespread forb species from 0.3 m to 1.0 m in height.



FIGURE 1

Regional Locality Plan

Project:
Soils and Land Capability MAC EA

Client:
Hansen Bailey

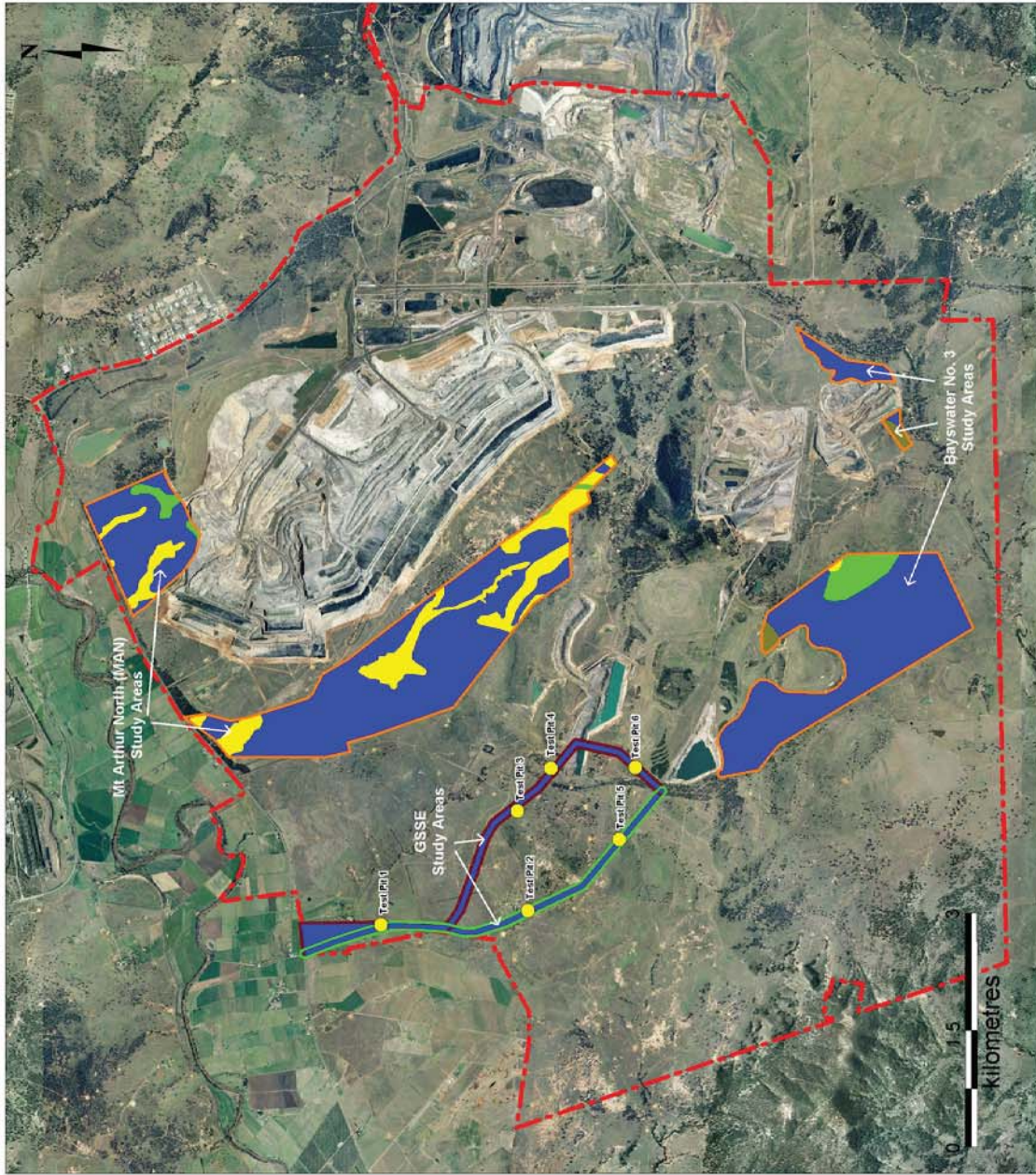
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Version: 1
Date: 6/8/09
Author: LF
Checked: SS
Approved: SS



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Legend

- Class 2 - Sandy Soils
- Class 3 - Gradational/Uniform Loams and Clays
- Class 4 - Yellow Duplex Soils
- Class 5 - Red and Brown Duplex Soils

Sources:
 (2 Northern Areas) - Mt Arthur EIS 2000 App C
 (Edderton Road) - GSSE 2009 Soil Survey
 (3 Southern Areas) - Resource Planning (1993)

- 2009 Soil Test Pit Locations
- Mine Extension Areas
- Edderton Road Realignment Option 1
- Edderton Road Realignment Option 2
- EA Boundary

FIGURE 2
Soil Distribution

Project: Soils & Land Capability MAC EA

Client: Hansen Bailey

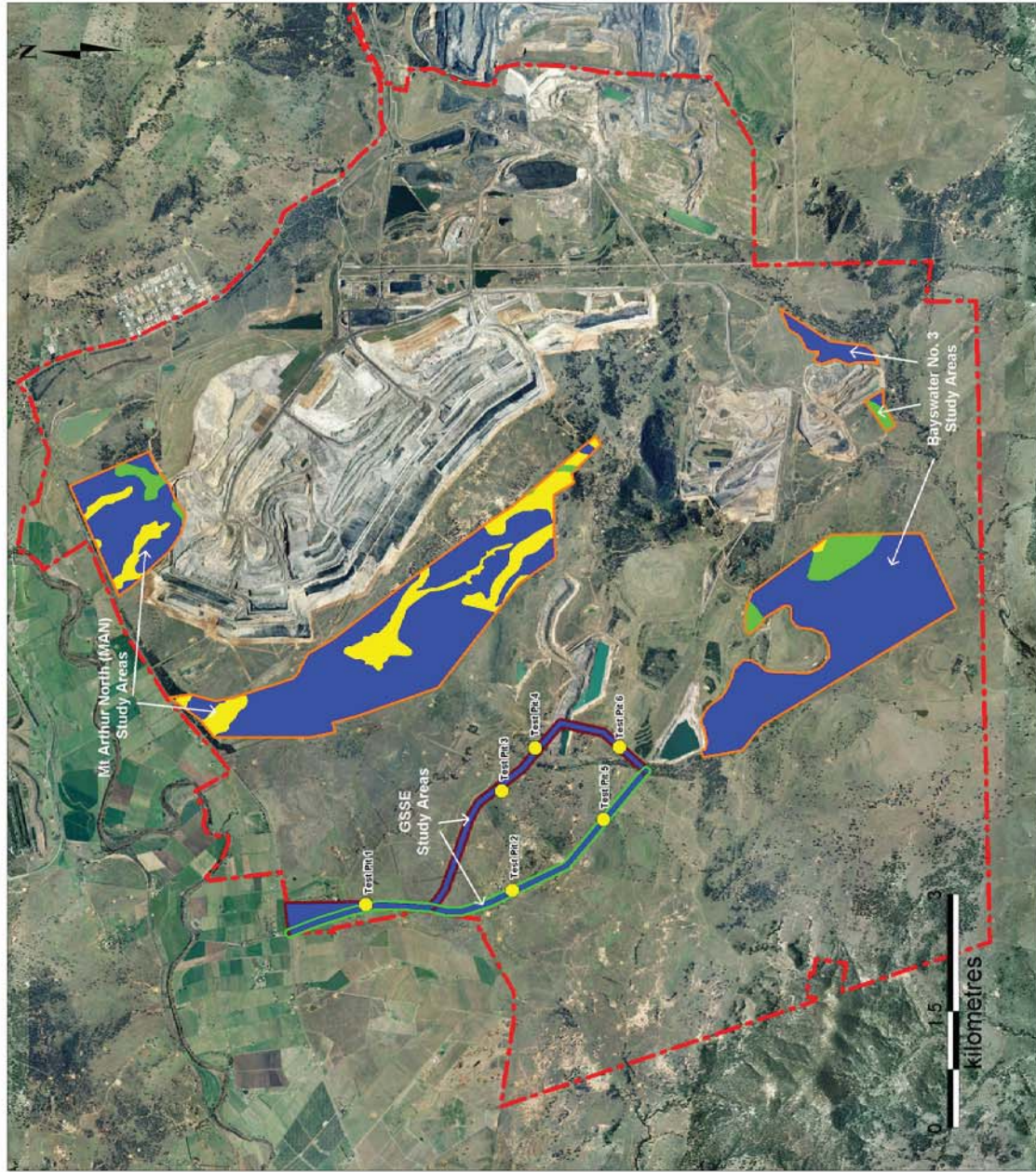
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Version	Date	Drawn By	Checked	Approved
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Legend

