APPENDIX

P

Soil and Land Capability Impact Assessment

FINAL

Maules Creek Coal Project

Soil and Land Capability Assessment

November 2010

HAN17-001

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

TABLE OF CONTENTS

TABLES

FIGURES

PLATES

APPENDICES

1.0 INTRODUCTION

GSS Environmental was commissioned by Hansen Bailey on behalf of Aston Resources Limited (Aston Resources) to undertake a Soil and Land Capability impact assessment for the Maules Creek Coal Project (the Project). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support an application for a contemporary Project Approval under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act) to facilitate the development of a 21 year open cut coal mining operation and associated infrastructure.

1.1 BACKGROUND

The Project is located approximately 18 km to the north-east of the township of Boggabri in the north-west region of NSW within the Narrabri Local Government Area **(Figure 1)**.

The Project is owned by Aston Coal 2 Pty Limited (Aston), a wholly owned subsidiary of Aston Resources. It is considered to be one of only a few remaining Tier 1 undeveloped semi soft coking and thermal coal assets in NSW. Located in the Gunnedah Coal Basin, it is a large delineated coal project with Joint Ore Reserves Committee (JORC) Coal Reserves of 610 Million tonnes (Mt) of semi-soft coking and thermal coal, capable of supporting a large open cut operation for more than 21 years.

Mining tenements across the Project were originally granted in the 1970s. Following this, extensive exploration activities were undertaken with the ultimate aim of defining the local geology and developing a viable open cut mine plan. To this end, the document entitled Maules Creek Coal Project Environmental Impact Statement (Maules Creek EIS) (KCC 1989) was prepared and submitted to the Narrabri Shire Council (NSC) in October 1989.

Development Consent approval (DA 85/1819) was granted on 12 June 1990 for the Maules Creek Coal Mine pursuant to the Maules Creek EIS. DA 85/1819 was physically commenced in 1995 with the construction of the Development Dam; however, no open cut mining has been undertaken at the site to date. DA 85/1819 has no sunset clause and remains valid.

1.2 PROJECT DESCRIPTION

Aston is seeking a contemporary Project Approval under Part 3A of the EP&A Act to facilitate the development of surface infrastructure and open cut mining activities for the Project generally within its current mining tenements for a period of 21 years. Specifically the Project will consist of:

- The construction and operation of an open cut mining operation extracting up to 13 Million tonnes per annum (Mtpa) Run of Mine (ROM) coal (predominantly metallurgical) to the Templemore Seam;
- Open cut mining fleet including excavator / shovels and fleet of haul trucks, dozers, graders and water carts utilising up to 470 permanent employees;
- The construction and operation of a Coal Handling and Preparation Plant (CHPP) with a throughput capacity of 13 Mtpa ROM coal;
- The construction and operation of a Tailings Drying Area;
- The construction and operation of a rail spur, rail loop, associated load out facility and connection to the Werris Creek to Mungindi Railway Line;
- The construction and operation of a Mine Access Road;
- The construction and operation of administration, workshop and related facilities;
- The construction and operation of water management infrastructure including a water pipeline, pumping station and associated infrastructure for access to water from the Namoi River;

- The installation of supporting power and communications infrastructure; and
- The construction and operation of explosives magazines and explosives storage areas.

The Project is shown on **Figure 2**.

1.3 ASSESSMENT OBJECTIVES

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

Objective 1-1 Classify and determine the soil profile types within the Project Boundary.

Objective 1-2 Determine alluvial soil boundaries along Back Creek, describe their extent, location and agricultural land suitability and land capability classifications.

Objective 2-1 Provide a description of, and figures showing, the pre and post land capability within the Project Boundary.

Objective 2-2 Provide a description of, and figures showing, the pre and post agricultural land suitability within the Project Boundary.

Objective 3-1 Provide selective topsoil and subsoil management recommendations.

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

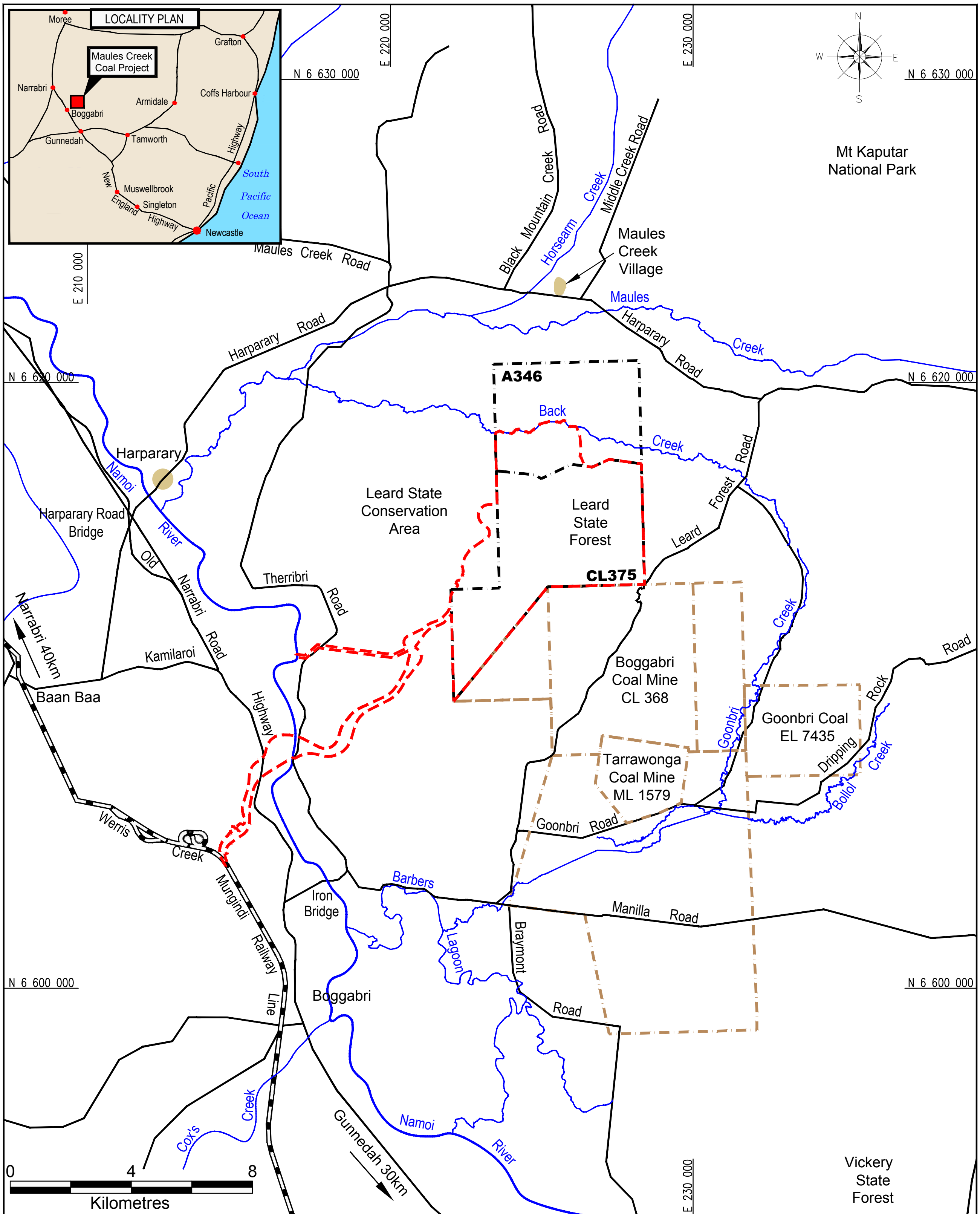
1.3.1 Standards

To satisfy Objectives 1-1 and 1-2 of the soil and land capability assessment, the soil taxonomic classification system used was the Australian Soil Classification (ASC) system. This system is routinely used as the soil classification system in Australia.

To satisfy Objectives 2-1 of the soil and land capability assessment, the relevant guideline applied was *Systems Used to Classify Rural Lands in New South Wales* (Cunningham et al., 1988). This is the guideline approved by Department of Environment, Climate Change & Water (DECCW) (formerly approved by the NSW Soil Conservation Service).

To satisfy Objective 2-2 of the soil and land capability assessment, the relevant guideline applied was the *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries, 1988). This is the guideline approved by Industry and Investment NSW (I&I NSW) (formerly the NSW Agricultural & Fisheries).

To satisfy Objective 3-1 of the soil and land capability assessment, the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot and Veness, 1981) was utilised to determine which soils throughout the site are suitable for conserving and utilising in the mine site rehabilitation program. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.



LEGEND

- Project Boundary
- Maules Creek Mining Tenements
- Other Mining Tenements
- Roads
- Railway
- Watercourses
- National Park
- State Forest
- Urban Areas

Source: Boggabri Coal 2009/2010, LPI 2009/2010, Aston 2010

Version	Date:	Author:	Checked:	Approved:
1	02/11/10	LH	KM	CR
2	11/11/10	LH	KM	CR
3	19/11/10	LH	KM	CR

FIGURE 1

Regional Locality

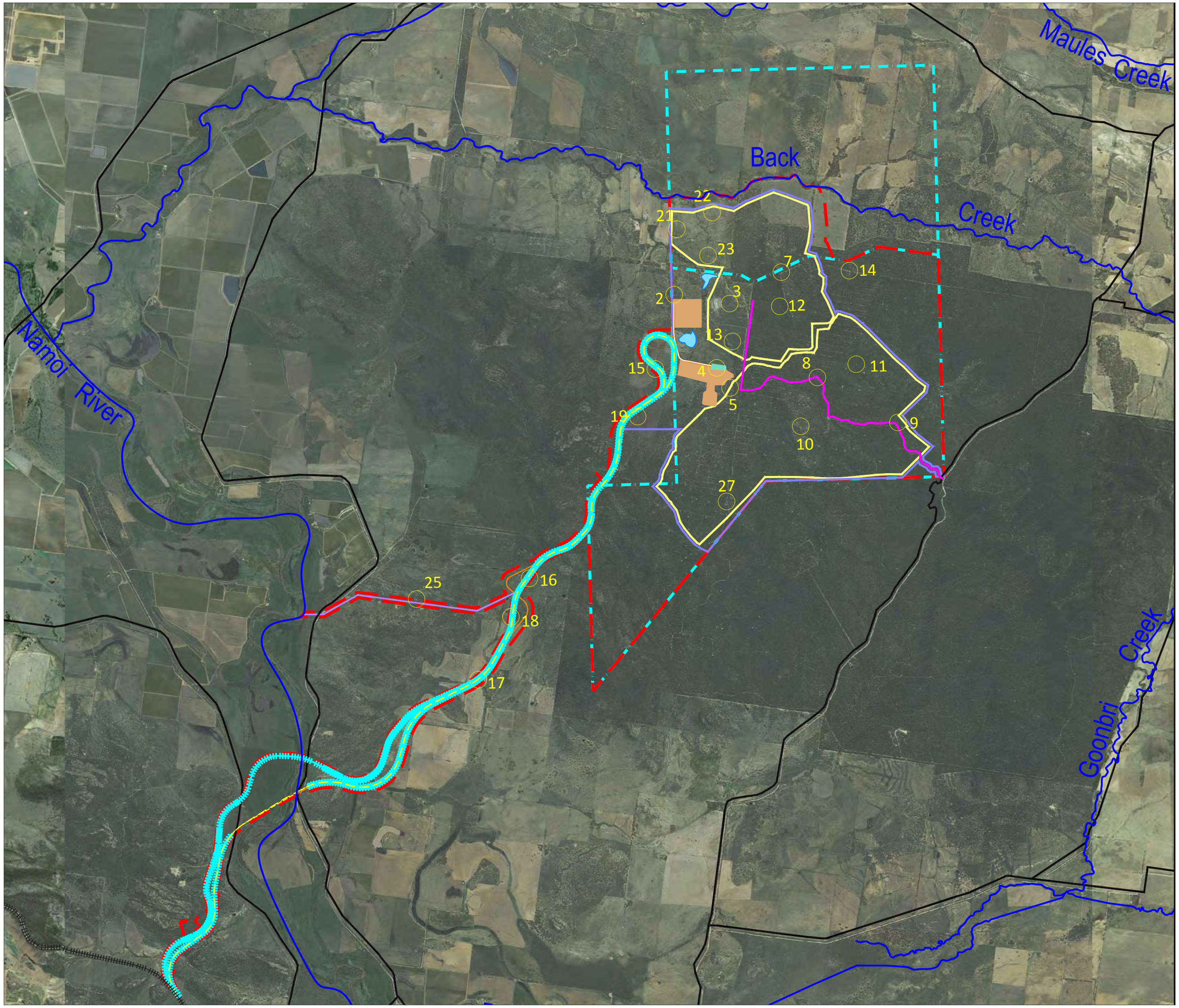
GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Maules Creek Soil & Land Capability Assessment (2010)

