NAMOI MINING PTY LTD

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Sunnyside Coal Project

via Gunnedah

Soils and Land Capability Assessment

Prepared by

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Specialist Consultant Studies Compendium
Part 9

Soils and Land Capability Assessment

of the

Sunnyside Coal Project
via Gunnedah

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EXECUTIVE SUMMARY

Soils in the Study Area have been described and three Soil Mapping Units [SMU 1, SMU 2 and SMU 3] 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 soils within SMU 1 and SMU 2 are currently relatively stable but have a generally **moderate** erodibility rating as determined using the laboratory data obtained from samples from the Study Area in the SOILOSS computer model and field observations;
- topsoils from both SMU 1 and SMU 2 exhibit slight dispersibility while the subsoil from both SMUs show a generally similar slight dispersibility for the layers that would be stripped and stockpiled for use in rehabilitation of disturbed areas; despite;
- this generally low dispersibility there still remains a need for rapid protection of stockpiled material and newly-rehabilitated areas by mulches and vegetation cover;
- the topsoil materials from both SMUs could be stored in the same stockpiles – ie. there is no need for segregation of the topsoils from the two units;
- the subsoil materials from both SMUs could also be stored in the same stockpiles – ie. there is no need for segregation of the subsoils from the two units;
- the soils have a generally moderate to high structure grade and so can be stripped and respread using scrapers without major impacts on soil structure;
- the topsoil material from the entire area covered by SMU 1 and SMU 2 would be stripped to a depth of 15cm from the present land surface; there is no need to segregate the topsoil material from the two SMUs;
- the subsoil material over the whole area to be disturbed would be stripped for a further 50cm to an overall depth of 65cm below the present land surface ; there is no need to segregate the subsoil material from the two SMUs;
- should mottled soil material or weathered rock be encountered stripping would cease on such areas – particularly within SMU 1;
- none of the soil material tested from SMU 1 and SMU 2 showed any saline tendencies;
- all soils would be subject to structural degradation if worked when too moist;
- the topsoil from SMU 3 which is associated with an endangered ecological community – Native Vegetation on Cracking Clay Soils of the Liverpool Plains – would be stripped to 15cm depth and stockpiled;

- any further soil that is required to be stripped during construction of the transport route would be held in a separate stockpile and respread during the rehabilitation phase before respreading of the topsoil; and
- no laboratory measurements were undertaken for the SMU 3 soil sample because of the small area that would be disturbed to a minimal degree.

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

The pre-disturbance Land Capability [**Classes II, III and VII**] and Agricultural Land Suitability [**Classes 2, 3, 4 and 5**] of the Study Area have been determined.

1 INTRODUCTION AND DESCRIPTION OF THE STUDY AREA

The soil survey and land capability study ('the study') was undertaken for Olsen Environmental Consulting Pty Ltd on behalf of Namoi Mining Pty Ltd [NMPL], the Proponent of the proposed Sunnyside Coal Mine. The Study Area for the soils study is located approximately 15km west of Gunnedah to the north of the Oxley Highway [and the old Gunnedah No. 5 Colliery surface facilities] and both east and west of the Coocooboonah Lane [see **Figure 1**].

The soils and land capability Study Area covers approximately 160ha of 'Sunnyside' property and is shown in **Figure 2** along with a proposed transport route corridor through 'Plain View' property as shown in **Figure 2.**

In the north, the Study Area comprises open, cleared gently sloping to almost level country. Almost all of this area is has been or is presently being used for cropping and pasture.

The southern section of the 'Sunnyside' property comprises a rocky scarp leading to a more hilly area that slopes to the south. This section comprises a mosaic of remnant native vegetation, cleared [previously farmed] land that is regenerating to native trees and shrubs and a bare eroded area that appears to have been used as a gravel quarry or for some similar purpose in the past.

The section of the Study Area on 'Plain View' property consists of level open crop and pasture land.

Specifically, the study was carried out to provide soils and land capability information relating to area proposed to be disturbed by works associated with the construction of the open cut mine, out-of-pit emplacement, site facilities and transport route.

Field sampling of the area was carried out on the 3rd and 4th October and 19th December, 2006.

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

(i) the soils on that part of the Project Site likely to be disturbed as a result of the proposed works; and

(ii) the land capability and agricultural land suitability of the Study Area.

The report was required to include sufficient level of detail to satisfy the Department of Primary Industries [Mineral Resources] Mining Operations Plan guidelines and to satisfy the requirements of the Department of Natural Resources' specifications for soil surveys associated with proposed mining operations. This report describes the soils based upon fifteen representative soil profiles as well as laboratory analyses of a selection of representative profiles and land capability of the Study Area.

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;

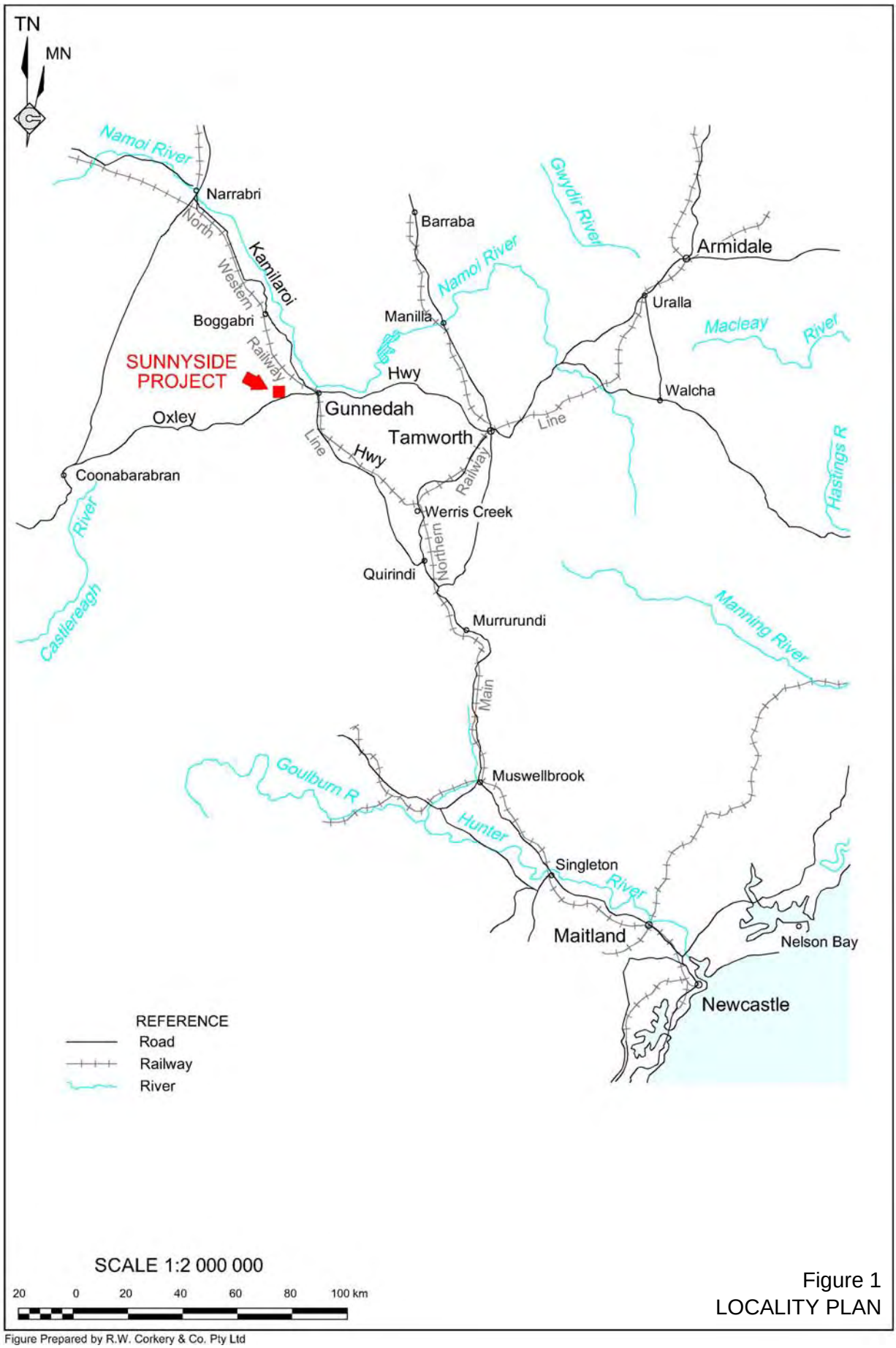

Figure 1
LOCALITY PLAN

Figure Prepared by R.W. Corkery & Co. Pty Ltd
Note: A colour version of this figure is presented on the Project CD

