



WHITEHAVEN COAL MINING PTY LTD

ABN: 65 086 426 253

Belmont Coal Project

via Gunnedah

Soils and Land Capability Assessment



Prepared by

Geoff Cunningham Natural Resource Consultants Pty Ltd

August, 2007

**Specialist Consultant Studies Compendium
Part 7**

Soils and Land Capability Assessment

of the

Belmont Coal Project

Prepared for: R.W. Corkery & Co. Pty. Limited
PO Box 80
ORANGE NSW 2800

Tel: 02 6362 5411
Fax: 02 6361 3622
Email: mail@rwcorkery.com

On behalf of: Whitehaven Coal Mining Pty Ltd
1/895 Ann Street
PO Box 2440
FORTITUDE VALLEY QLD 4006

Tel: 07 3000 5693
Fax: 07 3000 5699
Email: kross@whitehaven.net.au

Prepared by: Geoff Cunningham Natural Resource Consultants Pty Ltd
9 The Crest
KILLARA NSW 2071

Tel: 02 9416 1995
Fax: 02 9416 6626
Email: geoffcun@bigpond.net.au

August, 2007

COPYRIGHT

© Geoff Cunningham Natural Resource Consultants Pty Ltd, 2007
and
© Whitehaven Coal Mining Pty Ltd, 2007

All intellectual property and copyright reserved.

Apart from any fair dealing for the purpose of private study, research, criticism or review, as permitted under the Copyright Act, 1968, no part of this report may be reproduced, transmitted, stored in a retrieval system or adapted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without written permission. Enquiries should be addressed to Geoff Cunningham Natural Resource Consultants Pty Ltd.

CONTENTS

	Page
EXECUTIVE SUMMARY	7-7
1 INTRODUCTION AND DESCRIPTION OF THE STUDY AREA.....	7-9
1.1 Introduction.....	7-9
1.2 Description of the Study Area	7-9
2 PROJECT DESCRIPTION.....	7-12
3 LITERATURE REVIEW	7-13
3.1 Gunnedah District Soil Conservation Service Technical Manual [Anon, 1976]	7-13
3.1.1 Introduction.....	7-13
3.1.2 Duplex Soils	7-13
3.1.3 Gravelly Soils	7-13
3.2 Narrabri District Soil Conservation Service Technical Manual [Anon, 1978]	7-14
3.2.1 Introduction.....	7-14
3.2.2 Brown Solodic Brown Clay Complex – Type A	7-14
3.2.3 Shallow Loams	7-14
3.3 Unpublished Information on the Soil Landscapes of the Boggabri	7-14
4 SURVEY METHODOLOGY.....	7-15
4.1 Airphoto Interpretation of the Landforms of the Study Area	7-15
4.2 Field Procedures	7-15
4.3 Soil Stripping Suitability	7-17
5 RESULTS	7-17
5.1 Soil Mapping Units.....	7-17
5.2 Soil Mapping Unit Descriptions	7-19
5.2.1 Introduction.....	7-19
5.2.2 Soil Mapping Unit 1 – Upper Slopes and Crests	7-19
“Plain English” Description:.....	7-19
5.3 Technical Description	7-19
Layer 1 - A horizon [always present] [recorded 20 cm thick].....	7-19
Layer 2 - B1 horizon [always present] [recorded 75 cm thick].....	7-20
Layer 3 – B2 horizon [always present] [recorded 15 cm thick].....	7-20
5.3.1 Soil Mapping Unit 2 – Lower Slopes and Drainage Flats	7-20
“Plain English” Description:.....	7-20
5.4 Technical Description [based on test pits].....	7-20
5.4.1 Soil Mapping Unit 3 – Gilgai Depressions and Mounds	7-23
“Plain English” Description.....	7-23
[i] Gilgai Depression	7-23
[ii] Gilgai Mound.....	7-23
Technical Description [based on test pits].....	7-23
[a] Australian Soil Classification Names – Grey Vertosol [Depression] and Brown Chromosol [Mound].....	7-23
[b] Field Description:	7-24
[i] Gilgai Depression.....	7-24
[ii] Gilgai Mound.....	7-24
5.4.2 Soil Mapping Unit 4 – Midslopes.....	7-25
“Plain English” Description.....	7-25
Technical Description [based on test pits].....	7-25
[a] Australian Soil Classification Names – Yellow Chromosol	7-25
[b] Field Description:	7-26
5.5 Soil Laboratory Analyses	7-27
5.5.1 Introduction.....	7-27
5.5.2 Soil Physical Analyses.....	7-27
5.5.3 Soil Chemical Analyses	7-28

CONTENTS

	Page
6 DISCUSSION OF SOIL ANALYSES.....	7-28
6.1 Physical Attributes	7-28
6.1.1 Particle Size Analysis	7-28
6.1.2 Dispersion Percentage	7-31
6.1.3 Emerson Aggregate Test.....	7-32
6.2 Soil Chemical Analyses	7-33
6.2.1 Soil pH.....	7-33
6.2.2 Electrical Conductivity.....	7-34
6.2.3 Likelihood of Encountering Acid Sulfate Soils	7-35
6.3 Erosion Potential	7-37
6.4 SOLOSS Program	7-37
7 STRIPPING SUITABILITY OF SOIL MATERIALS.....	7-39
7.1 Stripping Recommendations for Soil Mapping Unit 1	7-40
7.1.1 Layer 1 – Topsoil [0-15cm depth]	7-40
7.1.2 Layer 2 – Subsoil [15-65 cm depth] -	7-40
7.1.3 Layer 3 [Remainder of the Profile]	7-41
7.2 Stripping Recommendations for Soil Mapping Unit 2	7-41
7.2.1 Layer 1 – Topsoil [0-15cm depth]	7-41
7.2.2 Layer 2 – Subsoil [15-65cm depth] –	7-42
7.2.3 Layer 3 [Remainder of the Profile]	7-43
7.3 Stripping Recommendations for Soil Mapping Unit 3	7-43
7.3.1 Gilgai Depression [where depth allows conventional stripping].....	7-43
7.3.1.1 Layer 1 - Topsoil [0-15cm depth] -	7-43
7.3.1.2 Layer 2	7-44
7.3.1.3 Layer 3 [Remainder of the Profile].....	7-45
7.3.2 Gilgai Mound	7-45
7.3.2.1 Layer 1 – Topsoil [0-15cm depth].....	7-45
7.3.2.2 Layer 2 – Subsoil [15-65cm depth] -	7-46
7.3.2.3 Layer 3 [Remainder of the Profile].....	7-46
7.4 Stripping Recommendations for Soil Mapping Unit 4	7-47
7.4.1 Layer 1 – Topsoil [0-15cm depth] -	7-47
7.4.2 Layer 2 - Subsoil [15-65cm depth] -	7-47
7.4.3 Layer 3 - [Remainder of the Profile]	7-48
8 HANDLING STRIPPED SOILS	7-49
8.1 General Issues	7-49
8.2 Stripping and Stockpiling Recommendations.....	7-50
8.2.1 Earthmoving Procedures	7-50
8.2.2 Soil Conservation Measures.....	7-50
9 LAND CAPABILITY AND AGRICULTURAL LAND SUITABILITY	7-51
9.1 Land Capability.....	7-51
9.1.1 Methodology	7-51
9.1.2 Land Capability as Mapped by DNR for the Study Area	7-52
9.1.3 Current Assessment	7-53
9.2 Agricultural Land Suitability Classification.....	7-53
9.2.1 NSW Department of Primary Industries [Agriculture] Assessment.....	7-53
9.2.2 Current Assessment	7-55
10 CONCLUSION.....	7-55
11 REFERENCES	7-56

CONTENTS

	Page
APPENDICES	
Appendix 1	Profile Descriptions 7-61
Appendix 2	Topsoil Stripping Suitability Key 7-87
Appendix 3	Basis of Land Capability Classification 7-91
Appendix 4	Glossary 7-95
TABLES	
Table 1	Physical Laboratory Analysis Data for Selected Soil Profiles [Whole Soil Particle Size Analysis] 7-29
Table 2	Chemical Analyses Laboratory Analysis Data for Selected Belmont Soil Profiles 7-31
Table 3	Interpretation of Dispersion Percentage Values 7-32
Table 4	Comparison of Aggregate Dispersibility and Emerson Aggregate Classes 7-33
Table 5	Texture Class Multipliers for Calculating ECe Values 7-35
Table 6	Calculated ECe Values and Salinity Status for Selected Belmont Soil Profiles 7-36
Table 7	Soil Erodibility Values and Ratings for a Selection of Soils from the Belmont Study Area 7-39
FIGURES	
Figure 1	Locality Plan 7-10
Figure 2	Project Site Layout and Project Site Study Area 7-11
Figure 3	Soil Sampling Locations 7-16
Figure 4	Soil Mapping Units 7-18
Figure 5	Land Capability and Agricultural Land Suitability 7-54

This page has intentionally been left blank

EXECUTIVE SUMMARY

Soils within the Project Site to be disturbed by the Belmont Coal Project ("the Study Area") have been described and four Soil Mapping Units identified.

The physical and chemical attributes of the soils of the Study Area have been quantified through a combination of field assessment and laboratory testing and indicate the following.

- The soils are currently relatively stable but have a generally moderate to high erodibility rating as determined using the laboratory data obtained from samples from the Study Area in the Soilloss computer model.
- The soils have a generally high structure grade and so can be stripped and respread using scrapers.
- For all SMU's, the topsoil is favourable for use in rehabilitating the disturbed landscape and should be stripped to a depth of at least 15cm. The topsoil from the different SMU's can be mixed in stockpiles prior to replacement over the final landform.
- The subsoil of all SMU's would be favourable in rehabilitating the disturbed landscape and should be stripped to a depth of 50cm below the topsoil layer. The subsoils can be mixed in stockpiles prior to use in rehabilitation.
- The lower subsoil layers have generally high pH levels and as such would be useful in neutralising acidity [if any] that may be generated from the broken rock overburden material.
- All soils will be subject to structural degradation if worked when too moist.

Depth of stripping recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and respreading.

The pre-mining land capability (Classes III, V and VI) and agricultural land suitability (Classes 3 and 4) of the Study Area has been determined.

This page has intentionally been left blank

1 INTRODUCTION AND DESCRIPTION OF THE STUDY AREA

1.1 Introduction

This soil survey and land capability study was carried out on behalf of Whitehaven Coal Mining Pty Ltd (WCM), as part of an Environmental Assessment for a proposed open cut coal mine centered on the "Belmont" property ("the Belmont Coal Project" or "the Project"), off Wean Road approximately 25km north of Gunnedah [see **Figure 1**].

The brief for the study required the preparation of a report on:

- (i) the soils of the Project Site likely to be disturbed as a result of the proposed open cut mine and associated activities, and
- (ii) the land capability and agricultural land suitability of the Project Site.

The report was required to include sufficient level of detail to satisfy the Department of Primary Industries in relation to Mining Operations Plan guidelines and to satisfy the requirements of the Department of Water and Energy (formerly the Department of Natural Resources) specifications for soil surveys associated with proposed mining operations.

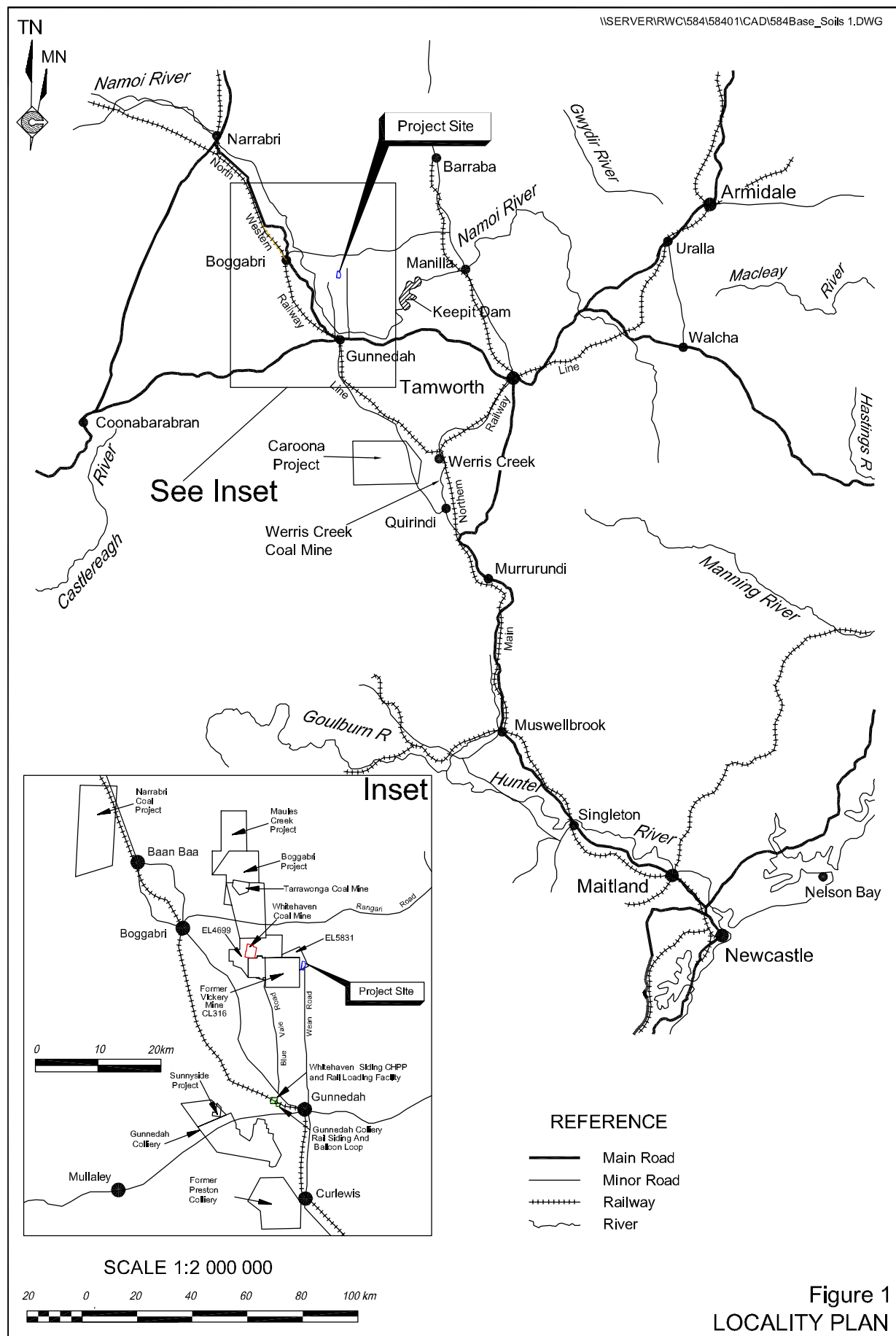
The report describes the soils based upon representative soil profiles as well as laboratory analyses of a selection of representative profiles and land capability of the Project Site.

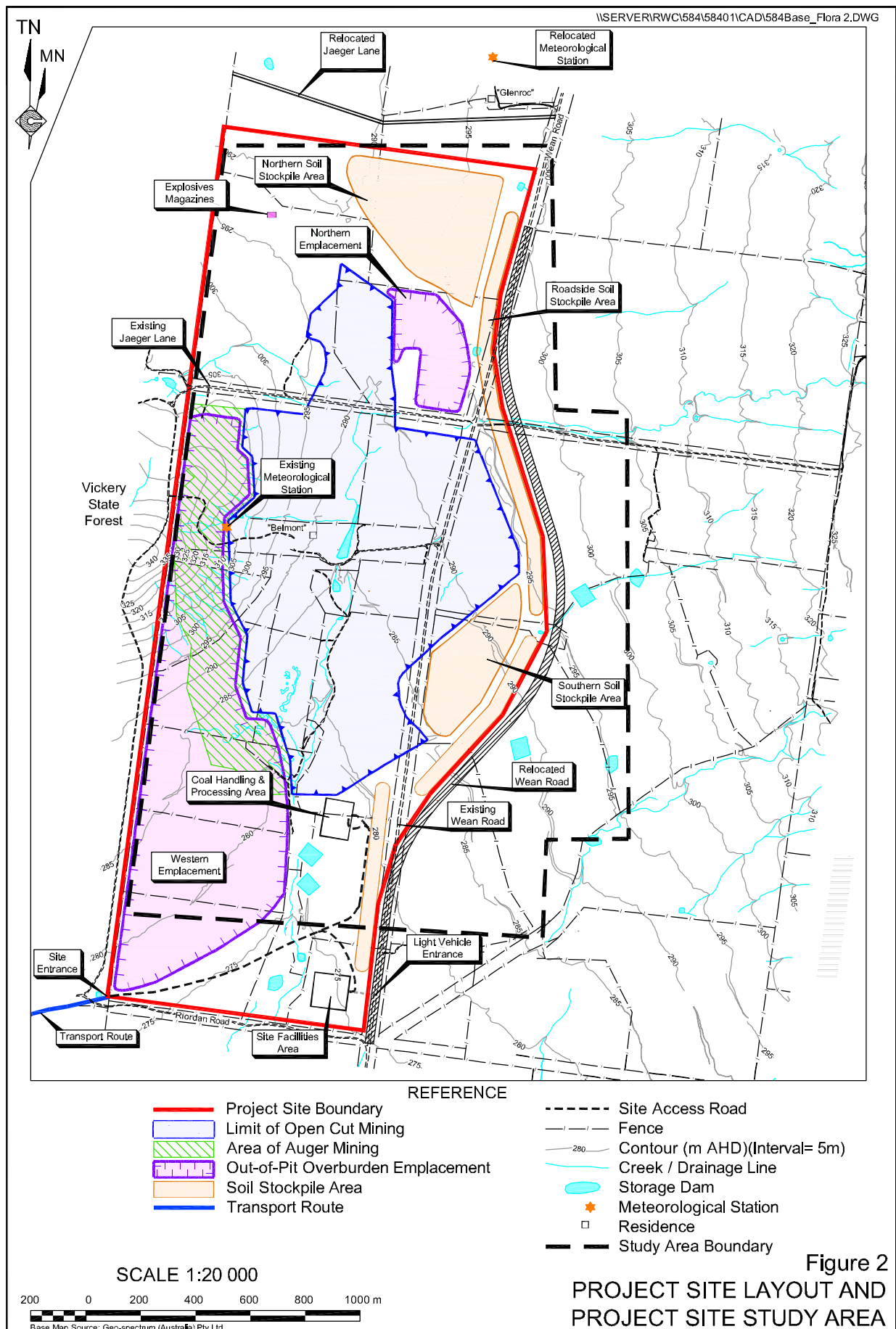
In particular, this report provides:

- the results of the field survey and laboratory testing of samples;
- a discussion of the results of field survey and laboratory physical and chemical analysis in technical as well as "Plain English" terms;
- a discussion of the stripping suitability of the soil materials identified on the Project Site;
- details of soil handling strategies and recommendations about soil stripping and stockpiling; and
- details of the land capability and agricultural suitability on the Project Site.

1.2 Description of the Study Area

The study area [see **Figure 2**] comprises those parts of the "Belmont", "Glenroc" and "Roseberry" properties that would be subject to activities associated with the proposed Belmont Coal Project ("the Project Site") along with a small sections of the "Brentry" and "Stratford" properties and road easement of Shannon Harbour Road required for the construction of a road between the Project Site and an established coal haulage route on Hoad Lane, Blue Vale Road and the Kamilaroi Highway (as currently used by coal carry trucks from the Whitehaven and Tarrawonga Coal Mines) ("the transport route"). The transport route would exit the Project Site from the southwestern corner and cross the western end of Riordan Road. A private section of road would be constructed through the "Brentry" property, along the southern edge of Vickery State Forest (1.1km). A private section of road would be constructed





Note: A Colour Version of this figure is available on the project CD

across the “Stratford” property (2.5km) to link the Riordan Road (SR 192) section of the transport route to Shannon Harbour Road (SR 93). The transport route would then incorporate a 2.5km length of an upgraded Shannon Harbour Road before intersecting with Hoad Lane (SR 95) approximately 200m north of the intersection between Hoad Lane and Braymont Road (SR 7).

The study area comprises approximately 285 hectares [see **Figure 2**].

The study area is situated in a broad valley between the hilly lands occupied by the Community Conservation Area Zone 2 – Kelvin and Vickery State Forests and occupies lands on both sides of the present alignment of the Wean Road

The study area comprises mainly open, cleared level to gently sloping country that is presently farmed and / or grazed. The remainder is timbered to varying degrees with the timber cover varying from remnant stands and areas of regeneration to scattered paddock trees.

A drainage line runs through the centre of the study area in a north - south direction. This “central drainage line”, which is aligned through the centre of the proposed limit of open cut mining, is ephemeral and only flows following periods of heavy or extended rainfall.

Small areas of the upper slopes and crests near the Vickery State Forest boundary have been used as gravel pits in the past.

2 PROJECT DESCRIPTION

The Project, if approved, would involve the following activities.

- Coal mining by open cut mining methods over the area defined by the “limit of mining” (114.1ha). The limit of open cut mining has been defined by drilling and a review of economic, geological and environmental considerations as described in Section 2.3. The area proposed for auger mining is identified beyond the western limit of open cut mining and incorporation of this into the mine plan would be determined primarily by economic factors at the time.
- Open cut mining would be by the conventional haulback method involving the sequential removal of soil and overburden / interburden materials above and within the coal seams, coal removal, and progressive backfilling and rehabilitation of the mined-out areas. Open cut mining may be supplemented by auger mining, to a distance of 200m beyond the western limit of the open cut.
- Annual ROM coal production would increase from an initial level of approximately 0.75Mtpa to a maximum annual rate of 1.5Mtpa.
- Programmed placement of overburden and interburden materials from the open cut area to a combination of out-of-pit and in-pit overburden emplacements.
- On-site size reduction of the ROM coal using a crushing plant positioned within the Coal Handling and Processing Area.
- Relocation of a section of Wean Road.
- Upgrading sections of Shannon Harbour Road and its intersection onto Hoad Lane to be incorporated into the proposed transport route.

- Transportation of coal from the Project Site to the Whitehaven CHPP for washing and/or despatch to export markets via rail to Port Newcastle. At least 85% of the Project ROM coal would require washing.
- Backloading of coarse and fine reject material from the Whitehaven CHPP for placement in the mined-out areas within the limit of mining.
- Installation of a range of services, structures and transportable buildings.
- Progressive shaping and rehabilitation of the areas of disturbance within the Project Site.