- 0.15 m
- 0.10 - 0.30 m
- 0.15 - 0.30 m

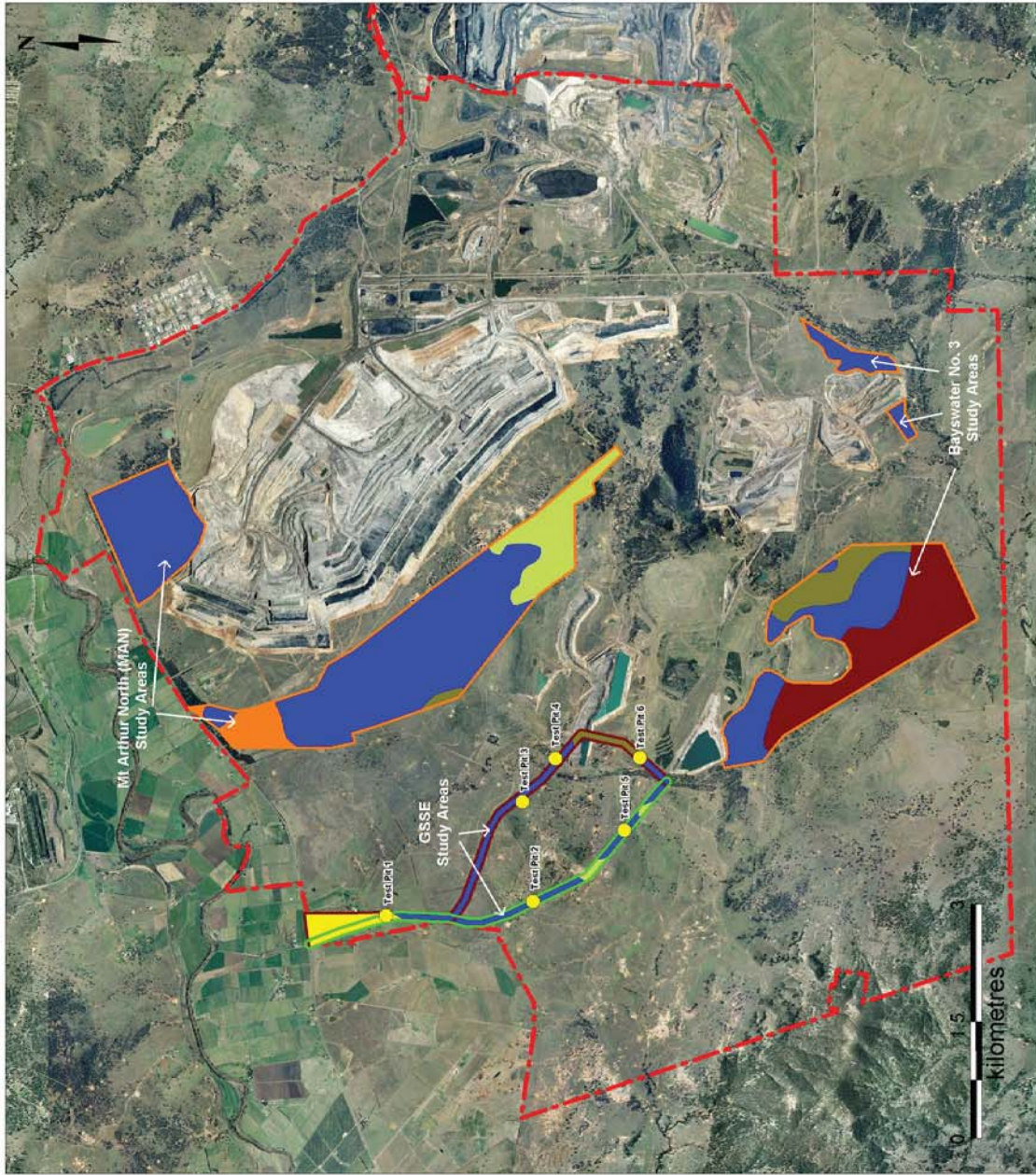
- 2009 Soil Test Pit Locations
- Mine Extension Areas
- Edderton Road Realignment Option 1
- Edderton Road Realignment Option 2
- EA Boundary

FIGURE 3
Soil Stripping Depths

Project: Soils & Land Capability MAC EA			
Client: Hansen Bailey			
File: HAN02-001			
Projection: GDA94 MGA Zone 56			
Version	Date	Drawn By	Checked
1	30/06/09	DJ	SS
			Approved
			RM



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Legend

Rural Land Capability Class:

- Class I
- Class II
- Class III
- Class IV
- Class V
- Class VI

Source: Rural Land Capability Mapping DTPNR 2003

2009 Soil Test Pit Locations

- Mine Extension Areas
- Edderton Road Realignment Option 1
- Edderton Road Realignment Option 2
- EA Boundary

FIGURE 4
Pre-mining Rural Land Capability Classification

Project: Soils & Land Capability MAC EA

Client: Hansen Bailey

File: HAN02-001

Projection: GDA94 MGA, Zone 56

Version	Date	Drawn By	Checked	Approved
1	30/06/09	DJ	SS	RM



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2.0 SURVEY METHODOLOGY

2.1 Introduction

A Soil and Land Capability Assessment has been previously undertaken by Dames & Moore (2000) for the MAN EIS and by Resource Planning (1993) for the Bayswater No. 3 EIS. These assessments cover the majority of the survey area to be addressed within this report, therefore, a desktop review of the Dames & Moore (2000) and the Resource Planning (1993) reports has been undertaken by GSSE to compile the majority of the information for this report. However some additional soil surveys have been undertaken by GSSE to cover those areas not addressed by Dames & Moore (2000) and Resource Planning (1993) for the Edderton Road realignment. This assessment has been undertaken to determine the following:

1. to classify and determine the soil types of the survey area;
2. to assess the suitability of the current topsoil material for future rehabilitation; and
3. to identify pre and post mining agricultural suitability and land capability.

The review has been conducted in accordance with the methodology outlined below.

2.2 Soil Mapping

A soils map (**Figure 2**) was developed using the following resources and techniques.

1) 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 survey area.

2) Previous soil survey results

A survey of the MAN project area (including the areas surveyed in this assessment) was undertaken by Dames & Moore (2000) and a survey of the Bayswater No. 3 area was undertaken by Resource Planning (1993). The survey map and report present a guide to the soils and landscape units across the Mt Arthur Coal site, including the survey area for this assessment.

During 1991, Kovac and Lawrie completed a soil survey of all the area contained in the Singleton 1:250,000 sheet. The survey area was included in this soil survey.

3) Stratified observations

Following production of a base soils map, surface soil exposures throughout the survey area were visually assessed to verify soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations of the proposed Edderton Road realignment area.

2.3 Soil Profiling

Six (6) soil profiles were assessed at selected sites throughout the Edderton Road realignment area to enable soil profile descriptions to be made. Subsurface exposure was generally undertaken by backhoe excavation of test pits to between 1 and 1.5 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 3**).

Soil profiles were also observed through the use of surface exposures located in existing track cuttings, gullies and creek banks. Soil test pit locations are shown in **Figure 2**.

2.4 Field Assessment

Soil profiles within the survey area 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. A more detailed explanation of the Elliot and Veness procedure is presented in **Appendix 1** to this report. The system remains the benchmark for land resource assessment in the Australian coal mining industry.

2.5 Laboratory Testing

Soil samples were collected from the exposed soil profiles and subsequently sent to the NSW Department of Lands Soil & Water Testing Laboratory at 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 and, conversely, soils that may have properties that are deleterious to vegetation establishment. Samples were analysed from the following sites (as shown on **Figure 2**):

- Test Pit 1 – 1/1 & 1/2
- Test Pit 2 – 2/1 & 2/2
- Test Pit 3 – 3/1 & 3/2
- Test Pit 4 – 4/1 & 4/2
- Test Pit 5 – 5/1 & 5/2
- Test Pit 6 – 6/1 & 6/2

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

- Colour.
- Particle Size Analysis.
- Emerson Aggregate Test.
- pH.
- Electrical Conductivity.

A description of the significance of each test and typical values for each soil characteristic is 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 rehabilitation of disturbed areas. Similarly, potentially unfavourable soil material can be identified. The soil test results for the soil survey are provided in **Appendix 3**.

2.6 Land Capability Assessment

The land capability assessment of the survey area was conducted in accordance with the Department of Environment and Climate Change (DECC) (formerly implemented by the NSW Department of Natural Resources) rural land capability classification system. The system consists of eight classes, which classify land on the basis of an increasing soil erosion hazard and decreasing versatility of use.