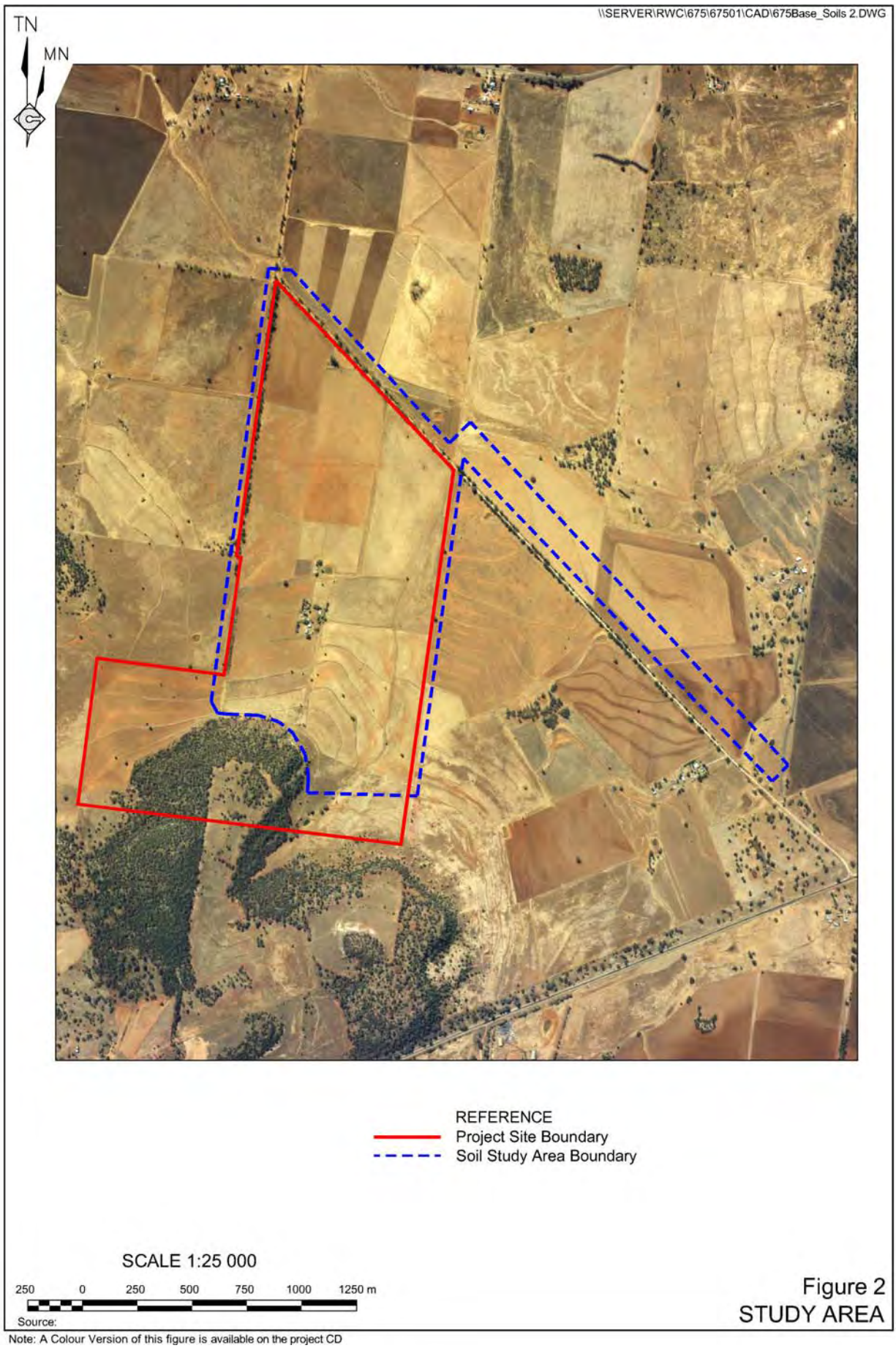

Figure 2
STUDY AREA

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

- a discussion of the stripping suitability of the soil materials found at the Project Site;
- details of soil handling strategies and recommendations about soil stripping and stockpiling; and
- details of the land capability and agricultural suitability at the Study Area.

2 PROJECT DESCRIPTION

Figure 3 displays the Project Site layout for the proposed Sunnyside Coal Mine. The area of the Project Site that would be subject to soil disturbance covers approximately 100ha.

The Project Site consists of the open cut area, the out-of-pit emplacement, run-of-mine (ROM) coal pad, site facilities, various roads and tracks. There is also a proposed coal transport route to the north of Coocooboonah Lane.

The mining activity within the Project Site would be located on a north facing area of sloping ground that has been extensively cleared for agriculture. The area has previously been used for cropping and grazing purposes and has been subject to rotational agricultural practices.

The open cut area is located upslope from the out-of-pit emplacement.

Surface runoff water from the catchment above the open cut area would be directed around the open cut pit in a series of diversion drains, dams and waterways. This water would pass through the Project Site in a series of waterways and sedimentation dams. Some of the water would be used to augment the water supply for site operations.

It is proposed to construct an amenity bund along the northern and western boundaries of the ROM coal pad and truck loading bin.

The out-of-pit emplacement would be located downslope and immediately to the north of the open cut pit. Once there is adequate capacity in the open cut pit, overburden would be backfilled within the pit. This would result in creation of a permanent out-of-pit emplacement, a recontoured area across the open cut area and a final void which represents the general shape of the pit at the completion of mining. It is proposed to shape the final void at the completion of mining. The maximum slope planned for the out-of-pit emplacement and the final void is 10 degrees.

During open cut operations, the potential to undertake some highwall auger mining would be assessed.

There would be a small area immediately downslope of the out-of-pit emplacement on which soil would be temporarily stockpiled. This soil would be prestripped from the area prior to commencing dumping on the out-of-pit emplacement and segregated into topsoil and subsoil components. It would be sequentially placed over the surface of the out-of-pit emplacement to promote better rehabilitation and revegetation.

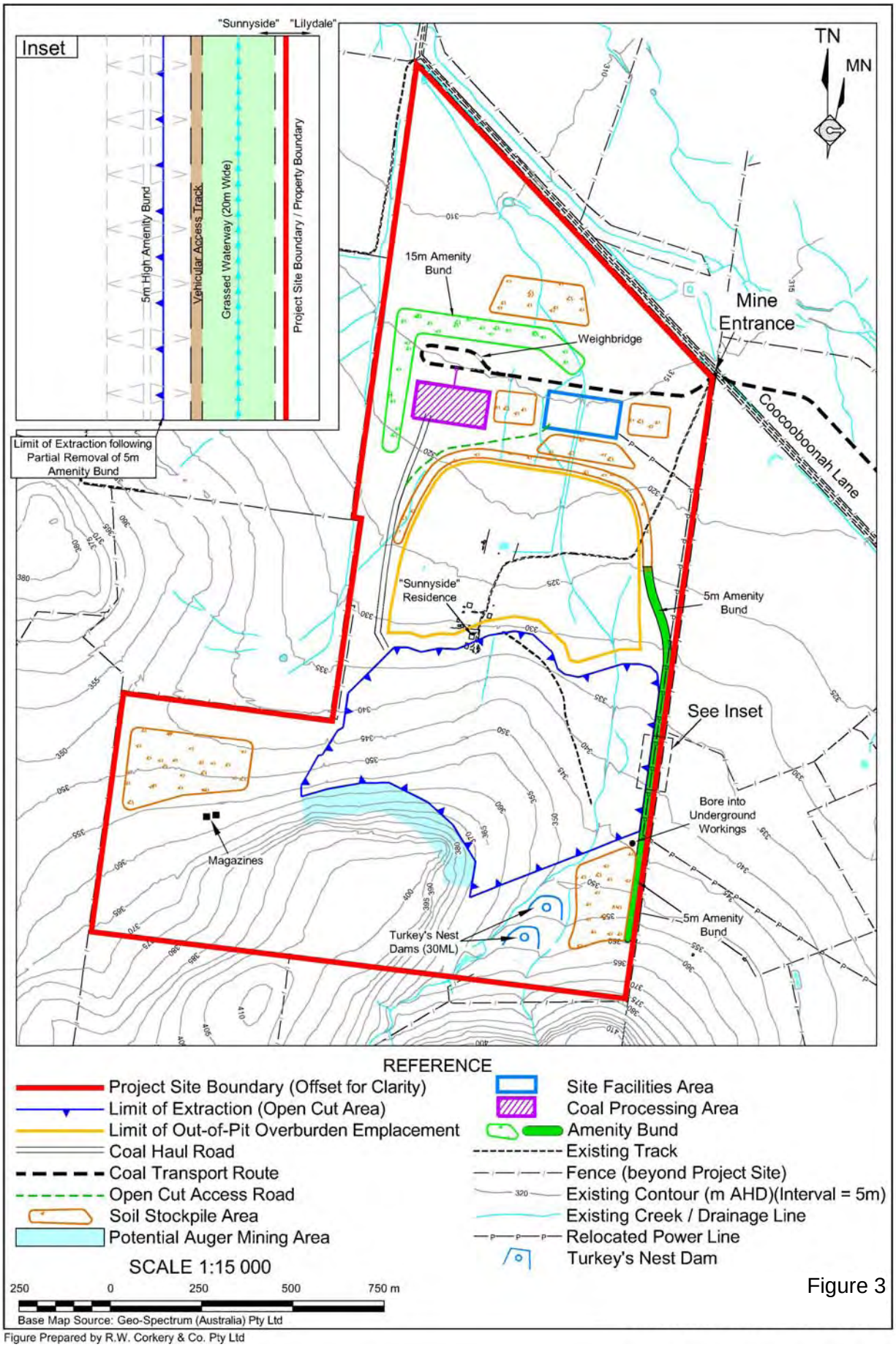

Figure 3

Figure Prepared by R.W. Corkery & Co. Pty Ltd
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The proposed site access road would enter the Project Site from the 'Plain View' property to the north of Coocooboonah Lane and would cross the Coocooboonah Lane at the northeast corner of the 'Sunnyside' property. This road would provide access to the site facilities.