Client: Hansen Bailey

File: Fg1_HAN17-001_Locality_101119

Projection: MGA94 Zone 56



LEGEND

- Lease Boundary
- Project Boundary
- Mine Disturbance Boundary
- 21 Year Mining Limit
- Soil Test Pit Location
- Roads
- Mine Access Road
- Indicative Haul Routes
- Temporary Access Road
- Pipeline
- Alternate Rail Alignment
- Existing Rail Line
- Indicative Rail Spur & Loop
- Proposed Infrastructure Area
- Tailings Drying Area
- Water Storage
- Watercourses

N W E S

0 0.5 1.0 1.5 2.0km

FIGURE 2

The Project and
Soil Test Pit Locations

Project: Maules Creek Soil & Land Capability Assessment (2010)

Client: Hansen Bailey

File: Fg2_HAN17-001_TestPits_101116.dwg

Projection: MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	5/07/2010	TC	CR	CR
2	12/10/2010	LH	CR	CR
3	03/11/2010	LH	CR	CR
4	16/11/2010	LH	CR	CR

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

2.0 EXISTING ENVIRONMENT

2.1 GEOLOGY

The Project Boundary is located within a major regional geological feature known as the Gunnedah Basin. The Gunnedah Basin is one of the main coal basins within NSW. The target coal resources for the Project occur within the early Permian Maules Creek Formation. The basement of the Maules Creek Formation is formed by the Boggabri Volcanics. The rhyolitic volcanics are overlain by the Leard Formation, a thin unit comprised by black claystone and thin coal seams. The Maules Creek Formation is up to 800 m thick within the Project Boundary and sits conformably on the Leard Formation (Sides, 2009).

All seam groups situated stratigraphically below the Braymont Seam lap onto the basement volcanics. The depth of weathering across the modelled area varies from 6 m to 113 m with the average depth being 25m. No significant faults have been identified.

2.2 LAND USE

The Project Boundary is predominately located within the Leard State Forest. The Leard State Forest is situated within an 8134 ha remnant patch of native vegetation. The bulk of the land within the Project Boundary has been affected by disturbances commonly associated with forestry operations. These disturbances include vegetation clearing, weed invasion, altered natural drainage and edge effects.

The active open cut mining operations of Boggabri Coal Mine and Tarrawonga Coal Mine are located to the south-east of the Project Boundary. Recent planning approval applications have been made for both Boggabri Coal Mine and Tarrawonga Coal Mine to facilitate ongoing operations, additional production rates and other mining flexibilities.

The land surrounding the Project Boundary is largely an agricultural landscape, comprising primarily grazing and cropping activities dominating the area to the north, south, east and west of the Leard State Forest. The regional climate allows summer and winter crops to be cultivated in the lower lying areas of the Namoi River floodplain. Many local properties also have the advantage of surface and underground water access for irrigation and hence many crops have been successfully cultivated including wheat, sorghum, oil seeds and livestock fodder.

2.3 TOPOGRAPHY

The southern to central portion of the Project Boundary generally consists of a series of ridges and narrow gullies above RL 350 m with slopes ranging up to 30%. The northern portion of the Project Boundary is generally more undulating with slopes ranging from 0 to 15%. In this area there are a series of lower hills and ridges that separate Back Creek from Maules Creek. Small areas of flat land exist in the northern portion of the Project Boundary near Back Creek.

2.4 HYDROLOGY

Within the Project Boundary, natural surface water flows along several unnamed drainage lines from the steeper slopes towards Back Creek which is located in the north of the Project Boundary. Back Creek flows through paddocks and farmland which have been largely modified by previous agricultural activities. The Willow Tree Range is located in the southern portion of the Project Boundary and directs surface water through natural drainage lines within the Leard State Forest toward the north which eventually flow into Back Creek. Back Creek flows to the west and is a tributary to Maules Creek which eventually flows into the Namoi River to the west of the Project Boundary. To the south-west of the Project Boundary surface water flows through several unnamed drainage lines and onto the Namoi River floodplain before making its way to the Namoi River.

2.5 VEGETATION

Heavy vegetation of forest and woodland communities exist within the Project Boundary. Areas of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, which is listed as a Critically Endangered Ecological Community (CEEC) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Endangered Ecological Community under the *Threatened Species Conservation Act 1997* (TSC Act) exist throughout the area within the Project Boundary. Areas to the north west and south of the Project Boundary have been highly modified through clearing and farming activities and are predominately pasture.

3.0 SOIL ASSESSMENT

A soil survey was undertaken in July and August 2010 by GSSE to:

1. Classify and determine the soil profile types of within the Project Boundary;
2. Assess the suitability of the current topsoil material for future rehabilitation; and
3. Identify any potentially unfavourable soil material for rehabilitation within the Project Boundary

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

3.1 SOIL SURVEY METHODOLOGY

A field survey and a desktop study were undertaken for the Project area.

3.1.1 Reference Map

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

- **Aerial photographs and topographic maps**;

  Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils within the Project Boundary;

- **Reference information**;

  Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included:

  - Cadastral data, prior and current physiographic, geological, vegetation, and water resources studies;

- **Previous reports**;

  The following previous reports were reviewed as part of the desktop assessment:

  - Gunnedah Coalfield (North) Regional Geology 1:100:000. First Edition Geological Survey of New South Wales; and
  - Namoi Catchment Management Authority (2009). Land Management Units in the Namoi Catchment – Map & Legend.

- **Stratified observations**;

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

3.1.2 Soil Profiling

Twenty two soil profiles were assessed at selected sites to enable soil profile descriptions to be made. Subsurface exposure was generally undertaken by backhoe excavation of 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.

Soil profiles were also observed through the use of surface exposures located in existing erosion gullies, creek banks, roadway cuttings, dams and disused quarries. Soil test pit locations and soil types are shown in **Figures 2** and **3.**

3.1.3 Soil Field Assessment

Soil profiles within the Project Boundary were assessed in accordance with the Australian Soil and Land Survey Field Handbook - Third Edition (NCST, 2009) soil classification procedures. Detailed soil profile descriptions recorded information that covered the parameters as specified in **Table 1**. Soil profile logging was undertaken in the field using soil data sheets.

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

Table 1 – Field Assessment Parameters

Descriptor	Application
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

Soil layers from each test pit 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, consistency, mottling and root presence. A more detailed explanation of the Elliot and Veness procedure is presented in **Appendix 1** of this report.

3.1.4 Soil Laboratory Testing

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas.

Soil samples of about 1 – 2 kg were collected from each soil layer. In total, 58 soil samples were sent to the Department of Lands Scone Research Centre (Scone Research Centre) for analysis. Certificate of analysis for these results are contained in **Appendix 3**. The selected physical and chemical laboratory analysis parameters and their relevant application are listed in **Table 2**.

Table 2 – 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
Cation exchange capacity (CEC) and exchangeable cations	Nutrient status; calculation of exchangeable sodium percentage (ESP); assessment of other physical and chemical properties, especially dispersivity, shrink – swell, water movement, aeration

The laboratory methods used by the Scone Research Centre for each physical and chemical parameter are provided in **Table 3**.

Table 3 – Laboratory Test Methods

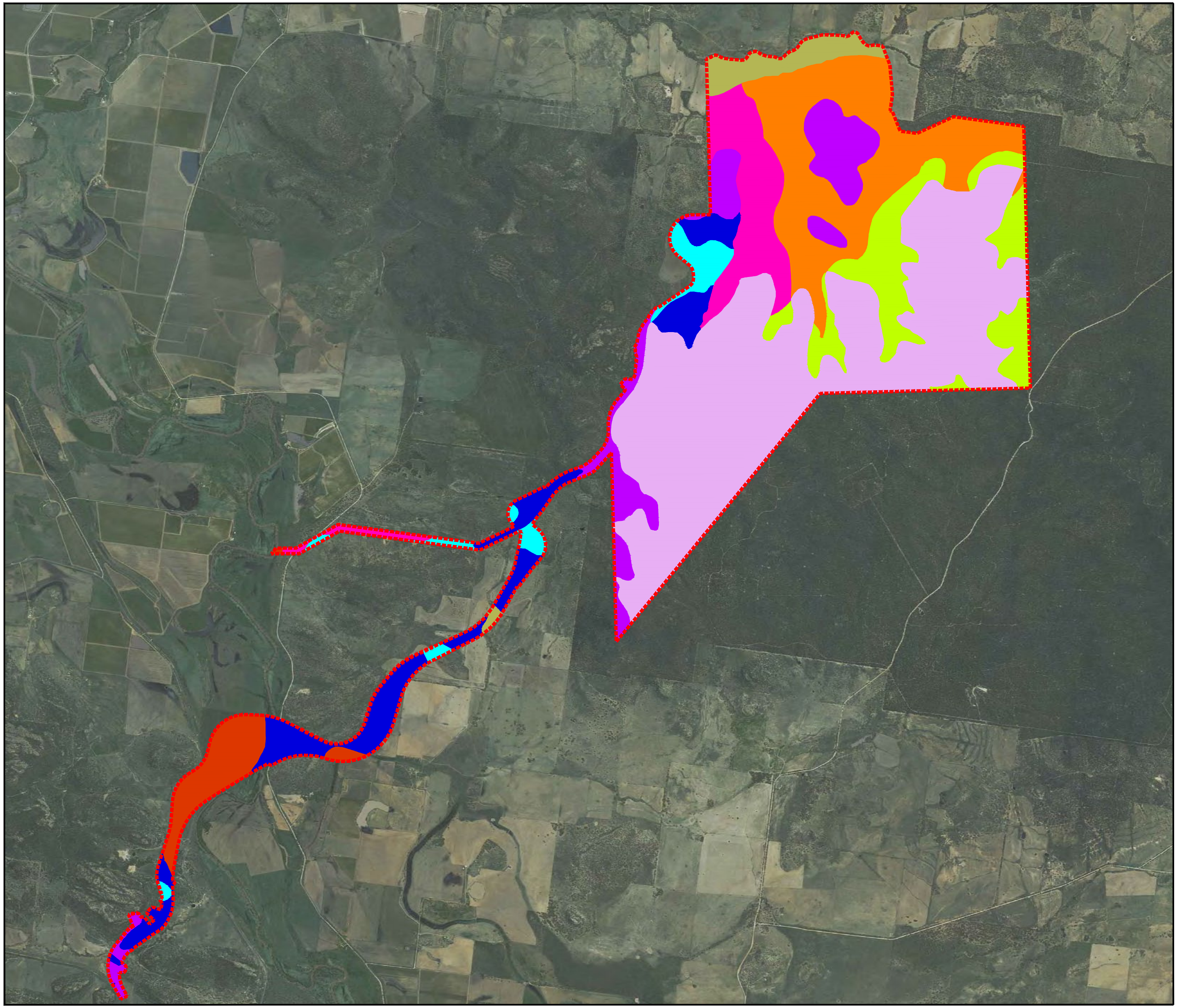
Analyte	Method
Particle Size Analysis (PSA)	Sieve & hydrometer
pH	1:5 soil/water extract
Electrical conductivity	1:5 soil/water extract
Emerson Rating	Emerson Aggregate Test
CEC & exchangeable cations	(AgTU)+ extraction

3.2 SOIL SURVEY RESULTS

Table 4 provides an overview of each soil type and their quantitative distribution within Project Boundary. **Figure 3** illustrates their spatial distribution. All soil test results are provided in **Appendix 3**.