It recognises the following three types of land uses:

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

These capability classifications identify limitations on the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognised by these capability classifications is the stability of the soil mantle (Soil Conservation Service, 1986).

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography, and the effects of past land uses. The classification does not necessarily reflect the existing land use; rather it indicates the potential of the land for uses such as crop production, pasture improvement and grazing.

The system allows for land to be allocated into eight possible classes (with land capability decreasing progressively from Class I to Class VIII). The classes are described in **Table 1** below.

A description of land capability classification for all land within the survey areas is discussed further in **Section 3.7**.

Table 1 – Rural Land Capability Classes

Rural Land Capability Classification System		
Land Class	Land Suitability	Land Definition
Class I	Regular Cultivation	No erosion control requirements
Class II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works
Class III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways
Class IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
Class V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks
Class VI	Grazing only	Managed to ensure ground cover is maintained
Class VII	Unsuitable for rural production	Green timber maintained to control erosion
Class VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
U	Urban areas	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production

Source: Department of Environment and Climate Change

2.7 Agricultural Suitability Assessment

The agricultural suitability assessment of the survey area was conducted in accordance with the Department of Primary Industries (DPI) (formerly NSW Agriculture & Fisheries) agricultural suitability classification system. The system consists of five classes, providing a ranking of 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.

The classification is based upon the effects of climate, topography and soil characteristics, the cultural and physical requirements for various crops and pastures, and existing socio-economic factors including local infrastructure and geographic location. These factors combine to determine the productive potential of the land and its capacity to produce crops, pastures and livestock. The classes are described in **Table 2** below.

Table 2 – Agricultural Suitability Classes

Agricultural Suitability Classification System		
Land Class	Agricultural Suitability	Land Definition
Class 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
Class 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
Class 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
Class 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
Class 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: Department of Primary Industries

3.0 RESULTS

3.1 Desktop Review – MAN EIS (2000)

3.1.1 Soil Classification

Table 3 contains the soil classification of the northern section of the survey area as determined by Dames & Moore (2000).

Table 3 – Soil Classes and Soil Types

Soil Class	Soil Type
Soil Class 1-3	1. Rock outcrop, skeletal soils and shallow gravelly soils – sandy, loam or clayey gravels with greater than 50% of coarse fragments
Soil Class 1-4	2. Predominantly course-textured (sandy) soils
Soil Class 4	3. Earthy sands, sandy earths
Soil Class 5	4. Massive earths, gradational, some uniform texture profiles, predominantly loamy
Soil Class 6	5. Yellow duplex soils
Soil Class 6-8	6. Red duplex (yellowish-red, reddish yellow) soils
Soil Class 7	7. Brown, yellow brown, grey or dark coloured duplex soils
Soil Class 8	8. Uniform or gradational, yellow, red, brown, grey-brown or dark clays
Total	

Eight soil classes have been used to describe the soils. General descriptions are as follows:

Soil Class 1

Soil Class 1 identifies those areas where rock outcrop, skeletal soils and/or shallow to moderately deep uniform or weakly gradational gravelly, loamy or clayey soils are present. They occupy the narrow crestal areas and upper marginal slopes of some higher hills and ridges. In term of the Great Soil Group (GSG), these soils are mainly Lithosols. In terms of the Australian Soil Classification (ASC), they comprise Leptic Rudosols and Paralithic Leptic Tenosols.

Soil Class 2

These comprise uniform brown sands or slightly silty or clayey sand soils. They are of very limited extent and occur along narrow drainage ways in the southern sector of the survey area. In terms of GSG, they include Earthy or Siliceous Sands or Alluvial Soils. In terms of the ASC, they comprise Stratic or Leptic Rudosols.

Soil Class 3

These soils include uniform or gradational earthy sand – sandy earth soils. They are generally acidic, with a fine sandy loam surficial soil horizon grading to a brown fine sandy clay loam subsoil. They are of limited occurrence within the survey area and occur associated with narrow drainage ways in the southern part of the site. These soils occur as Lithosols in the GSG and as Leptic Tenosols in the ASC.

Soil Class 4

These soils comprise Brown and Yellowish Brown Massive Earths. They have a gradational profile with dark brown to brown sandy clay loam surficial (A) horizons overlying bright brown clay loam to sandy light or medium clay subsoil (B) horizons. GSG's include Brown Earths and Yellow Earths and in the ASC they classify as Yellow and Brown Kandosols.

Soil Class 5

These soils include yellow mottled bleached duplex soils. They comprise shallow to moderately deep sandy loam to loamy surface soils generally with bleached or pale (A2) subsurface horizon underlain by acidic mottled bright yellowish brown light to medium sodic clay or sandy clay subsoils. They occur mainly in the northern and southern sectors of the survey area. The GSG is primarily Yellow Podzolics and in the ASC they are classified as Yellow Sodosols.

Soil Class 6

These soils occur fairly extensively throughout the survey area. They include mainly residual (formed *in situ*) red and yellowish red duplex soils, which typically have dark brown, hard-setting acidic loam to clay loam surface soils with acidic, neutral and alkaline light to medium well-structured clay subsoils. GSG's include Red-Yellow Podzolics, Non-calcic Brown Soils and Red Brown Earths. In terms of the ASC they occur mostly as Red or Yellow-red Chromosols or Red-Yellow Sodosols.

Soil Class 7

These soils are co-dominant with the Class 6 soils. They comprise of weakly developed duplex soils with brown to dark brown thin loamy surface (A) horizons, usually with a clear or sharp change to the moderately well structured, brown or yellowish-brown or grey-brown, sometimes acidic to neutral but frequently sodic alkaline, light to medium clay subsoil (B) horizons. GSG's include Brown Podzolics, Grey-brown Podzolics and Brown Duplex Soils. In terms of the ASC they occur mainly on Brown Sodosols or Brown Chromosols.

Soil Class 8

These soils have gradational or uniform profiles of predominantly finer-textured, dark coloured, dark grey-brown, dark brown and dark yellow-brown structured light to medium clay soils. They occur as residual soils on moderate to steep slopes and also on drainage flats and gully floors. These soils have clay loam, fine sandy clay loam or light clayey surface (A) horizons generally with light to medium well-structured neutral to alkaline clay subsoils. GSG's include Krasnozems on the steeper slope units and Prairie Soils and Grey-Brown Structured Earths on the alluvial flats. ASC's comprise Grey-Brown Dermosols and Sodic Brown Dermosols.

3.1.2 Soil Chemical Properties

Soil chemical properties were originally determined as part of the MAN EIS (2000) for soil classes 5, 6, 7 and 8 only. Soil class 4, however, does cover a reasonable area within the survey area and did not have chemical properties determined. For the purposes of this desk top soils assessment class 4 soils were included as a soil type, however, no additional chemical testing or review of these soils has been undertaken.

A summary of the soil chemical characteristics for the main soil types is outlined below.

Soil pH

Soil pH for topsoils of soil class 5 ranges from very strongly acid to neutral, however, they are generally medium acid. Soil pH for subsoils of soil class 5 is typically neutral.

Topsoils of soil class 6 range from strongly acid to slightly acid, but are generally medium acid. Soil pH for subsoils of soil class 6 range from medium acid to very strongly alkaline, but are mainly neutral.

Soil pH for topsoils of soil class 7 range from medium acid to neutral, but are mainly neutral. Soil pH for subsoils of soil class 7 range from mildly alkaline to very strongly alkaline, but are mainly strongly alkaline.

Topsoils of soil class 8 range from medium acid to mildly alkaline, but are generally neutral. Soil pH for subsoils of soil class 8 is mostly strongly alkaline, although some are neutral.

Salinity

ECe (saturation extract) levels for soil classes 5 and 6 are very low for both topsoil and subsoil (B) horizons. ECe levels for soil class 7 are generally very low for topsoils and high for the deeper subsoils. ECe levels for both topsoils and subsoils of soil class 8 are generally at moderate levels.

Chloride (Cl) levels within topsoils of all classes range from very low to low.

Major Cations

Effective cation exchange capacity (eCEC) for class 5 soils (both topsoils and subsoils) is typically very low to low. This reflects the generally low to moderate levels of individual cations within these soils. In relative terms, these soils tend to have very high levels of Magnesium (Mg) and Potassium (K), with moderate levels of Calcium (Ca) and Sodium (Na). Both the topsoils and the subsoils are sodic. These levels are reflected in typically low to very low Ca/Mg ratios, which suggests the potential for Ca deficiency.