3 LITERATURE REVIEW

3.1 Gunnedah District Soil Conservation Service Technical Manual [Anon, 1976]

3.1.1 Introduction

Anon [1976] indicates that the soils within the study area are Duplex and 'Gravelly' Soils. These soil are associated with the ridges on Pilliga and Narrabeen Sandstones and the slopes of Middle Carboniferous sedimentary formations in the Wean / Kelvin area within the Gunnedah region.

3.1.2 Duplex Soils

The duplex soils exhibit a strong texture differentiation with an abrupt boundary between the A and B horizons. Normally a well developed bleached A₂ horizon is present in the profile. The B horizon is usually blocky but may be columnar in structure. The A horizon is usually neutral to slightly acid in reaction while the B horizon is alkaline to strongly alkaline.

A typical generalized profile description provided by Anon [1976] is:

- **A₁ Horizon** – loose coarse sand to massive or weakly platy loam; brownish grey, light grey-brown or reddish brown in colour; weakly differentiated from;
- **A₂ Horizon** - loose coarse sand to massive or weakly platy loam; bleached white; varying from a thin capping a few centimetres thick to a layer 40cm thick above the B horizon, above;
- **B Horizons** – sandy clay to medium clay; grey, grey-brown, yellow brown, and red-brown coloured; frequently mottled.

3.1.3 Gravelly Soils

These soils are characterized by the presence of small rounded pebbles and gravelly material throughout the profile. The surface soil is usually moderately thick and mildly acid to neutral in pH while the B horizons are alkaline with occasional carbonate nodules present.

A typical generalized profile description provided by Anon [1976] is:

- **A Horizon** – loam; grey brown to red brown; weakly structured or massive; with a fairly clear boundary to;
- **B Horizon** – well developed blocky structure.

3.2 Narrabri District Soil Conservation Service Technical Manual [Anon, 1978]

3.2.1 Introduction

Anon [1978] indicates that the soils within the study area are Solodic Soils and Brown Clays [mapped as Brown Solodic Brown Clay Complex – Type A] and Shallow Solodic Soils and Lithosols [mapped as Shallow Loams].

These soil types are briefly described as follows.

3.2.2 Brown Solodic Brown Clay Complex – Type A

These soils are formed on alluvial and colluvial material and are often hardsetting, dull brown to grey brown coloured soils. In some situations these soils may be duplex in texture with a well developed A₂ horizon, while in others the soils are hardsetting brown - grey clays.

3.2.3 Shallow Loams

These soils are associated with the areas adjoining Vickery State Forest. The soils of the ridges are usually shallow and sandy and consist basically of an A horizon containing conglomerate material throughout the horizon.

Further down the slope, sandy solonetzic soils are typical, again containing much conglomerated derived gravel material

3.3 Unpublished Information on the Soil Landscapes of the Boggabri 1: 100 000 Sheet [Banks, pers.comm.]

The area in which the Project Site is located lies within the boundaries of the Boggabri 1:100 000 scale topographic map sheet area.

Field work for a soil survey of this area is currently complete but the data has yet to be published.

However, inquiries of the Department of Natural Resources [DNR] indicate that a number of individual soil profile descriptions are available for the general area [Robert Banks, pers. comm.].

Of the six profile descriptions available from the DNR, two are from upper slope sites in Vickery State Forest and four are from lower lying valley floor sites near Wean Road in the general area of "Roseberry" homestead.

The upper slope profiles were classified as Brown Chromosols and were generally shallower [45cm - 65cm] than the valley floor profiles [120cm - 140cm].

Analyses were not available to indicate the soil surface texture in the two upper slope profiles, however the valley floor sites had silty clay loam, silty clay and medium clay textured topsoils.

Two of the valley floor soils were classified as Brown Vertosols and the remaining two as Brown Sodosols.

4 SURVEY METHODOLOGY

4.1 Airphoto Interpretation of the Landforms of the Study Area

Prior to field investigations, the study area was subjected to stereoscopic airphoto interpretation to ascertain the nature of the landforms present at the site and to develop a broad appreciation of the landform units that would require sampling.

The prints used in the stereoscopic interpretation were Run 1, Print Nos. 37 - 41 and Run 2 Nos. 42 - 46, flown on 22nd November, 2001 by GEO-Spectrum [Australia] Pty Ltd.

In addition, 1: 25 000 scale prints obtained from the Department of Land and Property Information were used to view the study area. These prints were Boggabri Run 7, Prints 167 - 172 and Run 8, Prints 141 - 144, all of which were flown on 15th August, 2001.

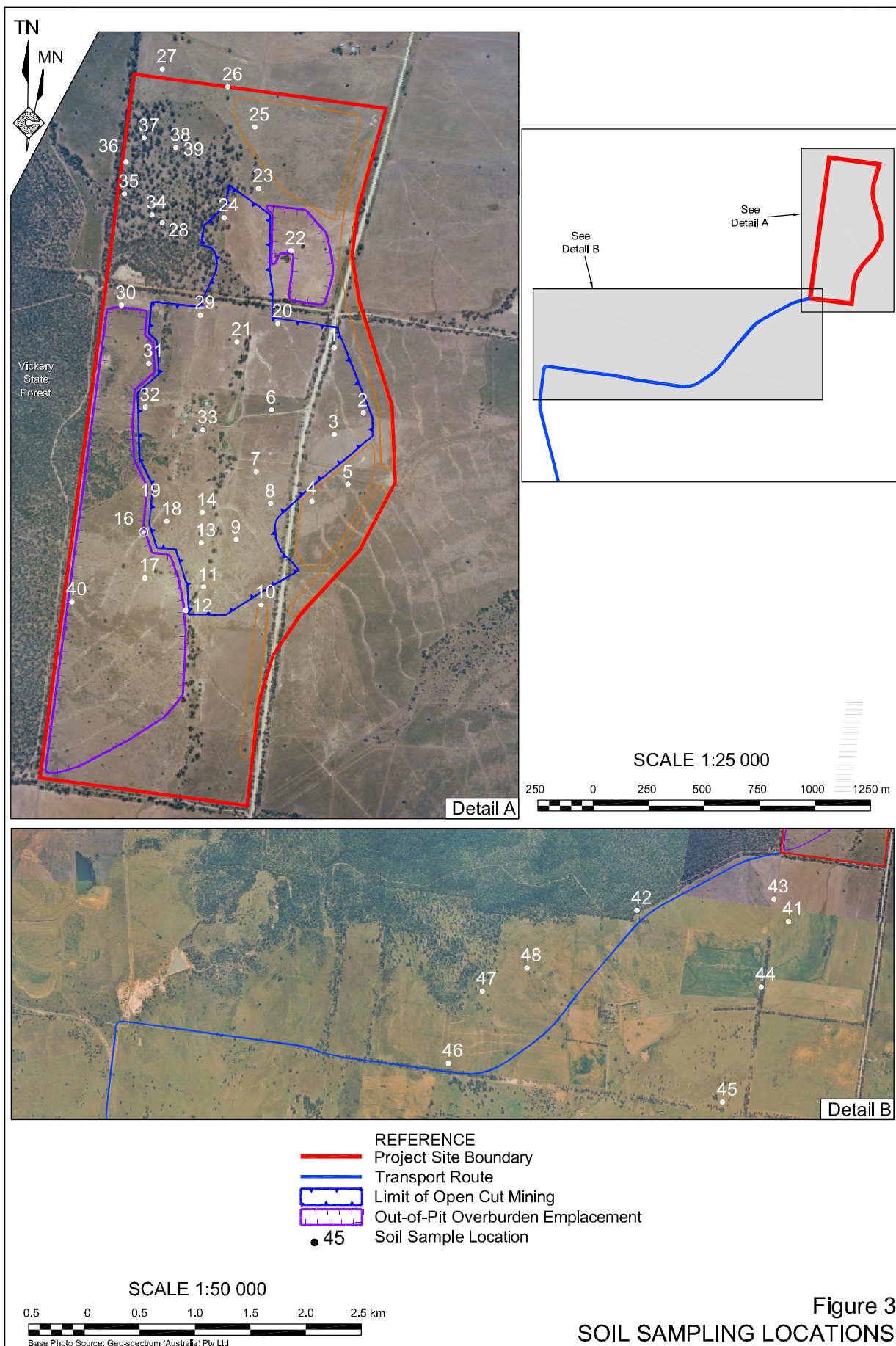
4.2 Field Procedures

Field sampling of soils was carried out on 22nd, 23rd, 24th and 25th July and 17th and 18th August, 2002 at sites representative of the different landforms and soil types that occur within the study area.

Sampling involved the complete description of forty profiles exposed in pits to a depth of 2.5m or the depth of backhoe refusal. The locations of the soil sampling sites within the study area are shown in **Figure 3**.

For each test profile [site] described, details of the following soil properties were noted.

- | | |
|--------------------------|---------------------------|
| • Texture | • Gravel/stone occurrence |
| • Fabric | • Presence of roots |
| • Structure | • Presence of lime |
| • Consistence | • Presence of manganese |
| • Boundary sharpness | • pH |
| • Colour [moist and dry] | |



Note: A Colour Version of this figure is available on the project CD

Soil pH was measured using the Raupach method [Raupach indicator and barium sulphate]. Soil colour [moist and dry] was determined using Munsell soil colour charts [Macbeth, 1992]. The classification of the soils that were described was based on Isbell [1996].

In determining the soil classifications the CD-ROM titled "The Australian Soil Classification - An Interactive Key" [Jacquier et al, 2001] was used.

The information obtained was recorded in a form that is compatible with that required for entry on soil data cards used in the DIPNR's SPADE Soil Database.

Samples from all layers in four profiles [Nos. 2, 6, 9 and 12] were forwarded to the Department of Lands' NATA - registered soil testing laboratory at Scone for more detailed analysis to determine the following properties.

- Range of particle size [particle size analysis].
- Dispersion percentage.
- Coherence [Emerson aggregate test].
- Electrical conductivity.

4.3 Soil Stripping Suitability

The stripping suitability of the soils at the sites sampled using the backhoe pits was determined on the basis of the procedure outlined by Elliott and Veness [1981].

From the data gained in this process, recommendations on the depths of topsoil and subsoil stripping were developed.

5 RESULTS

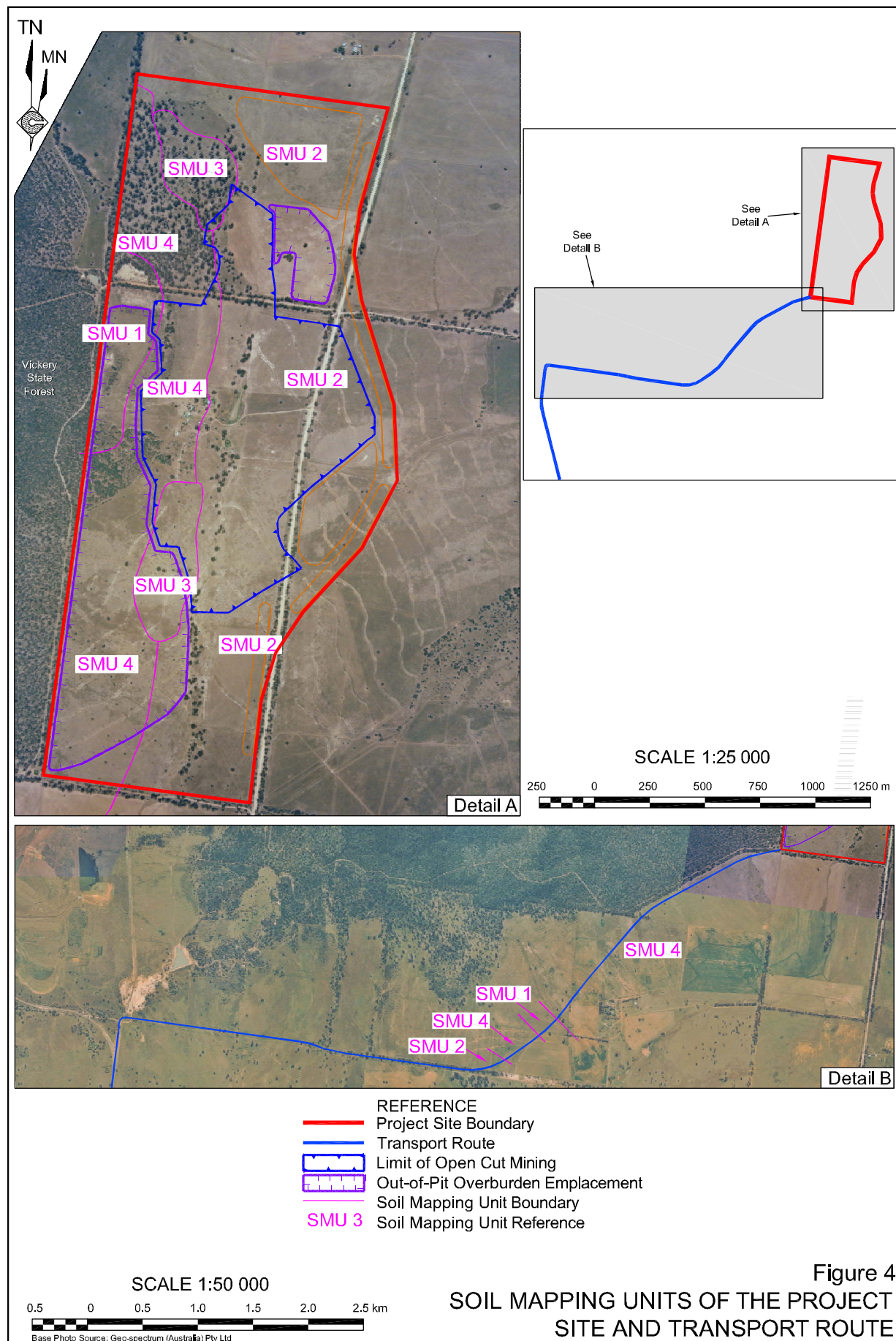
5.1 Soil Mapping Units

From the information gained from both the detailed soil profile descriptions four Soil Mapping Units [SMUs] were identified.

These SMUs and their general location are as follows.

- **Soil Mapping Unit 1** - upper slopes and crests.
- **Soil Mapping Unit 2** - lower slopes and drainage flats.
- **Soil Mapping Unit 3** - gilgai depressions and mounds.
- **Soil Mapping Unit 4** - mid-slopes.

The soil mapping unit boundaries are shown in **Figure 4**.



It is important to note that not all soil layers described for each of the Soil Mapping Units are present in every profile. Soils are inherently variable in nature and while they may have similar overall characteristics they may vary in layer detail and properties.

Appendix 1 contains detailed information on the layers present in the forty pits that were described in detail.

5.2 Soil Mapping Unit Descriptions

5.2.1 Introduction

Descriptions of the layers found in the profiles of the four SMUs identified within the study area are set out below.

In each case, the soil within each unit is described in two ways – a “Plain English” version followed by a technical description.

Definitions of the technical terms used in the descriptions can be found in McDonald et al [1990] or Houghton and Charman [1986].

5.2.2 Soil Mapping Unit 1 – Upper Slopes and Crests

“Plain English” Description:

Soil about 110cm deep, surface hardsetting; medium levels of large surface stone.

Topsoil - light to medium clay soil about 20cm deep; pH 6.5; roots common; gravel within the profile; greyish brown colour, well structured.

Subsoil - two layers recorded between 15cm and 75cm deep; both heavy clay in texture; small gravel and stones present; pH 9.0 to 9.5; well structured; upper horizon greyish brown in colour; lower horizon mottled light grey / light brownish grey.

Overlies - weathered conglomerate.

5.3 Technical Description

[a] Australian Soil Classification Names – Grey Chromosol

[b] Field Description:

Layer 1 - A horizon [always present] [recorded 20 cm thick]

Light to medium clay, pH 6.5, surface hardsetting, surface stone levels medium, to 10cm, rounded, contains small gravel; roots common; dark greyish brown [10YR4/2] dry, very dark greyish brown [10YR3/2] moist; peds rough, highly pedal [100%], polyhedral, 5-15mm; strong consistence [airdry]; coherent; *clear to*:

Layer 2 - B1 horizon [always present] [recorded 75 cm thick]

Heavy clay; pH 9.0; roots few; small gravel to 5mm; greyish brown [10YR5/2] dry, dark greyish brown [10YR4/2] moist; peds rough / smooth, highly pedal [100%], polyhedral, 5-10mm; very firm to strong consistence [airdry]; coherent; *gradual to*:

Layer 3 – B2 horizon [always present] [recorded 15 cm thick]

Heavy clay; pH 9.5; stones to 5cm x 4cm smooth, flattish and rounded; roots few; mottled 50% light grey [10YR7/2], 50% light brownish grey [10YR6/2] dry; 50% very pale brown [10YR7/3], 50% greyish brown [10YR5/2] moist; peds rough, highly pedal [100%], polyhedral, 5-15mm; strong consistence [airdry]; coherent; *clear to weathered conglomerate*.

5.3.1 Soil Mapping Unit 2 – Lower Slopes and Drainage Flats

“Plain English” Description:

Soil recorded to be from 173 to 290cm+ deep as excavated; surface condition soft, loose, firm, hardsetting to almost self mulching; surface stone usually absent, sometimes some to much surface stone present, 5-12cm, angular, blocky or rounded

Topsoil - 10 - 30 cm deep; sometimes consisting of three layers

sandy clay loam, silty clay loam, clay loam, fine sandy loam, light clay, light to medium clay, loam fine sandy, medium clay, medium to heavy clay textured; roots common to many; no lime present; no manganese present; usually pH 5.0 to 6.5, sometimes 7.0 to 8.5; gravel and stone usually absent, sometimes grit or gravel to 4cm present; variously brown and grey coloured; well structured, sometimes hydrophobic or almost so.

Subsoil - up to 280cm+ deep; consisting of many layers. Some profiles contained up to nine distinct subsoil layers.

The B horizons were generally medium to heavy clay textured with some occurrences being gritty, occasional sandy layers present; pH generally in the 9.0 to 9.5 range although occasional readings of 7.0 to 8.5 were recorded; colours generally shades of brown [pale brown, brown, light brown] or grey [light brownish grey, dark grey, light grey, pinkish grey]; roots more common in the upper layers but decreasing to absent below about 150cm depth; usually well structured, occasionally massive

5.4 Technical Description [based on test pits]

[a] Australian Soil Classification Names – Grey Dermosol

[b] Field Description:

Layer 1 – always present [recorded 10-30cm thick] - sandy clay loam, silty clay loam, clay loam, fine sandy loam, light clay, light to medium clay, loam fine sandy, medium clay, medium to heavy clay textured; roots common to many; no lime present; no manganese present; usually pH 5.0 to 6.5, sometimes 7.0 to 8.5; gravel and stone usually absent, sometimes grit or

gravel to 4cm present; not mottled not bleached; brown [7.5YR4/3, 7.5YR5/2, 10YR5/3], dark grey [7.5YR4/1], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], light yellowish brown [10YR6/4], pale brown [10YR6/3], pinkish grey 7.5YR7/2] dry; brown [7.5YR4/2, 7.5YR4/3], dark brown [10YR3/2, 7.5YR3/3], dark grey [10YR4/2], dark greyish brown [10YR4/2], very dark grey [7.5YR3/1, 7.5YR5/1], very dark greyish brown [10YR3/2] moist; peds usually rough-faced, sometimes rough- / smooth-faced; highly pedal [100%]; usually polyhedral, sometimes ABL, SABL or almost platy; <5-25cm in size; weak to strong consistence dry, usually firm; sometimes hydrophobic or almost so; *sharp, abrupt or clear to:-*

Layer 2 –always present [recorded 6-83cm thick] - clay loam, silty clay loam, light clay, light to medium clay, medium to heavy clay, sandy clay, sandy light clay, sandy light to medium clay, silty clay, heavy clay; roots usually common, sometimes few or many; usually no lime present, occasionally some flecks and nodules; no manganese present; pH 6.0 to 9.5-10; gravel and stone absent or some to much gravel 1-5cm present; **usually not mottled**; occasionally bleached; dark brown [7.5YR3/2], dark grey [7.5YR4/1], dark greyish brown [10YR4/2], dark reddish grey 5YR4/2, brown [7.5YR4/2, 7.5YR5/2], greyish brown [10YR5/2], pinkish grey [7.5YR5/2], light brownish grey [10YR6/2], pinkish grey [7.5YR6/2, 7.5YR7/2], light grey [10YR7/2] dry; brown [10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3], dark brown [7.5YR3/2, 7.5YR3/3], dark grey [7.5YR4/1], dark greyish brown [10YR4/2], dark reddish brown [5YR3/2], greyish brown [10YR5/2], very dark greyish brown [10YR3/2] moist; **rarely mottled** in colours of brown [7.5YR5/3], strong brown [7.5YR5/6] dry; dark brown [7.5YR3/2], brown [7.5YR4/4] moist; peds rough-faced, smooth-faced or rough- / smooth faced; highly pedal [100%], rarely weakly pedal [10%], polyhedral [occasionally SABL], <5-25mm in size; firm very firm or strong consistence dry; not hydrophobic; *abrupt, clear, gradual or diffuse to:-*

Layer 3 [always present] [recorded 16-140cm thick] - clayey sand, loam fine sandy, medium clay, medium to heavy clay [sometimes gritty], heavy clay; roots few, sometimes absent or common; lime absent or some to much present as flecks or nodules; manganese stains rarely present; pH 7.0 to 9.5-10; gravel and stone absent or some to much gravel 1-5cm present; not mottled; not bleached; brown [7.5YR4/3, 7.5YR5/3, 10YR5/3], greyish brown [10YR5/2], light brownish grey [10YR6/2], light greyish brown [10YR6/2], pinkish grey [7.5YR6/2], pale brown [10YR6/3], light brown [7.5YR6/3], light grey [10YR7/2], very pale brown [10YR7/3] dry; brown [10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/2, 7.5YR5/3, 10YR4/3] moist; dark greyish brown [10YR4/2], dark reddish grey [5YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], pale brown [10YR6/3], pinkish grey [7.5YR5/2], reddish brown [5YR4/3], very dark greyish brown [10YR3/2] moist; peds rough-faced or rough- / smooth faced, highly pedal [100%], usually polyhedral, sometimes ABL, SABL, platy; generally <5-20mm in size; firm to strong consistence dry; not hydrophobic; *abrupt, clear, gradual or diffuse to:-*