Table 4 – Soil Types

Soil Type	ASC Name	Project Soil Name	Area (%)	Area (ha)
1	Leached Brown Lithic Tenosol	Shallow Gravelly Brown Sandy Loams	42	1,489
2	Leached Yellow Kandosol	Gravelly Fine Brown Sandy Loams	9	321
3a	Red Chromosols	Gravelly Red Duplex Sandy Clay Loams over Rhyolite	8	292
3b	Brown & Grey Vertosols	Self-mulching Brown & Grey Clays over Andesite	3	94
4a	Red & Brown Lithic Tenosols	Shallow Bleached Reddish Brown Sandy Loams	16	565
4b	Brown & Grey Chromosols	Brown & Grey Duplex Sandy Loams	7	260
4c	Black & Grey Vertosols	Self-mulching Black Clays over Andesite	8	289
5	Sodic Brown Sodosols & Dermosols	Sodic Duplex and Gradational Brown Loams	3	103
6	Self-mulching Brown Vertosols	Brown Clays and Red Brown Earths	4	137
			100	**3,550**



LEGEND

- Project Boundary
- Soil Type - 1(1489 ha)
- Soil Type - 2 (321 ha)
- Soil Type - 3a (292 ha)
- Soil Type - 3b (94 ha)
- Soil Type - 4a (565 ha)
- Soil Type - 4b (260 ha)
- Soil Type - 4c (289 ha)
- Soil Type - 5 (103 ha)
- Soil Type - 6 (137 ha)

Total Area - (3550 ha)

N
W
E
S

0 0.5 1.0 1.5 2.0km

FIGURE 3

Soil Types within
The Project Boundary

Project:
Maules Creek Soil & Land Capability Assessment (2010)

Client:
Hansen Bailey

File:
Fg3_HAN17-001_SoilTypes_101116

Projection:
MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	14/10/10	LH	KM	JL
2	03/11/10	LH	KM	JL
3	16/11/10	LH	KM	JL

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

V:\HAN17-001\Figures\Drafts\Fg3_HAN17-001_SoilTypes_101116.dwg

Soil Type 1: Shallow Gravelly Brown Sandy Loams (Leached Brown Lithic Tenosol)

Description: These shallow soils generally consist of very dark greyish brown to brown gravelly sandy loams with a gradual change to bleached pink gravelly sandy loams. They are moderately poorly drained soils which range from slightly acidic to neutral in the upper layer becoming strongly acidic to neutral at depth. The soils are non-saline with poor to moderate fertility characteristics. They are non-sodic throughout the profile.

Location: These soils cover approximately 42% or 1489 ha of the area within the Project Boundary and are found on the waxing upper and mid slopes within the Leard State Forest. This soil type was found at profile sites 9,10,11,20 and 27.

Landuse: The land overlying these soils is currently designated state forest, and has been selectively logged for many years. Many tracks transect the vegetation which consists of young to mature trees.

Management: The soil is unsuitable for stripping and reuse as topdressing in rehabilitation due to high stone content. The subsoil is not recommended for rehabilitation due to the limiting factors of high stone content and moderate acidity at depth. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the low fertility and lack of organic matter in the subsoil, if the topsoil is removed, this may lead to dispersion and erosion in wet conditions.

Table 5 – Shallow Gravelly Brown Sandy Loam Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.25	Very dark greyish brown (10YR3/2), weak consistence gravelly sandy loam. Weak pedality (granular 2-5 mm) soil with neutral acidity (pH 6.5), slight dispersion (EAT 3(1), non-saline (0.02dS/m), roots few to common and 48% gravel (>2mm). Approximate sample depth 0.25 m. Gradual even boundary to Layer 2.
2	0.25-60	Bleached pink (7.5YR7/3 dry) weak consistence gravelly sandy loam. Weak pedality (granular <2 mm) soil acidic to neutral (pH 5.7), slight dispersion (EAT 3(1) non saline (0.02dS/m), roots few and 41% gravel (>2 mm). Approximate sample depth 0.25-60 m.

Plate 1 – Shallow Gravelly Brown Sandy Loam Profile

Plate 2 – Shallow Gravelly Brown Sandy Loam Landscape

Soil Type 2: Gravelly Fine Brown Sandy Loams (Leached Yellow Kandosol)

Description: These deeper soils generally consist of very dark brown to brown gravelly sandy loams with a gradual change to very pale brown or pink gravelly light sandy clay loams. These poorly drained soils range from strongly acidic to neutral in the upper layers to neutral at depth. The soils are non-saline with poor to moderate fertility characteristics. They are non-sodic throughout the profile.

Location: These soils cover 9% or 321 ha of the area within the Project Boundary and are found on the waning mid and lower slopes within the Leard State Forest. This soil type was found at profile site 8.

Landuse: The land overlying these soils is currently designated state forest, and has been selectively logged for many years. Many tracks transect the vegetation which consists of young to mature trees.

Management: The soil is marginally suitable for stripping and reuse as topdressing in rehabilitation due to high stone content. The subsoil is not recommended for reuse in rehabilitation due to the limiting factors of stone content and dispersiveness at depth. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the low fertility and lack of organic matter in the subsoil, if the topsoil is removed, it may lead to dispersion and erosion during wet conditions.

Table 6 – Gravelly Fine Brown Sandy Loam Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.25	Brown (7.5YR4/2), weak consistence gravelly sandy loam. Weak pedality (granular 2-5 mm) soil with strongly acid to neutral pH (pH 5.3-6.4), slight dispersion (EAT 3(1), non-saline (0.02dS/m), roots few to common and 40% gravel (>2mm). Approximate sample depth 0.25 m. Gradual even boundary to Layer 2.
2	0.25-55	White (7.5YR8/1 dry) weak consistence gravelly light sandy loam. Weak pedality (granular <2 mm) soil neutral (pH 6.9), high to moderate dispersion (EAT 2(1), non-saline (>0.01dS/m), roots few and 29% gravel (>2 mm). Approximate sample depth 0.25-60 m. Gradual wavy to Layer 3
3	55-100	Pinkish white (7.5YR8/2 dry) weak consistence gravelly light sandy clay loam. Weak pedality (granular <2 mm) soil neutral (pH 6.8), high to moderate dispersion (EAT 2(1), non-saline (0.02dS/m), no roots and 19% gravel (>2 mm).

Plate 3 – Gravelly Fine Brown Sandy Loam Profile

Plate 4 – Gravelly Fine Brown Sandy Loam Landscape

Soil Type 3a: Gravelly Red Duplex Sandy Clay Loams over Rhyolite (Red Chromosols)

Description: These soils generally consist of dark brown to brown gravelly sandy loams with a clear change to gravelly red clays. These moderately well drained soils are alkaline throughout the profile. The soils are non-saline with moderate fertility characteristics. They are non-sodic throughout the profile.

Location: These soils cover approximately 8% or 292 ha of the area within the Project Boundary and are found on the waning mid and lower slopes formed on rhyolite. This soil type was found at profile sites 2, 7, and 12.

Landuse: The land overlying these soils is currently designated state forest, and has been selectively logged for many years. Many tracks transect the vegetation which consists of young to mature trees.

Management: The soil is marginally suitable for stripping and reuse as topdressing in rehabilitation due to high stone content. The subsoil is not recommended for reuse in rehabilitation due to the higher clay content and alkalinity at depth. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the high clay content and lack of organic matter in the subsoil, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 7 – Gravelly Red Duplex Sandy Clay Loam Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Very dark brown (7.5YR 2.5/3), moderate consistence gravelly sandy clay loam. Weak pedality (granular 2-5 mm) soil with alkaline (pH 8.3), nil dispersion (EAT 4), non-saline (0.13dS/m), roots common and 30% gravel (>2mm). Approximate sample depth 0.20m. Clear even boundary to Layer 2.
2	0.20-60	Red (5YR4/6, moist) strong consistence, heavy clay. Strong pedality (granular <2 mm) soil strongly alkaline (pH 8.7), nil dispersion (EAT 4), non-saline (0.11dS/m), roots few and 38% gravel (>2 mm). Approximate sample depth 0.25-60 m.

Plate 5 – Gravelly Red Duplex Sandy Clay Loam Profile

Plate 6 – Gravelly Red Duplex Sandy Clay Loam Landscape

Soil Type 3b: Self-mulching Brown & Grey Clays over Andesite (Brown & Grey Vertosols)

Description: These cracking clays generally consist of very dark brown to dark greyish brown medium to heavy clays with a gradual even change to dark brown or grey clays. These moderately well drained soils are alkaline and become very alkaline at depth. The soils also become saline and slightly sodic at depth.

Location: These soils cover 3% or 94 ha of the area within the Project Boundary and are found on the waning mid and lower slopes formed on andesite. This soil type was found at profile sites 15 and 18.

Landuse: The land is currently cropped.

Management: The top 0.30 m of this soil is suitable for stripping and reused as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to the sodicity, alkalinity and salinity at depth. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the high clay content and lack of organic matter in the subsoil, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 8 – Self Mulching Brown & Grey Clays over Andesite Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.30	Very dark brown (7.5YR 2.5/3) strong consistence, heavy clay. Strong pedality (granular 2-5 mm) soil with alkaline (pH 8.3), nil dispersion (EAT 4), non-saline (0.12dS/m), roots common Approximate sample depth 0.30m. Gradual even boundary to Layer 2.
2	0.30-60	Very dark brown to (7.5YR 2.5/3) moist strong consistence heavy clay. Strong pedality (angular blocky 5-20 mm) soil strongly alkaline (pH 8.7), nil dispersion (EAT 4), non-saline (0.13dS/m), roots abundant Approximate sample depth 0.30-60 m. Gradual even boundary to Layer 3.
3	60-120	Dark brown to (7.5YR 3/3) moist strong consistence heavy clay. Strong pedality (prismatic 50-150 mm) soil alkaline (pH 8.4), nil dispersion (EAT 4), slightly saline (0.167dS/m), and sodic (ESP 5.3, roots few and 38% gravel (>2 mm). Approximate sample depth 0.60- 1.20 m.

Plate 7 – Self Mulching Brown & Grey Clays over Andesite Profile

Plate 8 – Self Mulching Brown & Grey Clays over Andesite Landscape

Soil Type 4a: Shallow Bleached Reddish Brown Sandy Loams (Red & Brown Lithic Tenosols)

Description: These shallow soils generally consist of dark brown sandy loams with a gradual change to bleached light reddish brown or pink sandy loams which may be gravelly. These moderately poorly drained soils are slightly acidic to neutral throughout the profile. The soils are non-saline with poor to moderate fertility characteristics. They are non-sodic throughout the profile.

Location: These soils cover 16% or 565 ha of the area within the Project Boundary and are found on the waxing upper and mid slopes within the Leard State Forest. This soil type was found at profile sites 6, 13 and 14.

Landuse: The land overlying these soils is currently designated state forest, and has been selectively logged for many years. Many tracks transect the vegetation which consists of young to mature trees.

Management: The top 0.30 m of this soil is suitable for stripping and reused as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to the limiting factors of poor fertility at depth. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the low fertility and lack of organic matter in the subsoil, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 9 – Shallow Bleached Reddish Brown Sandy Loams Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.30	Dark brown (7.5YR3/3), weak consistence sandy loam. Weak pedality (granular 5-10 mm) soil with neutral acidity (pH 6.8), slight to nil dispersion (EAT 3(1), non-saline (0.02dS/m), roots few to common. Approximate sample depth 0.25 m. Gradual even boundary to Layer 2.
2	0.30-50	Light reddish brown (5YR6/4, dry) weak consistence, sandy loam. Weak pedality (granular 5-20 mm) neutral (pH 7.2), high to moderate dispersion (EAT 2(1), non-saline (>0.01dS/m), roots few Approximate sample depth 0.30-50 m.

Plate 9 – Shallow Bleached Reddish Brown Sandy Loam Profile

Plate 10 – Shallow Bleached Reddish Brown Sandy Loam Landscape

Soil Type 4b: Brown & Grey Duplex Sandy Loams (Brown & Grey Chromosols)

Description: These duplex soils generally consist of very dark brown to dark greyish brown sandy loams with a clear change to dark brown, brown or grey clays at depth. These moderately well drained soils are neutral but can become very acidic at depth. Soils in lower lying area become saline with and slightly sodic at depth.

Location: These soils cover 7% or 260 ha of the area within the Project Boundary and are found on the waning lower slopes. Profile sites 1, 3, 4, 5, 23, and 25.

Landuse: The land is currently grazed.

Management: The top 0.20 m of this soil is suitable for stripping and reused as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to the highly dispersive subsoil. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the high clay content of the subsoil and lack of organic matter, if the topsoil is removed, there may be dispersion and erosion during wet conditions.

Table 10 – Brown & Grey Duplex Sandy Loams Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Dark brown (7.5YR 3/2) weak consistence sandy loam. Weak crumb structure pedality (granular 2-5 mm) soil with neutral (pH 7.2), slight dispersion (EAT 3 (1), non-saline (0.05dS/m), roots common Approximate sample depth 0.10m. Clear wavy boundary to Layer 2.
2	0.20- 30	Pinkish grey (7.5YR 7/2, dry) weak consistence sandy loam. massive soil slightly acidic (pH 6.5), high to moderate dispersion (EAT 2(1)), non-saline (0.05dS/m), few roots abundant Approximate sample depth 0.20-30 m. Clear irregular boundary to Layer 3
3	30-70	Brown (7.5YR 5/3 moist) pinkish grey (7.5YR 7/3 dry) strong consistence light medium clay. Moderate pedality (sub angular blocky) acidic subsoil (pH 5.9), strongly dispersive (EAT 2(2)), non-saline (0.02dS/m), and non sodic (ESP 3.3) roots few. Approximate sample depth 0.30- .50 m.