For soil class 6, eCEC is generally low in the topsoil and high in the subsoil. The topsoils generally have moderate levels of cations while the subsoils have high levels of cations. In relative terms, the topsoils tend to have very high levels of Mg and K, with high levels of Ca and low levels of Na. The topsoils tend to be non-sodic. The subsoils tend to have very high levels of K, with moderate levels of other cations. The subsoils tend to be sodic. Both the topsoils and the subsoils generally have low Ca/Mg ratios, suggesting the potential for Ca deficiencies.

The eCEC for the topsoil for soil class 7 is typically moderate, reflecting moderate levels of Ca and Na, and high levels of Mg and K. The eCEC for subsoils of soil class 7 is typically very high, reflecting generally very high levels of most cations. In relative terms, both topsoils and subsoils generally have very high levels of Mg, moderate levels of Ca, and variable levels of K and Na. The subsoils tend to be sodic. The Ca/Mg ratios for both topsoils and subsoils are typically low, suggesting the potential for Ca deficiencies.

For soil class 8, the eCEC is moderate in the topsoils and high in the subsoils. This reflects generally high to very high levels of cations. In relative terms, both topsoils and subsoils tend to have very high levels of Mg, and moderate levels of other cations. The topsoils tend to be sodic while the subsoils tend to be highly sodic. Ca/Mg ratios throughout the profile are typically low, suggesting the potential for Ca deficiencies.

3.2 Desktop Review – Bayswater No. 3 EIS (1993)

3.2.1 Soil Distribution and Properties

Resource Planning carried out a soil survey of the Bayswater No. 3 area during 1993. Within the study area for the Bayswater No. 3 EIS, eighty-seven (87) soil profiles were described. Soils were given a Northcote classification as well as a Great Soil Group name. Each described soil profile was then categorised into the following six (6) soil management groups as follows:

1. **Sandy Soils**

Sands (Uc 5.11)

Sandy earths (Gn 1.85)

Earthy sands (Uc 5.22)

2. **Black Structured Soils**

Prairie Soils (Gn 3.26, Gn 4.32)

Euchrosems (Gn 3.15)

Black earths (Ug 6.1)

3. **Yellow Duplex Soils**

Yellow solodics (Dy 2.32)

Yellow podzolics (Dy 2.12, Dy 2.22, Dy 4.22, Dy 5.22)

4. **Non – Calcic Browns (Dr 2.22, Db 1.22, Dr 2.12, Db 1.12, Db 1.53)**

5. **Skeletal Soils**

6. **Chocolate Soils (Db 3.12, Dr 4.12)**

The distribution and general characteristics of soils within each soil management groups are described below.

Sandy Soils

Sands (Uc 5.11)

This soil type was recorded on ridge crests and spurs west of the limit of the south western part of Saddlers Pit, adjacent to the main occurrence of black earths. Topsoil material consists of loamy sand with little structure. A2 and subsoil horizons are loamy structureless sand.

Earthy Sands (Uc 5.22)

Earthy soils occur on a spur adjacent to Mount Arthur. Topsoil consists of pink sandy loam to 14 cm and has moderate structure. Subsoil is generally pink clayey sand. Soil erodibility and erosion hazard, particularly wind erosion, for this soil type is high.

Sandy Earths (Gn 1.85)

These soils are found in association with the sands adjacent to Saddlers Pit. Topsoil is loamy sand to 17 cm with very weak pedality. Subsoil consists of light sandy clay loam. Soil erodibility and erosion hazard of this soil type are high.

Black Structured Soils

Black Prairie Soils (Gn 3.26, Gn 4.32)

Prairie soils occur on a mid slope north of Saddlers Creek and also on a previously cultivated paddock in the south-western corner of Belmont Pit.

Topsoil is generally dark fine sandy clay loam with friable surfaces. Subsoil consists of dark medium clay and linear gilgais are evident on steeper slopes.

Euchrozems (Gn 3.15)

This soil type occurs in association with black earths at the south western extremity of Saddlers Pit. Topsoil consists of sandy clay loam to 20 cm and the surface is hardsetting. Subsoil is generally red-brown light medium clay.

Black Earths (Ug 6.1)

The major occurrence of this soil type is on a moderately steep mid slope south of McDonalds Road. A small area was noted just north of the main creek crossing on McDonalds Road. Topsoil material is self mulching dark medium clay. Subsoil is dark medium clay to 40 cm depth with shrink-swell potential and aggregated peds.

Yellow Duplex Soils

Yellow Solodics (Dy 2.32)

These soils generally occur in drainage depressions and associated lower slopes. Profile descriptions indicate generally a 10 cm to 20 cm this dispersible A2 horizon, often bleached. Topsoil is loamy with medium clay subsoil. Soil erosion and erodibility is moderate to high and this soil type is often associated with moderate gullying in depressions.

Yellow Podzolics (Dy 2.12, Dy 2.22, Dy 4.22, Dy 5.22)

These soils generally occur in drainage depressions in association with yellow solodics. Topsoil texture is sandy to loamy and the A2 horizon is generally 5 cm to 20 cm thick, dispersible and often bleached. Subsoil is generally light to medium clay.

Non-calciic Browns (Dr 2.22, Db 1.22, Dr 2.12, Db 1.12, Db 1.53)

Non-calciic brown soils are the most widespread soil type in the lease area, generally occurring on the higher ridges and slopes. These soils have loamy topsoil with medium clay subsoil, low to moderate dispersibility, and are rarely stoney. Erosion hazard and soil erodibility are both moderate, but many soil profile sites exhibit moderate to severe sheet erosion due to overgrazing.

Skeletals

These soils occur on steeper areas of Mount Arthur and the ridge west of Belmont Pit. Erosion generally matches soil formation rates resulting in minimal soil depth and profile formation. Soils are usually rocky or sandy.

Chocolate Soils (Db 3.12)

This soil type occurs on an open depression on the proposed emplacement area south of McDonalds Road. Topsoil is dark friable loam fine sandy. Subsoil is dark medium clay with stoney pedality.

Several other soil types were described during field investigations but were restricted to small localised occurrences. These soils include red solodics (Dr 2.42), dark solonetzic (Db 3.42), dark solodics (Db 3.22) and red-brown earths (Dr 2.23).

3.2.2 Soil Analyses

Testing of forty-six (46) soil samples from nineteen (19) soil profiles was conducted as part of the Bayswater No. 3 EIS. The following general characteristics were derived from the soil test results:

- Field textures of the tested soils range from loamy sand to medium clay.
- Field and laboratory pH test results correlate well with only two samples showing a disparity of one unit. The pH readings range between 5.2 and 8.6, the lower pH's being from the duplex soils and the higher pH's from the black structured clays.
- Conductivities were generally low.
- Dispersion percentages range from slight to very high. The lowest readings are from the black structured clays and as was expected, the highest dispersion percentages related to the duplex soils, in particular the yellow podzolics and solodics.
- The Emerson Aggregate Test (EAT) results vary according to soil type in a similar fashion to dispersion percentages. Emerson Aggregate Test results range from Class 4 (aggregate) to Class 2 (susceptible to tunnelling).
- The gravel and sand percentages vary from 2% to 78%. Sand and gravel contents generally reduced with depth in any given soil profile.

3.3 Edderton Road Realignment Area Soil Survey Results

Yellow, brown and red duplex soil units were identified within the Edderton Road realignment area. Exposed profiles of the soil units are shown in **Plates 1 to 3**.

Yellow Duplex

This soil unit is characterised by an abrupt change in texture between the deep yellowish brown silty clay loam surface soils and the underlying clay horizons. The soil unit is situated on the low flat plains in the southern sections of the survey area east of Edderton Road. A representative soil profile of this soil unit is described in **Table 4** and shown in **Plate 1**.

Topsoil

The topsoil is approximately 10 cm in depth. Colour is light yellowish brown through to brown. Texture is generally silty clay loam. Structure is moderate sub – angular blocky with rough faced peds.

Emerson ratings of 2(1) at site 6 indicate that the topsoil has a moderate potential for dispersion. The topsoil is non-saline (EC 0.09 dS/m) and alkaline (pH 8.3). Sand content is low (approximately 39%). Root penetration is common and stones are absent.

Subsoil

The subsoil is yellowish brown to light yellowish brown through to very pale brown. Depth varies between 40 - 100 cm. Textures include medium to heavy clays. Structure is weak to moderate with sub – angular blocky peds, grading to massive structure with depth.

Site 6 subsoils are structurally stable with an Emerson rating of 4, indicating little potential for dispersion. The material is mildly saline (EC of 1.03 dS/m) and moderately alkaline (pH 9.0).