Layer 4 – [always present] [recorded 22-148cm thick] - sand; clayey sand, light to medium clay, medium to heavy clay, heavy clay, sandy clay [many clays often gritty]; roots few often absent; lime absent or some to many lime flecks and nodules evident; usually no manganese present, occasionally manganese stains common; pH commonly 9.5-10, sometime as low as 7.5; usually gravel to 2-10cm is very common as the whole layer or in pockets, sometimes gravel and stones absent; **usually not mottled**; not bleached; brown [7.5YR5/3], greyish brown [10YR5/2], light brownish grey [10YR6/2], pinkish grey [7.5YR6/2], pale brown [10YR6/3], light brown [7.5YR6/3, 7.5YR6/4], light grey [10YR7/2],

light yellowish brown [10YR6/4], very pale brown [10YR7/3] dry; brown [10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/2, 7.5YR5/3, [7.5YR5/4], dark grey [10YR4/1], light brown [7.5YR6/4], light brownish grey [10YR6/2], pale brown [10YR6/3], pinkish grey [7.5YR6/2], reddish grey [5YR5/2] moist; **rarely mottled** in colours of light brown [7.5YR6/3], brown [7.5YR4/4] dry and whole coloured brown [7.5YR4/3] moist; sometimes massive; usually well structured, peds rough-faced or rough- / smooth faced, occasionally smooth- faced, highly pedal [100%], occasionally moderately pedal [60%], polyhedral, occasionally platy, ABL or SABL; <5-20mm in size; very firm to strong consistence dry; not hydrophobic; *where further layers exist sharp, abrupt, clear or diffuse to:-*

Layer 5 – [often present] [recorded 5-124cm thick] – clayey sand, light sandy clay loam, sandy clay loam, medium clay, medium to heavy clay, heavy clay [clays often sandy or gritty]; roots usually absent, sometimes few present; lime often present as flecks and nodules, sometimes absent; manganese absent, sometimes much staining present; pH usually 8.0-10, occasionally 5.5; gravel and stone absent or varying amounts of gravel present, <1-5cm; usually not mottled; not bleached; brown [10YR5/3, 7.5YR5/3], light brownish grey [10YR6/2], pinkish grey [7.5YR6/2], pale brown [10YR6/3], light brown [7.5YR6/3, 7.5YR6/4], pinkish grey [7.5YR7/2], pink [7.5YR7/3] dry; brown [10YR5/3, 7.5YR4/4, 7.5YR5/2, 7.5YR5/3, 10YR5/3], light brown [7.5YR6/3], pale brown [10YR6/3], reddish brown [5YR4/3], yellowish brown [10YR5/4] moist; **occasionally mottled** in colours of light brownish grey [10YR6/2], brown [10YR5/3] dry, light brownish grey [10YR6/2], brown [10YR5/3] moist, peds rough-faced, smooth- faced or rough- / smooth-faced, highly pedal [100%], usually polyhedral, sometimes ABL, SABL or platy, <5-25 mm in size; very firm to strong consistence dry; *abrupt, clear, gradual or diffuse [where further horizons exist] to:-*

Layer 6 - [occasionally present] [recorded 30-116cm thick] – silty clay, gritty medium to heavy clay, o heavy clay; roots absent, occasionally few; much lime present, manganese absent or generally much present; pH 9.5-10, occasionally 8.5; grit and gravel present or absent ; not mottled; not bleached; greyish brown [10YR5/2], pale brown [10YR6/3], light brown [7.5YR6/3] very pale brown [10YR7/3] dry, pale brown [10YR6/3], brown [7.5YR4/3, 10YR5/3] moist; peds rough-faced or peds rough- / smooth-faced, highly pedal [100%], polyhedral [rarely ABL or SABL], <5-15mm in size; very firm to strong consistence dry; not hydrophobic; *abrupt, where lower horizons exist, to:-*

Layer 7 [rarely present] [recorded 20-40cm thick] – clayey sand or gritty clay [cemented sand]; roots few to absent; lime present or absent, no manganese present; pH 8.0-9.5; not bleached; **whole coloured** light grey [2.5YR7/1] dry, brown [10YR5/3] moist; or **mottled** in colours of light brownish grey [10YR6/2], brown [7.5YR5/2] dry, whole coloured brown [7.5YR5/3] moist; peds rough-faced, moderately pedal [50%] to highly pedal [100%], SABL, 5-15mm in size; firm to strong consistence dry; not hydrophobic; *abrupt, where lower horizons exist, to:-*

Layer 8 [rarely present] [recorded 30cm thick] - sandy medium clay; roots absent; no free lime present; manganese present; pH 9.5; grit plus gravel flat and rounded to 8cm common; not mottled; not bleached; light brownish grey [10YR6/2] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

Layer 9 [rarely present] [recorded 20cm thick] – sandy medium clay; roots absent; lime present; manganese present; pH 9.0; grit plus gravel to 4cm common; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Layer 10 – [rarely present] [recorded 70cm+ thick] - sandy medium clay; roots absent; lime present; manganese present; pH 9.0-10; some gravel to 3cm; not mottled; not bleached; greyish brown [10YR5/2] dry, light brownish grey [10YR6/2] moist; peds smooth-faced, highly pedal [100%], ABL, 10-20mm in size; strong consistence dry; not hydrophobic.

5.4.1 Soil Mapping Unit 3 – Gilgai Depressions and Mounds

“Plain English” Description

[i] Gilgai Depression

Soil sampled to 270cm depth, surface soft to self mulching; surface stone uncommon or absent

Topsoil – sandy clay loam to heavy clay soil about 20cm deep; pH 5.0-6.0; roots common; manganese staining sometimes present; some gravel within the profile; grey colour, well structured.

Subsoils up to 250cm deep; consisting of about three to five layers that are generally medium to heavy clay textured [sometimes gritty or sandy]; pH 5.5 to 6.0 closer to the surface and 9.5 at depth, light grey, grey, dark grey or greyish brown coloured; roots few to common in the upper layers, absent at depth; well structured

Overlying - soil material that extends below the base of the excavation

[ii] Gilgai Mound

Soil sampled to 252cm depth, surface soft to self mulching; surface stone present or absent.

Topsoil - clay loam to sandy light clay up to 25cm deep; pH 5.0 to 8.0; roots common to many; gravel common; brown to greyish brown colour, well structured

Subsoils up to 230cm deep; consisting of three or four layers; generally medium to heavy clay textured [sometimes gritty]; pH 8.5 to 10.0; brown or brownish grey coloured; roots few to common in upper layers, absent to few at depth; containing lime nodules and stains and manganese stains [at depth] ; well structured

Overlying - soil material that extended below the base of the excavation

Technical Description [based on test pits]

[a] Australian Soil Classification Names – Grey Vertosol [Depression] and Brown Chromosol [Mound]

[b] Field Description:

[i] Gilgai Depression

Layer 1 - A horizon [always present] [recorded 20cm thick] - sandy clay loam to clay loam or heavy clay; many roots; no lime present; manganese stains present; pH 5.0 to 6.0; occasional to moderate amounts of gravel, <1-3cm; not mottled; not bleached; grey [10YR6/1], dark grey [7.5YR4/1] dry, very dark greyish brown [10YR3/2], very dark grey [7.5YR3/1] moist; peds smooth-faced or rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; sometimes hydrophobic; *clear to*:-

Layer 2 - B1 horizon [always present] [recorded 32-43cm thick] - sandy clay to heavy clay; roots few to common; lime flecks present; no manganese present; pH 5.5 to 9.5; some rounded or angular gravel to 4cm; not mottled; not bleached; grey [10YR4/1], dark grey [10YR4/1] dry, grey [10YR4/1], very dark grey [10YR3/1] moist; peds rough- / smooth-faced or rough-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistence dry; not hydrophobic; *clear to*:-

Layer 3 - B2.1 horizon [sometimes present] [recorded 57-118cm thick] - medium to heavy clay [sometimes gritty]; roots few; no lime present or absent; no manganese present; pH 6.0 to 9.0; gravel to 2cm present, often in lenses; not mottled; not bleached; dark grey [7.5YR4/1] dry, very dark grey [7.5YR3/1, 10YR3/1] moist; peds rough- / smooth-faced or rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong to very strong consistence dry; not hydrophobic; *clear to*:-

Layer 4 - B2.2 horizon [sometimes present] [recorded 60cm thick] - gritty heavy clay; roots few; lime present; no manganese present; pH 9.0; some gravel to 1.5cm; not mottled; not bleached; light greyish brown [10YR6/2] dry, dark grey [10YR4/1]; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *diffuse to*:-

Layer 5 - B2.3 horizon [sometimes present] [recorded 50cm thick]; heavy clay; roots absent; lime present; no manganese present; pH 9.0; some gravel to 1.5cm; not mottled; not bleached; light grey [10YR7/2] with grey [10YR5/1] skins dry, light grey [10YR7/2] with dark grey [10YR4/1] skins moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *diffuse to*:-

Layer 6 - B3 horizon [always present] [recorded 60-70cm thick] - sandy clay or gritty heavy clay; roots absent; visible lime present or absent; no manganese present; pH 9.0 – 9.5; some gravel to 2cm [sometimes in lenses]; not mottled; not bleached; greyish brown [10YR5/2] or light grey [10YR7/2] with grey [10YR5/1] skins dry, grey [10YR5/1] or light grey [10YR7/2] with dark grey [10YR4/1] skins moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic.

[ii] Gilgai Mound

Layer 1 - A horizon [always present] [recorded 18-25cm thick] - clay loam to sandy light clay; roots common to many; lime present or absent; no manganese present; pH 5.0 to 8.0; gravel to 5cm common; not mottled; not bleached; brown [7.5YR5/3], greyish brown [10YR5/2] dry,

very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; firm to strong consistence dry; hydrophobic or slightly so; *abrupt to clear or gradual to:-*

Layer 2 - B1 horizon [always present] [recorded 43-62cm thick] - medium to heavy clay; roots few to common; much lime present; no manganese present; pH 9.5-10; some gravel, not mottled; not bleached; brown [7.5YR5/3], light greyish brown [10YR6/2] dry, brown [7.5YR4/3], light greyish brown [10YR6/2] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; very firm to strong consistence dry; hydrophobic or not hydrophobic; *clear to gradual to:-*

Layer 3 - B2 horizon [sometimes present] [recorded 82cm thick] - slightly gritty medium to heavy clay; roots few; lime flecks present; no manganese present; pH 9.5-10; rounded gravel to 5cm common; not mottled; not bleached; light brownish grey [10YR6/2] dry, greyish brown [10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

Layer 4 - B3 horizon [always present] [90-182cm thick] - heavy clay; roots absent to few; lime absent or much lime present at base; manganese common; pH 8.5 to 9.5-10; gravel and stones absent; not mottled; not bleached; greyish brown [10YR5/2], greyish brown [2.5Y5/2], light brownish grey [10YR6/2] dry, light brownish grey [10YR6/2] moist, peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic.

5.4.2 Soil Mapping Unit 4 – Midslopes

“Plain English” Description

Soil - recorded from 50cm to 250cm+ deep; *surface condition soft, loose, firm or almost self mulching, occasionally hardsetting; surface stone absent or some to much rounded and angular surface stone.*

Topsoil – 12-24cm deep, sandy loam; loam fine sandy, silty clay loam, fine sandy clay, loam sandy clay loam, light clay, light to medium clay in texture; often a bleached A2 horizon is present; roots common to many; no lime present; no manganese present; pH 5.5 to 7.0; gravel and stones absent or some to much rounded or angular gravel, 1-5cm, present; not mottled; not bleached; generally brown or greyish brown coloured; moderately to highly structured; sometimes hydrophobic.

Subsoil – up to 240cm thick; generally clay textured; gravel often present; lime usually present; pH often in the 9.5-10 range; generally coloured in various shades of brown; usually not mottled; generally well structured; not hydrophobic.

Technical Description [based on test pits]

[a] Australian Soil Classification Names – Yellow Chromosol

[b] Field Description:

[Note: because of the alluvial nature of much of the material comprising the soils of this SMU, and the presence of buried soils, it has not been possible to assign horizon designations. Instead the soils are described in terms of layers]

Layer 1 – A1.1 horizon [always present] [recorded 12-24cm thick] - sandy loam; loam fine sandy, silty clay loam, fine sandy clay, loam sandy clay loam, light clay, light to medium clay; roots common to many; no lime present; no manganese present; pH5.5 to 7.0; gravel and stones absent or some to much rounded or angular gravel, 1-5cm, present; not mottled; not bleached; brown [10YR5/3, 7.5YR4/2, 10YR5/2, 10YR5/3], dark greyish brown [10YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/4] dry; brown [7.5YR4/3], dark brown [7.5YR3/2], dark greyish brown [10YR4/2], dark reddish brown [5YR3/2, 5YR3/3], very dark grey [7.5YR3/1], very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%] occasionally moderately pedal [40-60%], usually polyhedral, rarely SABL, <5-25mm in size; firm to strong consistence [occasionally weak] dry; hydrophobic or not hydrophobic; *usually clear [sometimes abrupt] to:-*

Layer 2 - A1.2 horizon [often present] [recorded 10-47cm thick] [almost an A2 horizon] - loam fine sandy, fine sandy clay loam; sandy clay loam or clayey sand; roots common to many; no lime present; no manganese present; pH6.0 to 7.0; usually some gravel to 2cm present, occasionally almost entirely rounded gravel to 5cm; not mottled; not bleached; light brown [7.5YR6/3], pink [7.5YR7/4], pinkish grey [7.5YR6/2] dry; brown [7.5YR4/4], dark brown [7.5YR3/2], dark reddish brown [5YR3/2], reddish brown [5YR4/4] moist; sometimes massive, usually peds rough-faced, highly pedal [80-100%], polyhedral [occasionally SABL], <5-15mm in size; firm to very firm consistence dry; not hydrophobic; *abrupt to clear to:-*

Layer 3 – A2 horizon [sometimes present] [recorded 15-44cm thick] - loam fine sandy, sandy loam, sandy clay, sandy clay loam or clayey sand; roots few to common; no lime present; no manganese present; pH 5.0 to 7.0; some to much rounded or angular gravel to 2cm; not mottled; bleached; light grey [10YR7/2], pink [7.5YR7/3, 7.5YR7/4, 7.5YR8/3], pinkish white [7.5YR8/2] dry; brown [7.5YR5/4], pale brown [10YR6/3], light brown [7.5YR6/3] moist; massive between gravel ; or peds rough-faced, highly pedal [100%], polyhedral to SABL, 5-20mm in size and firm to strong consistence dry; rarely hydrophobic; *abrupt, clear or diffuse to:-*

Layer 4 – B1 horizon [mostly present] [recorded 11-135cm thick] - clayey sand; light clay , medium to heavy clay, sandy medium clay or heavy clay; roots few to common; lime nodules sometimes present; no manganese present; pH 7.0 to 9.5-10; some gravel to 10cm; usually not mottled; not bleached; dark greyish brown [10YR4/2], brown [7.5YR4/2, 7.5YR4/3], greyish brown [10YR6/3], pale brown [10YR6/3] dry, dark brown [7.5YR3/2], brown [7.5YR4/2, 10YR5/3, 7.5YR5/4], yellowish brown [10YR5/4] moist; occasionally mottled in colours of very pale brown [10YR7/3], light yellowish brown [10YR6/4] dry, yellowish brown [10YR5/4], brown [7.5YR5/4] moist; occasionally massive; usually peds smooth-faced, rough-faced, or peds rough- / smooth-faced, highly pedal [100%], polyhedral [occasionally ABL], <5-15mm in size; strong consistence dry; not hydrophobic; *abrupt, clear gradual or diffuse to:-*

Layer 5 – B2.1 horizon [often present] [recorded 29-52cm thick] - medium to heavy clay, sandy clay, heavy clay; roots few; usually much lime present; manganese absent or present; pH 7.0 to 9.5-10; gravel to 3cm usually common, sometimes absent; not bleached; usually not mottled

brown [7.5YR5/2] dry, greyish brown [10YR5/2], pale brown [10YR6/3] dry, brown [10YR5/3], greyish brown [10YR5/2] moist; sometimes mottled in colours of light greyish brown [10YR6/2], greyish brown [10YR6/3], very pale brown [10YR7/3], reddish yellow [7.5YR7/6] dry, brown [10YR5/3], greyish brown [10YR5/2], reddish yellow [5YR6/6] moist; peds rough-faced, smooth-faced, or rough- / smooth-faced, highly pedal [100%], polyhedral [occasionally SABL], 5-20mm in size; very firm to strong consistence dry; not hydrophobic; *clear gradual or diffuse to:-*

Layer 6 - B2.2 horizon [occasionally present] [recorded 84-98cm thick] - heavy clay, sometimes gritty; roots few to absent; some to much lime present; manganese concretions present or absent; pH 6.5 to 9.5; some rounded and angular gravel to 4cm, sometimes in lenses; not mottled; not bleached; brown [7.5YR5/3], light brown [7.5YR6/4] dry, brown [7.5YR5/3, 7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual or -diffuse to:-*

Layer 7 B3 horizon [always present] [recorded 5-156cm thick] - sand, sandy clay, clayey sand, medium clay, medium to heavy clay or heavy clay [sometimes gritty]; roots usually absent, sometimes few; usually no lime present, occasionally much; usually no manganese present, occasionally much staining; pH 5.0 to 8.0, sometimes pH 9.5-10; gravel and stones absent or some gravel <1-3cm present, sometimes weathering rock present; not bleached; usually whole coloured; brown [7.5YR5/2], light brown [7.5YR6/3], light yellowish brown [10YR6/4], pale brown [10YR6/3], pink [7.5YR8/3, 7.5YR8/4], very pale brown [10YR7/3] dry; brown [10YR5/2, 10YR5/3], light brown [7.5YR6/4], pale brown [10YR6/3] moist; sometimes mottled in colours of brown [7.5YR5/3], light brown [7.5YR6/4], light reddish brown [5YR6/4], pale brown [10YR6/3], pink [7.5YR7/3], pinkish grey [7.5YR7/2] dry; brown [10YR5/3, 7.5YR5/3], pinkish grey [7.5YR6/2], reddish brown [5YR5/4] moist; occasionally massive; usually well structured, peds rough- / smooth-faced, smooth-faced or rough-faced, highly pedal [100%], polyhedral [occasionally ABL or SABL], 5-25mm in size; firm to strong consistence dry; not hydrophobic.

5.5 Soil Laboratory Analyses

5.5.1 Introduction

33 samples from seven soil profiles were selected for laboratory analysis at the Department of Lands Soil and Water testing Laboratory at Scone.

Samples from one profile from within SMU 1, three from SMU 2, two from SMU 3 and one from SMU 4 were analysed in the laboratory.

5.5.2 Soil Physical Analyses

The tests performed which were aimed at assessing the potential erodibility of the soils and included:

- Particle Size Analysis (PSA);
- Dispersion % (D%);

- Emerson Aggregate Test (EAT); and
- Electrical Conductivity (EC).

Table 1 present the results obtained from laboratory analysis of the samples from the seven pits within the study area.

5.5.3 Soil Chemical Analyses

Laboratory testing of the Belmont samples extended only to an examination of the soil pH and electrical conductivity. The results of the analyses are contained in **Table 2**.

6 DISCUSSION OF SOIL ANALYSES

6.1 Physical Attributes

The laboratory analysis results contained in **Table 1** are important in assessing the erodibility of the soil units found within the study area.

The three tests [Particle Size Analysis, Dispersion %, Emerson Aggregate Test] carried out on samples from each of the horizons within the seven selected soil profiles, when considered together, provide a good indication of the soil's likely behaviour in relation to the erosive forces encountered in the field.

6.1.1 Particle Size Analysis

The Particle Size Analysis [PSA] test shows the amounts of gravel, clay, silt, fine sand and coarse sand contained within each sample.

The results shown in **Table 1** are those contained in the laboratory test report.

From this data it is evident that:

- the soils in SMU 1 contain little gravel throughout the profile.
- topsoil gravel content is moderate in SMU 2 although some profiles contain high levels [up to 71%] at depth.
- in SMU 3, gravel levels are variable with some layers containing moderate to high level; and
- SMU 4 contains moderate levels of gravel in the topsoil and upper subsoil.

The texture class of each soil layer is determined by analysis of the material [fine earth fraction] that is less than 2mm in size – ie. the sample from each tested horizon with the gravel removed. The calculated texture of the fine earth fraction of each of the layers tested in the laboratory is shown in **Table 1**.