Plate 11 – Brown & Grey Duplex Sandy Clay Loam Profile

Plate 12 - Brown & Grey Duplex Sandy Clay Loam Landscape

Soil Type 4c: Self-mulching Black Clays over Andesite (Black & Grey Vertosols)

Description: These cracking clays generally consist of very dark brown and black medium clays with a gradual even change to brown or dark greyish brown heavy clays. These moderately poorly drained soils are alkaline and can become very alkaline at depth the soils become slightly sodic at depth.

Location: These soils cover 8% or 289 ha of the area within the Project Boundary and are found on the waning and lower slopes formed on andesite. This soil type was found at profile sites 16 and 19.

Landuse: The land is currently cropped.

Management: The top 0.40 m of this soil is suitable for stripping and reused as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to the sodicity and alkalinity at depth. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the high clay content and lack of organic matter in the subsoil, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 11 – Self-mulching Black Clay Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.15	Very dark brown to (10YR 2/2) medium clay with strong consistence. Strong pedality (granular 2-5 mm) soil with alkaline (pH 8.2), nil dispersion (EAT 5), non-saline (0.1dS/m), roots common Approximate sample depth 0.-15 m. Gradual even boundary to Layer 2.
2	0.15-40	Very dark brown to (10YR 2/2) strong consistence heavy clay. Strong pedality (granular 2-5 mm) soil with alkaline (pH 8.2), slight dispersion (EAT3(1), non-saline (0.09dS/m), roots common Approximate sample depth 0.15-45 m. Gradual even boundary to Layer 3
3	40-70	Very dark greyish brown (10YR 3/2) moist strong consistence heavy clay. Strong pedality (prismatic 50-150 mm) soil alkaline (pH 8), slight dispersion (EAT 3(2)), non-saline (0.15dS/m), and non sodic (ESP 4) roots few. Approximate sample depth 0.40- .70 m.

Plate 13 – Self-mulching Black Clay Profile

Plate 14 – Self-mulching Black Clay Landscape

Soil Type 5: Sodic Duplex & Gradational Brown Loams (Sodic Brown Sodosols & Dermosols)

Description: These sodic soils generally consist of dark greyish brown clayey topsoils with a clear change to dark brown or dark greyish brown clays. These moderately poorly drained soils are alkaline and can become increasingly alkaline at depth. Sodicity and salinity increases down the profile.

Location: These soils cover approximately 3% or 103ha of the area within the Project Boundary and are found on stagnant alluvial terraces. This soil type was found at profile sites 17, 21, 22 and 24.

Landuse: The land is cleared and currently grazed.

Management: The top 0.20 m of this soil is suitable for stripping and reused as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to its sodic subsoil. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the high clay content of the subsoil and lack of organic matter, if the topsoil is removed, there may be dispersion and erosion during wet conditions.

Table 12 – Sodic Duplex & Gradational Brown Loams Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Very dark greyish brown to (10YR 4/2) weak consistence (wet) light medium clay. Strong sub angular blocky structure (granular 1-5 mm) soil with alkaline (pH 8.2), moderate dispersion (EAT 3(3), slightly sodic ESP 5.7% non-saline (0.07dS/m), roots common Approximate sample depth 0-0.10m. Sharp wavy boundary to Layer 2.
2	0.20- 40	Brown (10YR 4/3) moist, moderate consistence medium clay. Angular blocky soil, strongly alkaline (pH 9), no dispersion (EAT 4), sodic ESP 8.2% moderately saline (0.36dS/m), few roots Approximate sample depth 0.20-30 m. Clear irregular boundary to Layer 3
3	40-80	Brown (10YR 4/3) moist strong consistence medium clay. Strong pedality (angular blocky) strongly alkaline subsoil (pH 9.2), not dispersive (EAT 4), moderately saline (0.51dS/m), and sodic (ESP 11.7) no roots. Approximate sample depth 0.40- .60 m.

Plate 15 – Sodic Duplex & Gradational Loam Profile

Plate 16 – Sodic Duplex & Gradational Loam Landscape

Soil Type 6: Brown Clays and Red Brown Earths

Description: These soils are moderately well drained self-mulching brown clays or poorly drained red-brown earths or imperfectly drained self-mulching red clays. The topsoil is generally non-saline increasing to strongly alkaline at depth. Sodicity and salinity increases down the profile.

Location: These soils cover approximately 4% or 137ha of the area within the Project Boundary and are found on stagnant alluvial terraces of the Namoi River. No profiles sites were included for this soil type due to proximity to river and previous information being available, however information was extrapolated from the Namoi Catchment Map and a 2009 survey undertaken by GSSE within the local vicinity, to describe this soil type.

Landuse: Partially cleared woodlands and grasslands used for mixed grazing, cropping and irrigation.

Management: The top 0.20 m of this soil is suitable for stripping and reused as topdressing in rehabilitation. The subsoil is not recommended for reuse in rehabilitation due to its fine texture. This soil requires only the standard erosion and sediment control measures (as outlined in **section 5.2.4**) if disturbed, however given the high clay content of the subsoil, if the topsoil is removed, there may be dispersion and erosion during wet conditions.

Table 13 – Brown Clays and Red Brown Earths

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Brown (7.5YR 5/2), weak consistence loam. A moderate pedality (angular blocky peds 5-10 mm) soil with neutral acidity (pH 6.7), nil to moderate dispersion (EAT 8/3(2) & 2(2)), non saline (0.03dS/m), roots common to many and <10% stones (<10 mm). Approximate sample depth 0.10 m. Clear and even boundary to Layer 2.
2	0.20 to 0.50	Dark yellowish brown to pale brown (10YR 4/4 & 10YR 6/3), moderate to strong consistence clay loam to clay. An apedal massive soil that is moderately to strongly alkaline (pH 7.9-8.8), non-dispersion to highly dispersive (EAT 3(1) & 2(3)), non saline (0.05-0.17dS/m), roots none to few and 0-50% stones (<20 mm). Approximate sample depth 0.35 m. Gradual even boundary to Layer 3.
3	0.50 to 1.20	Brown (10YR 5/4), strong consistence clay loam to Clay. An apedal massive soil that is strongly alkaline (pH 9.0-9.6), borderline dispersive (EAT 2(1) & 2(2)) highly sodic (ESP 20), moderately saline (0.38-0.89dS/m), roots none and <10% stones (<10 mm). Approximate sample depth 0.90 m.

NB: The information displayed in Table 13 and Plates 17 and 18 was taken from previous soil survey undertaken in the Project Boundary by GSSE in 2009.

Plate 17 – Brown Clays and Red Brown Earths Profile

Plate 18 – Brown Clays and Red Brown Earths Landscape

3.3 ALLUVIAL SOIL INVESTIGATION

An assessment of the presence and extent of alluvial soils within the vicinity of Back Creek was undertaken in July 2010. The summary of the findings are presented below.

Back Creek is a small creek, which is cutting down into the footslopes of the Project Area. There was no evidence of extensive alluvial plains associated with Back Creek, and those that are present, are predominately located on the northern side of the creek. The majority of the cleared areas to the south of Back Creek consist of very gently undulating footslopes, composed of material deposited from sandstone conglomerates, rhyolites, and from a small outcrop of basalt and andesite further upslope.

There is a small area of higher terraces near the creek, which would not have been flooded for several thousand years. This ancient alluvium found on the higher terraces is above the limited area of current alluvial soils associated with Back Creek. The creek is currently cutting back into these terraces. These old terraces have developed duplex profiles with loamy topsoils and well drained red sub-soils (Red Chromosols) on the highest terraces, and finer silty clay surface soils (Brown Dermosols) occur in lower lying terraces, with less well drained brown clayey sub-soils. These soils were exposed in localised minor drainage gullies on the farm 'Teston' and they exhibited well developed soil profiles.

The majority of all the cleared footslopes found on the mine lease within in this area display evidence of being prone to soil erosion and are classified as Class IV Land Capability as shown in **Figure 4**.

4.0 LAND CAPABILITY AND SUITABLITY ASSESSMENT

The Project Boundary has been assessed for both rural land capability and agricultural suitability. The methods and results for both assessments are presented in this section fulfilling report objectives 2-1 and 2-2.

4.1 LAND CAPABILITY

4.1.1 Land Capability Methodology

The land capability system applied to the Project is in accordance with the Department of Environment, Climate Change & Water (DECCW) (formerly the NSW Soil Conservation Service). The relevant guideline is called S*ystems Used to Classify Rural Lands in New South Wales* (Cunningham et al., 1988).

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

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

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

The principal limitation recognised by these capability classifications is the stability of the soil mantle and classes are ranked on their increasing soil erosion hazard and decreasing versatility of use. A description of the eight land capability classes is provided in **Table 14**.

Table 14 – 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		
U	Urban areas	Unsuitable for rural production
SF	State Forests	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production

Source: Cunningham et al., 1988

4.1.2 Land Capability Results

The pre-mining and post-mining rural land capability classification of the area within the Project Boundary, in accordance with DECCW mapping, is shown in **Figures 4** and **5.** A comparison of the pre and post-mining rural land capability classification is provided in **Table 15.** No Class I Land Capability Units occur within the Project Boundary.

Table 15 – Comparison of Pre and Post-Mining Rural Land Capability Classes

Land Class	Pre-mining		Post-mining	
	ha	**%**	**ha**	**%**
Class II	191	5	191	6
Class III	161	4	161	4
Class IV	163	5	135.5	4
Class V	915	26	371.5	10
Class VI	631	18	737	21
Class VII	1489	42	1810	51
Class VIII	0	0	144	4
Total	**3,550**	**100**	**3,550**	**100**

4.1.2.1 Pre-Mining

Class II Land

Class II land consists of Soil Types 4c and 6 (Self-mulching Black Clays and Brown Clays & Red Earths). This land is well suited to a variety of agricultural uses and is suitable for regular cultivation.

Class III Land

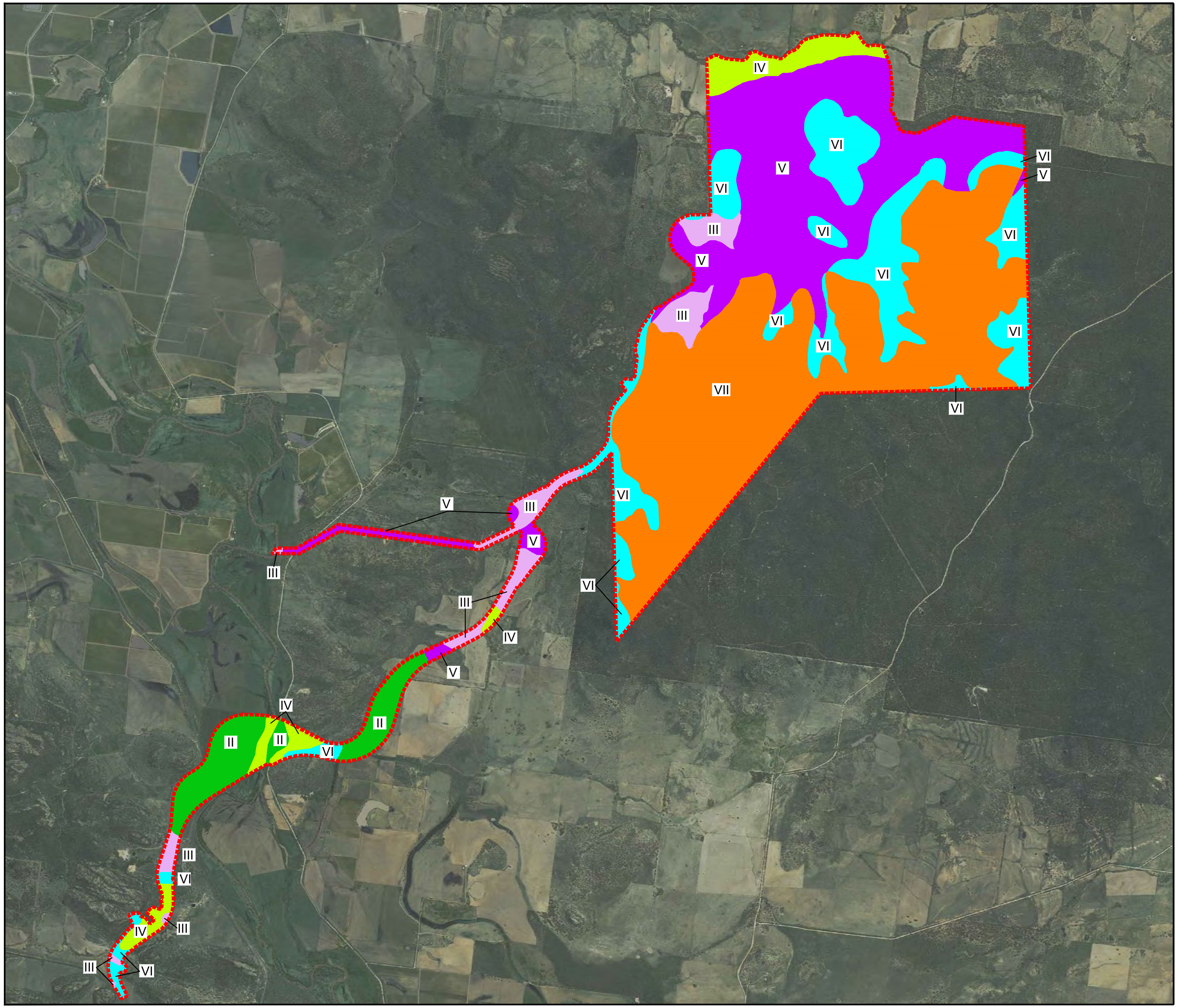
Class III land consists of Soil Types 4b, 4c and 6 (Brown & Grey Duplex Sandy Loams, Self-mulching Black Clays and Brown Clays and Red Brown Earths respectively). This classification indicates that the land is suited to regular cultivation and is considered to be very good cropping land. This land requires intensive soil conservation practices such as contour banks and waterways.