The subsoil has a finer texture with approximately 66% clay content. Root penetration is minimal to nil and no stones were observed in the subsoil layers.

Limiting Factors

The silty clay loam topsoil material is considered suitable for utilisation as a surface cover in rehabilitation and should be stripped to an approximate depth of 10 cm. Soils below 20 cm are not considered suitable for stripping or to be used as a growth medium in rehabilitation.

The Yellow Duplex soils do not display any specific management risk related to potential disturbance during stripping. The fine textured subsoil is unsuitable for use as a topdressing material due to its massive structure and alkalinity.

The loamy and silty clay loam topsoil material is considered suitable for utilisation as a surface cover in rehabilitation. These soils are especially suitable if the post-mining revegetation objective is to establish pasture. It is recommended that only the top 10 cm be recovered and conserved for use as a post-mining topdressing material as most of soil nutrients and seed bank are generally limited to this horizon. The material is non-saline and alkaline. The use of high sulfur fertiliser is recommended during rehabilitation works to reduce alkalinity.

Table 4 – Yellow Duplex Profile Description

SOIL UNIT: YELLOW DUPLEX		
LAYER	DEPTH (cm)	DESCRIPTION
Topsoil	0 – 10	Light yellowish brown (10YR 6/4) silty clay loam. Moderate to strong consistence. Roots are common and stones are absent in this layer. The lower boundary is clear and even to layer 2.
Subsoil	10 – 50	Very pale brown (10YR 7/4) medium to heavy clay. Moderate to strong consistence and massive. Few roots and stones are absent.



Plate 1 – Yellow duplex profile

Brown Duplex

This soil unit is characterised by an abrupt change in texture between the shallow brown loam surface soils and the underlying clay horizon. The soils are generally situated on the low flat plains in the northern, central and eastern sections of the survey area. A representative soil profile of this soil unit is described in **Table 5** and shown in **Plate 2**.

Topsoil

The topsoil is approximately 12 - 15 cm in depth. Colour is brown through to light yellowish brown to strong brown. Textures include loams to silty clay loams. Structure varies across the survey area from weak to moderate with generally sub – angular blocky peds. The soil has an earthy fabric.

Emerson ratings of 3(1) and 3(2) indicate that this topsoil is non-dispersive and structurally stable, however, site 5 exhibits a moderate potential for dispersion with an Emerson rating of 3(3).

The topsoil is non-saline (EC 0.02 dS/m to 0.07 dS/m) and acidic to mildly acidic (pH 5.4 to 6.7). Sand content is approximately 45% to 74% with approximately 12% to 30% clay. Root penetration is common and stones are generally absent.

Subsoil

The subsoil material is brown to dark yellowish brown. Textures range from clay loams to medium clays. Structure is moderate with sub – angular blocky peds grading to massive structure with depth.

The subsoils at sites 1 and 4 exhibit a moderate potential for dispersion with Emerson ratings of 2(1) and 2(2) respectively, however, sites 3 and 5 are structurally stable with Emerson ratings of 4 and 5 respectively. The material is non-saline (EC of 0.03 dS/m to 0.63 dS/m) and slightly alkaline to alkaline (pH of 7.6 to 9.2). The subsoil has a finer texture with approximately 42% to 71% clay content. Root penetration is minimal to nil and no stones were observed in the subsoil layers, however, site 1 contained 20% to 50% stone content.

Limiting Factors

The topsoil material is considered suitable for utilisation as a surface cover in rehabilitation to a depth of 15 cm. Below this depth, the clay subsoil is not considered suitable for use as a surface cover due to high clay content and a moderate potential for dispersion. The clay subsoil should not be left as a surface cover or mixed with topsoil material during stripping or rehabilitation works.

Table 5 – Brown Duplex Profile Description

SOIL UNIT: BROWN DUPLEX		
LAYER	DEPTH (cm)	DESCRIPTION
Topsoil	0 – 15	Strong brown (7.5YR 4/6) loam. Weak to moderate consistence and moderate pedality with sub – angular blocky, 20-50 mm peds. Earthy fabric. Roots are common and stones are 20-60 mm in diameter and occur at 20-50%. The lower boundary is clear and even to layer 2.
Subsoil	15 – 85+	Strong brown (7.5YR 5/6) medium clay. Moderate consistence and weak to moderate pedality with sub-angular-blocky, 50-100 mm peds. Roots are few and stones are absent in this layer.



Plate 2 – Brown duplex profile

Red Duplex

This soil unit is characterised by an abrupt change in texture between the shallow loamy surface layer and the underlying clay horizon. These soils are generally situated on the elevated ridges and hills in the north section of the Edderton Road survey area. A representative profile of this soil unit is described in **Table 6** and shown in **Plate 3**.

Topsoil

The topsoil is approximately 10 cm in depth. It is generally brown to reddish brown in colour. Soil texture consists of silty loams to silty clay loams and the soil has a weak to moderate angular-blocky structure.

Emerson rating of 3(1) indicates that this topsoil is non-dispersive and structurally stable. The topsoil is non-saline (EC of 0.02 dS/m) and slightly acidic (pH 6.3). Clay content is approximately 18% and sand content is 65%. Root penetration was observed as common and stones are generally absent.

Subsoil

The subsoils are light brown to reddish yellow with a moderate sub - angular blocky structure, grading to massive below approximately 60 cm. Texture generally consists of medium to heavy clays. Clay content is consistent throughout the subsoil at approximately 56%. Roots are few to none while stone content increases below 60 cm depth as weathered bedrock fragments are encountered.

Emerson ratings of 3(1) indicate that this subsoil is non-dispersive and structurally stable. The subsoil is non-saline (EC of 0.09 dS/m) and alkaline (pH 8.4).

Limiting Factors

The topsoil material is suitable for use as a growth medium in rehabilitation. The soil should be stripped to a maximum depth of 10 cm. Soils below 10 cm are not considered suitable for stripping and use as a growth medium in rehabilitation due to their high clay content and massive structure.

Table 6 – Red Duplex Profile Description

SOIL UNIT: RED DUPLEX		
LAYER	DEPTH (cm)	DESCRIPTION
Topsoil	0 – 10	Brown (7.5YR 5/4) loam. Moderate consistence and pedality with sub-angular-blocky, 20-50 mm peds. Roots are many and stones are absent. Lower boundary is clear and even to layer 2.
Subsoil	50 – 100+	Reddish yellow (5YR 6/6) medium clay. Moderate to strong consistence and massive at depth. Few to no roots and stones are 60-200 mm in diameter and occur at 20-50%.



Plate 3 – Red duplex profile

Table 7 provides a summary of the soil classifications used for the MAN EIS (2000) and the Bayswater No. 3 EIS (1993). GSSE have formulated soil classes that unifies these systems to form the “whole of site” MAC soil classes (refer to **Table 7**). The MAC soil classes include soil classification of units described by GSSE in the Edderton Road realignment area. **Figure 2** shows the soil distribution across the survey area in accordance with the MAC soil classification system.

Table 7 – Soil Classes

Mt Arthur North (MAN)		Bayswater No. 3		Mt Arthur Coal (MAC)	
Class No.	Description	Class No.	Description	Class No.	Description
1	Rock outcrop, skeletal soils & shallow gravelly soils	5	Skeletal soils	1	Skeletal soils
2 & 3	Course textured sandy soils, earthy sands & sandy earths	1	Sandy soils	2	Sandy soils
4 & 8	Gradational uniform loams & clay	2	Structured soils	3	Gradational / uniform loams & clays
5	Yellow duplex soils	5	Yellow duplex soils	4	Yellow duplex soils
6 & 7	Red & brown duplex soils	4 & 6	Non-calciic brown & chocolate soils	5	Red & brown duplex soils

3.4 Topdressing Suitability

Comment with respect to topdressing suitability for each soil class (as per the GSSE unified soil classification system) is provided below.

MAC Soil Class 1 – is not suitable as topdressing material due to its excessive sand and gravel content. Also this soil class is of relatively minor occurrence, being confined to associations with soil classes 3 and 4, typically along ridge crests. Occurrence of soil class 1 is also associated with rock outcrops, the presence of which would prohibit ready excavation of any topdressing material. No MAC class 1 soils are located within the mine extension areas proposed as part of the Project.

MAC Soil Class 2 – is generally not considered to be suitable as a topdressing material due to its apedal nature, generally sandy texture and poor water holding capacity. However, some of the sandy earths are suitable as a topdressing material, although the properties are somewhat marginal. Therefore, it may be best considered as an alternative source of topdressing material only if other sources are found to be insufficient. The surface soils are typically fine sandy loam texture or finer. The thickness of this topdressing material has been set at the minimum stripping thickness of 15 cm. The A horizon is typically thin, ranging from 5 to 14 cm, and the inclusion of the upper portion of the B horizon is considered acceptable as they typically comprise more clayey fines.