The site facilities would consist of transportable offices, bath-house, crib room, fuel and lubricants storage facility, stores and first aid buildings, enclosed workshop facility, equipment laydown and park up area and a light vehicle car park for the projected workforce of 24 full-time and 7 part-time employees.

Power to the Project Site would be provided by on site diesel-powered generators. Bath-house and potable water would be provided from off-site. An existing rural power supply to the 'Sunnyside' homestead would be re-located to service the proposed mine office and associated buildings.

Dust suppression water would be provided and stored on site in appropriately located dams. This water would be derived from both run-off harvesting and from in-pit groundwater seepage and runoff capture. There may be some water obtained from existing or purpose drilled water bores that access the local groundwater. When required, these sources of water would be augmented by water pumped via a bore from the Gunnedah Coal Mine No 5 Entry underground workings.

ROM coal would be removed from the open cut pit in trucks and deposited on the ROM coal pad. Coal would be crushed and blended on the ROM Coal Pad. There may be occasional need to undertake secondary blending at the Whitehaven Coal Handling and Preparation Plant (CHPP) and Rail Loading Facility.

Blended and crushed ROM coal would be loaded onto coal trucks via a Bin located over a loop in the access road. A front-end loader would load coal onto an elevator conveyor via a hopper. The conveyor would deliver the coal into the load out bin from where it would be loaded into road trucks for delivery to the Whitehaven CHPP and Rail Loading Facility.

Coal trucks of nominal 28t or 40t capacity would be loaded at 'Sunnyside' under the bin adjacent to the ROM coal pad. They would leave the property and cross over the existing Coocooboonah Lane via an at-grade crossing and proceed along the re-aligned Coocooboonah Lane approximately 100m north of and parallel to Coocooboonah Lane.

Approximately 450m before the existing intersection of Coocooboonah Lane with the Oxley Highway, the transport corridor would rejoin Coocooboonah Lane.

Trucks would turn left out of Coocooboonah Lane and proceed along the Oxley Highway before turning left into Blackjack Road. Blackjack Road was used in the past to transport coal from the Gunnedah Colliery to the old Gunnedah Mine rail siding opposite the Whitehaven CHPP. At the end of Blackjack Road, trucks would turn right into Quia Road. They would then turn left and pass under a rail overpass, then immediately turn left again into Torrens Road and proceed directly to the CHPP.

The trucks would unload at this site and would return to the Sunnyside Mine along the same route. Unloaded Sunnyside coal would be blended and prepared for loading onto trains through the Whitehaven Rail Loading Facility.

3 LITERATURE REVIEW

3.1 Gunnedah District Soil Conservation Service Technical Manual

The Gunnedah District Soil Conservation Service Technical Manual [Anon, 1976] shows three soil groups are mapped in the Study Area. These soils groups are:

- Clay Loams with Red Clay Subsoils;
- Duplex and 'Gravelly' Soils; and
- Skeletal Soils.

Details of these soils are presented below.

3.1.1 Clay Loams with Red Clay Subsoils

These are generally associated with Tertiary volcanics and gently undulating slopes.

They are highly structured soils with a lower clay content in the surface horizons, weak horizon differentiation and a neutral to slightly alkaline reaction trend. Soil pH increases from about 6.5 at the surface to 7.5 deep in the subsoil. Occasional pH readings of 8.0 can be found at the base of the profile and a little carbonate may occur.

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

A_1 or Surface Horizon – clay loam or light clay; dark reddish brown to dark brownish red; weak to strong fine crumb or polyhedral structure; porous; friable when moist; *changing gradually to*;

B Horizons – heavy clay; brownish red or red; moderate to strong fine polyhedral to angular blocky structure; peds smooth-faced.

In their virgin state these soils have a high fertility but after a long period of cropping respond to applications of sulphur and phosphorus.

3.1.2 Duplex and 'Gravelly' Soils

These soils are associated with the ridges on Pilliga and Narrabeen Sandstones and the slopes of Middle Carboniferous sedimentary formations.

3.1.2.1 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 A_2 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:

A_1 Horizon – loose coarse sand to massive or weakly platy loam; brownish grey, light grey-brown or reddish brown in colour; weakly differentiated from:

A_2 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

B Horizons – sandy clay to medium clay; grey, grey-brown, yellow brown, and red-brown coloured; frequently mottled.

3.1.2.2 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.

3.1.3 Skeletal Soils

These soils are associated with steep topography. They lack horizon development apart from the presence of an A1 horizon. Their texture is usually related to the rock on which they are developed

4 SURVEY METHODOLOGY

4.1 Field Procedures

For the soil study, sampling involved the complete description of nineteen profiles exposed in a pit 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 4**.

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

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

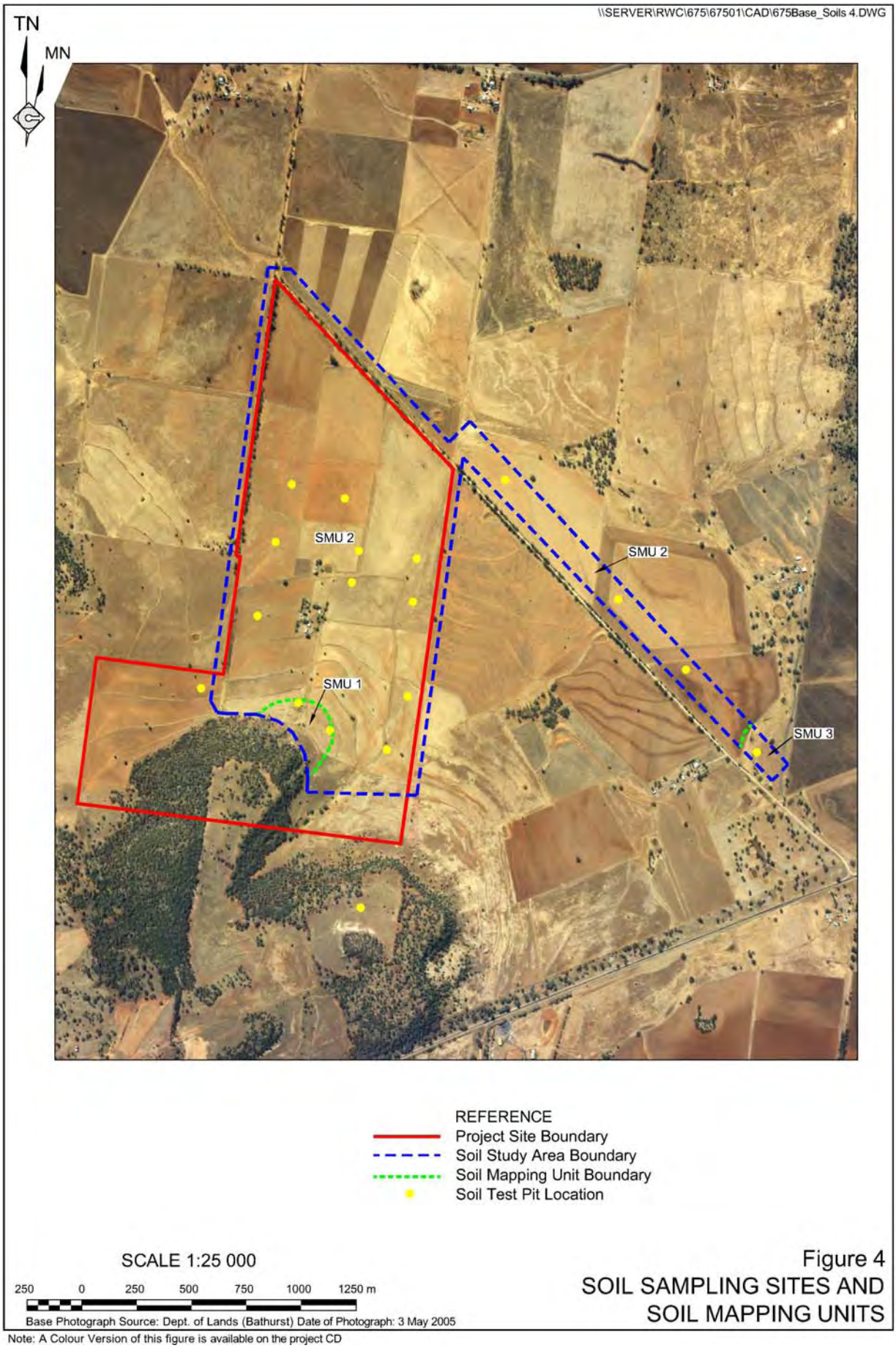


Figure 4
SOIL SAMPLING SITES AND SOIL MAPPING UNITS

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 Department of Natural Resources' [DNR] 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.