Class IV Land

Class IV land consists of Soil Type 5 (Sodic Duplex and Gradational Brown Loams). This classification indicates that the land is suitable for grazing with only occasional cultivation and is the best class of grazing land.

Class V Land

Class V land consists of Soil Types 3b (Self-mulching Brown and Grey Clays) and 4a (Shallow Bleached Reddish Brown Sandy Loams). Class V land is only suitable for grazing with very occasional cultivation. If cultivated then intensive soil conservation measures are required such as contour ripping and banks. Similar to Class IV this land is considered to be moderately productive and suited to improved pasture and cropping within a pasture rotation. However, more careful management practices are required due to slope and/or higher erosion risks as compared to Class IV land.



LEGEND

- Project Boundary
- Land Capability - II
- Land Capability - III
- Land Capability - IV
- Land Capability - V
- Land Capability - VI
- Land Capability - VII

N
W
E
S
0 0.5 1.0 1.5 2.0km

FIGURE 4

Pre-Mining Land Capability

Project: Maules Creek Soil & Land Capability Assessment (2010)

Client: Hansen Bailey

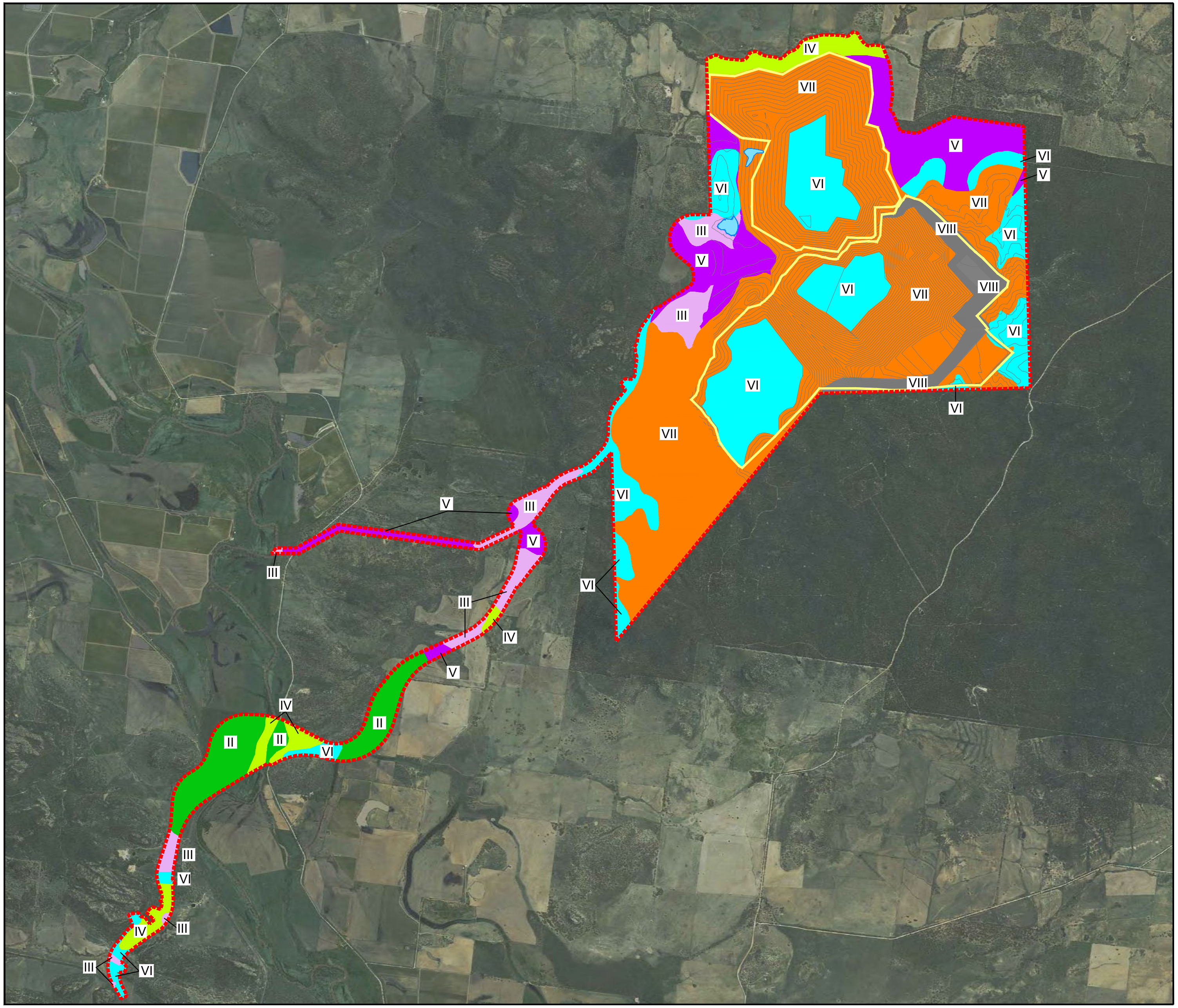
File: Fg4_HAN17-001_PreLandCap_101116

Projection: MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	14/10/10	LH	KM	JL
2	03/11/10	LH	KM	JL
3	04/11/10	TC	KM	JL
4	16/11/10	LH	KM	JL

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

V:\HAN17-001\Figures\Drafts\Fg4_HAN17-001_PreLandCap_101116.dwg



LEGEND

- Project Boundary
- Final Landform
- Land Capability - II
- Land Capability - III
- Land Capability - IV
- Land Capability - V
- Land Capability - VI
- Land Capability - VII
- Land Capability - VIII
- Water Storage

N
W E
S

0 0.5 1.0 1.5 2.0km

FIGURE 5

Post-Mining Land Capability

Project: Maules Creek Soil & Land Capability Assessment (2010)

Client: Hansen Bailey

File: Fg5_HAN17-001_PostLandCap_101116

Projection: MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	19/10/10	LH/LF	KM	JL
2	03/11/10	LH/LF	KM	JL
3	16/11/10	LH	KM	JL

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

V:\HAN17-001\Figures\Drafts\Fg5_HAN17-001_PostLandCap_101116.dwg

Class VI Land

Class VI land consists of Soil Types 2 (Gravelly Fine Brown Sandy Loams) and 3a (Gravelly Red Duplex Sandy Clay Loams). This classification indicates that this land must not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented. Class VI land is the lowest quality of grazing land. Provided structural conservation works are in place and managed to ensure ground cover is maintained grazing can occur. Constraints associated with soil types (2 and 3a) are as follows. Soils are constrained by its slope, heavy subsoil clay content, shallow topsoil depth and susceptibility to erosion.

Class VII Land

Class VII land consists of Soil Type 1 (Shallow Gravelly Brown Sandy Loams). Class VII land within the Project Boundary is generally located within the Leard State Forest. The Leard State Forest has a modified land capability classification of 'State Forest' due to the land use zoning of State Forests. This overrides the general capability of the land for this assessment. However, for the purposes of this assessment it has been classified as Class VII. Class VII land is considered unsuitable for rural production and is best protected by green timber to control erosion. Class VII land is land which usually has severe to very severe site limitations for other land uses, but may be suitable for wood production. Limitations include slope, terrain, soil erosion, shallow soils and stoniness and poor drainage.

4.1.2.2 Post-mining

All sites which are not disturbed by mining activities will remain the same land capability as the pre mining class. The main parameters for determining post mining land capability is steepness of slope and quality of material used as topdressing in rehabilitation. The majority of the disturbed post mining landform consists of slopes of 10 degrees and will be covered in low to moderate quality topdressing. These factors should result in a land capability class VII. The flatter slopes should result in rehabilitation to class V land. The steep highwalls and voids should be class VIII.

4.2 AGRICULTURAL SUITABILITY

4.2.1 Agricultural Suitability Methodology

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

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

The 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 16.**

Table 16 – 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.
3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation.	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture.
4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage.
5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land unsuitable for agriculture or at best suited only to light grazing.

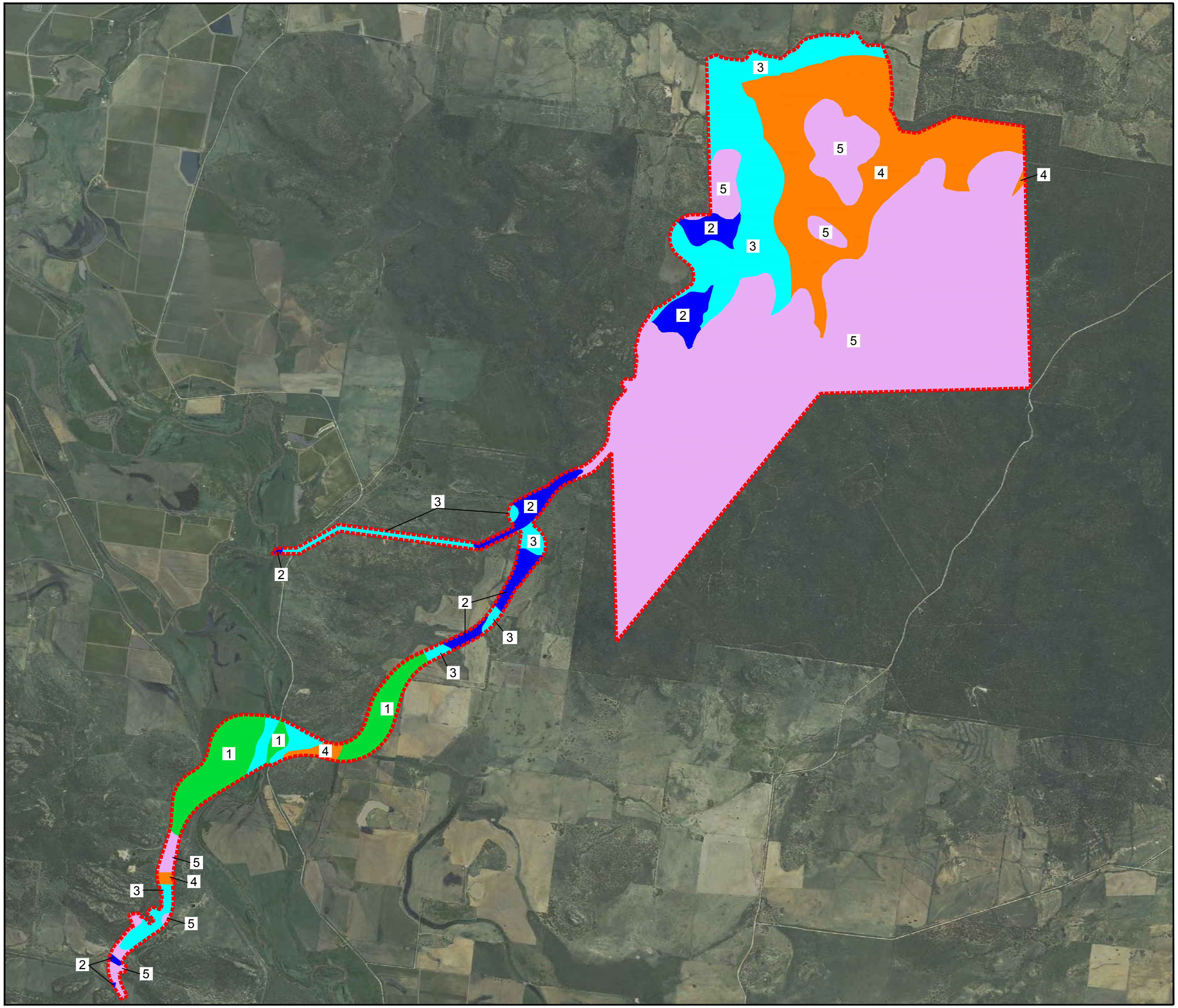
Source: NSW Agriculture & Fisheries (1990)