MAC Soil Class 3 – varies in suitability. The gravelly or stony loamy sand to sandy loam surface texture are considered to be only marginally suitable as a topdressing material. In some areas the top 15 cm is worth recovering to take advantage of the seed stock and micro-organisms in the material.

Some of the uniform and gradational clay loams are suitable as a topdressing material. The A horizons are mostly clay loams to medium clays and have suitable ped development, although some are apedal and mottled. The upper portion of the B horizons are generally suitable. This soil class may be stripped to 30 cm. This includes the A horizon and the upper portion of the B horizon.

MAC Soil Class 4 – is marginal as a topdressing material due to the shallow, sandy-textured surface soils and strongly to sporadically bleached immediate surface horizons. However the top 15 cm will be worth stripping to recover the seed stock and micro-organisms.

MAC Soil Class 5 – the red duplex soils are mostly suitable as a topdressing material by combining the thin loamy A horizons with the upper portion of the B horizons which typically comprise well-structured clays. Although the B horizons are generally whole-coloured, some show diffuse mottling, however, some of the material is considered acceptable as topdressing material. This soil class may be stripped to a depth of approximately 30 cm in some areas. The A horizons are typically 12 cm thick, with the balance being recovered from the upper B horizon.

The brown and darker coloured duplex soils are considered suitable as topdressing material. Although the A horizons occasionally have textures sandier than fine sandy loam, they are generally fairly thin and can be blended with the upper B horizons which typically comprise well-structured clays. They are sometimes diffusely mottled but are still considered suitable. This soil class may be stripped to a depth of 30 cm. This includes the A horizon and the upper portion of the B horizon.

A zone of deeper depositional soils (Classes 3 & 5) adjoins Denman Road. This area can be stripped to a depth of between 80 and 120 cm.

3.5 Topdressing Availability

Topdressing material stripping depths within the survey area are represented in **Figure 3**.

Individual volumes of available topdressing material for each recommended stripping depth are provided in **Table 8**. Some 1,220 ha of disturbed area associated with the mine extension areas and Edderton Road realignment may require rehabilitation. Allowing for a 10% handling loss, approximately 2,167,650 m³ of suitable topdressing is available within the area to be disturbed. Therefore, topdressing may be placed on the post-mining landform at a theoretical average depth of 18 cm. At other Hunter Valley mines a topdressing depth of 10 cm has been found to be adequate for healthy pasture establishment on rehabilitated spoil material. The depth of re-spread topdressing material is not critical for tree establishment.

Table 8 – Topdressing Availability

Stripping Depth (cm)	Area (ha)	Volume (m ³)*
15	63	94,500
10-30 *	1,018	2,036,000
15 -30 *	139	278,000
Total	1,220	2,408,500
Total** (Less 10% Handling Loss)	1,220	2,167,650

* Assumes average stripping depth of 20 cm

** Applies to all Mine extension disturbance areas and Edderton Road realignment.

3.6 Erosion Potential

Many of the soil types within the project area include soil horizons which exhibit a slight to high potential for dispersion and consequently are likely to be subject to sheet, rill and gully erosion if left exposed and unprotected during mining operations. If the topsoil of these soil units is disturbed or removed and the subsoils are exposed, the potential for erosion may be increased.

Disturbance occurring within the vicinity of a drainage line could impact on downstream water quality through an increase in sediment loads. These soils should, therefore, be managed to ensure that the subsoils are not exposed without suitable controls being implemented.

3.7 Potential Acid Generating Material

The potential for acid generation from regolith material (topsoil and subsoil) within the survey area is low. An assessment of acid generating potential of overburden material (consolidated bedrock below 2-3 m depth) was not undertaken as part of this report.

Acid Sulphate Soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. There has been little history of acid generation from regolith material in the Muswellbrook area (which is located approximately 130 km from the coast).

3.8 Land Capability

3.8.1 Pre - mining

The pre-mining rural land capability classification of the Mine extension areas (in accordance with DNR mapping) is shown in **Figure 4**. The percentage area of each class in the survey area is shown in **Table 9**.

Table 9 – Pre & Post-mining Rural Land Capability

Land Class	Pre-mining ha (%)	Post-mining ha (%)
Class I	3	Nil
Class II	3	9
Class III	16	16
Class IV	6	7
Class V	64	6
Class VI	8	49
Class VII	Nil	13
Total	100	100

Class V land dominates the site comprising some 64% of the survey area. Class V land is not suitable for cultivation on a regular basis due to considerable limitations of slope gradient, soil erosion, shallowness, rockiness or a combination of these factors.

Some Class I and II lands occur in small areas adjoining Denman Road and the Hunter River floodplain. These lands have very low slope gradients, are depositional soils and are suitable for a wide variety of uses. The combined Class I / Class II land component represents approximately 6% of the survey area.

Class III land appears in the southern area within the Saddlers Creek catchment. The area of Class III land represents some 16% of the total survey area. It is sloping land that is suitable for cultivation and cropping on a rotational basis.

Structural soil conservation works such as graded banks, waterways and diversion banks together with soil conservation practices such as conservation tillage and adequate crop rotation are required to protect this class of land. Some Class IV land (approximately 6% of the survey area) is situated to the east of this area. Class IV land comprises the better classes of grazing land and whilst it can sustain cultivation for an occasional crop, it is not suitable for cultivation on a regular basis owing to limitations of slope and erosion potential.

Class VI land accounts for some 8% of the survey area. This class of land comprises the less productive grazing land. Soil conservation practices include limitation of stock, prevention of fire and destruction of vermin to maintain stability.

3.8.1 Post Mining

The post mining rural land capability classification of the Mine extension areas is shown in **Figure 5**. The percentage area of each class in the survey area is shown in **Table 9**.

Class VI land will dominate the site after cessation of mining. Some 48% of the extraction area will be returned to Class VI land. Whilst there will be no Class I land in the rehabilitated landform, Class II land will increase from 3% to 9%. The class III land percentage will remain unchanged and class IV land is very similar (6% pre-mining vs 7% post mining). Approximately 13% of the area will be returned to class VIII land due to the creation of a final void area.

3.9 Agricultural Suitability

3.9.1 Pre - mining

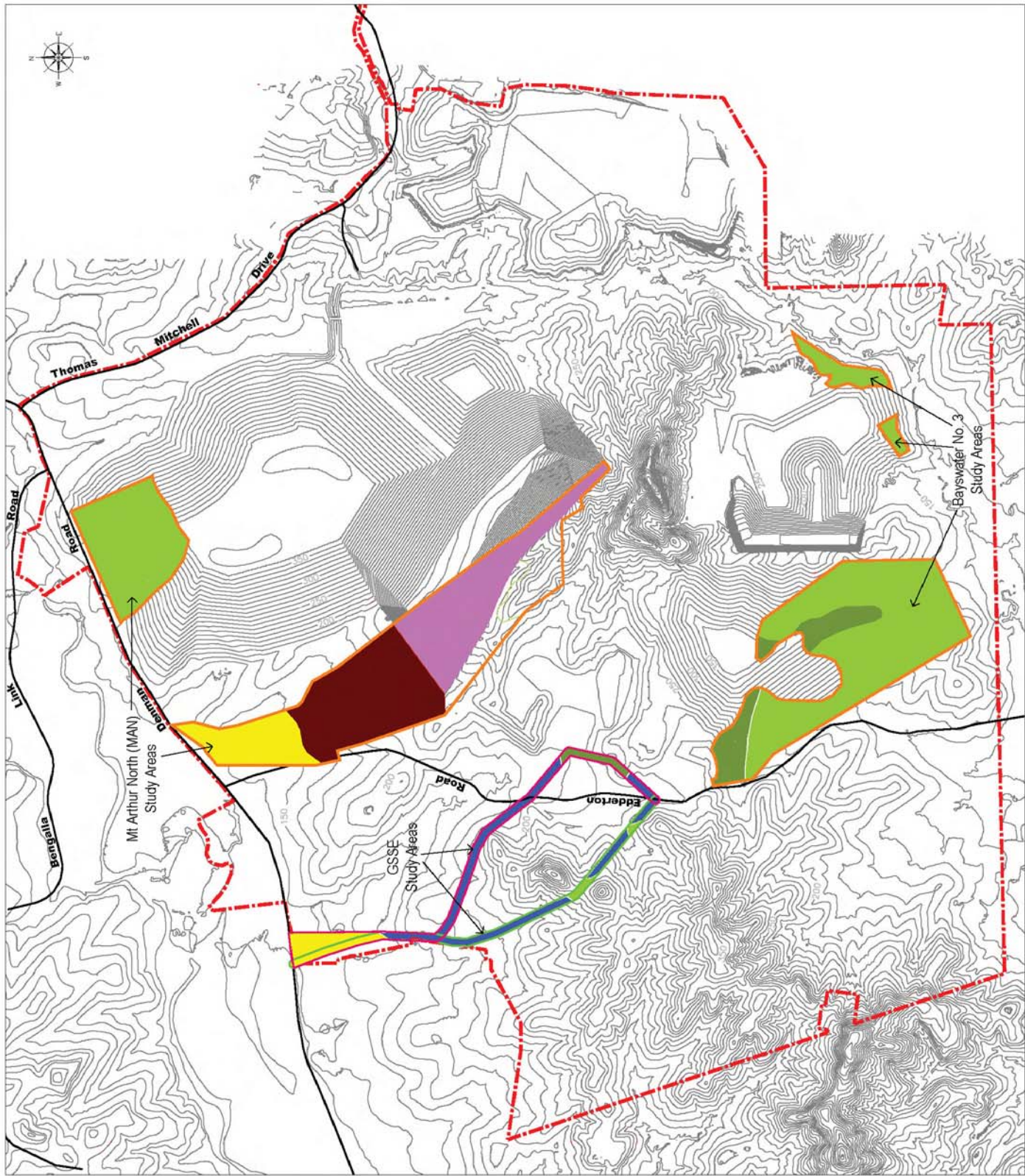
The pre-mining agricultural suitability classification of the Mine extension areas is shown in **Figure 6**. The percentage area of each class in the survey area is shown in **Table 10**.