4.2 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

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

> The first SMU [**SMU 1**] occurs in upper slope areas below the rocky scarp in the southern section of the proposed area to be mined while the second [**SMU 2**] occurs on the mid- and lower slopes over the remainder [northern section] of the Study Area. The third SMU[**SMU 3**] is associated with a small occurrence of endangered ecological community – Native Vegetation on Cracking Clay Soils of the Liverpool Plains - located on the eastern end of the proposed transport route on 'Plain View' property.

The locations of the sampled soil profiles and the boundaries of the three SMUs are shown in **Figure 4**.

It is important to note that not all soil layers described for 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 of the layers present in the nineteen pits that were described in detail as well as for an additional site adjacent to the location of Profile 2 where the soil was substantially shallower.

5.1 Soil Mapping Unit Descriptions

Descriptions of the layers found in the profiles of the three SMUs identified within the Study Area are set out below.

The soils within the units are 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 **Appendix 3** or by consulting McDonald et al [1990] or Houghton and Charman [1986].

5.1.1 Description of SMU 1 –Soils of the Upper Slopes

5.1.1.1 'Plain English' Description:

Soil to 145cm deep over weathered rock; upper slope location; surface condition loose to firm; moderate to large amounts of surface stone present, rounded / angular to 15cm.

Topsoil to 21cm deep - loam fine sandy, sandy clay to silty clay, medium to heavy clay; roots common to many; pH 6.0 to 6.5; some rounded and angular gravel 1-3cm; brown / reddish brown coloured; highly pedal [100%], weak, firm or strong consistence dry; hydrophobic; slightly hydrophobic or not hydrophobic; with an abrupt or gradual transition to the subsoil.

Subsoil of two layers, gritty light clay, medium to heavy clay; heavy clay; roots few to common; no lime present; no manganese present; pH 6.0 to 8.5; some to much rounded gravel to 5cm; sometimes massive, earthy / rough fabric; otherwise highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; firm to strong to very strong consistence dry; not hydrophobic;

5.1.1.2 Technical Description [based on test pits]

[a] Australian Soil Classification Name –Grey Chromosol

[b] Field Description:

Layer 1 – [A horizon [always present] [13cm to 21cm thick]

Loam fine sandy, sandy clay to silty clay, medium to heavy clay; roots common to many; no lime present; no manganese present; pH 6.0 to 6.5; some rounded and angular gravel 1-3cm; not mottled; not bleached; brown [7.5YR4/4], reddish brown [5YR4/3] dry, dark brown [7.5YR3/3], very dark brown [7.5YR2.5/3]; dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough-faced or rough- / smooth-faced, polyhedral,<5-15mm in size; weak, firm or strong consistence dry; hydrophobic; slightly hydrophobic or not hydrophobic; *abrupt or gradual to:-*

Layer 2 – [B1 horizon] [always present] 43cm to 67cm thick]

Medium to heavy clay; heavy clay; roots few to common; no lime present; no manganese present; pH 6.0 to 8.0; much rounded gravel to 5cm; some rounded gravel to 2cm; some to much rounded and angular gravel to 2 to 5 cm; not mottled; not bleached; weak red [7.5YR4/4], red 10R4/6] dry, reddish brown [5YR4/3] dry, red 10R4/6], dark red 10R3/4], dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough- faced or rough- / smooth-faced, polyhedral, <5-15mm in size; strong to very strong consistence dry; not hydrophobic; *abrupt or gradual to:-*

Layer 3 [B2 horizon] [mostly present] [65cm to 80cm thick]

Gritty light clay to heavy clay; few roots; no lime present; no manganese present; pH 8.0 to 8.5; some to much angular gravel 1-2cm to 8cm ; not mottled, pinkish white [7.5YR8/2] dry, very pale brown [10YR7/4] moist; sometimes mottled; 90% light grey [10YR7/2], 10% yellowish red [5YR4/6] dry, 90% light brownish grey [10YR6/2], 10% yellowish red [5YR4/6] moist; not bleached; sometimes massive, earthy / rough fabric; otherwise highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; firm consistence dry; not hydrophobic; *diffuse to- weathered rock*

5.1.2 Description of SMU 2 – Soils of the Mid- and Lower Slopes

5.1.2.1 'Plain English' Description:

SMU 2 – Layer Descriptions
Soil recorded to 260cm+ deep; mid- and lower slope location; surface condition loose, firm or hardsetting; surface stone absent or some surface stone present, rounded or angular, 1-15cm [usually <10cm]

Topsoil mainly loam fine sandy texture, occasionally light clay, sandy clay loam to clay loam or silty clay; many roots; no lime present; no manganese present; pH 5.5 to 6.0, occasionally 7.0; gravel absent or some gravel, rounded to <5mm to 2cm; not mottled; not bleached; red and brown coloured; often highly pedal [100%], sometimes weakly pedal [20-30%] or moderately pedal [50-60%], weak, firm or firm consistence dry; sometimes hydrophobic or slightly so; with a usually abrupt, occasionally gradual, transition to the subsoil

Subsoil consisting of three or four horizons; variously clay textured; stones and gravel usually present in most horizons though at times only in pockets; usually whole coloured in shades of brown and red, occasionally mottled, in colours of brown, red and yellow; highly pedal; firm to very strong consistence dry; not hydrophobic.

5.1.2.2 Technical Description [based on test pits]

[a] Australian Soil Classification Names –Red and Brown Chromosols

[b] Field Description:

Layer 1 – [A horizon] [always present] [13cm to 24cm thick]

Mainly loam fine sandy, occasionally light clay, light to medium clay, sandy clay loam to clay loam or silty clay; many roots; no lime present; no manganese present; pH 5.5 to 6.0, occasionally 7.0; gravel absent or some gravel, rounded to <5mm to 2cm not mottled; not bleached; brown [7.5YR4/3; 7.5YR4/4; 7.5YR5/4], reddish brown [5YR4/4; 5YR4/5], strong brown [7.5YR4/6], yellowish red 5YR5/6] dry, dark brown [7.5YR3/4, 7.5YR3/3, 7.5YR3/2], dark reddish brown [2.5YR3/3; 5YR2.5/2; 5YR3/2; 5YR3/3], very dark brown [7.5YR 2.5/3; 7.5YR2.5/2] moist; usually highly pedal [100%], sometimes weakly pedal [20-30%] or moderately pedal [50-60%], peds rough-faced, usually polyhedral, sometimes polyhedral / platy, <5-15mm in size; weak, firm or firm consistence dry; sometimes hydrophobic or slightly so; *usually abrupt, or clear, occasionally gradual to:-*

Layer 2 – [B1.1 horizon] [always present] [22cm to 84cm thick]

Light clay, light to medium clay, loam fine sandy, medium clay or sandy clay; few to many roots, sometimes roots common; no lime present; usually no manganese present, occasionally manganese concretions present; pH 6.0 to 8.5; some rounded or angular gravel to 2cm, sometimes in distinct pockets, occasionally gravel absent; not mottled; not bleached; brown [7.5YR4/4],7.5YR4/3, red [2.5YR4/6; 2.5YR4/8], weak red [10R4/4], reddish brown [2.5YR4/4; 5YR4/3, 5YR4/4; 5YR5/4], yellowish red [5YR4/4; 5YR4/6; 5YR5/6] dry, dark red [2.5YR3/6], dark reddish brown [2.5YR3/4; 5YR2.5/2; 5YR3/2; 5YR3/3; 5YR3/4], red [2.5YR4/6], weak red [10R4/4], dark brown [7.5YR3/3], reddish brown [2.5YR4/4] moist; highly pedal [100%], peds rough-faced, smooth-faced or rough- / smooth-faced, polyhedral,<5-20mm in size; firm, very firm, strong [mainly] or very strong consistence dry; not hydrophobic; *abrupt, clear, gradual or diffuse to:-*

Layer 3 - [B1.2 horizon] [always present] [27cm to 112cm thick]

Silty clay, light clay, light to medium clay, medium clay, medium to heavy clay, heavy clay; roots absent, few, common or many; usually lime stains and nodules present; usually no manganese present, sometimes manganese stains and concretions present to common; pH 7.0 to 8.5, rarely 9.0; usually some gravel, rounded to 3cm, sometimes in pockets or occasionally forming a gravelly horizon of rounded / angular gravel and stones 2-15cm; not bleached; **usually whole coloured** red [2.5YR4/8; 2.5YR4/6], reddish brown [10R4/4, 5YR4/4; 5YR5/4, 5YR4/3], strong brown [7.5YR5/6], yellowish red [5YR4/6; 5YR5/6] dry, dark red [2.5YR3/6], dark reddish brown [5YR3/3, 2.5YR3/4], red [2.5YR4/6; 2.5YR4/8], red [2.5YR4/8], reddish brown [10R4/4, 5YR4/4], strong brown [7.5YR5/6], yellowish red [5YR4/6]] moist; **occasionally mottled** in colours of brown [7.5YR5/4, reddish brown [5YR4/4], red [2.5YR4/6] dry, strong brown [7.5YR4/6], dark yellowish brown [10YR4/6], yellowish red [5YR4/6] moist; highly pedal [100%], peds usually rough- / smooth-faced, sometimes peds rough-faced or smooth-faced, usually polyhedral, sometimes polyhedral / platy, <5-20mm in size; very firm, strong to very strong consistence dry; not hydrophobic; *gradual or diffuse to:-*