Table 1
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

Page 1 of 2

SMU PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
SMU 1 [SITE 30]	1	clay loam	0 – 20	34	21	33	11	44	1
	2	clay	20 – 95	54	15	21	8	29	2
	3	clay loam	95 – 110	30	14	42	12	54	2
SMU 2 [SITE 3]	1	clay	0 – 20	42	19	28	8	36	3
	2	clay	20 – 90	61	14	16	6	22	3
	3	clay	90 – 110	38	19	26	15	41	2
	4	sand	110 - 180	2	1	7	23	30	67
	5	loamy sand	180 - 210	8	15	37	40	77	0
SMU 2 [SITE 20]	1	loam/loamy sand	0 – 18	13	24	36	20	56	7
	2	loam/silty loam	18 – 38	15	25	39	20	59	1
	3	clay loam	38 – 80	34	21	32	13	45	<1
	4	sandy loam	80 – 111	4	3	8	14	22	71
	5	silt loam	111 - 141	16	29	37	17	54	1
	6	clay loam	141 - 257	27	13	36	22	58	2
SMU2 [SITE 24]	1	loam	0 – 17	15	18	39	23	62	5
	2	clay	17 – 40	41	17	23	12	35	7
	3	clay	40 – 126	37	10	23	12	35	18
	4	clay	126 - 240	36	15	27	12	37	10
SMU 3 [SITE18]	1	silty clay loam	0 – 20	32	32	27	7	34	2
	2	silty clay loam	20 - 63	30	28	29	9	38	4
	3	silt loam	63 – 120	25	33	28	10	38	4
	4	clay loam	120 - 160	20	11	15	23	38	31
	5	clay loam	160 - 210	33	21	26	20	46	<1
	6	loam	210 - 270	16	11	24	47	71	2
SMU 3 [SITE 19]	1	sandy loam	0 – 18	9	5	28	15	43	43
	2	clay	18 – 80	31	10	23	19	42	17
	3	loam/clay loam	80 – 162	11	8	15	15	30	51
	4	clay	162 - 252	43	20	23	12	35	2
SMU 4 [SITE 29]	1	clay/clay loam	0 – 12	26	9	24	18	42	23
	2	clay loam	12 – 23	17	11	22	14	36	36
	3	clay	23 – 52	42	13	20	15	35	10
	4	clay	52 – 150	54	12	22	11	33	1
	5	clay	150 - 250	50	14	30	6	36	<1

texture based on laboratory measurements

Table 1 [cont]
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

Page 2 of 2

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D%	D% level of dispersion	EAT	EAT level of dispersion
SMU 1 [SITE 30]	1	clay loam	0 - 20	23	slight	3[1]	slight
	2	clay	20 - 95	41	moderate	4	negligible
	3	clay loam	95 - 110	47	moderate	3[1]	slight
SMU 2 [SITE 3]	1	clay	0 - 20	19	slight	3[1]	slight
	2	clay	20 - 90	64	high	3[1]	slight
	3	clay	90 - 110	36	moderate	2[1]	high to moderate
	4	sand	110 - 180	14	slight	3[1]	slight
	5	loamy sand	180 - 210	27	slight	8 / 3[1]	negligible to slight
SMU 2 [SITE 20]	1	loam / loamy sand	0 - 18	17	slight	8 / 3[2]	negligible to slight
	2	loam / silty loam	18 - 38	56	high	3[2]	slight
	3	clay loam	38 - 80	40	moderate	3[3]	moderate
	4	sandy loam	80 - 111	40	moderate	3[3]	moderate
	5	silt loam	111 - 141	33	moderate	2[1]	moderate
	6	clay loam	141 - 257	86	very high	2[2]	high
SMU2 [SITE 24]	1	loam	0 - 17	8	slight	3[2]	slight
	2	clay	17 - 40	33	moderate	3[2]	slight
	3	clay	40 - 126	52	high	2[1]	high to moderate
	4	clay	126 - 240	40	moderate	2[2]	high
SMU 3 [SITE18]	1	silty clay loam	0 - 20	22	slight	3[2]	slight
	2	silty clay loam	20 - 63	36	moderate	2[1]	high to moderate
	3	silt loam	63 - 120	49	moderate	2[2]	high
	4	clay loam	120 - 160	55	high	2[3]	very high
	5	clay loam	160 - 210	81	very high	2[3]	very high
	6	loam	210 - 270	53	high	2[3]	very high
SMU 3 [SITE 19]	1	sandy loam	0 - 18	0	negligible	3[1]	slight
	2	clay	18 - 80	51	high	2[3]	very high
	3	loam/clay loam	80 - 162	69	very high	2[3]	very high
	4	clay	162 - 252	9	very high	1	very high
SMU 4 [SITE 29]	1	clay/clay loam	0 - 12	18	slight	8 / 3[2]	negligible to slight
	2	clay loam	12 - 23	29	slight	2[1]	high to moderate
	3	clay	23 - 52	64	high	3[1]	slight
	4	clay	52 - 150	62	high	2[1]	high to moderate
	5	clay	150 - 250	56	high	2[1]	high to moderate

Notes: D = Dispersion EAT = Emerson Aggregate Test # texture based on laboratory measurements

Table 2
Chemical Analyses Laboratory Analysis Data for Selected Belmont Soil Profiles

SOIL MAPPING UNIT and SITE	LAYER	TEXTURE [#]	DEPTH [cm]	pH [water]	EC [dS/m]
SMU 1 [SITE 30]	1	clay loam	0 - 20	6.7	0.14
	2	clay	20 - 95	9.1	0.36
	3	clay loam	95 - 110	9.3	0.33
SMU 2 [SITE 3]	1	clay loam	0 - 20	8.9	0.16
	2	loam	20 - 90	9.4	0.46
	3	clay	90 - 110	9.2	0.93
	4	clay	110 - 180	9.7	0.38
	5	clay	180 - 210	6.1	0.33
SMU 2 [SITE 20]	1	clay	0 - 18	6.7	0.06
	2	clay	18 - 38	8.1	0.05
	3	clay	38 - 80	8.2	0.06
	4	sand	80 - 111	9.3	0.07
	5	loamy sand	111 - 141	9.3	0.07
	6	loam/loamy sand	141 - 257	10.0	0.27
SMU 2 [SITE 24]	1	loam/silty loam	0 - 17	6.1	0.10
	2	clay loam	17 - 40	8.3	0.07
	3	sandy loam	40 - 126	9.7	1.00
	4	silt loam	126 - 240	9.6	1.28
SMU 3 [SITE 18]	1	silty clay loam	0 - 20	5.9	0.08
	2	silty clay loam	20 - 63	6.5	0.06
	3	silt loam	63 - 120	7.1	0.06
	4	clay loam	120 - 160	9.7	0.21
	5	clay loam	160 - 210	9.7	0.35
	6	loam	210 - 270	9.6	0.24
SMU 3 [SITE 19]	1	sandy loam	0 - 18	5.7	0.10
	2	clay	18 - 80	9.6	0.29
	3	loam/clay loam	80 - 162	9.7	0.81
	4	clay	162 - 252	8.6	1.20
SMU 4 [SITE 29]	1	clay/clay loam	0 - 12	7.2	0.10
	2	clay loam	12 - 23	7.7	0.11
	3	clay	23 - 52	9.5	0.84
	4	clay	52 - 150	7.1	1.23
	5	clay	150 - 250	4.7	0.92

texture based on laboratory measurements

It should be noted that the field textures of almost all layers of the forty profiles that were examined indicated that the soils were generally more clayey than was shown in the laboratory analyses.

6.1.2 Dispersion Percentage

The Dispersion Percentage [D%] test indicates the proportion of the soil material less than 0.005 mm in size that will disperse on wetting [ie. the clay and some of the silt fractions].

Hazelton and Murphy [in press] provide the following guides to the interpretation of D% values in **Table 3**.

In interpreting the results of the values of dispersion percentage obtained in laboratory testing it is important to consider other related soil attributes such as the Particle Size Analysis [PSA] and Emerson Aggregate Test [EAT] data.

Table 3
Interpretation of Dispersion Percentage Values
[after Hazelton and Murphy, in press]

D% Value	Dispersion Rating
< 6	negligible
6 – 30	slight
30 – 50	moderate
50 – 65	high
> 65	very high

Soil horizons with high clay contents and high Dispersion % values will be more dispersive in practice than those with a high Dispersion % value and a low clay content in the soil.

The D% values shown in **Table 1** indicate that the topsoils in all SMUs have negligible to slight D% values [ie. low dispersibility].

These values may be further influenced in some profiles by the higher clay contents of the topsoil layers.

In all SMUs, the subsoil D% values usually ranged from moderate to very high, although some instances of slight dispersibility were recorded. Some of the subsoils contain moderate to high levels of clay and this fact undoubtedly makes them more dispersive than the analyses indicate, although for many this is difficult since they already exhibit high and very high values.

Given this, the erosion potential is undoubtedly high to very high for any areas of exposed subsoil.

Consequently, appropriate measures need to be taken to protect the stockpiles of stripped subsoil. The same material, when respread, should be afforded protection from soil erosion in the form of vegetative cover.

6.1.3 Emerson Aggregate Test

This test provides a measure of the coherence of soil aggregates when they are immersed in water. Natural peds are used [Houghton and Charman, 1986] and the method used by the Department of Land and Water Conservation to determine the Emerson Class Number is fully described in Craze et al [1993].

Basically, the degree of soil aggregate stability increases from Class 1 through to Class 8. Classes 2 and 3 have a number of subclasses based on the degree of dispersion.

Aggregates in Emerson Classes 1 and 2 are generally regarded as being unstable while those in classes 4 to 8 are considered to be stable.

Hazelton and Murphy [in press] present a summary of the Emerson Aggregate Classes. This is contained in **Table 4**.

The EAT data in **Table 1** show that the surface layers of the soil analysed for SMU 1 have a negligible to slight dispersibility rating. The lower horizons have mainly negligible to slight values.

Table 4
Comparison of Aggregate Dispersibility and Emerson Aggregate Classes
[after Hazelton and Murphy, in press]

Aggregate Dispersibility	Emerson Aggregate Classes*
Very High	1 and 2[3]
High	2[2]
High to Moderate	2[1]
Moderate	3[4] and 3[3]
Slight	3[2], 3[1] and 5
Negligible / Aggregated	6,7,and 8
* NOTE – the subclasses of the Emerson Aggregate Test [EAT] Classes are as follows: [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 [NB – Class 2[4] is equivalent to Class 1]	

The surface layers of the soils analysed for SMU 2 have a negligible to slight dispersibility rating while the lower layers within the profile generally show moderate to high dispersibility values.

In SMU 3, the surface layer in both gilgai depression and mound soils shows only slight dispersibility but all subsequent layers down the profile show high to very high [mainly] dispersibility.

For SMU 4, the surface layer shows negligible to slight dispersibility but the lower profile layers are moderately to highly dispersible.

Based on this data it can be concluded that the EAT testing indicates that the topsoils in all SMUs show dispersibility values ranging from negligible and slight. However, the subsoil material in all SMUs is generally highly dispersible making it essential that any exposed subsoil is adequately protected from soil erosion.

As a consequence, this subsoil material will require adequate protection by vegetative cover in the stockpile and rehabilitation stages.

6.2 Soil Chemical Analyses

6.2.1 Soil pH

In general, the pH [water] range in most soils is between 4.0 and 8.5 although pH values above and below this range are measured at times [Glendinning, 1990].

This range of soil pH levels is generally accepted as being one that is suitable for plant growth.

The pH 6.0 to 6.5 range is usually regarded as the optimum for growth of most plants and there are some more serious impacts on the growth of many species at the lower, or acid, end of the range.

As the pH scale [between 0 and 14] is a logarithmic one, a soil with a pH of 5.0 is ten times as acid as a soil of pH 6.0 and 100 times as acid as one with a pH of 7.0.

Perusal of the data in the pH [water] column in **Table 2** indicates that only fifteen of the thirty three samples tested showed pH levels within the 4.0 to 8.5 range.

In general, the uppermost soil layer had a pH within the acceptable range but in most cases the layers beneath were usually very alkaline and outside the range acceptable for plant growth.

This indicates that the pH values of the topsoil layer that will be stripped from all SMUs for use in rehabilitation are within acceptable limits.

However, the upper subsoil material to be stripped and stockpiled would, in some areas at least, have higher than ideal pH values. This should not present a problem as the process of stripping and respreading will mix the soil materials from higher and lower pH areas and result in material with an acceptable pH level.

The laboratory measurements of very high pH levels in the lower subsoils were mirrored in the field measurements in the remaining sample pits.

This indicates that the lower subsoil material may be difficult to stabilise with vegetation and should, wherever possible, be moved direct from its original site to an area being stabilised to avoid problems with stability in a stockpile *[given the additional problem of the generally high dispersibility of the material that has been discussed above]*.

6.2.2 Electrical Conductivity

Soil salinity is a measure of the presence of water-soluble salts, mainly of sodium, calcium and magnesium in the soil solution. These salts may be chlorides, sulphates or carbonates and can have a major impact on plant growth if they occur in sufficiently large quantities.

The level of salinity in a soil sample is determined by measuring the electrical conductivity [EC] of a 1:5 soil / water suspension.

As the published salinity tolerance data for crops and pastures is based on the electrical conductivity of a saturated extract of the soil solution, a series of conversion factors, based on the estimated water holding capacity of soil sample, are used to convert the measured EC value to one for the conductivity of the saturated extract [EC_e].

The electrical conductivity of the 1:5 soil / water suspension and that of the saturated extract are measured in units called deciSiemens / metre [dS/m].

The measured level of electrical conductivity of the 1:5 soil / water suspension is multiplied by the appropriate factor in **Table 5** [extracted from Hazelton and Murphy, in press] based on the measured soil texture.

Table 6 shows the calculated EC_e values for the samples analysed in the laboratory and shows the salinity status of the various horizons based on these EC_e values.

Table 5
Texture Class Multipliers for Calculating EC_e Values

Soil Texture Class	Multiplier Factor
loamy sand, clayey sand, sand	23
sandy loam, fine sandy loam, light sandy clay loam	14
loam, loam fine sandy, silt loam, sandy clay loam	9.5
clay loam, silty clay loam, fine sandy clay loam, sandy clay, silty clay, light clay	8.6
light medium clay	7.5
medium clay	5.8
heavy clay	5.8

Hazelton and Murphy [in press] note that EC_e values below 2.0 indicate non-saline horizons while values between 2 and 4 indicate slight salinity. Values between 4 and 8 indicate moderate salinity while those between 8 and 16 indicate high salinity.

The data in **Table 6** indicate that all topsoil materials within the four SMUs are non-saline.

However, the material that it is proposed to strip as subsoil material [*ie. the material between 15cm and 50cm depth*] is in some instances slightly to moderately saline.

The mixing process during stripping and dumping using a scraper will have a diluting effect on this lesser amount of saline material and result in a product that should generally pose few problems from a soil salinity viewpoint during the stockpiling phase.

However, there is always a small chance that a pocket of saline material may result with consequent revegetation problems during stockpiling. Any such problems will have to be addressed if they occur.

The deeper subsoils in all SMUs are slightly to highly [usually moderately] saline and again this should be recognised by avoiding the need to temporarily stockpile and stabilise this material. This end would be met by using a system of direct transfer from in situ to placement on a rehabilitation site.

6.2.3 Likelihood of Encountering Acid Sulfate Soils

Acid sulfate soils are basically confined to coastal estuarine floodplain areas in New South Wales.

These soils are extremely acidic soil layers that develop as a consequence of the aeration of soil materials that are rich in iron sulfides, primarily pyrite [FeS].

When drainage or excavation brings these previously waterlogged soil layers into contact with oxygen, the pyrite is oxidised to form sulfuric acid.

If the production of acid exceed the neutralising capacity of the particular soil such that the pH falls below 4.0, these soils are known as acid sulfate soils.

Table 6
Calculated EC_e Values and Salinity Status for Selected Belmont Soil Profiles

SOIL MAPPING UNIT and SITE	LAYER	DEPTH [cm]	TEXTURE [#]	EC [dS/m]	MULTI-PLIER	CALCULATED EC _e	SOIL SALINITY STATUS
SMU 1 [SITE 30]	1	0 - 20	clay loam	0.14	8.6	1.20	non-saline
	2	20 - 95	clay	0.36	5.8	2.09	moderately saline
	3	95 - 110	clay loam	0.33	8.6	2.84	moderately saline
SMU 2 [SITE 3]	1	0 - 20	clay	0.16	5.8	0.93	non-saline
	2	20 - 90	clay	0.46	5.8	2.67	slight salinity
	3	90 - 110	clay	0.93	5.8	5.39	moderate salinity
	4	110 - 180	sand	0.38	23	8.74	high salinity
	5	180 - 210	loamy sand	0.33	23	7.59	moderate salinity
SMU 2 [SITE 20]	1	0 - 18	loam / loamy sand	0.06	14	0.84	non-saline
	2	18 - 38	loam / silt loam	0.05	9.5	0.48	non-saline
	3	38 - 80	clay loam	0.06	9.5	0.57	non-saline
	4	80 - 111	sandy loam	0.07	14	0.98	non-saline
	5	111 - 141	silt loam	0.07	9.5	0.67	non-saline
	6	141 - 257	clay loam	0.27	8.6	2.32	slightly saline
SMU 2 [SITE 24]	1	0 - 17	loam	0.10	9.5	0.95	non-saline
	2	17 - 40	clay	0.07	5.8	0.41	non-saline
	3	40 - 126	clay	1.00	5.8	5.80	moderately saline
	4	126 - 240	clay	1.28	5.8	7.42	moderately saline
SMU 3 [SITE 18]	1	0 - 20	silty clay loam	0.08	8.6	0.69	non-saline
	2	20 - 63	silty clay loam	0.06	8.6	0.52	non-saline
	3	63 - 120	silt loam	0.06	9.5	0.57	non-saline
	4	120 - 160	clay loam	0.21	14	2.94	slight salinity
	5	160 - 210	clay loam	0.35	14	4.90	moderate salinity
	6	210 - 270	loam	0.24	9.5	2.28	slight salinity
SMU 3 [SITE 19]	1	0 - 18	sandy loam	0.10	14	1.40	non-saline
	2	18 - 80	clay	0.29	5.8	1.68	slight salinity
	3	80 - 162	loam / clay loam	0.81	9.5	7.70	moderately saline
	4	162 - 252	clay	1.20	5.8	6.96	moderately saline
SMU 4 [SITE 29]	1	0 - 12	clay / clay loam	0.10	7.5	0.75	non-saline
	2	12 - 23	clay loam	0.11	8.6	0.95	non-saline
	3	23 - 52	clay	0.84	5.8	4.87	moderately saline
	4	52 - 150	clay	1.23	5.8	7.13	moderately saline
	5	150 - 250	clay	0.92	5.8	5.34	moderately saline

The soils at the study area almost universally increase in alkalinity with depth [often to pH 9.5 - 10] and are not waterlogged. There is a considerable quantity of neutralising capacity in all soils within the study area.

As a consequence of these features and the fact that the site is not located on a coastal estuarine floodplain it is extremely unlikely that any acid sulfate soils will impact in any way on the mine during its working life or on the success of subsequent rehabilitation.

6.3 Erosion Potential

The soils within the study area are currently generally stable except for some minor areas of sheet erosion on the slopes and some gully erosion in the main drainage line.

As the study area is flanked on two sides by hills, with those to the east being particularly steep, it is likely that considerable volumes of runoff water will have to be managed in years of high rainfall.

This has obviously been a problem in the past and the area has been subjected to an intensive erosion control program as is evidenced by the diversion bank and waterway systems present over almost all of the study area.

The development of the open cut and ancillary works will result in disruption to some of these existing bank and waterway systems, as well as to the central drainage line of the Project Site.

Care should be taken to minimise any such disruption and the assistance of the local staff of the Department of Lands should be sought to design and construct alternative water management and disposal systems where they are required.

Groundcover varies over the site, however, the cleared and remnant vegetation areas generally support a good cover of native and naturalised species.

It will be essential, if erosion is to be prevented, to maintain an adequate groundcover on the existing landscape, on any stockpiles created during the mine's operation and on the reformed landscapes after rehabilitation work is carried out.

6.4 SOILOSS Program

An appropriate method of assessing the erosion hazard associated with the soils of the study area is to use the SOILOSS computer program devised by Rosewell and Edwards [1988] and updated by Rosewell [1993].

This program computes soil loss values for a given site under various land uses and climatic [rainfall] conditions and so provides an indication of erosion hazard.

SOILOSS is based on the Universal Soil Loss Equation or USLE described by Wischmeier and Smith [1978] and subsequently updated as the Revised Universal Soil Loss Equation or RSLE [Renard et al, 1993].

The USLE is

$$A = R * K * L * S * P * C$$

where

- A is the average annual soil loss [tonnes / hectare]
- R is the rainfall erosivity factor, a measure of the erosive power of the rain
- K is the soil erodibility factor, a measure of the resistance of the soil to erosion
- L is the slope length factor
- S is the slope steepness factor
- P is the support practice factor, a measure of the effect on erosion of soil conservation measures such as contour cultivation and bank systems
- C is the crop and cover management factor

In using SOILOSS, the rainfall erosivity factor is obtained from maps provided with the program manual [Rosewell, 1993].

Soil erodibility is either estimated from details of the soil type and soil surface texture by comparison with a table of soils presented by the program or is derived from a knowledge of soil particle size analysis, organic matter content, surface soil structure and profile permeability.

Slope length and steepness factors are derived from field measurements and / or examination of topographic maps or airphotos.

The support practice factor is estimated by the program from a description of the land management practices in use, details of cultivation direction and information on bank systems if these are present.

To determine the value of the 'K' factor for use in the program, a generic or standard method can be utilised from within the program to indicate the likely soil losses from a range of crop rotations and management practices.

In addition, a more detailed approach can be used to determine likely soil loss given the availability of precise detail relating to sowing dates, cultivation practices etc.

Provision is made within the program for estimating soil loss from areas with a range of non-arable uses.

Table 7 provides details of the calculated erodibility values [K] and erodibility ratings for topsoils and subsoils from a selection of soil profiles in the study area. The erodibility estimates contained in **Table 7** for the four Soil Mapping Units have been calculated using part of the overall SOILOSS program capability and the Particle Size Analysis and other data for four typical soil profiles at the study area.

The only value for which estimates were used in the calculations were those for organic matter %. After a perusal of the data for this variable for similar topographic sites and soil landscapes in the publication titled Soil Landscapes of the Curlew 1: 100 000 Sheet [Banks, 1995], values of 2.4% [topsoils] and 0.4% [subsoils] were chosen.

The Erodibility classes used were < 0.020 = LOW; 0.020 – 0.040 = MODERATE; > 0.040 = HIGH.

Table 7
Soil Erodibility Values and Ratings for a Selection of Soils from the Belmont Study Area

SOIL MAPPING UNIT	PIT NUMBER	TOPSOIL LAYER	TOPSOIL 'K' RATING	SUBSOIL LAYER	SUBSOIL 'K' RATING	AVERAGE 'K' RATING [WHOLE SOIL]	SOIL MAPPING UNIT ERODIBILITY
1	30	0-20cm	0.027 / MOD	20-95cm	0.019 / LOW	0.023	MODERATE
2	3	0-20cm	0.026 / MOD	90-110cm	0.030 / MOD	0.025	MODERATE
3	18	0-20cm	0.038 / MOD	63-120cm	0.045 / HIGH	0.042	HIGH
4	29	0-12cm	0.035 / MOD	52-150cm	0.018 / LOW	0.027	MODERATE

The data in **Table 7** show that the SOILOSS program predicts that the soils sampled have MODERATE erodibility with the erodibility of the profile from SMU 3 [Pit 18] being HIGH.

Because of the MODERATE to HIGH erodibility of the soils as assessed by the SOILOSS analysis, they should be managed carefully during the stripping and rehabilitation stages to ensure that soil structure damage is minimal and that they are suitably protected by vegetation or some other medium at all times.

This erodibility constraint, when considered with the measured high pH and relatively high dispersibility and salinity levels in the subsoil materials, indicates that the subsoil materials will have to be very carefully managed during the life of the Project.

7 STRIPPING SUITABILITY OF SOIL MATERIALS

An approach has been developed by Elliott and Veness [1981] to determine the stripping suitability of soil materials found at a site where stripping of upper soil layers is required. The key used in this method of stripping suitability assessment is contained in Appendix 2. This method has been used in the present study.

The basis of Elliott and Veness approach is that not all soil material that might be available for topdressing of disturbed sites is suitable for the purpose. Some may be saline, poorly structured, too sandy or gravelly or too poorly drained to allow a stabilising vegetative cover to develop.