4.2.2 Agricultural Suitability Results

The main soil properties and other landform characteristics considered significant for the agricultural land suitability assessment are topsoil texture, topsoil pH, solum depth, external and internal drainage, topsoil stoniness and slope as well as bio-physical factors such as elevation, rainfall and temperature. A comparison of the pre and post-mining agricultural land suitability classification is provided in **Table 17.** The pre-mining and post-mining agricultural suitability classification of the area within the Project Boundary, in accordance with I&I mapping, is shown in **Figures 6** and **7.**

Table 17 – Comparison of Pre and Post-mining Agricultural Land Suitability Classes

Land Class	Pre-mining		Post-mining	
	ha	**%**	**ha**	**%**
Class 1	191	5	191	5
Class 2	146.5	4	146.5	4
Class 3	514	15	507	14
Class 4	582.5	16	524.5	15
Class 5	2116	60	2181	62
Total	**3,550**	**100**	**3,550**	**100**



V:\HAN17-001\Figures\Drafts\Fg6_HAN17-001_PreAgSuit_101116.dwg

LEGEND

- Project Boundary
- Agricultural Suitability - 1
- Agricultural Suitability - 2
- Agricultural Suitability - 3
- Agricultural Suitability - 4
- Agricultural Suitability - 5

N
W E
S

0 0.5 1.0 1.5 2.0km

FIGURE 6

Pre-Mining
Agricultural Suitability

Project:
Maules Creek Soil & Land Capability Assessment (2010)

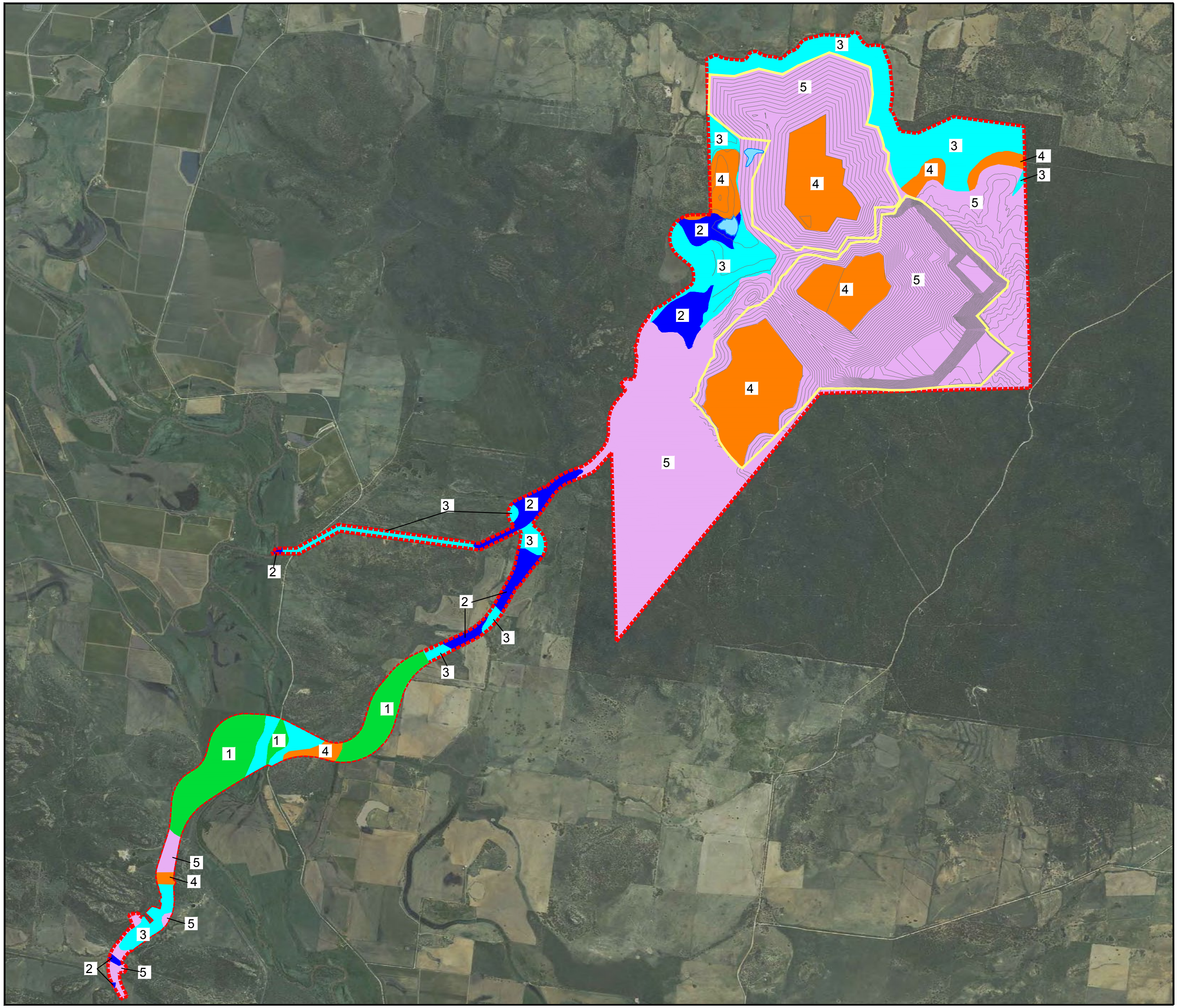
Client:
Hansen Bailey

File:
Fg6_HAN17-001_PreAgSuit_101116

Projection:
MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	14/10/10	LH	KM	JL
2	03/11/10	LH	KM	JL
3	16/11/10	LH	KM	JL

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants



V:\HAN17-001\Figures\Drafts\Fg7_HAN17-001_PostAgsuit_101116.dwg

LEGEND

- Project Boundary
- Final Landform
- Agricultural Suitability - 1
- Agricultural Suitability - 2
- Agricultural Suitability - 3
- Agricultural Suitability - 4
- Agricultural Suitability - 5
- Water Storage

N W E S

0 0.5 1.0 1.5 2.0km

FIGURE 7

Post-Mining
Agricultural Suitability

Project: Maules Creek Soil & Land Capability Assessment (2010)

Client: Hansen Bailey

File: Fg7_HAN17-001_PostAgsuit_101116

Projection: MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	19/10/10	LH/LF	KM	JL
2	03/11/10	LH/LF	KM	JL
3	16/11/10	LH	KM	JL

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

4.2.2.1 Pre-Mining

Class 1 Land

Class 1 land consists of Soil Types 4c and 6 (Self-mulching Black Clays and Brown Clays & Red Earths). Class 1 land includes highly productive land suited to both row and field crops which are suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.

Class 2 Land

Class 2 land consists of Soil Types 4b, 4c and 6 (Brown & Grey Duplex Sandy Loams, Self-mulching Black Clays, and Brown Clays and Red Brown Earths). Class 2 land includes highly productive land suited to both row and field crops, however, it is not suited to continuous cultivation

Class 3 Land

Class 3 land consists of Soil Types 3b (Self-mulching Brown & Grey Clays) and 5 (Sodic Duplex and Gradational Brown Loams). This class indicates that the land is moderately productive and well suited to grazing or to crop cultivation with a pasture rotation

Class 4 Land

Class 4 land consists of Soil Types 4a (Shallow Bleached Reddish Brown Sandy Loams). This classification indicates that this land must not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented. Class 4 land indicates that the land is marginally suitable for grazing and not suitable for cultivation. Grazing productivity is low to very low and pastures are to be based on native or improved pastures established with minimum tillage techniques. Although production may be high seasonally, the overall level of production is low as a result of a number of major constraints, both environmental and edaphic.

Class 5 Land

Class 5 land consists of Soil Types 1, 2, and 3a (Shallow Gravelly Brown Sandy Loams, Gravelly Fine Brown Sandy Loams and Gravelly Red Duplex Sandy Clay Loams respectively). Class 5 lands are marginal lands not suitable for cultivation and with a low to very low productivity for grazing. These lands are located generally within the Leard State Forest and small patches associated with steep hillsides and hilltops.

4.2.2.2 Post-mining

All sites which are not disturbed by mining activities will remain the same agricultural suitability as the pre mining class. The main parameters for determining post mining agricultural suitability, as with land capability, is steepness of slope and quality of material used as topdressing in rehabilitation. The majority of the disturbed post mining landform consists of slopes of 10 degrees and will be covered in low to moderate quality topdressing. These factors should result in an agricultural suitability class 5. The flatter slopes should result in rehabilitation to class 4 land. The steep highwalls and voids should also be class 5.

5.0 SOIL MANAGEMENT

Soil that is proposed to be disturbed during the Project has been assessed to determine its suitability for stripping and re-use on rehabilitation sites. This assessment is an integral process for successful rehabilitation of the Project. This report provides information on the following key areas related to the management of the topsoil resources for the area within the Project Boundary.

- 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 volume assessment calculated from recommended stripping depths of each soil type;
- Topsoil balance assessment to calculate the area and volume of soil required to rehabilitate all disturbed areas; and
- Topsoil management for soil that is stripped, stored and used as a topdressing material for rehabilitation.

5.1 TOPSOIL STRIPPING ASSESSMENT

5.1.1 Topsoil Stripping Methodology

Determination of suitable soil to conserve for later use in mine rehabilitation has been conducted in accordance with Elliott and Veness (1981). The approach remains the benchmark for land resource assessment in the Australian mining industry. This procedure involves assessing soils based on a range of physical and chemical parameters. **Figure 8** summarises the procedure for the selection of soil material for use as topdressing of areas disturbed by the Project and **Table 18** lists the key parameters and corresponding desirable selection criteria.

Table 18 – 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 8** were determined during the field assessment.

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

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

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

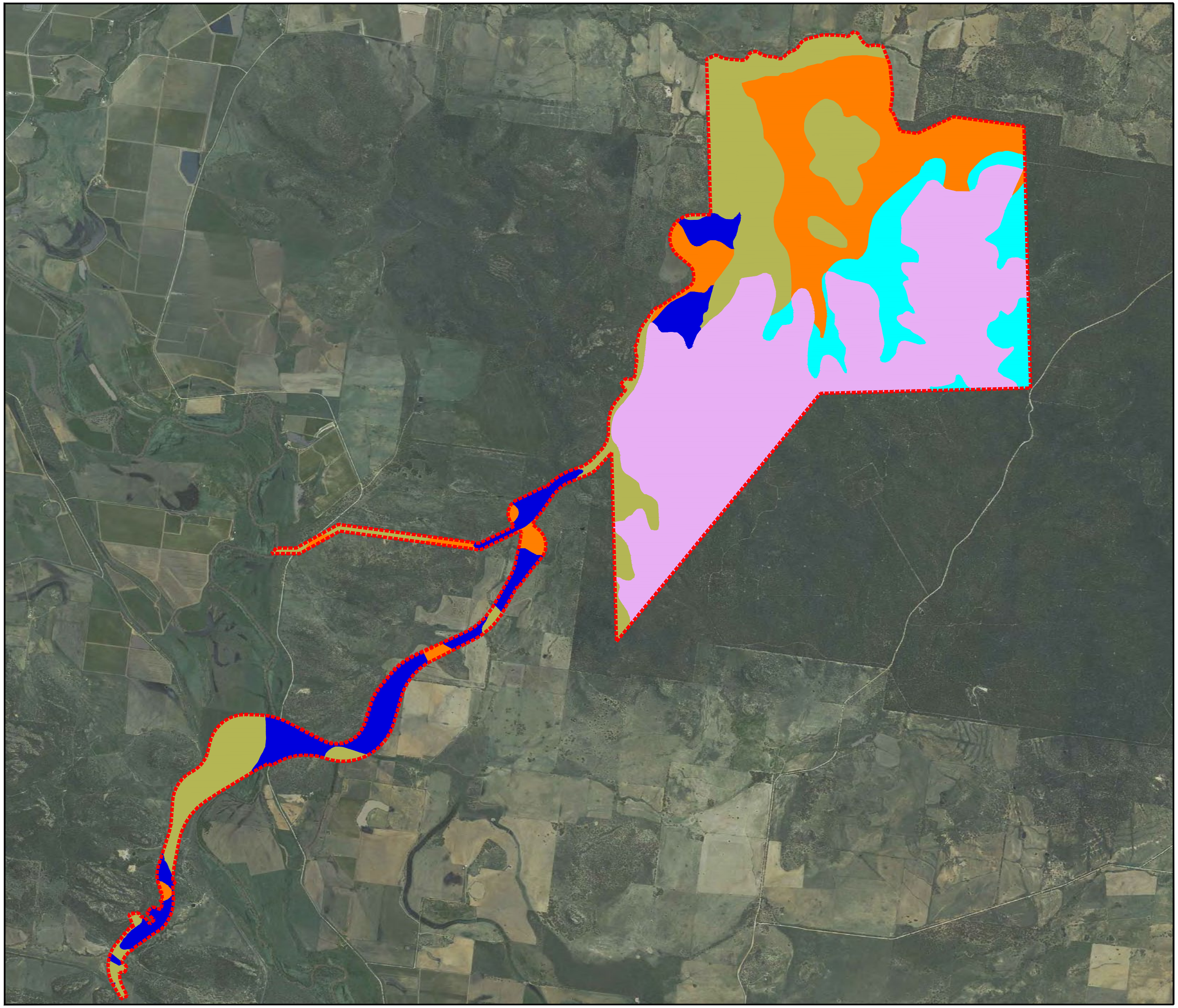
The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities, however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions.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