Layer 4 – [B2.1 horizon] [always present] [43cm to 138cm thick]

Light to medium clay, medium clay, medium to heavy clay, heavy clay; few roots or roots absent; no lime present sometimes many stains and nodules present; manganese absent or some to much manganese stains and small concretions present; pH 7.5 to 8.5, occasionally 9.5 to 10; gravel absent or occasional to common rounded or angular gravel <1cm to 10cm present, [often in pockets] occasionally stones to 15cm present; not bleached; usually **whole coloured** brown [7.5YR4/4], red [2.5YR4/6; 2.5YR5/6], reddish brown [5YR4/3, 5YR3/4, 2.5YR4/4], strong brown [7.5YR4/6; 7.5YR5/6], weak red [10R4/4], yellowish red [5YR5/6] dry, brown [7.5YR4/4], dark reddish brown [2.5YR3/4, 5YR3/4], dusky red 10R3/4], red [2.5YR4/6], reddish brown [5YR4/4, 2.5YR4/4], strong brown [7.5YR4/6], weak red [10R4/4], yellowish red [5YR5/6] moist; **very occasionally mottled** in colours of weak red [10R4/4], yellowish red [5YR5/6] dry, weak red [10R4/4], yellowish red [5YR4/6] moist; highly pedal [100%], peds usually rough- / smooth-faced, sometimes rough- faced or smooth- faced, peds smooth-faced, polyhedral; <5-20mm in size; very firm, strong or very strong consistence dry; not hydrophobic; *profile continues or changes gradually to:-*

Layer 5 – [B2.2 horizon] [occasionally present [measured 100cm thick]

Medium clay or medium to heavy clay; few roots or roots absent; no lime present or many lime nodules present; some manganese stains or concretions present; pH 8.0-9.0; gravel or stones absent or much rounded gravel to 2cm; not mottled; not bleached; red [2.5YR5/6, 2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; firm to very firm or very strong consistency dry; not hydrophobic;

5.1.3 Description of SMU 3 – Soils of the Drainage Depression

5.1.3.1 'Plain English' Description:

SMU 3 – Layer Descriptions

Soil *recorded to 260cm+ deep; surface condition self mulching and cracking; surface stone absent*

Topsoil heavy clay; many roots; some lime stains present ; no manganese present; pH 8.0-9.0; gravel and stones absent; not mottled; not bleached; dark reddish brown dry, dusky red moist; highly pedal [100%],; strong consistence dry; not hydrophobic; with an abrupt transition to the subsoil.

Subsoil consisting of three horizons; medium to heavy clay textured; pH 8.0-9.5; lime common; stones and gravel usually absent but occasionally present; whole coloured in shades of red and reddish brown; and yellow; highly pedal; very firm to very strong consistence dry; not hydrophobic.

5.1.3.2 Technical Description [based on test pits]

[a] Australian Soil Classification Names – Self-mulching Brown Vertosol

[b] Field Description:

Layer 1 – [A horizon] [always present] recorded 19cm thick]

Heavy clay; many roots; some lime stains present; no manganese present; pH 8.0-9.0; gravel and stones absent; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

Layer 2 – [B1 horizon] [always present] recorded 43cm thick]

Heavy clay; many roots; many small lime nodules present; no manganese present; pH 9.0-9.5; occasional rounded gravel to 1cm; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

Layer 3 – [B2.1 horizon] [always present] recorded 40cm thick]

Heavy clay; roots few; many lime stains and nodules present; no manganese present; pH 9.0-9.5; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; very firm to strong consistence dry; not hydrophobic; *diffuse to:-*

Layer 4 – [B2.2 horizon] [always present] recorded 156cm thick]

Medium to heavy clay; roots few; many lime stains and nodules present; many manganese stains present; pH 9.0-9.5; gravel and stones absent; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; strong consistence dry; not hydrophobic. *continues*

5.2 Soil Laboratory Analyses

Fourteen samples from four soil profiles were selected for laboratory analysis at the Department of Lands' Soil and Water testing Laboratory at Scone. Note that, due to the small area affected, no samples from the single profile representing SMU 3 were laboratory tested.

The tests performed aimed at assessing the potential erodibility of the soils [Particle Size Analysis [PSA], Dispersion % [D%] and Emerson Aggregate Test [EAT]] and the likely salinity risk using Electrical Conductivity [EC] as a primary measure.

5.2.1 Soil Physical Analyses

Tables 1 and **2** show the results obtained from laboratory analysis of the samples from Pits 2, 7, 9 and 12.

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 PIT 2	**1**	**loam**	**0-21**	13	11	37	23	60	16
	2	**clay**	**21-65**	33	6	11	17	28	33
	3	**loamy sand**	**65-145**	4	5	17	18	35	66
SMU 1 PIT 7	**1**	**loam**	**0-13**	19	18	42	17	59	4
	2	**clay**	**13-56**	47	13	28	12	40	<1
SMU 2 PIT 9	**1**	**loamy sand**	**0-18**	7	9	52	26	78	6
	2	**sandy clay loam**	**18-58**	17	4	28	15	43	36
	3	**clay**	**58-85**	42	9	37	11	48	1
	4	**clay loam**	**85-150**	29	9	44	12	56	6
	5	**clay loam**	**150-250**	21	12	30	12	42	25
SMU 2 PIT 12	1	**sandy loam**	**0-16**	20	10	50	20	70	<1
	2	**clay loam**	**16-80**	26	11	44	18	62	1
	3	**clay**	**80-170**	52	8	30	9	39	1
	4	**clay loam**	**170-250**	29	17	38	13	51	3

Note: PSA = Particle Size Analysis # texture based on laboratory measurements

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

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D%	D% level of dispersion	EAT	EAT level of dispersion
SMU 1 PIT 2	**1**	**loam**	**0-21**	10	slight	3[1]	Slight
	2	**clay**	**21-65**	20	slight	3[2]	Slight
	3	**loamy sand**	**65-145**	19	slight	3[1]	Slight
SMU 1 PIT 7	**1**	**loam**	**0-13**	14	slight	3[1]	Slight
	2	**clay**	**13-56**	12	slight	5	Slight
SMU 2 PIT 9	**1**	**loamy sand**	**0-18**	14	slight	3[1]	Slight
	2	**sandy clay loam**	**18-58**	21	slight	3[2]	Slight
	3	**clay**	**58-85**	13	slight	3[2]	Slight
	4	**clay loam**	**85-150**	34	moderate	2[1]	high to moderate
	5	**clay loam**	**150-250**	19	slight	2[1]	high to moderate
SMU 2 PIT 12	1	**sandy loam**	**0-16**	16	slight	3[2]	Slight
	2	**clay loam**	**16-80**	13	slight	3[2]	Slight
	3	**clay**	**80-170**	8	slight	3[2]	Slight
	4	**clay loam**	**170-250**	36	moderate	3[2]	Slight

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

Table 2
Chemical Analyses Laboratory Analysis Data for Selected Soil Profiles

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH *	EC [dS/m]#
SMU 1 PIT 2	**1**	**loam**	**0-21**	6.5	0.10
	2	**clay**	**21-65**	8.0	0.05
	3	**loamy sand**	**65-145**	8.5	0.06
SMU 1 PIT 7	**1**	**loam**	**0-13**	6.0	0.10
	2	**clay**	**13-56**	8.0	0.11
SMU 2 PIT 9	**1**	**loamy sand**	**0-18**	6.0	0.01
	2	**sandy clay loam**	**18-58**	6.0	<0.01
	3	**clay**	**58-85**	8.0	0.03
	4	**clay loam**	**85-150**	8.0	0.03
	5	**clay loam**	**150-250**	8.0	0.03
SMU 2 PIT 12	1	**sandy loam**	**0-16**	5.5	0.01
	2	**clay loam**	**16-80**	8.0	0.03
	3	**clay**	**80-170**	8.0	0.03
	4	**clay loam**	**170-250**	8.0	0.02

texture and EC based on laboratory measurements
+ pH based on field measurements

5.2.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity. Soil pH was measured in the field using the Raupach method. The results of the laboratory analyses and the field pH measurements 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 four 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 topsoils in both SMUs contain relatively low levels of gravel and consequently the material is suitable for use in rehabilitation works.

The subsoils exhibited variable gravel contents with those from SMU 1 containing generally more gravel. Despite this higher gravel content, the subsoils are suitable for use in rehabilitation.

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**.

It should be noted that the field textures of almost all layers of the two 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 would 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 [**Table 3**]

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

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.