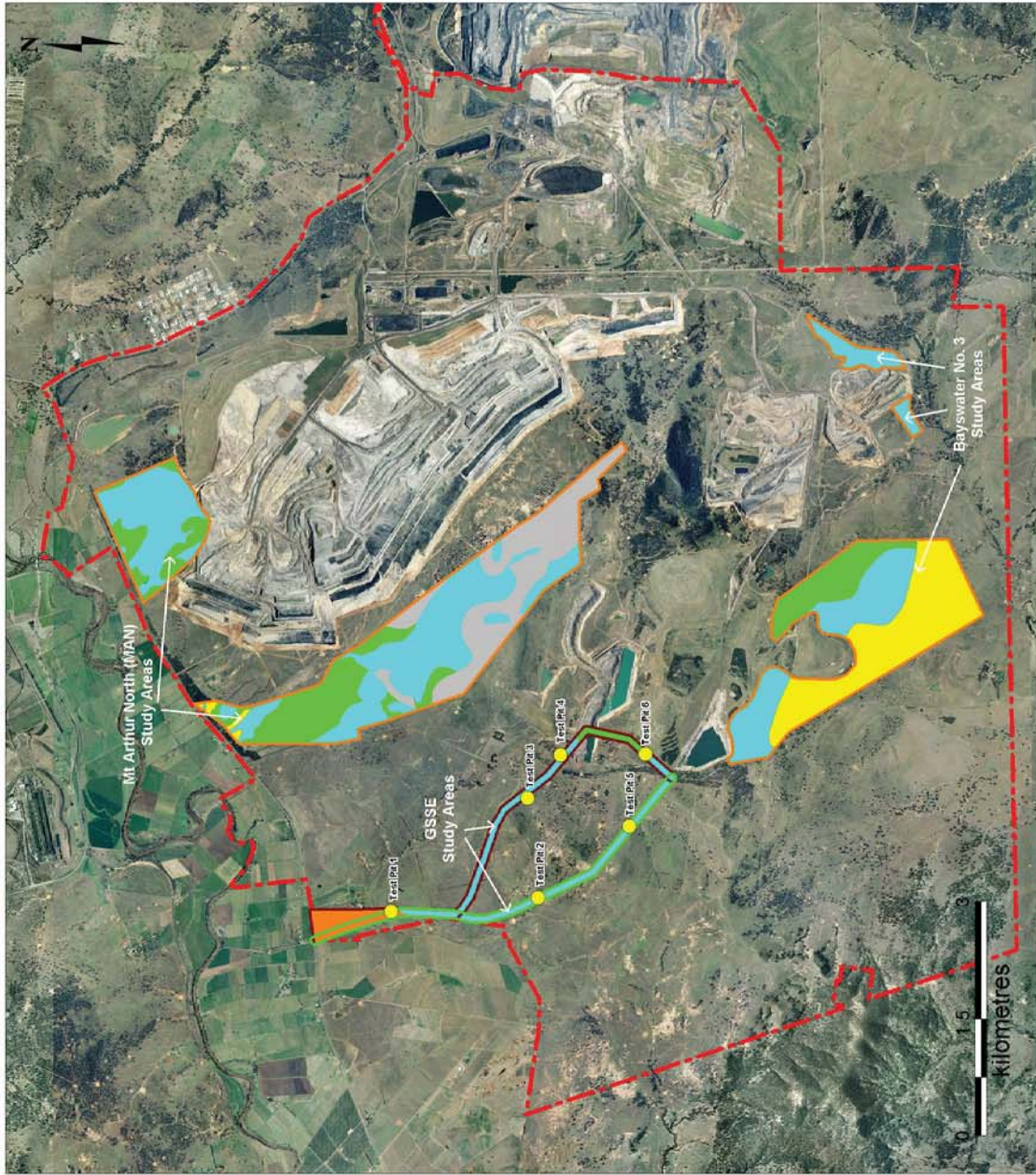
Table 10 – Pre-mining Agricultural Suitability

Land Class	Pre-mining ha (%)	Post-mining ha (%)
Class 1	2	9
Class 2	17	16
Class 3	19	7
Class 4	47	55
Class 5	15	13
Total	100	100

Class 4 land dominates the site comprising some 47% of the survey area. Class 4 land is suitable for grazing but not for cultivation. Agriculture for Class 4 land is based on native or improved pastures established using minimum tillage.

Some Class 1 and 2 lands occur in small areas adjoining Denman Road and the Hunter River floodplain. These lands have very low slope gradients, are depositional soils and are suitable for a wide variety of uses. Class 1 land represents approximately 2% of the survey area and occurs in the vicinity of the Edderton Road / Denman Road intersection. Class 2 land also appears in the southern area within the Saddlers Creek catchment.





Legend

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5

Sources:
(2 NW Areas) - Mt Arthur EIS 2000 App C
(Other Areas) - GSSE (2009)

- 2009 Soil Test Pit Locations
- Mine Extension Areas
- Edderton Road Realignment Option 1
- Edderton Road Realignment Option 2
- EA Boundary

FIGURE 6
Pre-mining Agricultural
Suitability Classification

Project: Soils & Land Capability MAC EA				
Client: Hansen Bailey				
File: HAN02-001				
Projection: GDA94 MGA Zone 56				
Version	Date	Drawn By	Checked	Approved
1	30/06/09	DJ	SS	RM



The total area of Class 2 land represents some 17% of the total survey area. The area is arable land suitable for regular cultivation for crops but not suited to continuous cultivation.

Class 3 land, i.e. grazing land or land well suited to pasture improvement occurs throughout the site and occupies approximately 19% of the survey area. Class 5 land occurs in the central area of the site where slope gradients are high. Approximately 15% of the survey area is covered by this class of land which is unsuitable for agriculture or at most, suited to light grazing.

3.9.2 Post Mining

The post mining agricultural suitability classification of the Mine extension area is shown in **Figure 7**. The percentage area of each class in the survey area is shown in **Table 10**.

Class 4 land will dominate the site after cessation of mining. Some 55% of the extraction area will be returned to Class 4 land. This represents a similar pre-mining percentage of Class 4 land. Class 1 land will increase from 2% (pre-mining) to 9% (post mining). Whilst the Class 2 land percentage remains similar to pre-mining, Class 3 land is reduced from a pre-mining percentage of 19% to 7% after mining. The area of Class 5 land remains the same.