5.1.2 Topsoil Stripping Depths & Volume

Laboratory soil analytical results (refer **Appendix 3**) were used in conjunction with the field assessment (refer **Appendix 1**) to determine the depth of soil material suitable for recovery and re-use as a topdressing material in rehabilitation. Structural and textural properties of subsoils, along with stones, dispersion potential, sodicity and acidity/alkalinity are the most common and significant limiting factors in determining depth of soil suitability for re-use. The recommended stripping depth for each soil type, together with area of land across the project area and calculated volume are provided in **Table 19**.

Table 19 – Recommended Stripping Depths

Soil Type	Project Soil Name	Recommended Stripping Depth (m)	Project Area (ha)	Volume (m^3)
1	Shallow Gravelly Brown Sandy Loams	Stripping not recommended	1,489	0
2	Gravelly Fine Brown Sandy Loams	0.25	321	802,500
3a	Gravelly Red Duplex Sandy Clay Loams over Rhyolite	0.20	292	584,000
3b	Self-mulching Brown & Grey Clays over Andesite	0.30	94	282,000
4a	Shallow Bleached Reddish Brown Sandy Loams	0.30	565	1,695,000
4b	Brown & Grey Duplex Sandy Loams	0.20	260	520,000
4c	Self-mulching Black Clays over Andesite	0.40	289	1,156,000
5	Sodic Duplex and Gradational Brown Loams	0.20	103	206,000
6	Brown Clays and Red Brown Earths	0.20	137	274,000
		Total Volume		**5,519,500**
		Total Volume (10% handling loss allowance)		**4,967,550**



LEGEND

- Project Boundary
- Stripping Depth
  - Nil/ Not Recommended
  - 0.2m
  - 0.25m
  - 0.3m
  - 0.4m

N
W E
S

0 0.5 1.0 1.5 2.0km

FIGURE 8

Stripping Depth

Project: Maules Creek Soil & Land Capability Assessment (2010)

Client: Hansen Bailey

File: Fg8_HAN17-001_Strip Depth_101116

Projection: MGA94 Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	19/10/10	LH	KM	JL
2	03/11/10	LH	KM	JL
3	16/11/10	LH	KM	JL

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

V:\HAN17-001\Figures\Drafts\Fg8_HAN17-001_Strip Depth_101116.dwg

Allowing for a 10% handling loss, approximately 4,967,550 m^3 of suitable topdressing is available within the project boundary. The majority of topsoil disturbance will result from the excavation of the open cut pit, which is generally located in the Leard State Forest upon the soil types 1, 2, 3a and 4a. Areas to be disturbed by pipelines and rail line will be stripped and stockpiled for re-use in rehabilitation for the area from where it was stripped.

5.1.3 Topsoil Balance

The topsoil balance was undertaken with the following assumptions:

- Only topsoil will be used as the final surface topdressing in rehabilitation. All subsoils are assumed to be only suitable as an intermediate layer between the overburden and the final surface topdressing material;
- Not all topsoil will be salvaged within the open cut footprint;
- A 10% handling loss has been applied;
- Rehabilitation (including topsoil respreading) will not occur on the entire open cut footprint;
- Topsoil will be respread on final landforms at depths stated in **Table 21**.

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 Project would have an overall deficit or surplus of topdressing material available for rehabilitation.

As shown in **Table 20** below, there is approximately 2,542,500m3 of material from the disturbed area potentially available for salvage and reuse in rehabilitation. Furthermore, the volume of material required to meet the rehabilitation and land capability objective is calculated in **Table 21**.

Table 20 – Topsoil Balance – Disturbance Area

Soil Type	Project Soil Name	Recommended Stripping Depth (m)	Mine Disturbance Area (ha)	Volume (m^3)	Volume (10% loss) (m^3)
1	Shallow Gravelly Brown Sandy Loams	Stripping not recommended	865	0	0
2	Gravelly Fine Brown Sandy Loams	0.25	198	495,000	445,500
3a	Gravelly Red Duplex Sandy Clay Loams over Rhyolite	0.20	175	350,000	315,000
3b	Self-mulching Brown & Grey Clays over Andesite	0.30	17	51,000	45,900
4a	Shallow Bleached Reddish Brown Sandy Loams	0.30	393	1,179,000	1,061,100
4b	Brown & Grey Duplex Sandy Loams	0.20	241	482,000	433,800
4c	Self-mulching Black Clays over Andesite	0.40	49	196,000	176,400
5	Sodic Duplex and Gradational Brown Loams	0.20	36	72,000	64,800
6	Brown Clays and Red Brown Earths	0.20	0	0	0
Total Disturbance Area			**1,974 ha**		
		Total Volume		**2, 825,000**	
		Total Volume (10% handling loss allowance)		**2,542,500**	

Table 21 – Topsoil Balance – Volume Required

Soil Land Capability Class	Recommended Spreading Depth	Area (ha)	Volume Required
VI	0.20	422	844,000
VII	0.15	1016	1,524,000
VIII	Nil	132	
Total Area (Ha)			1,570
Total Volume			2,368,000 m^3

The results of the Topsoil Balance shown in **Table 20** and **Table 21** above indicate a topsoil surplus across the entire proposed open cut footprint of 174,500m^3.

5.2 TOPDRESSING MANAGEMENT

Where topsoil stripping and transportation is required, the following topsoil handling techniques are recommended to prevent excessive soil deterioration, note this also applies to subsoil stripping:

- Strip material to the depths stated in **Table 19**, 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 for loading into rear dump trucks by front-end loaders, are examples of preferential less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by overburden trucks may be placed directly into storage.
- The surface of soil stockpiles should be left in as coarsely structured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of 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 12 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward will provide sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.
- Where possible, mulch will be blended into the stockpiled topsoil to enhance breakdown of vegetation material, minimise dust and erosion and promote water retention.
- 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.

5.2.1 Topsoil Re-spreading and Seedbed Preparation

Where practical, suitable topsoil should be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil should be spread to a nominal depth of 100 mm on all re-graded spoil. 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. 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.

5.2.2 Landform Design and Erosion Control

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

5.2.1 Post-Disturbance Re-grading

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.

5.2.2 Erosion and Sediment Control

The most effective 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 are considered when selecting sites for sediment control dams where possible.

- Each dam is 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 should be treated treatment with, gypsum and/or bentonite to prevent failure of the wall by tunnel erosion. Failure by tunnelling is may occur 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 for appropriate intensity and duration rainfall events. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

6.0 REFERENCES

Cunningham G.M., Higginson F.R, Riddler A.M.H and Emery K.A. (1988) Rural Land Capability Mapping, Soil Conservation Service of NSW. Sydney, NSW.

Elliot, G.L. and Veness, R.A. (1981). *Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley,* J. Soils Cons. NSW 37 37-40.

Isbell RF 1996 "The Australian Soil Classification". CSIRO Publishing, Australia Hazelton PA & Murphy BW 2007 Interpreting Soil Test Results: what do the numbers mean. (2nd ed) CSIRO Publishing, Australia

Kembla Coal & Coke Pty. Limited (1989), Maules Creek Coal Project EIS September 1989.
Report prepared for Coal Cliff Collieries Pty Limited.

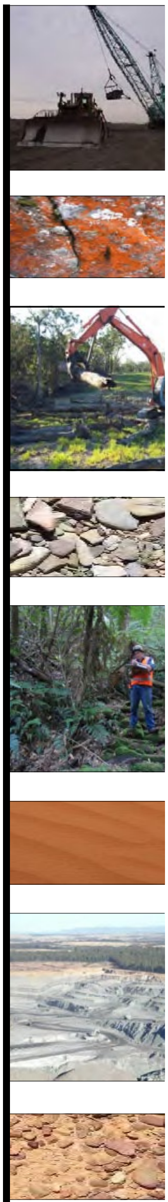
Macbeth (1994). *Munsell Soil Colour Charts*. Revised Edition.

Namoi Catchment Management Authority (2009). Land Management Units in the Namoi Catchment – Map & Legend.

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

The National Committee on Soil and Terrain (NCST) (2009) Australian Soil and Land Survey Field Handbook, 3rd edition (CSIRO, Aust).

Pratt W. 1998 Gunnedah Coalfield (North) Regional Geology 1:100:000. First Edition Geological Survey of New South Wales, Sydney.



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

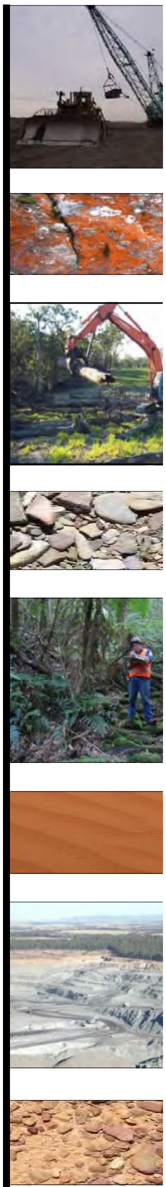
Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as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

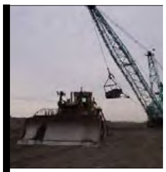
An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R.,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

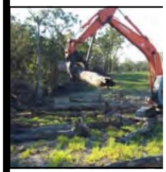
EC

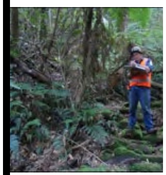
Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

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.








Soil Test Results

APPENDIX 3

Soil Conservation Service

SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO10/221R1

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

REPORT ON: Twenty three soil samples
Maules Creek HAN17-001

PRELIMINARY RESULTS ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 20 August 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

G Holman
(Technical Officer)

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: SCO10/221R1
Client Reference: Klay Marchant
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	Dry	Moist
1	4-1	49	21	22	6	2	5	0.10	8.2	41.5	0.5	1	10YR3/3	10YR2/2
2	4-2	56	19	15	7	3	3(1)	0.09	8.2	43.6	1.1	3	10YR3/3	10YR2/2
3	4-3	57	21	15	6	1	3(2)	0.15	8.0	44.5	1.8	4	10YR4/2	10YR3/2
4	5 0-25	12	5	10	38	35	3(1)	0.02	6.4	12.3	0.2	3	7.5YR5/3	7.5YR2.5/2
5	5 25-60	10	9	11	40	30	3(1)	0.01	7.2	9.6	0.3	3	7.5YR7/3	7.5YR4/6
6	7-1	8	5	12	24	51	3(1)	0.02	6.0	12.4	0.1	1	7.5YR5/3	7.5YR3/4
7	7-2	13	7	11	37	32	3(1)	<0.01	5.3	7.6	0.1	1	7.5YR6/4	7.5YR4/6
8	8-1	7	10	18	23	42	3(1)	0.02	6.3	8.5	0.2	2	7.5YR6/2	7.5YR4/2
9	8-2	9	10	22	30	29	2(1)	<0.01	6.9	6.7	0.2	3	10YR8/1	10YR5/3
10	8-3	15	12	21	33	19	2(1)	0.02	6.8	9.3	0.3	3	10YR8/2	10YR6/4
11	9 0-25	5	6	14	19	56	3(1)	0.01	6.4	8.8	0.1	1	7.5YR5/3	7.5YR3/3
12	9 25-80	9	10	20	26	35	3(1)	<0.01	5.6	6.4	0.2	3	7.5YR7/3	7.5YR5/4

G Holmen.