Soil horizons with high clay contents and high Dispersion % values would 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 all of the topsoils analysed [both SMU 1 and SMU 2] showed a slight dispersibility.

The subsoil D% values for both SMUs were, for the most part, also in the slight dispersibility category. The exceptions were moderate values for the lower horizons in both profiles from SMU 2 – material that would not have to be stripped to any degree and stockpiled for use in rehabilitation.

While the measured dispersibility values for both the topsoil and subsoil in both SMUs are low there is still a need for appropriate measures to be taken to protect the stockpiles of stripped soil. The stockpiled material, when respread, would be afforded rapid 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.**

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 EAT values shown in **Table 1** indicate that all of the topsoils analysed [both SMU 1 and SMU 2] showed EAT values in the slight class – indicating general soil stability.

The subsoil EAT values for both SMUs, with the exception of the two lowest horizons in profile 9 [SMU 2] were in the slight category. The high to moderate values for the two lower horizons in Profile 9 indicate a considerably lesser stability. Given the depth at which this material occurs there would not be a need for it to be stripped to any degree and stockpiled for use in rehabilitation.

The measured EAT values for both the topsoil and subsoil in both SMUs are generally low. Nevertheless appropriate protective measures are required to ensure the protection of stockpile surfaces and areas where the material is respread to ensure that soil erosion does not occur.

6.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity.

Soil pH was measured in the field using the Raupach method. The results of the laboratory analyses and the field pH measurements are contained in **Table 2.**

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 column in **Table 2** indicates that both of the topsoil samples tested showed pH levels within the 4.0 to 8.5 range. The subsoil values of the two profiles from both SMUs were also within this acceptable range.

This is also generally the case for the topsoils and subsoils of the profiles that were not subjected to laboratory analysis but were tested in the field – although the lower subsoil horizons in two profiles had values on the 9.5-10 category. This is not a concern as the material would not be stripped and stockpiled for use in rehabilitation.

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 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

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.

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 topsoils and subsoils in all tested profiles are non-saline.

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

SMU / PIT NO.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	EC [dS/m]#	MULTI-PLIER	CALCULATED EC_e	SOIL SALINITY STATUS
SMU 1 PIT 2	**1**	**loam**	**0-21**	0.10	9.5	0.95	non-saline
	2	**clay**	**21-65**	0.05	5.8	0.29	non-saline
	3	**loamy sand**	**65-145**	0.06	**23**	0.14	non-saline
SMU 1 PIT 7	**1**	**loam**	**0-13**	0.10	9.5	0.95	non-saline
	2	**clay**	**13-56**	0.11	5.8	0.64	non-saline
SMU 2 PIT 9	**1**	**loamy sand**	**0-18**	0.01	23	0.23	non-saline
	2	**sandy clay loam**	**18-58**	<0.01	9.5	0	non-saline
	3	**clay**	**58-85**	0.03	7.5	0.23	non-saline
	4	**clay loam**	**85-150**	0.03	8.6	0.17	non-saline
	5	**clay loam**	**150-250**	0.03	8.6	0.26	non-saline
SMU 2 PIT 12	1	**sandy loam**	**0-16**	0.01	14	0.14	non-saline
	2	**clay loam**	**16-80**	0.03	8.6	0.26	non-saline
	3	**clay**	**80-170**	0.03	5.8	0.17	non-saline
	4	**clay loam**	**170-250**	0.02	8.6	0.17	non-saline

EC based on laboratory measurements

6.3 Erosion Potential

The soils within the Study Area are currently generally stable except for some areas of sheet erosion on the slopes and some gully erosion in the main drainage lines and tracks.

The more sloping sections of the Study Area have been protected in the past by soil conservation graded bank and waterway systems. These would be retained on areas that are not subject to disturbance with appropriate modifications as necessary.

Groundcover varies over the Project Site, but there is generally a reasonable groundcover present.

It would be essential, if erosion is to be prevented, to maintain an adequate groundcover on the existing landscape, on any stockpiles during the proposed mining and on the reformed landscapes after rehabilitation work is carried out.

The design services provided by the Soil Conservation Service would be utilized to ensure that any disturbance of the existing soil conservation works does not predispose the landscape to erosion and that the post-mining landscape is adequately protected.

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 the four soil profiles from the Study Area that were tested in the laboratory.

Table 7
Soil Erodibility Values and Ratings for a Selection of Soils

PIT NUMBER	TOPSOIL LAYER [cm]	TOPSOIL 'K' RATING	SUBSOIL LAYER [cm]	SUBSOIL 'K' RATING	AVERAGE 'K' RATING [WHOLE SOIL]	SOIL MAPPING UNIT ERODIBILITY
PIT 2 SMU 1	**0-21 cm**	0.033	**21-65cm**	0.015	0.024	moderate
PIT 7 SMU 1	**0-13 cm**	0.033	**13-56 cm**	0.018	0.026	moderate
PITT 9 SMU 2	**0.18cm**	0.035	**18-58 cm**	0.032	0.034	moderate
PIT 12 SMU 2	**0-16 cm**	0.027	**16-80 cm**	0.033	0.030	moderate

The erodibility estimates contained in **Table 7** for two of the SMUs [**1 and 2**] recorded from the Study Area have been calculated using part of the overall SOILOSS program capability and the Particle Size Analysis and other data for the two typical soil profiles from the Study Area that were subjected to laboratory testing.

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 the Staffords Gap [equivalent to SMU 1] and Fullwoods Road [equivalent to SMU 2] Soil Landscapes within *Soil Landscapes of the Curlewis 1: 100 000 Sheet Report* [Banks, 1995], mean values of 2.7% [topsoil] and 0.8% [subsoil] for SMU 1 and 4.5% [topsoil] and 0.5% [subsoil] for SMU 2, were chosen.

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

The soils from SMUs 1 and 2 were allotted a MODERATE erodibility by the SOILOSS model based on their physical characteristics.

The field observation of an extensive soil conservation bank and waterway system on the area occupied by both SMUs and indicates that the SOILOSS classification accurately reflects the erosion potential of the Study Area.

Because of this MODERATE erodibility, as assessed by the SOILOSS analysis and filed observations, both SMUs would 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.

7 DESIGN AND OPERATIONAL SAFEGUARDS

7.1 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 for the Elliott and Veness approach is that not all soil material that might be available for topdressing of disturbed sites is suitable for agricultural or pastoral use: some may be 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

7.2 Stripping Recommendations

7.2.1 SMU 1 Areas

7.2.1.1 Layer 1 [0 - 15cm depth]

Loam fine sandy, sandy clay to silty clay, medium to heavy clay; roots common to many; no lime present; no manganese present; pH 6.0 to 6.5; some rounded and angular gravel 1-3cm; not mottled; not bleached; brown [7.5YR4/4], reddish brown [5YR4/3] dry, dark brown [7.5YR3/3], very dark brown [7.5YR2.5/3]; dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough-faced or rough- / smooth-faced, polyhedral,<5-15mm in size; weak, firm or strong consistence dry; hydrophobic; slightly hydrophobic or not hydrophobic;

Suitability Assessment [based on Elliott and Veness key]: structure grade 3; strongly coherent dry, mottles absent; macrostructure always suitable; force to disrupt peds suitable; texture suitable; sand and gravel content suitable; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and would be stockpiled and used later for rehabilitation of the final landscape or moved direct from stripped areas to areas being rehabilitated.

Recommendations for Layer 1 Materials

1. Strip all of the Layer 1 material to a depth of 15cm.
2. Layer 1 materials would be stockpiled as **topsoil** provided suitable stripping and storage methods are used [see Section 6.3]. In order to maximise the regeneration of native species in the soil it is recommended that topsoil from areas currently vegetated by native species is transferred directly to areas to be revegetated.
3. Topsoil stripping would be carried out on all areas that would be disturbed by mining and reshaping activity.

7.2.1.2 Layer 2 [15 – 65cm depth]

Medium to heavy clay; heavy clay; roots few to common; no lime present; no manganese present; pH 6.0 to 8.0; much rounded gravel to 5cm; some rounded gravel to 2cm; some to much rounded and angular gravel to 2 to 5 cm; not mottled; not bleached; weak red [7.5YR4/4], red 10R4/6] dry, reddish brown [5YR4/3] dry, red 10R4/6], dark red 10R3/4], dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough- faced or rough- / smooth-faced, polyhedral, <5-15mm in size; strong to very strong consistence dry; not hydrophobic; *abrupt or gradual to:-*

Suitability Assessment [based on Elliott and Veness key]: structure grade 3; very strongly coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture suitable; sand and gravel content suitable; pH levels suitable; salt content suitable.

This material is suitable for subsoiling on the basis of the Elliott and Veness key. It contains valuable organic matter, nutrient reserves and would be stockpiled and used later for rehabilitation of the final landscape or moved direct from stripped areas to areas being rehabilitated.

Recommendations for Layer 2 Materials

Strip all of the Layer 2 subsoil to a depth of 65cm below the current soil surface [ie. a layer 50cm thick] where deep disturbance is to occur [versus shallow disturbance on road and facilities areas etc]. Layer 2 material would be stockpiled as subsoil provided suitable stripping and storage methods are used. [See Section 6.3] or moved direct from stripped areas to areas being rehabilitated.