In their work, Elliott and Veness established that there are a number of critical soil physical attributes that can be used to distinguish between suitable and unsuitable topdressing materials. These are:

- (a) soil structure
- (b) soil macrostructure
- (c) soil coherence
- (d) soil texture
- (e) the force necessary to disrupt peds

NOTE: The following descriptions of soil materials are based on the detail gained from all 40 profiles sampled in the field

7.1 Stripping Recommendations for Soil Mapping Unit 1

7.1.1 Layer 1 – Topsoil [0-15cm depth]

Light to medium clay, pH 6.5, surface hardsetting, surface stone levels medium, to 10cm, rounded, contains small gravel; roots common; dark greyish brown [10YR4/2] dry, very dark greyish brown [10YR3/2] moist; peds rough, highly pedal [100%], polyhedral, 5-15mm; strong consistence [airdry]; coherent.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture suitable; layer contains little sand and gravel; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. In addition, it contains valuable seed, organic matter and nutrient reserves. These features indicate its suitability to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 1 topsoil to a depth of 15cm from the current surface. The topsoil soil material from the SMU 1 area can be mixed and stored in the same topsoil stockpiles as the topsoil from the other three SMUs identified within the study area

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development. It should not be necessary to further strip areas that are only to be used for roads, buildings, hardstand areas etc.]

However, on areas where the disturbance is deeper – ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below.]

7.1.2 Layer 2 – Subsoil [15-65 cm depth] -

Heavy clay; pH 9.0; roots few; small gravel to 5mm; greyish brown [10YR5/2] dry, dark greyish brown [10YR4/2] moist; peds rough / smooth, highly pedal [100%], polyhedral, 5-10mm; very firm to strong consistence [airdry]; coherent.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains little sand and gravel; pH levels marginally high; salt content marginal.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 2 subsoil to a depth of 50cm below the base of Layer 1 if soil depth allows - ie. a total depth from the surface of 65cm. The subsoil soil material from the SMU 1 area can be mixed and stored in the same stockpiles as the subsoil from the other three SMUs identified within the study area

7.1.3 Layer 3 [Remainder of the Profile]

Although limited sampling was carried out within this SMU because of its restricted distribution, the material below 65cm depth [the base of layer 2] is predominantly medium to heavy clay in texture with some grit and sand in some layers. In addition, the pH of the layers sampled was generally >8.5.

Because of the moderate dispersibility and salinity levels and the generally very high pH readings, it is considered that the remaining soil material below the base of Layer 2 should be used to cover emplaced rock and to form a soil base over which Layers 1 and 2 can be spread during the rehabilitation process.

Recommendation – Strip the remainder of the profile down to bedrock and use it to cover emplaced rock material as a base for subsoil and topsoil respreading.

This soil material has generally high pH levels and as such will assist in neutralising acidity [if any] that may be generated from the broken rock overburden material. Initially, this layer should be stockpiled to allow dumps of rock overburden to be constructed and shaped. The material can then be respread or maintained in a stockpile until mine closure. Ideally, once mining and rehabilitation are in progress, this material should be transferred progressively direct from sites being prepared for mining to the areas being rehabilitated

7.2 Stripping Recommendations for Soil Mapping Unit 2

7.2.1 Layer 1 – Topsoil [0-15cm depth]

Sandy clay loam, silty clay loam, clay loam, fine sandy loam, light clay, light to medium clay, loam fine sandy, medium clay, medium to heavy clay textured; roots common to many; no lime present; no manganese present; usually pH 5.0 to 6.5, sometimes 7.0 to 8.5; gravel and stone usually absent, sometimes grit or gravel to 4cm present; not mottled not bleached; brown [7.5YR4/3, 7.5YR5/2, 10YR5/3], dark grey [7.5YR4/1], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], light yellowish brown [10YR6/4], pale brown [10YR6/3], pinkish grey 7.5YR7/2] dry; brown [7.5YR4/2, 7.5YR4/3], dark brown [10YR3/2, 7.5YR3/3], dark grey [10YR4/2], dark greyish brown [10YR4/2], very dark grey [7.5YR3/1, 7.5YR5/1], very dark greyish brown [10YR3/2] moist; peds usually rough-faced, sometimes rough- / smooth-faced; highly pedal [100%]; usually polyhedral, sometimes ABL, SABL or almost platy; <5-25cm in size; weak to strong consistence dry, usually firm; sometimes hydrophobic or almost so; *sharp*.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains little sand and gravel; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. In addition, it contains valuable seed, organic matter and nutrient reserves. These features indicate its suitability to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 1 topsoil to a depth of 15cm from the current surface. The topsoil soil material from the SMU 2 area can be mixed and stored in the same topsoil stockpiles as the topsoil from the other three SMUs identified within the study area

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development. It should not be necessary to further strip areas that are only to be used for roads, buildings, hardstand areas etc.]

However, on areas where the disturbance is deeper – ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below.]

7.2.2 Layer 2 – Subsoil [15-65cm depth] –

Clay loam, clayey sand, heavy clay; light clay [sometimes sandy], light to medium clay [sometimes sandy], loam fine sandy, medium clay, medium to heavy clay [sometimes gritty], sandy clay, silty clay loam, silty clay, roots usually common, sometimes absent, few or many; lime usually absent or some to much present as flecks or nodules; manganese stains rarely present; pH 6.0 to 9.5-10; gravel and stone absent or some to much gravel 1-5cm present; **usually not mottled**; occasionally bleached; brown [7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 7.5YR5/3, 10YR5/3], dark brown [7.5YR3/2], dark grey [7.5YR4/1], dark greyish brown [10YR4/2], dark reddish grey [5YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], light grey [10YR7/2], light greyish brown [10YR6/2], pale brown [10YR6/3], pinkish grey [7.5YR5/2, 7.5YR6/2, 7.5YR7/2], very pale brown [10YR7/3] dry; brown [10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/2, 7.5YR5/3, 10YR4/3], dark brown [7.5YR3/2, 7.5YR3/3], dark grey [7.5YR4/1], dark greyish brown [10YR4/2], dark reddish brown [5YR3/2], dark reddish grey [5YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/3], light brownish grey [10YR6/2], pale brown [10YR6/3], pinkish grey [7.5YR5/2], reddish brown [5YR4/3], very dark greyish brown [10YR3/2] moist; **rarely mottled** in colours of brown [7.5YR5/3], strong brown [7.5YR5/6] dry; dark brown [7.5YR3/2], brown [7.5YR4/4] moist; peds rough-faced, smooth-faced or rough- / smooth faced; highly pedal [100%], rarely weakly pedal [10%], polyhedral [occasionally ABL, SABL], <5-25mm in size; firm, very firm or strong consistence dry; not hydrophobic.

Suitability Assessment: usually structure grade 3, rarely grade 1; coherent dry, mottles rare; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer usually contains little sand and gravel however field inspection revealed layers of stones and gravel in some profiles - many of these were in lenses and were discontinuous; pH levels generally suitable although approaching the high range; salt content suitable in some profiles and marginal in others.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key.

The rare presence of mottles will not place any major limitations on the use of this material as their impact will be ameliorated by the mixing process. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 2 subsoil to a depth of 50cm below the base of Layer 1 – ie. a total depth from the surface of 65cm. The subsoil soil material from the SMU 2 area can be mixed and stored in the same stockpiles as the subsoil from the other three SMUs identified within the study area

7.2.3 Layer 3 [Remainder of the Profile]

The material below 50cm depth [the base of layer 2] is predominantly medium to heavy clay in texture with some grit and sand in some layers. In addition, the pH of over 70% of the layers sampled was >8.5 and a further 19% of the readings were in the 8.0 to 8.5 range.

Layers of stones of varying thickness are also found in the subsoil in many profiles within this SMU.

Because of the, at times, moderate to high salinity levels, the moderate to very high dispersibility, the generally very high pH readings and the presence of large amounts of stones in many profiles, it is considered that the remaining soil material below the base of Layer 2 should be used to cover emplaced rock and to form a soil base over which Layers 1 and 2 can be spread during the rehabilitation process.

Recommendation – Strip the remainder of the profile down to bedrock and use it to cover emplaced rock material as a base for subsoil and topsoil respreading. This soil material has generally high pH levels and as such will assist in neutralising acidity [if any] that may be generated from the broken rock overburden material.

Initially this layer should be stockpiled to allow dumps of rock overburden to be constructed and shaped. The layer can then be respread or maintained in a stockpile until mine closure. Ideally, once mining and rehabilitation are in progress, this material should be transferred progressively direct from sites being prepared for mining to the areas being rehabilitated.

7.3 Stripping Recommendations for Soil Mapping Unit 3

7.3.1 Gilgai Depression [where depth allows conventional stripping]

7.3.1.1 Layer 1 - Topsoil [0-15cm depth] -

Sandy clay loam to clay loam or heavy clay; many roots; no lime present; manganese stains present; pH 5.0 to 6.0; occasional to moderate amounts of gravel, <1-3cm; not mottled; not bleached; grey [10YR6/1], dark grey [7.5YR4/1] dry, very dark greyish brown [10YR3/2], very dark grey [7.5YR3/1] moist; peds smooth-faced or rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; sometimes hydrophobic.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains little sand and gravel; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. In addition, it contains valuable seed, organic matter and nutrient reserves. These features indicate its suitability to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 1 topsoil to a depth of 15cm from the current surface. The topsoil soil material from the SMU 3 area can be mixed and stored in the same topsoil stockpiles as the topsoil from the other three SMUs identified within the study area

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development. It should not be necessary to further strip areas that are only to be used for roads, buildings, hardstand areas etc.]

However, on areas where the disturbance is deeper – ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below.]

7.3.1.2 Layer 2

Sandy clay loam, clay loam, sandy clay, gritty medium clay or heavy clay; roots few, common or many; lime flecks present or absent; manganese stains present or absent; pH 5.0 to 9.5; occasional to moderate amounts of gravel, <1-4cm; not mottled; not bleached; grey [10YR4/1, 10YR6/1], dark grey [7.5YR4/1, 10YR4/1] dry, grey [10YR4/1], very dark greyish brown [10YR3/2], very dark grey [7.5YR3/1, 10YR3/1] moist; peds smooth-faced, rough-faced, rough- / smooth-faced or rough-faced, highly pedal [100%], polyhedral, <5-20mm in size; strong consistence dry; sometimes hydrophobic.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer usually contains gravel; pH levels generally suitable although approaching the high range in some profiles; salt content suitable.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in Section 8].

Recommendation – Strip all of the Layer 2 subsoil to a depth of 50cm below the base of Layer 1 – ie. a total depth from the surface of 65cm. The subsoil soil material from the SMU 3 area can be mixed and stored in the same stockpiles as the subsoil from the other three SMUs identified within the study area.

7.3.1.3 Layer 3 [Remainder of the Profile]

The material below 65cm depth [the base of layer 2] is predominantly medium to heavy clay in texture with some grit and sand in some layers. Layers of stones of varying thickness are also found below 50cm in many profiles within this SMU.

Because of the usually very high dispersibility, the moderate salinity and the generally very high pH readings, it is considered that the remaining soil material below the base of Layer 2 should be used to cover emplaced rock and to form a soil base over which Layers 1 and 2 can be spread during the rehabilitation process.

Recommendation – Strip the remainder of the profile down to bedrock and use it to cover emplaced rock material as a base for subsoil and topsoil respreading. This soil material has generally high pH levels and as such will assist in neutralising acidity [if any] that may be generated from the broken rock overburden material.

Initially this layer should be stockpiled to allow dumps of rock overburden to be constructed and shaped. The layer can then be respread or maintained in a stockpile until mine closure. Ideally, once mining and rehabilitation are in progress, this material should be transferred progressively direct from sites being prepared for mining to the areas being rehabilitated.

7.3.2 Gilgai Mound

7.3.2.1 Layer 1 – Topsoil [0-15cm depth]

Clay loam to sandy light clay; roots common to many; lime present or absent; no manganese present; pH 5.0 to 8.0; gravel to 5cm common; not mottled; not bleached; brown [7.5YR5/3], greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; firm to strong consistence dry; hydrophobic or slightly so.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains some gravel; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. In addition, it contains valuable seed, organic matter and nutrient reserves. These features indicate its suitability to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 1 topsoil to a depth of 15cm from the current surface. The topsoil soil material from the SMU 3 area can be mixed and stored in the same topsoil stockpiles as the topsoil from the other three SMUs identified within the study area.

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development. It should not be necessary to further strip areas that are only to be used for roads, buildings, hardstand areas etc.]

However, on areas where the disturbance is deeper – ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below.]

7.3.2.2 Layer 2 – Subsoil [15-65cm depth] -

Clay loam, sandy light clay; medium to heavy clay; roots few, common or many; some to much lime present or lime absent; no manganese present; pH 5.0 to 9.5-10; gravel to 5cm present or common; not mottled; not bleached; brown [7.5YR5/3], greyish brown [10YR5/2] dry, light greyish brown [10YR6/2] dry, brown [7.5YR4/3], light greyish brown [10YR6/2], very dark greyish brown [10YR3/2] moist; peds rough-faced or smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; firm to strong consistence dry; very firm to strong consistence dry; hydrophobic or not hydrophobic.

Suitability Assessment: structure grade 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer usually contains stones and gravel; pH levels generally suitable although approaching the high range; salt content suitable.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key.

This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in this report].

Recommendation – Strip all of the Layer 2 subsoil to a depth of 50cm below the base of Layer 1 – ie. a total depth from the surface of 65cm. The subsoil soil material from the SMU 3 area can be mixed and stored in the same stockpiles as the subsoil from the other three SMUs identified within the study area.

7.3.2.3 Layer 3 [Remainder of the Profile]

The material below 50cm depth [the base of layer 2] is predominantly medium to heavy clay in texture with some grit and sand in some layers.

Because of the usually very high dispersibility, the moderate salinity and the generally very high pH readings generally, it is considered that the remaining soil material below the base of Layer 2 should be used to cover emplaced rock and to form a soil base over which Layers 1 and 2 can be spread during the rehabilitation process.

This material is suitable for use as subsoil on the basis of the Elliott and Veness key.

This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in Section 8].

Recommendation – Strip the remainder of the profile down to bedrock and use it to cover emplaced rock material as a base for subsoil and topsoil respreading. This soil material has generally high pH levels and as such will assist in neutralising acidity [if any] that may be generated from the broken rock overburden material.

Initially this layer should be stockpiled to allow dumps of rock overburden to be constructed and shaped. The layer can then be respread or maintained in a stockpile until mine closure. Ideally, once mining and rehabilitation are in progress, this material should be transferred progressively direct from sites being prepared for mining to the areas being rehabilitated.

7.4 Stripping Recommendations for Soil Mapping Unit 4

7.4.1 Layer 1 – Topsoil [0-15cm depth] -

Sandy loam; loam fine sandy, silty clay loam, fine sandy clay, loam sandy clay loam, light clay, light to medium clay; roots common to many; no lime present; no manganese present; pH5.5 to 7.0; gravel and stones absent or some to much rounded or angular gravel, 1-5cm, present; not mottled; not bleached; brown [10YR5/3, 7.5YR4/2, 10YR5/2, 10YR5/3], dark greyish brown [10YR4/2], greyish brown [10YR5/2], light brown [7.5YR6/4] dry; brown [7.5YR4/3], dark brown [7.5YR3/2], dark greyish brown [10YR4/2], dark reddish brown [5YR3/2, 5YR3/3], very dark grey [7.5YR3/1], very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%] occasionally moderately pedal [40-60%], usually polyhedral, rarely SABL, <5-25mm in size; firm to strong consistence [occasionally weak] dry; hydrophobic or not hydrophobic.

Suitability Assessment: structure grade 2 to 3; coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture suitable; layer contains much gravel; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. In addition, it contains valuable seed, organic matter and nutrient reserves. These features indicate its suitability to be stripped and stockpiled as **topsoil** provided suitable stripping and storage methods are used [discussed later in Section 8].

Recommendation – Strip all of the Layer 1 topsoil to a depth of 15cm from the current surface. The topsoil soil material from the SMU 4 area can be mixed and stored in the same topsoil stockpiles as the topsoil from the other three SMUs identified within the study area.

[NOTE: Topsoil stripping should be carried out on all areas that will be disturbed by mining and associated infrastructure development. It should not be necessary to further strip areas that are only to be used for roads, buildings, hardstand areas etc.]

However, on areas where the disturbance is deeper – ie. areas to be mined, waste rock emplacements etc - the subsoil should be stripped as indicated for layers 2 and 3 below.]

7.4.2 Layer 2 - Subsoil [15-65cm depth] -

Clay loam, clayey sand, fine sandy clay loam, heavy clay, light clay, light to medium clay, loam fine sandy, medium to heavy clay, sand, sandy clay loam, sandy clay, sandy loam, sandy medium clay, silty clay loam; roots few, common or many; lime usually absent but some to much lime recorded in a few layers; no manganese present; pH usually 5.0-7.5, sometimes to

9.5-10; some to much gravel, 1-5cm, present in all layers, sometimes layers are almost completely composed of gravel; occasionally bleached; **usually whole coloured**; dark greyish brown [10YR4/2], brown [7.5YR4/2, 7.5YR4/3, 7.5YR5/2, 10YR5/2, 10YR5/3], greyish brown [10YR5/2], pinkish grey [7.5YR6/2], greyish brown [10YR6/3], light brown [7.5YR6/3], light brown [7.5YR6/4], light grey [10YR7/2], pink [7.5YR7/3, 7.5YR7/4], pinkish white [7.5YR8/2], pink [7.5YR8/3, 7.5YR8/4] dry, brown [10YR5/3, 7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/4], dark brown [7.5YR3/2], dark reddish brown [5YR3/2], dark reddish brown [5YR3/3], greyish brown [10YR5/2], light brown [7.5YR6/3, 7.5YR6/4], pale brown [10YR6/3], reddish brown [5YR4/4], very dark greyish brown [10YR3/2] moist; **occasionally mottled** in colours of greyish brown [10YR6/3], light greyish brown [10YR6/2], very pale brown [10YR7/3], light yellowish brown [10YR6/4] dry, brown [10YR5/3, 7.5YR5/4], greyish brown [10YR5/2], yellowish brown [10YR5/4], moist; occasionally massive; usually well structured; peds rough-faced or rough- / smooth-faced, usually highly pedal [100%], occasionally moderately pedal [40-50%], usually polyhedral, occasionally SABL, <5-25mm in size; firm to strong consistence, rarely weak, dry; occasionally hydrophobic.

Suitability Assessment: structure grade 3; coherent dry, mottles sometimes present but in a small proportion of sites; macrostructure suitable; force to disrupt peds generally suitable; texture suitable; layer contains little sand and gravel; pH levels generally suitable; salt content generally suitable [but may be a problem in some instances].

This material is generally suitable for use as subsoil on the basis of the Elliott and Veness key. The only exceptions are the mottled soil layers that are encountered in a few areas. The extent of these mottled areas appears to be minimal and so the mottled soil material, when mixed with the overwhelming bulk of unmottled soil, will not provide any impediment to rehabilitation. This allows it to be stripped and stockpiled as **subsoil** provided suitable stripping and storage methods are used [discussed later in Section 8].

Recommendation – Strip all of the Layer 2 subsoil to a depth of 50cm below the base of Layer 1 – ie. a total depth from the surface of 65cm. The subsoil soil material from the SMU 4 area can be mixed and stored in the same stockpiles as the subsoil from the other three SMUs identified within the study area.

7.4.3 Layer 3 - [Remainder of the Profile]

The material below 50cm depth [the base of layer 2] is predominantly medium to heavy clay [occasional light clay] in texture with some grit and sand in some layers. Some mottled material is present. In addition, the pH of many of the layers sampled was >8.5.

Because of the moderate to high dispersibility, the moderate salinity and the generally very high pH readings, it is considered that the remaining soil material below the base of Layer 2 should be used to cover emplaced rock and to form a soil base over which Layers 1 and 2 can be spread during the rehabilitation process.

Recommendation – Strip the remainder of the profile down to bedrock and use it to cover emplaced rock material as a base for subsoil and topsoil respreading. This soil material has generally high pH levels and as such will assist in neutralising acidity [if any] that may be generated from the broken rock overburden material.

Initially this layer should be stockpiled to allow dumps of rock overburden to be constructed and shaped. The layer can then be respread or maintained in a stockpile until mine closure. Ideally, once mining and rehabilitation are in progress, this material should be transferred progressively direct from sites being prepared for mining to the areas being rehabilitated.

8 HANDLING STRIPPED SOILS

8.1 General Issues

Stripping of topsoil materials is proposed for those sections of the study area to be used for the development of the proposed limit of open cut mining and construction of the related coal handling and administrative facilities.

In addition, subsoil material will need to be stripped from the area to be disturbed by the proposed open cut mine and overburden dumps for later use in rehabilitation.

It is appropriate to consider, in this report, the techniques for handling the soil materials that are to be stripped, stockpiled and then respread during the rehabilitation phase. The recommendations made are based on an interpretation of the results of soil survey at the study area and the associated laboratory analysis data.

As a general rule in soil stripping, stockpiling etc, the weaker [more sandy] the *in situ* structure of the soil being removed, the more care that is required in all phases of handling. The soil needs to be handled [disturbed] as little as possible to minimise mechanical damage to soil structure that will be detrimental to rapid establishment of ground cover once rehabilitation works commence.

There have been a number of studies in the past relating to the impact of the stripping and stockpiling of soils associated with mining and similar activities.

Working of soils in situations where the soil moisture content is too high can have detrimental impacts on soil structure [Elliott and Veness, 1985; Hunter and Currie, 1956]. There are also unfavourable effects related to mixing of soil materials with different fertility levels, textures and other critical soil properties.

Stockpiling also has its effects although there is evidence that the impacts are, at least to some degree, reversible. Jenkin et al [1987] have noted that these effects seem similar to those of normal agricultural uses on soils.

Dougall [1950] has noted that stockpiling of soil results in some structure breakdown and changes associated with some other physical and chemical properties.

However, despite these negative impacts, Elliott and Veness [1985] conclude that the quality of stockpiled soil can, in fact, improve with time – especially in the outer layers of material.

8.2 Stripping and Stockpiling Recommendations

8.2.1 Earthmoving Procedures.

As mentioned previously, the topsoils and subsoils to be moved within the Belmont study area generally have good structure. However, the topsoil structure is generally somewhat weaker than that of the subsoils - particularly in the moist state.