LEGEND

- Mina Extension Areas
- Edderton Road Realignment Option 1
- Edderton Road Realignment Option 2
- EA Boundary

AGRICULTURAL SUITABILITY CLASS:

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5

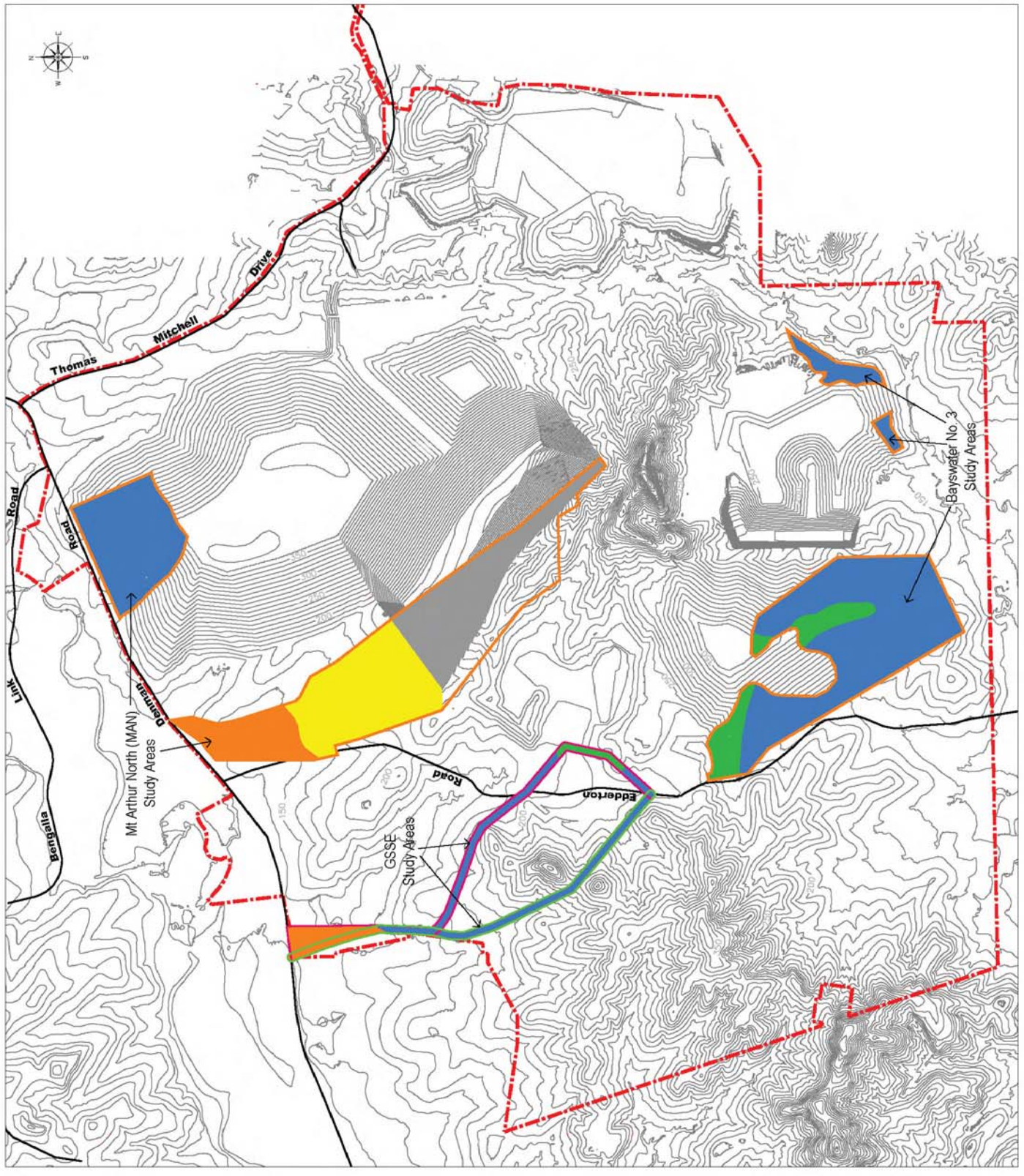
Note: Areas outside specific Land Classes will remain undisturbed



FIGURE 7

Post Mining Agricultural Suitability

Project	Soils & Land Capability MAC EA									
Client	Hansen Bailey									
File	Fg7_HAN02-001_Ag Suit_090814									
Projection	MGA Zone 56									
Version:	1	Date	30/6/09	Author:	LF	Checked	RM	Approved	RM	
	2		14/8/09		LF		SS		SS	



4.0 DISTURBANCE MANAGEMENT

In order to reduce the potential for degradation within the survey area and adjoining lands, the following management and mitigation strategies are recommended for implementation during mining.

4.1 Topsoil Stripping and Handling

Where topsoil stripping and transportation is required, the following topsoil handling techniques are recommended to prevent excessive soil deterioration.

- Strip material to the depths stated in **Section 3.3**, 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 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 dump 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 an as coarsely textured 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 sandier 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 provides 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 nominal depth of <10 cm.

4.2 Topsoil Re-spreading

Where possible, suitable topsoil should be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil should be spread to a nominal depth of 10 cm on all re-graded spoil. Topsoil should be spread, treated with fertilizer or ameliorants (if required – refer **Section 3.2**) and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion.

4.3 Landform Design, Erosion Control and Seeding

Rehabilitation strategies and concepts proposed below have been formulated according to results of industry-wide research and experience.

4.3.1 *Post Disturbance Regrading*

The main objective of regrading 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.

4.3.2 *Erosion & Sediment Control*

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 will cause erosion. As the slope angle increases, the banks or furrows must 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 down slope.

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 mine site and, through the provision of semi-permanent water storages, enhance the ecological diversity of the area.

The following points should be considered when selecting sites for sediment control dams.

- Each dam should be located so that runoff may be easily directed to it, without the need for extensive channel excavation or for excessive channel gradient. Channels must be able to discharge into the dam without risk of erosion. Similarly, spillways must be designed and located so as to safely convey the maximum anticipated discharge.
- The material from which the dam is constructed must be stable. Dispersible clays will require treatment with lime, gypsum and/or bentonite to prevent failure of the wall by tunnel erosion. Failure by tunnelling is most likely in dams which store a considerable depth of water above ground level, or whose water level fluctuates widely. Dams should always be well sealed, as leakage may lead to instability, as well as allowing less control over the storage and release of water.
- The number and capacity of dams should be related to the total area of catchment and the anticipated volume of runoff. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

4.3.3 Seedbed Preparation

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 will 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.

5.0 REFERENCES

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FIELD ASSESSMENT PROCEDURE



APPENDIX 1

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.

SOIL INFORMATION



APPENDIX 2

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° (dS/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) **Australian 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.

SOIL TEST RESULTS



APPENDIX 3



Department of Lands

Land Administration & Management
Property & Spatial Information

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

Page 1 of 2

REPORT NO: SCO09/083R1

REPORT TO: Klay Marchant
GSS Environmental
PO Box 907
Hamilton NSW 2303

REPORT ON: Twelve soil samples
Ref: HAN2-001

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 26 March 2009

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

G Holman
(Technical Officer)

SOIL AND WATER TESTING LABORATORY

Scone Research Service Centre

Page 2 of 2

Report No: SCO09/083R1
 Client Reference: Klay Marchant
 GSS Environmental
 PO Box 907
 Hamilton NSW 2303

Lab No	Method Sample Id	P7B/1 Particle Size Analysis (%)					P9B/2 EAT	C1A/4 EC (dS/m)	C2A/3 pH	Colour	
		clay	silt	f sand	c sand	gravel				Dry	Moist
1	1/1 0-15cm	12	14	44	18	12	3(1)	0.03	5.4	7.5YR4/6	7.5YR3/3
2	1/2 15-100cm	71	7	9	7	6	2(1)	0.08	7.9	7.5YR5/6	7.5YR4/6
3	2/1 0-10cm	18	17	55	9	1	3(1)	0.02	6.3	7.5YR5/4	7.5YR3/4
4	2/2 10-50cm	56	16	25	3	<1	3(1)	0.09	8.4	5YR6/6	5YR5/8
5	3/1 0-13cm	28	25	39	7	1	3(3)	0.02	6.7	7.5YR5/4	7.5YR3/4
6	3/2 13-63cm	36	23	32	8	1	4	0.10	8.4	7.5YR5/6	7.5YR4/4
7	4/1 0-15cm	25	10	40	17	8	3(2)	0.02	6.5	7.5YR4/6	7.5YR3/3
8	4/2 15-75cm	41	8	35	16	<1	2(2)	0.63	9.2	7.5YR6/6	7.5YR5/6
9	5/1 0-12cm	30	25	38	7	0	3(2)	0.07	6.3	10YR5/4	10YR3/3
10	5/2 12-62cm	42	16	35	7	<1	5	0.03	7.6	10YR4/4	10YR3/3
11	6/1 0-10cm	56	5	28	11	<1	2(1)	0.09	8.3	10YR6/4	10YR4/6
12	6/2 10-50cm	66	14	15	5	0	4	1.03	9.0	10YR7/4	10YR5/6

END OF TEST REPORT