7.2.1.3 Layer 3 [Remainder of the Profile]

Use for respreading over the reshaped overburden / rock material in situations where deep disturbance occurs, otherwise do not strip.

Recommendations for Layer 3 Materials

Strip as required and, if necessary, stockpile for use in site rehabilitation as a layer over the final reshaped landform prior to respreading of subsoil and topsoil.

7.2.2 SMU 2 Areas

7.2.2.1 Layer 1 [0 - 15cm depth]

Mainly loam fine sandy, occasionally light clay, sandy clay loam to clay loam or silty clay; many roots; no lime present; no manganese present; pH 5.5 to 6.0, occasionally 7.0; gravel absent or some gravel, rounded to <5mm to 2cm1cm; not mottled; not bleached; brown [7.5YR4/3; 7.5YR4/4; 7.5YR5/4], reddish brown [5YR4/4; 5YR4/5], strong brown [7.5YR4/6], yellowish red 5YR5/6] dry, dark brown [7.5YR3/4], dark reddish brown [2.5YR3/3; 5YR2.5/2; 5YR3/2; 5YR3/3], very dark brown [7.5YR 2.5/3; 7.5YR2.5/2] moist; often highly pedal [100%], sometimes weakly pedal [20-30%] or moderately pedal [50-60%], peds rough-faced, usually polyhedral, sometimes polyhedral / platy, <5-15mm in size; weak, firm or firm consistence dry; sometimes hydrophobic or slightly so.

Suitability Assessment [based on Elliott and Veness key]: structure grade 2 – 3; firmly to very strongly coherent dry, mottles absent; macrostructure always suitable; force to disrupt peds suitable; texture suitable; sand and gravel content suitable; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and would be stockpiled and used later for rehabilitation of the final landscape or moved direct from stripped areas to areas being rehabilitated.

Recommendations for Layer 1 Materials

1. Strip all of the Layer 1 material to a depth of 15cm.
2. Layer 1 materials would be stockpiled as **topsoil** provided suitable stripping and storage methods are used [see Section 6.3] or moved direct from stripped areas to areas being rehabilitated.
3. Topsoil stripping would be carried out on all areas that would be disturbed by mining and associated activity.

7.2.2.2 Layer 2 [15 - 65cm depth]

Loam fine sandy, sandy clay; silty clay, light clay, light to medium clay, medium clay, medium to heavy clay, heavy clay; roots few, common or many; no lime present; sometimes manganese stains and concretions present to common; pH 6.0 to 8.5; rarely 9.0; usually some gravel, rounded to 3cm, sometimes in pockets or occasionally forming a gravelly horizon of rounded / angular gravel and stones 2-15cm, occasionally gravel absent; not bleached; **usually whole coloured;** brown [7.5YR4/4], red [2.5YR4/6; 2.5YR4/8], reddish brown [2.5YR4/4; 5YR4/4; 5YR5/4], strong brown [7.5YR5/6], yellowish red [5YR4/4; 5YR4/6; 5YR5/6] dry, dark red [2.5YR3/6], dark reddish brown [2.5YR3/4; 5YR2.5/2; 5YR3/2; 5YR3/3; 5YR3/4], red [2.5YR4/6; 2.5YR4/8], reddish brown [2.5YR4/4; 5YR4/4], strong brown [7.5YR5/6], yellowish red [5YR4/6]] moist; **occasionally mottled** in colours of brown [7.5YR5/4, reddish brown [5YR4/4], red [2.5YR4/6] dry, strong brown [7.5YR4/6], dark yellowish brown [10YR4/6], yellowish red [5YR4/6] moist; highly pedal [100%], peds usually rough- / smooth-faced, sometimes peds rough-faced or smooth-faced, usually polyhedral, sometimes polyhedral / platy, <5-20mm in size; firm, very firm, strong or very strong consistence dry; not hydrophobic

Suitability Assessment [based on Elliott and Veness key]: structure grade 3; strongly to very strongly coherent dry, mottles generally absent; macrostructure always suitable; force to disrupt peds suitable; texture suitable; sand and gravel content suitable; pH levels generally suitable; salt content suitable.

This material is suitable for subsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and would be stockpiled and used later for rehabilitation of the final landscape. Some profiles contain mottled material but this is relatively rare.

Recommendations for Layer 2 Materials

Where surface disturbance for roads, hardstand areas, buildings etc is minimal then only Layer 1 would be stripped. However, where facility development requires disturbance to a greater depth, strip all of the Layer 2 subsoil to a depth of 65cm below the current soil surface [ie. a layer 50cm thick] unless mottled horizons are encountered at lesser depths. If mottled material is exposed at a depth of <65cm from the surface or [in the unlikely event that] bedrock is encountered, subsoil stripping would cease. If the stripping depth that is required is less than 65cm then strip to that depth.

Layer 2 material would be stockpiled as subsoil provided suitable stripping and storage methods are used. [See Section 6.3] or moved direct from stripped areas to areas being rehabilitated.

7.2.2.3 Layer 3 [Remainder of the Profile]

Use for respreading over the reshaped overburden / rock material in situations where deep disturbance occurs, otherwise do not strip

Recommendations for Layer 3 Materials

Strip as required and, if necessary, stockpile for use in site rehabilitation as a layer over the final reshaped landform prior to respreading of subsoil and topsoil.

7.2.3 SMU 3 Areas

7.2.3.1 Layer 1 [0 - 15cm depth]

Heavy clay; many roots; some lime stains present; no manganese present; pH 8.0-9.0; gravel and stones absent; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

Suitability Assessment [based on Elliott and Veness key]: structure grade 2 – 3; firmly to very strongly coherent dry, mottles absent; macrostructure always suitable; force to disrupt peds suitable; texture suitable; sand and gravel content suitable; pH levels marginally suitable [but native vegetation grows well]; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and would be stockpiled and used later for rehabilitation of the final landscape or moved direct from stripped areas to areas being rehabilitated. This topsoil material would contain seed of the native species characteristic of the Native Vegetation of the Cracking Clay Soils of the Liverpool Plains endangered ecological community.

Recommendations for Layer 1 Materials

Strip all of the Layer 1 material to a depth of 15cm. and place in a separate topsoil stockpile to conserve the integrity of the soil seed bank – ie. do not mix with other topsoil Suitable stripping and storage methods would be used [see Section 6.3] and the material would be stored for the duration of use of the transport route. Topsoil stripping would be carried out on all areas that would be disturbed to allow construction of this section of the transport route.

7.2.3.2 Layer 2 [below 15cm depth]

Heavy clay; many roots; many small lime nodules present; no manganese present; pH 9.0-9.5; occasional rounded gravel to 1cm; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

Suitability Assessment [based on Elliott and Veness key]: structure grade 3; strongly to very strongly coherent dry, mottles generally absent; macrostructure always suitable; force to disrupt peds suitable; texture suitable; sand and gravel content suitable; pH levels marginally suitable; salt content suitable.

This material is suitable for stockpiling and then reuse as subsoil on the basis of the Elliott and Veness key. It would be stockpiled as a separate material and respread on the area disturbed by construction of the relevant section of the transport route during rehabilitation and prior to respreading of the topsoil.

Recommendations for Layer 2 Materials

This material would be only removed where absolutely necessary and only to a depth of 65cm below the present soil surface. To allow road construction. All placed road base would be removed during the rehabilitation process and the original contours of the landscape restored during the rehabilitation process.

Layer 2 material would be separately stockpiled as subsoil provided suitable stripping and storage methods are used. [See Section 6.3].

7.2.3.3 Layer 3 [Remainder of the Profile]

Do not disturb.

Recommendations for Layer 3 Materials

Do not disturb.

7.3 Handling Stripped Soils

7.3.1 Introduction

Stripping of soil materials is proposed for those sections of the Project Site to be used for the proposed mining and related operations. This section outlines the recommended 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 Project Site and the associated field and 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 would 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 unfavourable 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.

7.3.2 Stripping and Stockpiling

7.3.2.1 Earthmoving Procedures

The majority of the soils to be disturbed are highly structured, but excessive handling of the materials during the stripping and stockpiling operation and handling when the soils are wet would be avoided to protect any structure that may have developed.

The stripping operation can be carried out using machines such as scrapers, excavators and bulldozers. Care would be taken to ensure that topsoils and subsoils are not stripped when they are too moist as greater damage would occur at this time.

Driving of machinery on the topsoil and subsoil stockpiles, would be kept to an absolute minimum to maximise soil aggregation and prevent compaction, particularly when the stockpiles are moist. Ideally, the topsoil stockpiles would be 1 metre high but, if necessary, higher dumps can be used. These would not exceed about 2 metres in height. The subsoil stockpiles would not exceed 3 metres in height.

These stockpiles would need to be positioned to prevent sediment-laden runoff from entering the local watercourses.

7.4 Soil Conservation Measures

Measures would be taken to minimise loss of soil materials from the stockpiles, especially in the period before they are stabilised, eg using geotextile ‘silt fences’ or lines of straw / hay bales etc.