As a consequence, improper or excessive handling of the material during the stripping and stockpiling operation has the potential to destroy the soil structure by mechanically breaking down the soil aggregates that are present.

Notwithstanding the comments above, the generally good structure grades of both topsoils and subsoils will allow the stripping operation to be carried out using machines such as open-bowl scrapers and bulldozers. However, the scrapers should dump their loads neatly to form a uniform dump that requires little further forming prior to establishment of a vegetation cover.

Even so, care should be taken to ensure that topsoils are not stripped when they are too moist as greater damage will occur at this time. Similar precautions should be taken with the subsoils.

Driving of machinery on the topsoil and subsoil stockpiles, other than the scrapers during unloading, should be kept to an absolute minimum to maximise soil aggregation and prevent compaction.

Ideally the topsoil stockpiles should be 1 metre high but, if necessary, higher dumps can be used. These should not exceed about 2 metres in height.

The subsoil stockpiles should not exceed 3 metres in height.

8.2.2 Soil Conservation Measures

Stockpiles should preferably be positioned where runoff water from upslope does not pose a problem, with the best stockpile sites being on a level ridgetop.

However, as a suitably-sized ridgetop site is not available at the Belmont site, an upper slope position or some other relatively level area will be an acceptable alternative, provided an appropriate soil conservation bank design is used immediately above the site to prevent erosion of the stockpile by runoff water.

In addition, measures should be taken to minimise loss of soil material from the stockpiles, especially in the period before they are stabilised, eg. using geotextile "fences" or lines of hay or straw bales etc.

The stockpile surfaces should be left with a "rough" but even surface to assist in runoff control and seed retention and germination and be sown with stabilising species as soon as possible after placement. Where stockpile construction is conducted in stages, the stockpiles should be progressively stabilised.

9 LAND CAPABILITY AND AGRICULTURAL LAND SUITABILITY

9.1 Land Capability

9.1.1 Methodology

Houghton and Charman [1986] in their “Glossary of Terms Used in Soil Conservation” define land capability as follows.

“The ability of land to accept a type and intensity of use permanently, or for specified periods under specific management, without permanent damage.”

They further note that land capability is “...an expression of the effect of biophysical land resources, including climate, on the ability of land to sustain use without damage under various uses such as crop production requiring regular tillage, grazing, woodland or wildlife. Land capability involves consideration of:

- the various land resources;
- the production to be obtained from the land;
- the activities or inputs required to achieve that production;
- the risks of damage to the land, on-site or off-site, resulting from those activities; and
- the inter-relations of the above.”

Houghton and Charman note that land capability is taken into account in determining land suitability – another form of land classification relating to use for various purposes.

Land that is used beyond its capability ultimately loses its productive capacity as a consequence of exhaustion of soil nutrient supplies or the development of various forms of land degradation.

The land capability classification system used in New South Wales has been described by Emery [undated] and is a modification of the system devised and used by the former USDA Soil Conservation Service in the United States of America.

Emery’s paper [in its **Table 1**] contains details of the Land Capability legend used on land capability maps prepared by the former Soil Conservation Service of New South Wales [now part of DNR].

This shows the hierarchical classification used in the eight class system based on the management and protection needs of different types of land ranging from land needing no special soil conservation works or practices [Class 1] through to land that is unsuitable for agricultural or pastoral production [Class 8].

Emery's table also shows two other land capability classes – Mining and Urban land use – and also deals with class subscripts used to further subdivide some capability classes. The information presented by Emery is contained in **Appendix 3**.

9.1.2 Land Capability as Mapped by DNR for the Study Area

It should be noted that both the NSW Department of Natural Resources [DNR] Land Capability mapping and the Agricultural Land Suitability mapping of NSW Department of Primary Industries [Agriculture] were carried out at a very different scale to that of the present study and in most cases the assessments were subjected to only limited field checking.

As a consequence, there are often differing assessments that result from more detailed examination of relatively small study areas.

The 1: 100 000 scale Land Capability map of the Boggabri map sheet area prepared by the former Soil Conservation Service of NSW [Department of Natural Resources, Parramatta - GIS] shows the study site to comprise **Classes II, III and IV** land.

Class II land is *land suitable for regular cultivation using soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation*.

Class III land is *land suited to regular cultivation provided it is suitably protected by soil conservation measures and practices*.

Class IV land is *land suitable for grazing with occasional cultivation and use of suitable soil protection measures such as pasture improvement, stock control and application of fertiliser*.

The level to low slope land within the study area is mapped as **Class II** land.

However, it should be noted that all of this land within the study area has been protected by soil conservation earthworks [dams, banks and waterways] indicating that, in practice, this land has been erosion prone when being cultivated. These level and low slope lands also receive considerable flows of run-on water from the surrounding steep hill areas, further compounding the problem.

In addition, the current soils study results indicate that this land is frequently underlain by gravel beds that appear to impact on available soil moisture storage and hence crop yields and probably pasture growth - particularly in dry seasons.

The mid-slope country within the study area is mapped by DNR as **Class III** land. Field inspection revealed that some of this land has deep gilgais closely spaced over the landscape.

The upper slope land and drainage lines are mapped by DNR as **Class IV**

9.1.3 Current Assessment

After a stereoscopic interpretation of airphotos of the site and field assessments during the vegetation and soil survey within the study area, it is evident that:

- the DNR mapped **Class II** lands are more realistically **Class III** land;
- the DNR mapped **Class III** lands, *other than the gilgais*, are **Class III** land;
- the gilgai country is **Class VI** land because of the gilgai depth and density; and
- the DNR mapped **Class IV** lands are generally correctly mapped, although some sections of the drainage line component are undoubtedly **Class V** land because of the erosion control structures required [*and already constructed*].

Class V land is land suitable for grazing with occasional cultivation. Structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with use of suitable soil protection measures such as pasture improvement, stock control and application of fertiliser

Class VI land is land suitable for grazing with no cultivation. Soil conservation practices including limitation of stock, broadcasting of seed and fertiliser, prevention of fire and destruction of vermin are required along with some isolated structural soil conservation works.

Figure 5a displays the mapped land on the Project Site and along the northern section of the transport route.

9.2 Agricultural Land Suitability Classification

9.2.1 NSW Department of Primary Industries [Agriculture] Assessment

Information supplied by NSW Department of Primary Industries [Agriculture] [DPI] at Gunnedah [Bob Bennett, pers.comm.] indicates that the Department has classified the lands of the area around Belmont using its agricultural land suitability system.

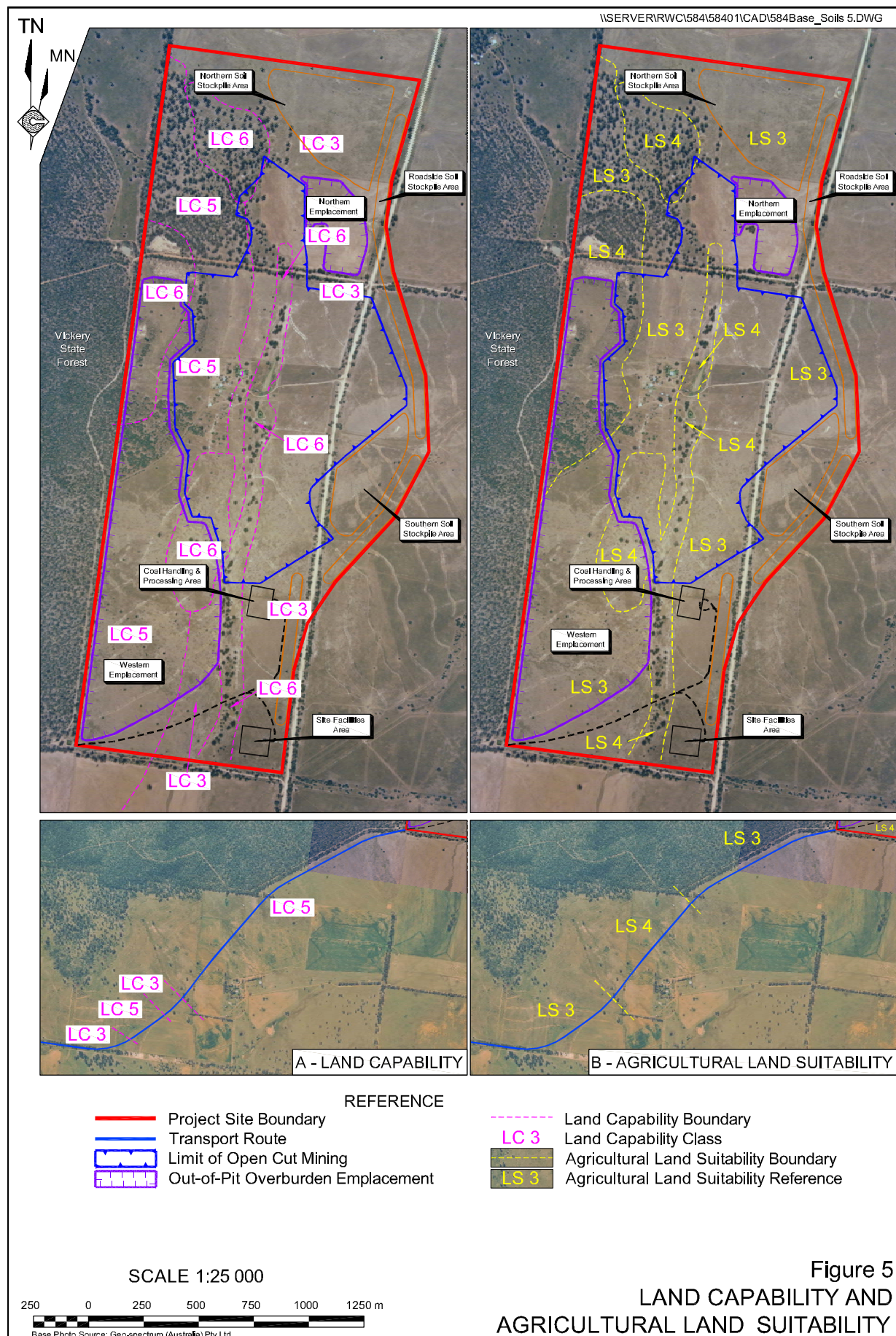
The maps showing the Belmont study area indicate that the lands are mainly **Class 3** and **Class 2** land with **patches of Class 4** land.

The **Class 2** land is located on the valley floor and the **Class 3** land on the surrounding slopes.

The **Class 4** land is associated with the more elevated sites near the Vickery State Forest and the main gilgai area in the north of the study site.

The NSW DPI Agricultural Land Suitability classification defines these land classes as follows:

- **Class 2** lands are arable lands that are suitable for regular cultivation for crops but not for continuous cultivation. These lands have a moderate to high suitability for agriculture but soil and / or environmental constraints reduces productivity
- **Class 3** lands are grazing lands or those well suited to pasture improvement. These lands have a moderate productivity and may be cultivated or cropped in rotation with pasture although soil and environmental constraints [eg. erosion hazard and soil structure breakdown] limit productivity.



- **Class 4** lands are suited suitable for grazing [using native pastures or possibly for pasture improvement with minimum tillage] but not for cultivation. These lands have a low overall productivity although production may be high in some seasons.

9.2.2 Current Assessment

A more detailed study of the Belmont site indicates that the Class 2 lands shown in the NSW DPI mapping probably do not extend onto the Project Site.

Part [the lower sections] of SMU 4 and the sections of SMU 2 away from the actual drainage line passing through the centre of the study area are Class 3 lands.

The remainder of the study area - SMUs 1 and 3, the upper sections of SMU 4 and the drainage line component of SMU 2 are Class 4 lands.

Figure 5b displays the various classes of agricultural land suitability across the Project Site and the northern section of the transport route.

10 CONCLUSION

Soils within the Belmont study area have been described and four Soil Mapping Units have been identified. Forty soil pits were dug to a depth of 2.5m or to a point where bedrock was encountered or the backhoe refused to deepen the pit.

The physical and chemical attributes of the soils of the study area have been quantified through a combination of field assessment and laboratory testing and indicate the following.

- The soils are currently stable but have a generally moderate to high erodibility rating as determined using the laboratory data obtained from samples from the study area in the SOILOSS computer model.
- The soils of much of the study area are currently protected by systems of soil conservation banks and waterways. These protective systems will have to be altered to ensure adequate surface water management during the development of the Project and in the post-mining period.
- The soils have a generally high structure grade and so can be stripped and respread using scrapers and bulldozers.
- The topsoil material [to 15cm depth] and the subsoil [to about 65cm total depth below the original soil surface] are favourable for use in rehabilitating the disturbed landscape. However the lower subsoil material has limitations imposed by high dispersibility, moderate salinity and generally very high pH levels.
- All soils would be subject to structural degradation if worked when too moist.

Depth of stripping recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and resspreading.

The pre-mining Land Capability [**Classes III, V and VI**] and Agricultural Land Suitability [**Classes 3 and 4**] of the study area has been determined.

11 REFERENCES

Anon [1976] – Gunnedah District Technical Manual. Soil Conservation Service of NSW, Sydney.

Anon [1978] – Narrabri District Technical Manual. Soil Conservation Service of NSW, Sydney.

Cunningham, G.M., Higginson, F.R., Riddler, A.M.H. and Emery, K.A. [undated] – Systems Used to Classify Rural Lands in New South Wales. Soil Conservation Service of NSW and NSW Department of Agriculture, Sydney.

Dougall, B.M. [1950] – The Effects of Open-Cut Coal Mining on Agricultural Land. J. Sci. Fd. Agric. 11: 225 - 229

Elliott, G.L. and Veness, R.A. [1981] – Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley. J. Soil Cons. NSW 37: 37-40

Emery, K.A. [undated] – Rural Land Capability Mapping, Scale 1: 100 000. Soil Conservation Service of New South Wales, Sydney.

Glendinning, J.S. [1990] – Fertiliser Handbook. Incitec Ltd, Morningside.

Hazelton, P.A. and Murphy, B.W. [Eds] [in press] – What Do All the Numbers Mean? A Guide for the Interpretation of Soil Test Results. Department of Land and Water Conservation, Sydney and University of Technology, Sydney.

Hunter, F. and Currie, J.A. [1956] – Structural Changes During Bulk Soil Storage. J. Soil Sci. 7: 75 – 80

Isbell, R.F. [1996] - The Australian Soil Classification. Australian Soil and Land Survey Handbook. CSIRO Publishing, Collingwood.

Jacquier, D.W, McKenzie, N.J., Brown, K.L., Isbell, R.F. and Paine, T.A. [2001] - The Australian Soil Classification - An Interactive Key. Version 1.0. CSIRO Publishing, Melbourne.

Jenkin, J.F., Elliott, G.L. and Veness, J.A. [1987] - Soil Stockpiling, Profile Reconstruction and Crop Growth on Reconstituted Soils: Dartbrook, Hunter Valley, NSW. Australian Mining Industry Council, Proceedings of Environmental Workshop, Adelaide.

Macbeth [1992] – Munsell Soil Colour Charts. 1992 Revised Edition. Macbeth Division of Kollmorgen Instruments Corporation, Newburgh, New York.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. [1990] – Australian Soil and Land Survey Field Handbook. Second edition. Inkata Press, Melbourne.

Murphy, B.W. and Lawrie, J.W. [1998] – Soil Landscapes of the Dubbo 1; 100 000 Sheet Report. Department of Land and Water Conservation, Sydney.

Northcote, K.H. [1971] – A Factual Key for the Recognition of Australian Soils. Rellim Technical Publications, Glenside.

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K. and Yoder, D.C. [1993] – Predicting Soil Erosion by Water: A Guide to Conservation Planning with the revised Universal Soil Loss Equation [RUSLE]. USDA Agriculture Handbook. Washington DC.

Rosewell, C.J. [1993] – SOILOSS, A Program to Assist in the Selection of Management Practices to Reduce Erosion. Second Edition. Department of Conservation and Land Management, Sydney.

Rosewell, C.J. and Edwards, K. [1988] – SOILOSS. A Program to Assist in the Selection of Management Practices to Reduce Erosion. Technical Handbook No. 11. Soil Conservation Service of NSW, Sydney.

Wischmeier, W.H. and Smith, D.D. [1978] – Predicting Rainfall Erosion Losses – A Guide to Conservation Planning. Handbook 537, USDA, Washington DC.

Geoff Cunningham B.Sc.Agr.[Hons], FAIAST.
Managing Director and Principal Soil Scientist,
Geoff Cunningham Natural Resource Consultants Pty Ltd
1st February, 2007

This page has intentionally been left blank

APPENDICES

- Appendix 1 Profile Descriptions**
- Appendix 2 Topsoil Stripping Suitability Key**
- Appendix 3 Basis of Land Capability
Classification**
- Appendix 4 Glossary**

(No. of pages excluding this page = 27)

This page has intentionally been left blank

Appendix 1

Profile Descriptions*

(No. of pages excluding this page = 24)

* Note: All profile descriptions are included in full on the Project CD.

This page has intentionally been left blank

APPENDIX 1 – Profile Descriptions

NOTE – in descriptions of peds the abbreviations ABL [angular blocky] and SABL [sub-angular blocky] are used in the following text.

Profile 1 [SMU 2] - lower slope location; surface condition firm to hardsetting; some surface stone present, to 10cm, prismoid and rounded

0-30cm; light to medium clay; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/2] dry, very dark grey [7.5YR3/1] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

30-56cm;sandy clay; roots common; no lime present; no manganese present; pH 7.5; occasional rounded gravel to 1cm; not mottled; not bleached; pinkish grey [7.5YR5/2] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

56-77cm;clayey sand; roots few; no lime present; no manganese present; pH 8.0; rounded and angular gravel 2-5cm; not mottled; not bleached; light brownish grey [10YR6/2] dry, pinkish grey [7.5YR5/2] moist; peds rough-faced, highly pedal [100%], SABL 5-20mm in size; firm consistence dry; not hydrophobic; *diffuse to:-*

77-173cm; gritty medium clay - weathering rock; roots few; no lime present; no manganese present; pH 7.5; some gravel present; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; very firm consistence dry; not hydrophobic.

Profile 2 [SMU 2] - lower slope location; surface condition firm to hardsetting; some surface stone present, 5-10cm, angular blocky

0-10cm; medium clay; roots common; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; greyish brown [10YR5/2] dry, dark grey [10YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very firm to strong consistence dry; slightly hydrophobic; *abrupt to:-*

10-51cm; medium to heavy clay; roots common; no lime present; no manganese present; pH 9.0; some flat and rounded gravel to 3cm; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds smooth-faced, highly pedal [100%], polyhedral, 10-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

51-101cm; medium to heavy clay; roots few; no lime present; no manganese present; pH 9.5-10; moderate amounts of rounded and flat gravel to 3cm; not mottled; not bleached; light grey [10YR7/2] dry, light brownish grey [10YR6/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic;

101-195cm; heavy clay; roots few; no lime present; no manganese present; pH 9.5-10; some small gravel to 2cm; not mottled; not bleached; pale brown [10YR6/3] dry, pinkish grey [7.5YR6/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

195-200cm; heavy clay; roots absent; no lime present; no manganese present; pH 9.5-10; some gravel to 5cm; not mottled; not bleached; light brown [7.5YR6/3] dry, light brown [7.5YR6/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, 10-20 mm in size; very firm to strong consistence dry; not hydrophobic.

Profile 3 [SMU 2] - lower slope location; surface condition self mulching; occasional surface stone present, blocky, to 10cm

0-20cm; medium to heavy clay; many roots; no lime present; no manganese present; pH 8.5; rounded gravel to 2-3cm common; not mottled; not bleached; dark grey [7.5YR4/1] dry, very dark grey [7.5YR3/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

20-90cm; medium to heavy clay; roots common; lime present; no manganese present; pH 9.0; rounded gravel to 3cm common; not mottled; not bleached; dark grey [7.5YR4/1] dry, dark grey [7.5YR4/1] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

90-110cm; medium clay; roots absent; no lime present; no manganese present; pH 9.5; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, pale brown [10YR6/3] moist; peds rough-faced, highly pedal [100%], SABL, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

110-180cm; sand; roots absent; no lime present; no manganese present; pH 8.0; mainly cemented gravel to 5mm; not mottled; not bleached; light brown [7.5YR6/4] dry, brown [7.5YR4/4] moist; massive, fabric rough, strong dry; not hydrophobic; *abrupt to:-*

180-210+cm; sandy clay loam; roots absent; no lime present; no manganese present; pH 5.5; gravel and stone absent; not mottled; not bleached; pink [7.5YR7/3] dry, brown 7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 4 [SMU 2] - lower slope location; surface condition firm to hardsetting; surface stone present, blocky to 10cm

0-11cm; clay loam; many roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistence dry; not hydrophobic; *sharp to:-*

11-94cm; heavy clay; roots common; no lime present; no manganese present; pH 9.5-10; scattered gravel to 2cm; not mottled; not bleached; brown [7.5YR4/2] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

94-110cm; medium to heavy clay; roots absent; no lime present; no manganese present; pH 9.0; gravel and stone absent; not mottled; not bleached; light greyish brown [10YR6/2] dry, greyish brown [10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-25mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

110-185cm; clayey sand; roots absent; lime nodules present; no manganese present; pH 8.0; comprised mainly of gravel to 5cm, rounded; not mottled; not bleached; light grey [10YR7/2] dry, brown [7.5YR5/3] moist; peds rough-faced, highly pedal [100%], SABL, <5-20mm in size; very firm consistence dry; not hydrophobic; *diffuse to:-*

185-210+cm; light sandy clay loam; roots absent; no lime present; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, brown [7.5YR4/4] moist; peds rough faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 5 [SMU 4] - midslope location; surface condition almost self mulching; surface stone absent

0-23cm; light clay; many roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; brown 10YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], SABL, 10-25mm in size; firm consistence dry; not hydrophobic; *clear to:-*

23-57cm; fine sandy clay loam; roots common; no lime present; no manganese present; pH 7.0; some gravel to 2cm; not mottled; not bleached; pink [7.5YR7/4] dry, reddish brown [5YR4/4] moist; peds rough-faced, highly pedal [100%], SABL, <5-15 mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

57-74cm; sandy loam; roots few; no lime present; no manganese present; pH 6.5; some angular gravel to 1cm; not mottled; bleached; pink [7.5YR8/3] dry, brown [7.5YR5/4] moist; peds rough-faced, highly pedal [100%], SABL, 5-20mm in size; firm consistence dry; not hydrophobic; *clear to:-*

74-154cm; sandy clay; roots few; no lime present; no manganese present; pH 5.5; some gravel <1cm but a layer of larger gravel to 3cm present at 132-142cm depth; mottled; not bleached; 90% light brown [7.5YR6/4], 10% pink [7.5YR7/3] dry, 90% reddish brown [7.5YR5/4], 10% brown [7.5YR5/3] moist; peds rough-faced, highly pedal [100%], ABL, 5-20mm in size; very firm consistence dry; not hydrophobic.