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO10/221R1
Client Reference: Klay Marchant
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	Dry	Moist
13	10-1	10	9	24	34	23	3(1)	0.01	6.5	10.9	0.1	1	7.5YR6/4	7.5YR4/4
14	10-2	7	7	18	34	34	2(1)	<0.01	6.5	8.5	0.2	2	7.5YR7/4	7.5YR4/6
15	11 0-10	7	9	21	41	22	3(1)	0.02	6.7	13.9	0.2	1	7.5YR5/3	7.5YR3/3
16	11 10-45	5	7	18	27	43	3(1)	<0.01	5.7	9.8	0.2	2	7.5YR6/4	7.5YR4/6
17	11 45-100	6	6	13	28	47	2(1)	<0.01	6.1	7.8	0.4	5	7.5YR7/4	7.5YR4/6
18	12/1	20	11	22	17	30	4	0.13	8.3	31.9	0.5	1	7.5YR4/3	7.5YR2.5/3
19	12/2	39	4	7	12	38	4	0.11	8.7	25.4	0.6	2	5YR5/6	5YR4/6
20	14/1	6	8	16	25	45	5	0.04	7.3	11.9	0.6	5	10YR5/4	10YR3/4
21	14/2	5	6	10	17	62	3(1)	0.01	6.1	7.8	0.1	1	7.5YR7/4	7.5YR5/6
22	27/1	7	6	13	26	48	3(1)	0.02	6.5	13.8	0.1	1	10YR5/2	10YR3/2
23	27/2	8	7	12	32	41	3(1)	0.02	5.7	7.4	0.1	1	7.5YR7/3	7.5YR4/6

END OF TEST REPORT

Land and Property Management Authority

Soil Conservation Service

SOIL TEST REPORT

Page 1 of 7

Scone Research Centre

REPORT NO:	SCO10/268R3
REPORT TO:	John Lawrie GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Thirty seven soil samples
PRELIMINARY RESULTS ISSUED:	28 September 2010
REPORT STATUS:	Final
DATE REPORTED:	29 September 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

G Holman
(Technical Officer)

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

NSW GOVERNMENT

ABN 33 537 762 019 | www.lpma.nsw.gov.a

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/268R3
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)						C8B/1	
	Sample Id	EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	P sorp index
1	HAN Pit 2 a 0-25	0.15	8.0	32.3	0.7	1.9	13.6	11.2	<0.1	249	2.2
2	HAN Pit 2 b 25-40	0.15	8.9	35.3	1.3	1.6	13.6	14.0	<0.1	276	2.3
3	HAN Pit 2 c 40-70	0.58	9.0	40.4	2.9	0.9	15.8	17.5	<0.1	273	2.3
4	HAN Pit 3 1 0-10	0.05	7.2	12.9	0.2	1.0	6.5	2.2	<0.1	137	1.4
5	HAN Pit 3 b 20-30	0.01	6.5	9.2	0.2	0.2	4.4	1.5	<0.1	139	1.4
6	HAN Pit 3 c 30-50	0.02	5.9	15.0	0.5	0.4	6.1	4.8	<0.1	138	1.4
7	HAN Pit 3 d 50-70	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
8	HAN Pit 13 a 0-30	0.02	6.8	8.0	0.1	0.5	4.4	0.7	<0.1	135	1.4
9	HAN Pit 13 b 30-50	0.01	7.2	6.7	0.1	0.4	3.6	0.9	<0.1	83	0.8
10	HAN Pit 13 c 65-85	0.01	7.2	8.7	0.2	0.3	4.2	1.9	<0.1	61	0.5
11	HAN Pit 15 a 0-30	0.12	8.3	45.4	0.5	1.1	34.3	5.7	<0.1	449	3.2
12	HAN Pit 15 b 30-60	0.13	8.7	48.8	1.2	0.4	38.2	6.7	<0.1	411	2.9
13	HAN Pit 15 c 60-120	0.67	8.4	48.6	2.6	0.5	36.8	9.6	<0.1	418	3.0

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/268R3
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)						C8B/1	
	Sample Id	EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	P sorp index
14	HAN Pit 16 a 0-40	0.12	8.7	56.3	0.9	0.7	45.9	8.7	<0.1	464	3.1
15	HAN Pit 16 b 40-80	0.22	8.9	55.6	3.6	0.3	41.6	11.2	<0.1	472	3.2
16	HAN Pit 16 c 80-120	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
17	HAN Pit 17 a 0-25	0.17	8.2	36.2	3.6	0.5	23.5	6.7	<0.1	300	2.5
18	HAN Pit 17 b 25-50	0.21	8.8	40.5	4.9	0.4	24.6	7.1	<0.1	283	2.4
19	HAN Pit 17 c 50-100	0.54	9.2	31.4	5.2	0.3	19.1	5.5	<0.1	189	1.8
20	HAN Pit 18 a 0-20	0.04	7.5	33.3	0.8	0.9	21.1	6.5	<0.1	397	2.9
21	HAN Pit 18 b 20-70	0.06	8.4	35.1	1.3	0.3	19.0	9.7	<0.1	522	3.5
22	HAN Pit 19 c 60-100	0.21	9.2	40.0	2.9	0.1	22.1	13.1	<0.1	404	2.9
23	HAN Pit 19 a 0-20	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
24	HAN Pit 19 b 20-40	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
25	HAN Pit 19 c 40-100	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/268R3
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)						C8B/1	
	Sample Id	EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	P sorp index
26	HAN Pit 21 a 0-20	0.08	7.3	15.4	0.8	0.7	7.8	3.3	<0.1	181	1.8
27	HAN Pit 21 b 20-40	0.16	8.5	29.4	2.8	0.5	15.9	7.9	<0.1	238	2.1
28	HAN Pit 21 c 60-80	0.31	9.1	24.7	2.8	0.4	12.7	6.3	<0.1	200	1.9
29	HAN Pit 22 a 0-10	0.07	8.2	28.1	1.6	0.6	15.9	8.9	<0.1	227	2.0
30	HAN Pit 22 b 20-40	0.36	9.0	36.5	3.0	0.4	23.0	10.3	<0.1	274	2.3
31	HAN Pit 22 c 40-60	0.51	9.1	35.0	4.1	0.3	21.8	10.5	<0.1	215	2.0
32	HAN Pit 23 a 0-30	0.02	6.5	17.3	0.3	1.4	10.0	3.0	<0.1	147	1.6
33	HAN Pit 23 b 30-50	0.03	7.5	22.9	0.7	0.6	14.1	5.7	<0.1	220	2.0
34	HAN Pit 23 c 55-90	0.13	8.8	31.1	1.9	0.5	19.9	8.0	<0.1	198	1.9
35	HAN Pit 25 a 0-15	0.02	6.2	11.0	0.3	1.0	5.4	1.6	<0.1	174	1.7
36	HAN Pit 25 b 15-35	0.03	7.5	13.6	1.0	0.5	6.8	3.1	<0.1	132	1.4
37	HAN Pit 25 c 35-70	0.50	8.4	24.4	4.5	0.4	9.8	7.0	<0.1	207	1.9

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/268R3
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	P14B/1	P18B/2 AWC		Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	BD (Mg/m^3)	0.3 bar (%)	15 bar (%)	Dry	Moist
1	HAN Pit 2 a 0-25	35	12	17	17	19	3(1)	1.71	33.9	18.4	10YR5/2	10YR4/2
2	HAN Pit 2 b 25-40	52	11	17	17	3	3(1)	1.75	40.3	21.3	10YR6/1	10YR5/1
3	HAN Pit 2 c 40-70	54	13	19	14	<1	4	1.71	35.3	19.9	10YR6/1	10YR5/1
4	HAN Pit 3 1 0-10	16	20	28	31	5	3(1)	1.65	19.2	7.7	7.5YR5/2	7.5YR3/2
5	HAN Pit 3 b 20-30	17	15	27	30	11	2(1)	1.45	17.0	7.4	7.5YR7/2	7.5YR5/2
6	HAN Pit 3 c 30-50	42	15	22	19	2	2(2)	1.54	25.3	14.8	7.5YR7/3	7.5YR5/3
7	HAN Pit 3 d 50-70	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
8	HAN Pit 13 a 0-30	12	10	27	40	11	3(1)	1.52	13.5	7.0	7.5YR5/3	7.5YR3/3
9	HAN Pit 13 b 30-50	12	9	27	41	11	2(1)	1.78	12.4	6.4	5YR6/4	5YR4/4
10	HAN Pit 13 c 65-85	17	11	26	39	7	2(2)	1.70	16.3	9.0	5YR6/4	5YR4/6
11	HAN Pit 15 a 0-30	60	19	17	4	<1	4	1.59	48.8	26.3	7.5YR3/3	7.5YR2.5/3
12	HAN Pit 15 b 30-60	61	18	17	4	<1	4	1.43	45.5	26.4	7.5YR3/3	7.5YR2.5/3
13	HAN Pit 15 c 60-120	63	20	10	7	<1	4	1.69	45.0	26.0	7.5YR4/3	7.5YR3/3

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/268R3
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	P14B/1	P18B/2 AWC		Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	BD (Mg/m^3)	0.3 bar (%)	15 bar (%)	Dry	Moist
14	HAN Pit 16 a 0-40	62	22	11	4	1	4	1.31	48.4	29.6	10YR2/2	10YR2/1
15	HAN Pit 16 b 40-80	68	19	9	4	<1	4	1.54	54.0	30.4	10YR3/2	10YR2/2
16	HAN Pit 16 c 80-120	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
17	HAN Pit 17 a 0-25	46	25	20	9	0	2(1)	1.83	39.7	19.9	10YR5/2	10YR4/2
18	HAN Pit 17 b 25-50	50	23	17	10	<1	2(1)	1.67	42.5	21.0	10YR5/2	10YR4/2
19	HAN Pit 17 c 50-100	30	15	22	26	7	3(1)	1.70	32.6	15.5	7.5YR4/3	7.5YR3/3
20	HAN Pit 18 a 0-20	47	15	25	12	1	5	1.62	34.4	19.1	10YR4/3	10YR3/3
21	HAN Pit 18 b 20-70	52	13	24	11	<1	3(1)	1.69	36.7	20.4	10YR4/3	10YR3/3
22	HAN Pit 19 c 60-100	31	13	15	21	20	4	1.86	31.1	17.3	10YR5/3	10YR4/3
23	HAN Pit 19 a 0-20	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
24	HAN Pit 19 b 20-40	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
25	HAN Pit 19 c 40-100	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/268R3
Client Reference: John Lawrie
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	P14B/1	P18B/2 AWC		Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	BD (Mg/m^3)	0.3 bar (%)	15 bar (%)	Dry	Moist
26	HAN Pit 21 a 0-20	25	15	290	25	6	2(1)	1.71	24.0	11.1	10YR5/2	10YR4/2
27	HAN Pit 21 b 20-40	53	14	20	13	<1	2(2)	1.70	34.3	18.7	10YR5/1	10YR4/1
28	HAN Pit 21 c 60-80	31	7	14	36	12	3(1)	1.77	23.7	13.4	10YR6/3	10YR5/3
29	HAN Pit 22 a 0-10	41	17	25	15	2	3(3)	1.73	31.3	16.5	10YR4/2	10YR3/2
30	HAN Pit 22 b 20-40	51	16	20	12	1	4	1.63	37.6	19.4	10YR5/3	10YR4/3
31	HAN Pit 22 c 40-60	48	18	21	12	1	4	1.67	38.0	18.9	10YR5/3	10YR4/3
32	HAN Pit 23 a 0-30	22	7	25	33	13	3(3)	1.60	21.6	10.8	10YR5/2	10YR4/2
33	HAN Pit 23 b 30-50	38	19	26	11	6	3(3)	1.65	29.6	15.2	10YR5/2	10YR4/2
34	HAN Pit 23 c 55-90	59	18	17	6	<1	3(1)	1.85	36.4	18.8	10YR5/1	10YR4/1
35	HAN Pit 25 a 0-15	12	14	35	24	15	3(1)	na	20.1	7.0	7.5YR5/3	7.5YR3/3
36	HAN Pit 25 b 15-35	15	9	25	27	24	2(1)	1.72	20.4	8.6	7.5YR6/2	7.5YR5/2
37	HAN Pit 25 c 35-70	33	6	35	20	6	2(1)	1.67	31.3	15.1	7.5YR6/4	7.5YR5/4

nt = not tested; na = not applicable; AWC = moisture content (%) by weight

END OF TEST REPORT