Profile 6 [SMU 2] - drainage depression location; surface condition loose to almost self mulching; surface stone absent

0-13cm; clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; weak to firm consistence dry; not hydrophobic; *clear to:-*

13-40cm; clay loam; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

40-97cm; medium clay; roots few; small lime nodules present; no manganese present; pH 9.0-9.5; some rounded gravel to 2cm common; not mottled; not bleached; brown [7.5YR5/3] dry, reddish brown [5YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral/platy, 5-15mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

97-245cm; medium to heavy clay; roots absent; small lime nodules present; no manganese present; pH 9.0-9.5; gravel and stone in a 5-15m discontinuous band about 180-200cm depth; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic.

Profile 7 [SMU 2] - lower slope / depression location; surface condition soft to firm; surface stone absent

0-22cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/2] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistence dry; hydrophobic; *abrupt to:-*

22-53cm; sandy light clay; roots common; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; almost bleached in places; pinkish grey [7.5YR6/2] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very firm to strong consistence dry; not hydrophobic; *diffuse to:-*

53-69cm; medium to heavy clay; roots few; no lime present; no manganese present; pH 8.5; pockets of rounded gravel to 1cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

69-170cm; medium to heavy clay; roots few; zone of lime concretions at 170-220cm depth; no manganese present; pH 8.5; gravel and stones absent; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

170-240cm; heavy clay; roots absent; many lime nodules present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; pink [7.5YR7/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic.

**Profile 8 [SMU 2] - lower slope location; surface condition soft; occasional surface stones present **

0-14cm; clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/2] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; weak to firm consistence dry; not hydrophobic; *clear to:-*

14-23cm; light clay; roots few; no lime present; no manganese present; pH 7.0; some grit present; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

23-90cm; sandy medium to heavy clay; roots few; lime flecks present; no manganese present; pH 8.5; grit to 2-5mm common; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral/platy, 10-25 mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

90-150cm; sandy medium to heavy clay; roots few; no lime evident; no manganese present; pH 9.0-9.5; grit to 2-5mm common; mottled; not bleached; 60% light brown [7.5YR6/3], 40% brown [7.5YR4/4] dry, 100% brown [7.5YR4/3] moist; peds earthy- rough- smooth faced, moderately pedal [60%], polyhedral / platy, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *layer of stones above weathered bedrock*

Profile 9 [SMU 2] - drainage depression location; surface condition hardsetting; surface stone absent

0-10cm; light clay; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm to very firm consistence dry; not hydrophobic; *abrupt to:-*

10-60cm; heavy clay with some grit; roots common; lime flecks present; no manganese present; pH 9.0; occasional small gravel; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

60-155cm; heavy clay; roots few; much lime present; no manganese present; pH 9.5; gritty; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, dark reddish grey [5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

155-250cm; medium to heavy clay; roots few; many lime nodules present; no manganese present; pH 9.5-10; pockets of angular and rounded gravel, 2-6cm; not mottled; not bleached; light brown [7.5YR6/4] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic;

Profile 10 [SMU 2] - lower slope location; surface condition firm to hardsetting; surface stone absent

0-11cm; sandy clay loam; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *sharp to abrupt to:-*

11-52cm; medium to heavy clay; roots common; no lime present; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; greyish brown [10YR5/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

52-68cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; very pale brown [10YR7/3] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

68-172cm; clayey sand; roots few; much lime present; no manganese present; pH 9.0; layer of rounded gravel to 5cm; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR5/3] moist; massive, weak to firm strength dry; not hydrophobic; *sharp to clear to:-*

172-245cm; heavy clay; roots absent; much lime present; manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, brown [10YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral to ABL, 5-10mm in size; strong consistence dry; not hydrophobic.

Profile 11 [SMU 2] - drainage depression location; surface condition firm to hardsetting; surface stone absent

0-14cm; clay loam; roots common; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; pinkish grey [7.5YR7/2] dry, brown [7.5YR4/2] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistence dry; hydrophobic; *abrupt to clear to:-*

14-40cm; light clay; roots common; no lime present; no manganese present; pH 6.0; occasional gravel to 3cm; not mottled; appears bleached; light grey [10YR7/2] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm to strong consistence dry; not hydrophobic; *clear to:-*

40-72cm; medium to heavy clay; roots few; lime flecks present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, dark greyish brown [10YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

72-185cm; heavy clay; roots few; lime nodules present; no manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, dark grey [10YR4/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-25mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

185-250cm; gritty medium clay; roots absent; lime nodules present; manganese stains present; pH 9.5-10; contains discontinuous pockets of gravel to 5cm; not mottled; not bleached; light brown [7.5YR6/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-25 mm in size; strong consistence dry; not hydrophobic.

Profile 12 [SMU 2] - *drainage depression location; surface condition firm to hardsetting; surface stone absent*

0-16cm; light to medium clay; many roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], SABL, <5-15mm in size; very firm consistence dry; hydrophobic; *sharp to:-*

16-24cm; sandy light to medium clay; many roots; no lime present; no manganese present; pH 6.0; some gravel to 5mm; mottled; not bleached; 95% brown [7.5YR5/3], 5% strong brown [7.5YR5/6] dry, 95% dark brown [7.5YR3/2], 5% brown [7.5YR4/4] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-25mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

24-90cm; medium to heavy clay; roots few; flecks of lime present; no manganese present; pH 9.0; some gravel to 5mm; not mottled; not bleached; brown [10YR5/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 10-20mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

90-160cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; discontinuous pockets of gravel present; not mottled; not bleached; light brown [7.5YR6/4] dry, light brown [7.5YR6/4] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, 5-25mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

160-215cm; heavy clay; roots absent; lime flecks present; no manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic.

Profile 13 [SMU 2] - drainage depression location; surface condition firm to hardsetting surface stone absent

0-12cm; silty clay loam; many roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], SABL, 5-10mm in size; firm to very firm consistence dry; hydrophobic; *abrupt to*

12-26cm; silty clay loam; roots common; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral / SABL 5-15mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

26-43cm; loam fine sandy; roots few; no lime present; no manganese present; pH 7.0; some rounded gravel to 1cm; not mottled; not bleached; light grey [10YR7/2] dry, greyish brown [10YR5/2] moist; peds rough-faced, highly pedal [100%], SABL, 5-20mm in size; firm to very firm consistence dry; not hydrophobic; *abrupt to:-*

43-111cm; medium to heavy clay; roots few; no lime present; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral / ABL, 5-20 mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

111-165cm; clayey sand; roots few; much lime present; no manganese present; pH 8.5; varying amounts of gravel present, <1-2cm; not mottled; not bleached; brown [7.5YR5/3] dry, reddish brown [5YR4/3] moist; peds rough-faced, highly pedal [100%], SABL, 5-20 mm in size; very firm consistence dry; not hydrophobic; *diffuse to:-*

165-205cm; silty clay; roots absent; lime flecks present; no manganese present; pH 8.5; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], ABL, 5-20mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

205-245cm; clayey sand; roots absent; no lime observed; no manganese present; pH 8.0; occasional gravel to 5cm; mottled; not bleached; 50% light brownish grey [10YR6/2], 50% brown [7.5YR5/2] dry, 100% brown 7.5YR5/3] moist; peds rough-faced, moderately pedal [50%], SABL, 5-15mm in size; firm consistence dry; not hydrophobic.

Profile 14 [SMU 2] - drainage depression location; surface condition firm; surface stone absent

0-19cm; clay loam; roots common; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; firm consistence dry; hydrophobic; *abrupt to clear to:-*

19-43cm; sandy clay; roots few; no lime present; no manganese present; pH 7.5; some gravel to 1cm; not mottled; bleached; pinkish grey [7.5YR7/2] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

43-183cm; light clay; roots few; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, brown 7.5YR5/2] moist; peds rough-faced, highly pedal [100%], polyhedral / platy, 10-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

183-220cm; sandy heavy clay; roots absent; no lime observed; no manganese present; pH 9.5-10 ; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/2] moist; peds rough-faced, moderately pedal [60%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile 15 [SMU 4] - midslope location; surface condition soft; surface stone present, blocky to 15cm

0-22cm; sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; some round gravel to 2.5cm; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm to very firm consistence dry; not hydrophobic; *clear to:-*

22-37cm;sandy clay; roots few; no lime present; no manganese present; pH 6.5; some rounded gravel to 4cm; not mottled; bleached; light grey [10YR7/2] dry, pale brown [10YR6/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to diffuse to:-*

37-90cm;clayey sand; roots few; no lime present; no manganese present; pH 7.0; some gravel to 10cm; mottled; not bleached; 60% very pale brown [10YR7/3], 40% light yellowish brown [10YR6/4] dry, 60% yellowish brown [10YR5/4], 40% brown [7.5YR5/4] moist; massive, very firm dry; not hydrophobic; *clear to diffuse to:-*

90-135cm; sandy clay; roots few; no lime present; much manganese present; pH 7.0; some gravel present; mottled; not bleached; 50% very pale brown [10YR7/3], 50% reddish yellow [7.5YR7/6] dry, 50% brown 10YR5/3], 50% reddish yellow [5YR6/6] moist; peds rough- faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *clear to diffuse to:-*

135-175cm; clayey sand; roots absent; no lime present; no manganese present; pH 7.5; weathering rock; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; massive, strong dry; not hydrophobic.

Profile 16 [SMU 4] - midslope location; surface condition firm; surface stone generally absent

0-12cm; sandy clay loam; many roots; no lime present; no manganese present; pH 5.5; gravel and stone absent; not mottled; not bleached; brown [10YR5/3] dry, dark greyish brown [10YR4/2] moist; peds rough-faced, moderately pedal [40%], polyhedral, 5-15mm in size; firm consistence dry; hydrophobic; *clear to:-*

12-22cm; sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; gravel 1-2cm present; not mottled; almost bleached; pinkish grey [7.5YR6/2] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [80%], polyhedral, 5-10mm in size; firm consistence dry; not hydrophobic; *clear to:-*

22-45cm; medium to heavy clay; roots few; no lime present; no manganese present; pH 9.0; gravel 1-2cm present; not mottled; not bleached; greyish brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

45-72cm; medium to heavy clay; roots few; lime present; no manganese present; pH 9.5; gravel 1-2cm present; mottled; not bleached; 50% greyish brown [10YR6/3], 50% light greyish brown [10YR6/2] dry, 50% brown [10YR5/3], 50% greyish brown [10YR5/2] moist; peds rough faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

72-156cm; gritty heavy clay; roots absent; much lime present; no manganese present; pH 9.5; pockets of rounded and angular gravel to 1-4cm, some larger to 8cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

156-240cm; gritty heavy clay; roots absent; much lime present; no manganese present; pH 9.5; some angular gravel; mottled; not bleached; 50% pale brown [10YR6/3], 50% brown [7.5YR5/3] dry, 100% brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic.

Profile 17 [SMU 2] - lower slope location; surface condition firm to hardsetting; surface stone absent

0-13cm; loam fine sandy; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, dark brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], ABL, 5-10mm in size; weak to firm consistence dry; hydrophobic; *clear to:-*

13-31cm; silty clay; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; dark greyish brown [10YR4/2] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

31-70cm; medium clay; roots common; lime flecks present; no manganese present; pH 8.5; some flat gravel to 4cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown 10YR4/3] moist; peds rough-faced, highly pedal [100%], ABL / polyhedral, 5-20mm in size; very firm to strong consistence dry; not hydrophobic; *abrupt to:-*

70-92cm; sandy medium clay; roots few; lime present as flecks and some nodules; no manganese present; pH9.0; rounded and flat gravel to 5cm present; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR5/4] moist; peds rough-faced, highly pedal [100%], SABL, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

92-120cm; sandy medium clay; roots few; no lime present; no manganese present; pH 9.5-10; some gravel to 3cm; not mottled; not bleached; light brown [7.5YR6/3] dry, pale brown [10YR6/3] moist; peds smooth-faced, highly pedal [100%], ABL / platy, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

120-150cm; gritty medium to heavy clay; roots few; much lime present; manganese present; pH 9.5-10; some grit to 5mm; not mottled; not bleached; greyish brown [10YR5/2] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], SABL, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

150-170cm; gritty clay [cemented sand]; roots few; much lime present; no manganese present; pH 9.5; much gravel to 8cm; not mottled; not bleached; light grey [2.5YR7/1] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], SABL, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

170-200cm; sandy medium clay; roots absent; no free lime present; manganese present; pH 9.5; grit plus gravel, flat and rounded, to 8cm common; not mottled; not bleached; light brownish grey [10YR6/2] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

200-220cm; sandy medium clay; roots absent; lime present; manganese present; pH 9.0; grit plus gravel to 4cm common; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

220-290cm; sandy medium clay; roots absent; lime present; manganese present; pH9.0-10; some gravel to 3cm; not mottled; not bleached; greyish brown [10YR5/2] dry, light brownish grey [10YR6/2] moist; peds smooth-faced, highly pedal [100%], ABL, 10-20mm in size; strong consistence dry; not hydrophobic.

Profile 18 [SMU 3] - gilgai depression location; surface condition; occasional surface stone present, to 10cm

0-20cm; heavy clay; many roots; no lime present; manganese stains present; pH 5.0; occasional gravel to 5mm; not mottled; not bleached; grey [10YR6/1] dry, very dark greyish brown [10YR3/2] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

20-63cm; heavy clay; roots common; lime flecks present; no manganese present; pH 5.5; occasional rounded gravel to 1.5cm; not mottled; not bleached; dark grey [10YR4/1] dry, very dark grey [10YR3/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

63-120cm; medium to heavy clay; roots few; no lime present; no manganese present; pH 6.0; gravel to 2cm present; not mottled; not bleached; dark grey [7.5YR4/1] dry, very dark grey [7.5YR3/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong to very strong consistence dry; not hydrophobic; *clear to:-*

120-160cm; gritty heavy clay; roots few; lime present; no manganese present; pH 9.0; some gravel to 1.5cm; not mottled; not bleached; light greyish brown [10YR6/2] dry, dark grey [10YR4/1] peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

160-210cm; heavy clay; roots absent; lime present; no manganese present; pH 9.0; some gravel to 1.5cm; not mottled; not bleached; light grey [10YR7/2] with grey [10YR5/1] skins dry, light grey [10YR7/2] with dark grey [10YR4/1] skins moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

210-270cm; gritty heavy clay; roots absent; no lime recorded; no manganese present; pH 9.0; some gravel to 1.5cm; not mottled; not bleached; light grey [10YR7/2] with grey [10YR5/1] skins dry, light grey [10YR7/2] with dark grey [10YR4/1] skins moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic.

Profile 19 [SMU 3] - gilgai puff location; surface condition soft to firm; surface stone absent

0-18cm; clay loam; roots common; no lime present; no manganese present; pH 5.0; gravel to 5cm common; not mottled; not bleached; brown [7.5YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; firm consistence dry; hydrophobic; *abrupt to clear to:-*

18-80cm; medium to heavy clay; roots common; lime nodule layer begins at 40cm; no manganese present; pH 9.5-10; some gravel not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; hydrophobic; *clear to gradual to:-*

80-162cm; slightly gritty medium to heavy clay; roots few; lime flecks present; no manganese present; pH 9.5-10; rounded gravel to 5cm common; not mottled; not bleached; light brownish grey [10YR6/2] dry, greyish brown [10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

162-252cm; heavy clay; roots absent; much lime present at base; manganese common; pH 8.5; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, light brownish grey [10YR6/2] moist, peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic.

Profile 20 [SMU 2] - drainage flat location; surface condition firm, approaching cracking; surface stone present, blocky to 12cm

0-18cm; light clay; roots few; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/2] dry, very dark grey [7.5YR5/1] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *abrupt to clear to:-*

18-38cm; light to medium clay; roots few; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; bleached; pinkish grey [7.5YR7/2] dry, brown [7.5YR5/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; not hydrophobic; *abrupt to clear to:-*

38-80cm; heavy clay; roots few; no lime present; no manganese present; pH 7.5; some rounded gravel to 2cm; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *abrupt to clear to:-*

80-111cm; sandy clay; roots few; no lime present; no manganese present; pH; 8.5; comprised mainly of rounded gravel to 4cm; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, brown [7.5YR5/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm to strong consistence dry; not hydrophobic; *clear to gradual to:-*

111-141cm; medium to heavy clay; roots absent; lime present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, brown [7.5YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *gradual to:-*

141-257cm; slightly gritty medium to heavy clay; roots absent; lime present; no manganese present; pH 9.0-9.5; grit present; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic.

Profile 21 [SMU 2] - drainage flat location; surface condition firm; some surface stone present, to 5cm

0-24cm; light clay; roots common; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm to very firm consistence dry; not hydrophobic; *abrupt to:-*

24-30cm; light to medium clay; roots common; no lime present; no manganese present; pH 6.0; gravel to 2cm common; not mottled; not bleached; light brownish grey [10YR6/2] dry, dark greyish brown [10YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

30-101cm; heavy clay; roots common; lime flecks present; no manganese present; pH 8.0; some gravel <1-5cm; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

101-163cm; slightly sandy heavy clay; roots few; much lime present; no manganese present; pH 9.0; gravel 3-8cm common; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, reddish grey [5YR5/2] moist; massive, very firm to strong dry; not hydrophobic; *abrupt to:-*

163-268cm; gritty heavy clay; roots absent; no lime present; no manganese present; pH 9.0; some gravel to 2cm; mottled; not bleached; 60% light brownish grey [10YR6/2], 40% brown [10YR5/3] dry, 60% light brownish grey [10YR6/2], 40% brown [10YR5/3] moist, peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong dry; not hydrophobic.

Profile 22 [SMU 2] - drainage flat location; surface condition - cultivated; surface stone absent

0-14cm; light clay; roots common; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm to very firm consistence dry; not hydrophobic; *abrupt to:-*

14-25cm; light to medium clay; roots few; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

25-146cm; heavy clay; roots few; zone of lime accumulation; no manganese present; pH 9.0; some small gravel to 5mm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

146-172cm; clayey sand; roots absent; scattered lime flecks present; no manganese present; pH 9.5-10; gravel to 5cm common but in some areas is absent; not mottled; not bleached; pale brown [7.5YR6/3] dry, brown [7.5YR4/3] moist; massive, very firm dry; not hydrophobic; *abrupt to clear to:-*

172-270cm; heavy clay; roots absent; much lime present; no manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; light brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic.

Profile 23 [SMU 2] - drainage depression location; surface condition hardsetting; surface stone absent present

0-20cm; light clay; many roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, dark brown [7.5YR3/26] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

20-88cm; heavy clay; roots common; small lime nodules present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

88-187cm; heavy clay; roots few in upper section; lime nodules common; no manganese present; pH 9.5-10; gravel to 5cm common; not mottled; not bleached; pinkish grey [7.5YR6/2] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; very firm consistence dry; not hydrophobic; *clear to gradual to:-*

187-257cm; heavy clay; roots absent; small lime nodules present; no manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; light brownish grey [10YR6/2] dry, light brownish grey [10YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very firm consistence dry; not hydrophobic.

Profile 24 [SMU 2] - lower slope location; surface condition hardsetting; surface stone absent

0-17cm; light to medium clay; roots few; no lime present; no manganese present; pH 6.5; some small gravel to 5mm; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; slightly hydrophobic; *abrupt to:-*

17-40cm; light to medium clay; roots few; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to clear to:-*

40-126cm; heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; occasional rounded gravel to 5cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/3] moist, peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

126-260cm; heavy clay; roots few; scattered lime present; manganese stains common; pH 9.5-10; some gravel to 1.5cm; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 25 [SMU 2] - lower slope location; surface condition hardsetting; some surface stone rounded, to 6cm

0-13cm; light clay; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, dark greyish brown [10YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral / platy, 5-25 mm in size; firm to very firm consistence dry; slightly hydrophobic; *abrupt to:-*

13-47cm; medium to heavy clay; roots common; some lime flecks present; no manganese present; pH 7.0; some gravel to 1cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

47-140cm; heavy clay; roots few; lime flecks present; no manganese present; pH 9.0; some gravel to 2cm; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

140-240cm; heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; some pockets of gravel; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 26 [SMU 2] - level plain location; surface condition loose; surface stone absent

0-13cm; clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stone absent; not mottled; not bleached; brown [7.5YR5/2] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

13-50cm; heavy clay; roots few; no lime present; no manganese present; pH 7.0; some gravel to 1cm; not mottled; not bleached; brown [7.5YR5/2] dry, brown [7.5YR5/2] moist, peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

50-105cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 9.0; gravel and stone absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; very firm to strong consistence dry; not hydrophobic; *variable to:-*

105-136cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 9.0-9.5; pockets of rounded gravel to 2cm; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; very firm to strong consistence dry; not hydrophobic; *variable to:-*

136-260cm; medium to heavy clay; roots few; many lime flecks present; no manganese present; pH 9.0-9.5; gravel and stone absent; not mottled; not bleached; pinkish grey [7.5YR7/2] dry, light brown [7.5YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 27 [SMU 2] - lower slope location; surface condition hardsetting; much rounded and angular surface stone present, 1-5cm

0-10cm; fine sandy loam; roots common; no lime present; no manganese present; pH 6.0; rounded gravel to 2cm present; not mottled; not bleached; light yellowish brown [10YR6/4] dry, brown [7.5YR4/3+Q129] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

10-38cm; medium to heavy clay; roots few; some lime nodules present; no manganese present; pH 8.5; gravel and stone absent; not mottled; not bleached; dark brown [7.5YR3/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

38-137cm; heavy clay; roots few; lime present; no manganese present; pH 9.5-10; gravel 1-5cm common; not mottled; not bleached; light brown [7.5YR6/3] dry, light brown [7.5YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

137-173cm; heavy clay; roots absent; much lime present; no manganese present; pH 9.5-10; some gravel to 3cm; not mottled; not bleached; very pale brown [10YR7/3] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

173-213cm; heavy clay; roots absent; lime present; much manganese present; pH 9.5-10; gravelly layer, most 2-3cm and up to 6cm; not mottled; not bleached; pale brown [10YR6/3] dry, pale brown [10YR6/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *abrupt to clear to:-*

213-250cm; heavy clay; roots absent; lime nodules present; much manganese present; pH 9.5-10; much gravel to 1cm; not mottled; not bleached; pale brown [10YR6/3] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic.

Profile 28 [SMU 4] - midslope location; surface condition loose; surface stone absent

0-20cm; fine sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; some gravel to 1.5cm; not mottled; not bleached; light brown [7.5YR6/4] dry, brown [7.5YR4/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistence dry; hydrophobic; *abrupt to:-*

20-35cm; loam fine sandy; roots few; no lime present; no manganese present; pH 5.0; much gravel; not mottled; bleached; pinkish white [7.5YR8/2] dry, light brown [7.5YR6/3] moist; massive, fabric rough, firm dry; hydrophobic; *abrupt to clear to:-*

35-170cm; sandy medium clay; roots few; layer of lime present about 120cm; no manganese present; pH 9.5-10; some gravel to 2cm; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

170-220cm; sandy medium clay; roots few; lime present; much manganese staining present; pH 9.5-10; much gravel 3-8cm, some stone to 10cm; not mottled; not bleached; very pale brown [10YR7/3] dry, light yellowish brown [10YR6/4] moist; massive material in interspaces in gravel, firm dry; not hydrophobic; *gradual to:-*

220-230cm; heavy clay; roots absent; no lime recorded; much manganese staining present; pH 9.5-10; gravel and stone absent; not mottled; not bleached; very pale brown [10YR7/3] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 29 [SMU 4] - midslope location; surface condition firm to hardsetting; much rounded and angular surface stone present, 5-10cm

0-12cm; light to medium clay; many roots; no lime present; no manganese present; pH 6.0; some rounded gravel to 2cm; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

12-23cm; light to medium clay; roots common; no lime present; no manganese present; pH 6.5; some rounded gravel to 4cm; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

23-52cm; heavy clay; roots few; many lime nodules present; no manganese present; pH 9.5-10; some gravel present; not mottled; not bleached; greyish brown [10YR5/2] dry, greyish brown [10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

52-150cm; heavy clay; roots few; some lime present; manganese concretions present; pH 6.5; some gravel to 2cm; not mottled; not bleached; light brown [7.5YR6/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

150-250cm; heavy clay; roots absent; no lime present; no manganese present; pH 5.0; occasional weathered stones; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [10YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic;

Profile 30 [SMU 1] - crest location; surface condition hardsetting; moderate amounts of rounded surface stone present, to 20cm

0-20cm; light to medium clay; roots common; no lime present; no manganese present; pH 6.5; some small gravel; not mottled; not bleached; dark greyish brown [10YR4/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

20-95cm; heavy clay; roots few; no lime recorded; no manganese present; pH 9.0; gravel to 5mm present; not mottled; not bleached; greyish brown [10YR5/2] dry, dark greyish brown [10YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very firm to strong consistence dry; not hydrophobic; *gradual to:-*

95-110cm; heavy clay; roots absent; no lime present; no manganese present; pH 9.5; flat to rounded gravel to 5cm present; mottled; not bleached; 50% light grey [10YR7/2], 50% light brownish grey [10YR6/2] dry, 50% very pale brown [10YR7/3], 50% greyish brown [10YR5/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to to:-*

110-135cm; weathered conglomerate

Profile 31 [SMU 4] - midslope location; surface condition loose; moderate amounts of surface stone to 20cm, flat and round

0-14cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; much gravel to 5cm; not mottled; not bleached; brown [10YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, moderately pedal [50%], polyhedral, 5-10mm in size; firm consistence dry; not hydrophobic; *clear to:-*

14-40cm; sandy clay loam; roots few; no lime present; no manganese present; pH 7.0; some gravel to 8cm; not mottled; bleached; pink [7.5YR7/4] dry, brown [7.5YR 5/4] moist; massive between gravel, very firm dry; not hydrophobic; *clear to:-*

40-50cm; sandy clay; roots few; no lime present; no manganese present; pH 7.0; basically weathered conglomerate; not mottled; not bleached; pink [7.5YR8/4] dry, light brown [7.5YR6/4] moist; massive between gravel; not hydrophobic.

Profile 32 [SMU 4] - midslope location ;surface condition loose; some rounded surface stone to 5cm present

0-12cm; sandy loam; many roots; no lime present; no manganese present; pH 5.5; rounded and angular gravel to 5cm present; not mottled; not bleached; dark greyish brown [10YR4/2] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm consistence dry; hydrophobic; *clear to:-*

12-33cm; loam fine sandy; roots common; no lime present; no manganese present; pH6.0; some gravel to 4cm; not mottled; not bleached; light brown [7.5YR6/3] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to clear to:-*

33-70cm; sand; roots few; no lime present; no manganese present; pH7.0; almost completely gravel 1-5cm; not mottled; not bleached; pink [7.5YR8/3] dry, light brown [7.5YR6/4] moist; massive, firm dry; not hydrophobic; *abrupt to clear to:-*

70-98cm; weathered conglomerate; roots few;

Profile 33 [SMU 2] - lower slope location; surface condition firm; surface stone absent

0-12cm; clay loam; many roots; no lime present; no manganese present; pH 5.5; some gravel to 4cm; not mottled; not bleached; pale brown [10YR6/3] dry, brown [7.5YR4/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm consistence dry; hydrophobic; *clear to:-*

12-47cm; sandy clay; many roots; no lime present; no manganese present; pH 6.5; pockets of gravel 2-4cm; not mottled; appears bleached; light brownish grey [10YR6/2] dry, greyish brown [10YR5/2] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

47-135cm; light to medium clay; roots few; no lime present; no manganese present; pH 7.5; pockets of gravel to 1cm, some to 5cm; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

135-269cm; gritty light to medium clay; roots few; lime flecks present; no manganese present; pH 8.0; occasional large gravel 5-10cm, rounded; not mottled; not bleached; greyish brown [10YR5/2] dry, dark grey [10YR4/1] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-15mm in size; very firm consistence dry; not hydrophobic.

Profile 34 [SMU 2] - mid to lower slope location; surface condition firm; surface stone absent

0-14cm; clay loam; many roots; no lime present; no manganese present; pH 5.0; occasional grit to 5mm; not mottled; not bleached; brown [7.5YR4/3] dry, 7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

14-30cm; light clay; roots common; no lime present; no manganese present; pH 6.0; some gravel to 1.5cm; not mottled; not bleached; dark reddish grey 5YR4/2] dry, dark reddish brown [5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

30-63cm; heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; much gravel 5mm to 2cm; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/4] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

63-134cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; some gravel; not mottled; not bleached; light yellowish brown [10YR6/4] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *clear to:-*

134-160cm; medium clay; roots few; lime present; much manganese staining; pH 9.5-10; layer of 1-2cm gravel of variable width; not mottled; not bleached; brown [10YR5/3] dry, brown [10YR5/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

160-202cm; gritty medium clay mixed with gravel; roots absent; lime present; much manganese staining; pH 9.5-10; some gravel 5-9cm; not mottled; not bleached; very pale brown [10YR7/3] dry, pale brown [10YR6/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic.

Profile 35 [SMU 4] - midslope location; surface condition firm; moderate levels of surface stone present, 1-2cm, angular

0-14cm; sandy clay loam; many roots; no lime present; no manganese present; pH 5.5; much rounded and angular gravel to 2cm; not mottled; not bleached; dark greyish brown [10YR4/2] dry, very dark grey [7.5YR3/1] moist; peds rough-faced, moderately pedal [60%], polyhedral, 5-10mm in size; firm consistence dry; hydrophobic; *clear to:-*

14-28cm; sandy clay loam; many roots; no lime present; no manganese present; pH 6.0; much small gravel 1-3cm; not mottled; not bleached; brown [10YR5/3] dry, brown [7.5YR4/3] moist; peds rough-faced, moderately pedal [40%], polyhedral, <5-10mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

28-72cm; clayey sand; roots common; no lime present; no manganese present; pH 7.5; much gravel <1-2cm; not mottled; bleached; pink [7.5YR7/3] dry, brown [7.5YR5/4] moist; massive, firm dry; not hydrophobic; *abrupt to:-*

72-77cm; sandy clay; roots absent; no lime evident; no manganese present; pH 8.0; mottled; not bleached; 50% light reddish brown [5YR6/4], 50% pinkish grey [7.5YR7/2] dry, 50% reddish brown [5YR5/4], 50% pinkish grey [7.5YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-25mm in size; strong consistence dry; not hydrophobic.

Profile 36 [SMU 4] - mid to lower slope location; surface condition hardsetting; surface stone absent or much gravel present

0-12cm; clay loam; many roots; no lime present; no manganese present; pH 6.0; some angular gravel to 3cm; not mottled; not bleached; brown 10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

12-32cm; heavy clay; roots few; some lime nodules present; no manganese present; pH 9.5; occasional gravel to 3cm; not mottled; not bleached; dark greyish brown [10YR4/2] dry, brown [7.5YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

32-84cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; brown 7.5YR5/2] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *gradual to:-*

84-240cm; medium to heavy clay; roots absent; no lime present; no manganese present; pH 5.5-6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/2] dry, brown 10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic.

Profile 37 [SMU 2] - lower slope location; surface condition firm; surface stone absent

0-22cm; sandy clay loam; many roots; no lime present; no manganese present; pH 5.5; some grit to 5mm; not mottled; not bleached; brown [10YR5/3] dry, dark brown [7.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

22-37cm; sandy clay; roots common; no lime present; manganese stains present; pH 6.5; much gravel, to 3cm; not mottled; bleached; pinkish grey [7.5YR7/2] dry, dark brown [7.5YR3/3] moist; peds rough-faced, slightly pedal [10%], polyhedral, <5-10mm in size; firm to very firm consistence dry; not hydrophobic; *abrupt to clear to:-*

37-186cm; gritty medium to heavy clay; roots few; lime present; manganese stains present; pH 9.0; much rounded gravel to 3cm; not mottled; not bleached; brown [10YR5/3] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

186-250cm; medium to heavy clay; roots absent; much lime present; much manganese staining; pH 9.5-10; much gravel to 6cm, rounded; not mottled; not bleached; greyish brown [10YR5/2] dry, light brownish grey [10YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic.

Profile 38 [SMU 3] - *gilgai depression location; surface condition self mulching; surface stone absent or some surface gravel 1-2cm and occasional stones to 12cm present*

0-20cm; sandy clay loam to clay loam; many roots; no lime present; no manganese present; pH 6.0; moderate amounts of gravel, 1-3cm; not mottled; not bleached; dark grey [7.5YR4/1] dry, very dark grey [7.5YR3/1] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; strong consistence dry; hydrophobic; *clear to:-*

20-52cm; sandy clay; roots few; lime flecks present; no manganese present; pH 9.5; some gravel to 4cm, angular; not mottled; not bleached; grey [10YR4/1] dry, grey [10YR4/1] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; not hydrophobic; *clear to:-*

52-170cm; gritty medium clay; roots few; lime present; no manganese present; pH 9.0; lenses of gravel 3-6cm; not mottled; not bleached; dark grey [10YR4/1] dry, very dark grey [10YR3/1] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic; *to:-*

170-240cm; sandy clay; roots absent; lime layer present; no manganese present; pH 9.5; occasional lenses of 1-2cm gravel; not mottled; not bleached; greyish brown [10YR5/2] dry, grey [10YR5/1] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic.

Profile 39 [SMU 3] - *gilgai puff location; surface condition self mulching; much rounded and angular surface stone to 5cm present*

0-25cm; sandy light clay; many roots; lime present; no manganese present; pH 8.0; gravelly; not mottled; not bleached; greyish brown [10YR5/2] dry, very dark greyish brown [10YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20mm in size; strong consistence dry; slightly hydrophobic; *gradual to:-*

25-68cm; heavy clay; roots few; much lime present; no manganese present; pH 9.5-10; some rounded gravel; not mottled; not bleached; light greyish brown [10YR6/2] dry, light greyish brown [10YR6/2] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10mm in size; very firm to strong consistence dry; not hydrophobic; *gradual to:-*

68-250cm; heavy clay; roots few; no lime present; no manganese present; pH 9.5-10; gravel and stone absent; not mottled; not bleached; greyish brown [10YR5/2] dry, greyish brown [2.5Y5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic.

Profile 40 [SMU 4] - *midslope location; surface condition hardsetting; some rounded / angular stone absent present, to 4cm*

0-24cm; silty clay loam; roots common; no lime present; no manganese present; pH 6.5; some gravel present; not mottled; not bleached; brown [7.5YR5/3] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15mm in size; weak consistence dry; hydrophobic; *clear to:-*

24-71cm; clayey sand; many roots; no lime present; no manganese present; pH 7.0; almost entirely rounded gravel to 5cm; not mottled; not bleached; light brown [7.5YR6/3] dry, brown [7.5YR4/4] moist; massive, firm dry; not hydrophobic; *abrupt to:-*

71-98cm; medium to heavy clay; roots few; no lime present; no manganese present; pH 8.5; some gravel present; not mottled; not bleached; pale brown [10YR6/3] dry, yellowish brown [10YR5/4] moist; peds smooth-faced, highly pedal [100%], ABL, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

98-143cm; medium to heavy clay; roots few; much lime present; no manganese present; pH 8.5; gravel to 3cm common; not mottled; not bleached; pale brown [10YR6/3] dry, brown [10YR5/3] moist; peds smooth-faced, highly pedal [100%], SABL, 5-15mm in size; very firm to strong consistence dry; not hydrophobic; *gradual to:-*

143-233cm; medium clay; roots; lime present; manganese present; pH 9.5-10; gravel and stone absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], SABL, 5-15mm in size; firm to very firm consistence dry; not hydrophobic.

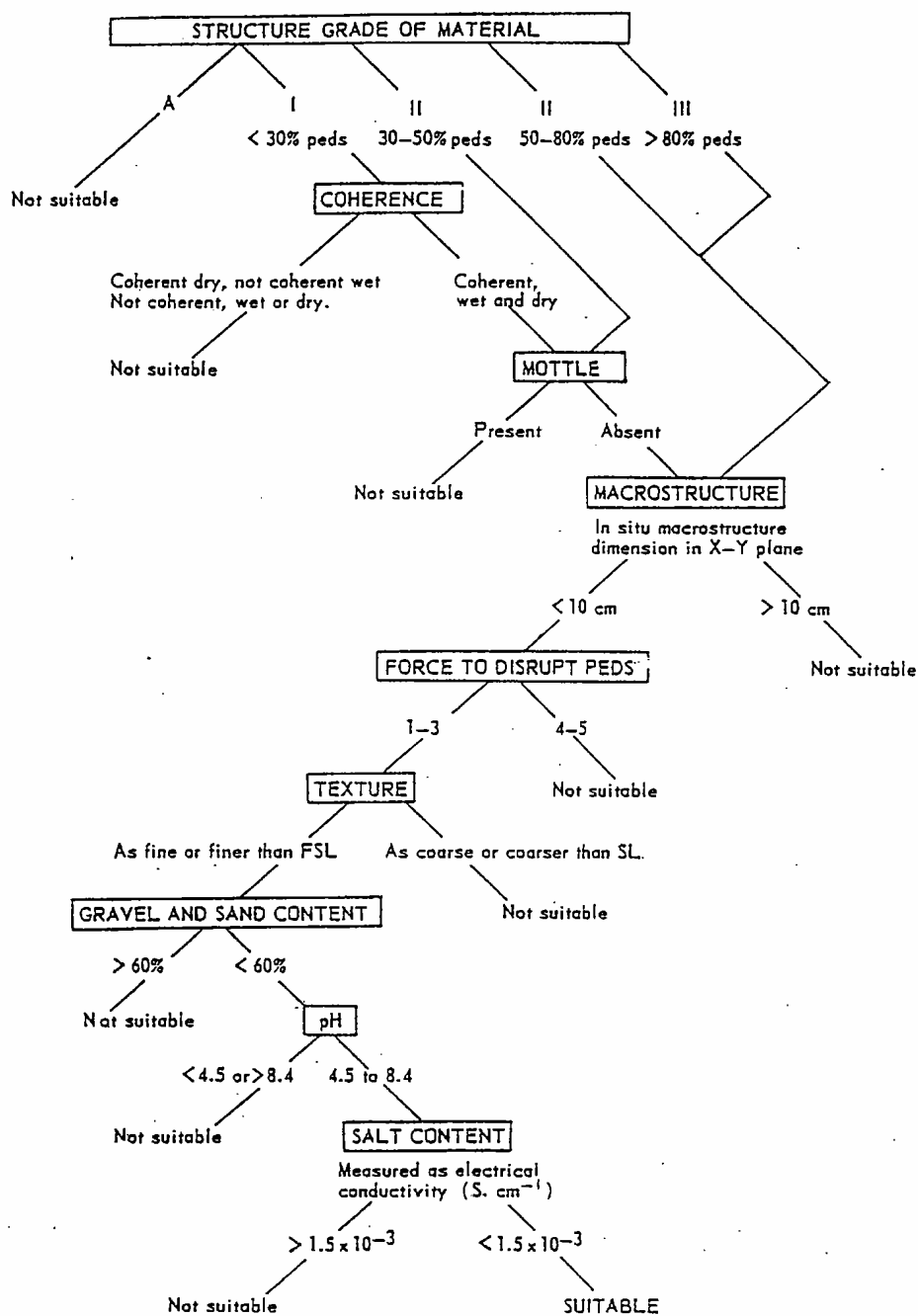
Appendix 2

Topsoil Stripping Suitability Key [after Elliott and Veness, 1981]

(No. of pages excluding this page = 1)

This page has intentionally been left blank

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



This page has intentionally been left blank

Appendix 3

Basis of Land Capability Classification [after Emery, undated]

(No. of pages excluding this page = 1)

This page has intentionally been left blank

Table 1 Land Capability Map Legend

LAND CLASSIFICATION AND SOIL CONSERVATION PRACTICES			INTERPRETATIONS AND IMPLICATIONS	
SUITABLE FOR REGULAR CULTIVATION	I	No special soil conservation works or practices.	Land suitable for a wide variety of uses. Where soils are fertile, this is land with the highest potential for agriculture, and may be cultivated for vegetable and fruit production, cereal and other grain crops, energy crops, fodder and forage crops, and sugar cane in specific areas. Includes "prime agricultural land".	
	II	Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation.	Usually gently sloping land suitable for a wide variety of agricultural uses. Has a high potential for production of crops on fertile soils similar to Class I, but increasing limitations to production due to site conditions. Includes "prime agricultural land".	
	III	Structural soil conservation works such as graded banks, waterways and diversion banks, together with soil conservation practices such as conservation tillage and adequate crop rotation.	Sloping land suitable for cropping on a rotational basis. Generally used for the production of the same type of crops as listed for Class I, although productivity will vary depending upon soil fertility. Individual yields may be the same as for Classes I and II, but increasing restrictions due to the erosion hazard will reduce the total yield over time. Soil erosion problems are often severe. Generally fair to good agricultural land.	
SUITABLE FOR GRAZING	Occasional Cultivation	IV	Land not suitable for cultivation on a regular basis owing to limitations of slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of these factors. Comprises the better classes of grazing land of the State and can be cultivated for an occasional crop, particularly a fodder crop, or for pasture renewal. Not suited to the range of agricultural uses listed for Classes I to III. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal and selection of safe building sites and access roads.	
		V	Land not suitable for cultivation on a regular basis owing to considerable limitations of slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of these factors. Soil erosion problems are often severe. Production is generally lower than for grazing lands in Class IV. Can be cultivated for an occasional crop, particularly a fodder crop or for pasture renewal. Not suited to the range of agricultural uses listed for Classes I to III. If used for "hobby farms" adequate provision should be made for water supply, effluent disposal, and selection of safe building sites and access roads.	
	No Cultivation	VI	Productivity will vary due to the soil depth and the soil fertility. Comprises the less productive grazing lands. If used for "hobby farms", adequate provision should be made for water supply, effluent disposal, and selection of safe building sites and access roads.	
OTHER	VII	Land best protected by green timber.	Generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire. Destruction of trees is not generally recommended, but partial clearing for grazing purposes under strict management controls can be practised on small areas of low erosion hazard. Where clearing of these lands has occurred in the past, unstable soil and terrain sites should be returned to timber cover.	
	VIII	Cliffs, lakes or swamps and other lands unsuitable for agricultural and pastoral production.	Land unusable for agricultural or pastoral uses. Recommended uses are those compatible with the preservation of the natural vegetation, namely: water supply catchments, wildlife refuges, national and state parks, and scenic areas.	
	U	Urban areas	CLASS SUBSCRIPTS	SPECIAL USES
	M	Mining and quarrying areas.	c	Terrain developed for a specific crop (capability class range IV to VII) as a result of the combination of particular soil, terrain, climatic and economic conditions. The class includes such crops as grapes, bananas, avocados and pineapples.
			d	Terrain developed for intensive agricultural production and associated with flood irrigation. The class includes land developed for cotton and rice production.

This page has intentionally been left blank

Appendix 4

Glossary

(No. of pages excluding this page = 1)

This page has intentionally been left blank

apedal - describes a soil in which none of the soil material occurs in the form of peds in the moist state. Such a soil is without apparent structure and is typically massive or single-grained.

consistence - the degree of resistance to deformation or rupture exhibited by a soil.

fabric - the appearance of a soil when examined with a 10x hand lens with the similarities and differences between samples being based on presence or absence of ped, lustre (or its absence of the ped surfaces and the presence, size and arrangement of voids within the soil sample.

horizon - a layer of soil material within a soil profile with distinct characteristics and properties that are produced by soil forming processes, and that are different from those of the layers above and below.

hydrophobic - describes soils that are water repellent and that resist wetting when dry. Drops of water do not spread spontaneously over their surface and into the pores.

lateritic - describes soil layers comprised of iron-rich material, often concentrated in separate nodules (gravel) or as masses of individual nodules cemented together.

massive - the condition of a soil layer in which the layer appears as a coherent or solid mass that is largely devoid of peds.

ped - an individual natural soil aggregate or unit of structure.

structure - describes the combination or spatial arrangement of primary soil particles (clay, silt, sand, gravel) into aggregates such as peds or clods and their stability to deformation.

texture - the coarseness or fineness of soil material as it affects the behaviour of a moist ball of soil when pressed between the thumb and forefinger. It is generally related to the proportion of soil particles of differing sizes (sand, silt, clay and gravel) in a soil but is influenced by the organic matter content as well.

This page has intentionally been left blank