The formed stockpile surfaces would have a generally even surface that is as 'rough' as possible, in a micro-sense, to assist in runoff control and seed retention and germination. They would be sown with stabilising species as soon as possible after placement and watered if necessary to speed up establishment. Where stockpile construction is conducted in stages, the stockpiles would be progressively stabilised.

8 IMPACT ASSESSMENT

8.1 Soils Generally

Adherence to the recommended soil stripping, handling and storage procedures would result in a minimal impact from a soils and land capability viewpoint at the Project Site.

8.2 Soils Supporting the Native Vegetation on Cracking Clay Soils of the Liverpool Plains endangered ecological community

The impact of the proposed development on the soils within the small area of this community that would be affected by the construction of the proposed transport route would be temporary and not significant if the soil stripping, stockpiling and rehabilitation recommendations outlined in this study are adhered to.

9 LAND CAPABILITY AND AGRICULTURAL LAND SUITABILITY

It would be noted that both the NSW Department of Natural Resources 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.

9.1 Land Capability

9.1.1 Overview of the 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

The 1: 100 000 scale Land Capability map of the Boggabri map sheet area prepared by the former Soil Conservation Service of NSW [DNR, Parramatta - GIS] shows the Study Area mapped mainly as **Class II** [lower slopes] and **Class III** [mid-slopes] with an area of **Class IV** land associated with the scarp adjacent to the southern boundary of the proposed open cut mine.

Class II land is land suitable for regular cultivation. Soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation would be used.

Class III land is sloping land suitable for cropping on a rotational basis. Structural soil conservation works such as graded banks, waterways and diversion banks, together with soil conservation practices such as conservation tillage and adequate crop rotations are required.

Class IV land is land not capable of being regularly cultivated but suitable for grazing with occasional cultivation and requiring soil conservation practices such as pasture improvement, application of fertilizer and minimal cultivation for the establishment or re-establishment of permanent pasture.

9.1.3 Current Assessment

After field assessments during the soil survey, it is evident that the areas delineated as **Class II** and **Class III** land are correctly identified. The area of **Class IV** land is more correctly classed as Class **VII** land.

Class VII land is land best protected by green timber. It 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.

This land capability assessment applies to the Study Area alone. [see **Figure 5**].

9.1.4 Post-Mining Land Capability

Following rehabilitation, there would be five main landforms in the open cut area.

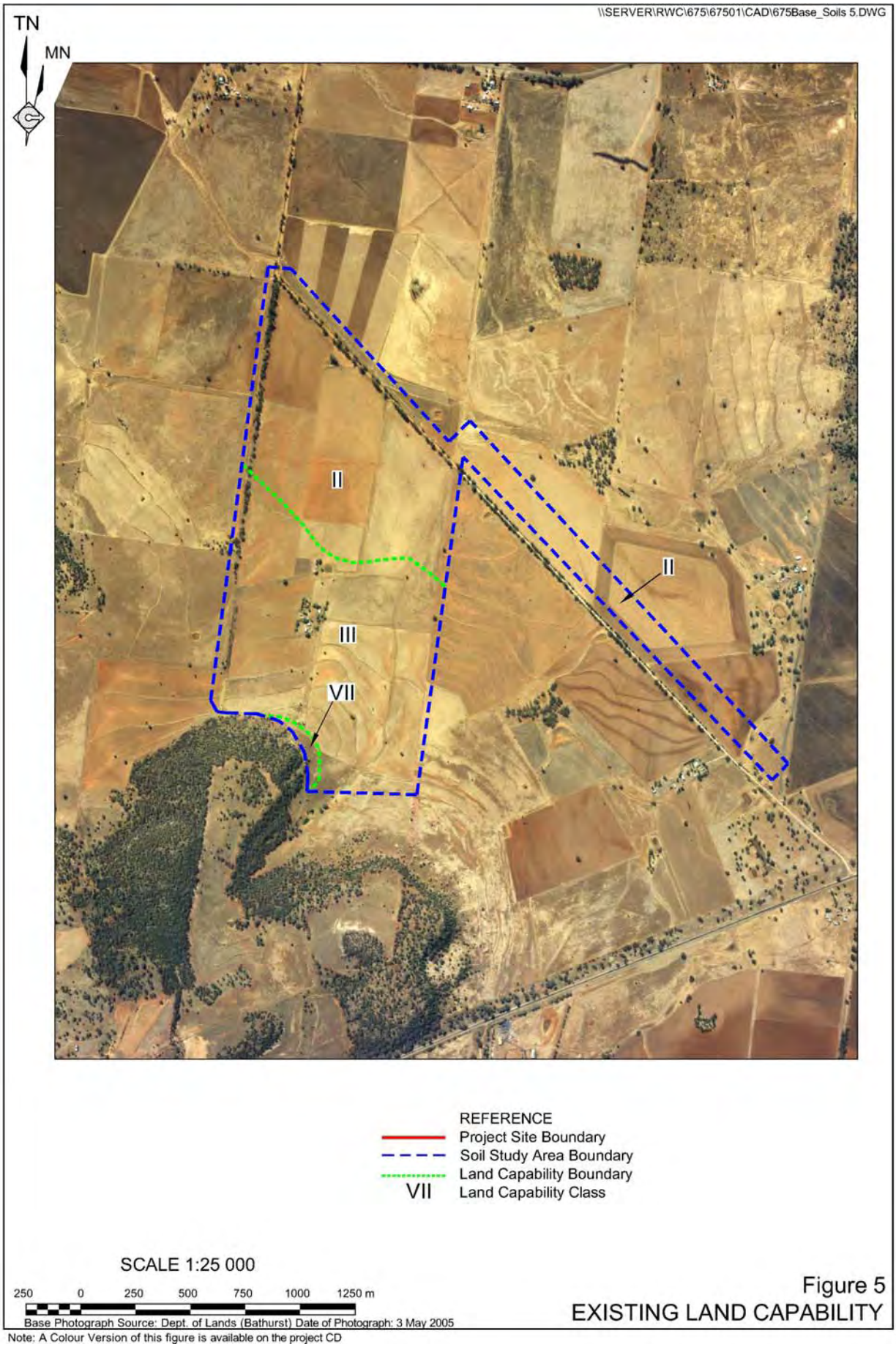
- The back-filled pit area with contours and grades similar to those which existed pre-mining.
- The depression representing the re-shaped final void.
- Those areas relatively undisturbed during the mining process which would be readily returned to agricultural use.
- The mounded area previously used for the out-of-pit emplacement.
- The shallow raised area formed by re-profiling the 15m amenity bund across the coal processing area.

Figure 7 shows the post-mining land capability classification after rehabilitation.

The areas that are easily returned to agricultural use and the backfilled open cut area would have land capability similar to pre-mining levels.

The mounded area would have a land capability classification of **Class VI** and there would be approximately 16.7ha of this Class of land. **Class VI** land is *land not suitable for cultivation, but suitable for grazing with use of soil conservation practices such as limitation of stock, broadcasting of seed and fertilizer, fire prevention and destruction of feral animals.*

The depression would have a land capability classification of **Class VIII** and there would be approximately 18.4ha of this Class of land. **Class VIII** land *includes cliffs, lakes and swamps and other lands incapable of sustaining agricultural or pastoral production*.



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

9.2 Agricultural Land Suitability Classification

9.2.1 NSW Agriculture Assessment

Information supplied by NSW Department of Primary Industries [Agriculture] at Tamworth and Orange [Andrew Scott and Dr Richard Roger, pers.comm.] indicates that the Department has classified the lands of the Study Area using its agricultural land suitability system [Cunningham *et al*, undated; Hulme *et al*, 2002].

The mapped agricultural suitability of the lands indicates the presence of Class 2, Class 3 and Class 4 [Agricultural Suitability] lands. The area comprises mainly Class 2 land with minor areas of Classes 3 and 4

Class 2 land is *'arable land suitable for regular cultivation for crops but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but edaphic [soil factors] or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures*.'

Class 3 land is *'grazing land that is well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall level of production is moderate as a result of edaphic [soil related] or environmental constraints. Erosion hazard or soil structural breakdown limit the frequency of ground disturbance, and conservation or drainage works may be required*.'

Class 4 land is *'land suitable for grazing but not for cultivation. Agriculture is based on native pastures established using minimum tillage techniques. Production may be high seasonally but the overall level of production is low as a result of a number of major constraints, both environmental and edaphic [soil related]'*.

9.2.2 Current Assessment

After field inspection during the soil survey, it is evident that, the NSW Department of Primary Industries [Agriculture] assessment of the agricultural land suitability of the Study Area is generally correct, although the area of **Class 4** land associated with the scarp near the southern boundary of the mine pit would be classed as **Class 5** land as shown in **Figure 6**.

Class 5 land is *'land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low to zero as a result of severe constraints, including economic factors, which preclude improvement'*.

9.2.3 Post-Mining Land Suitability

Following rehabilitation there would be five main landforms in the open cut area.

- The back-filled pit area with contours and grades similar to those which existed pre-mining.

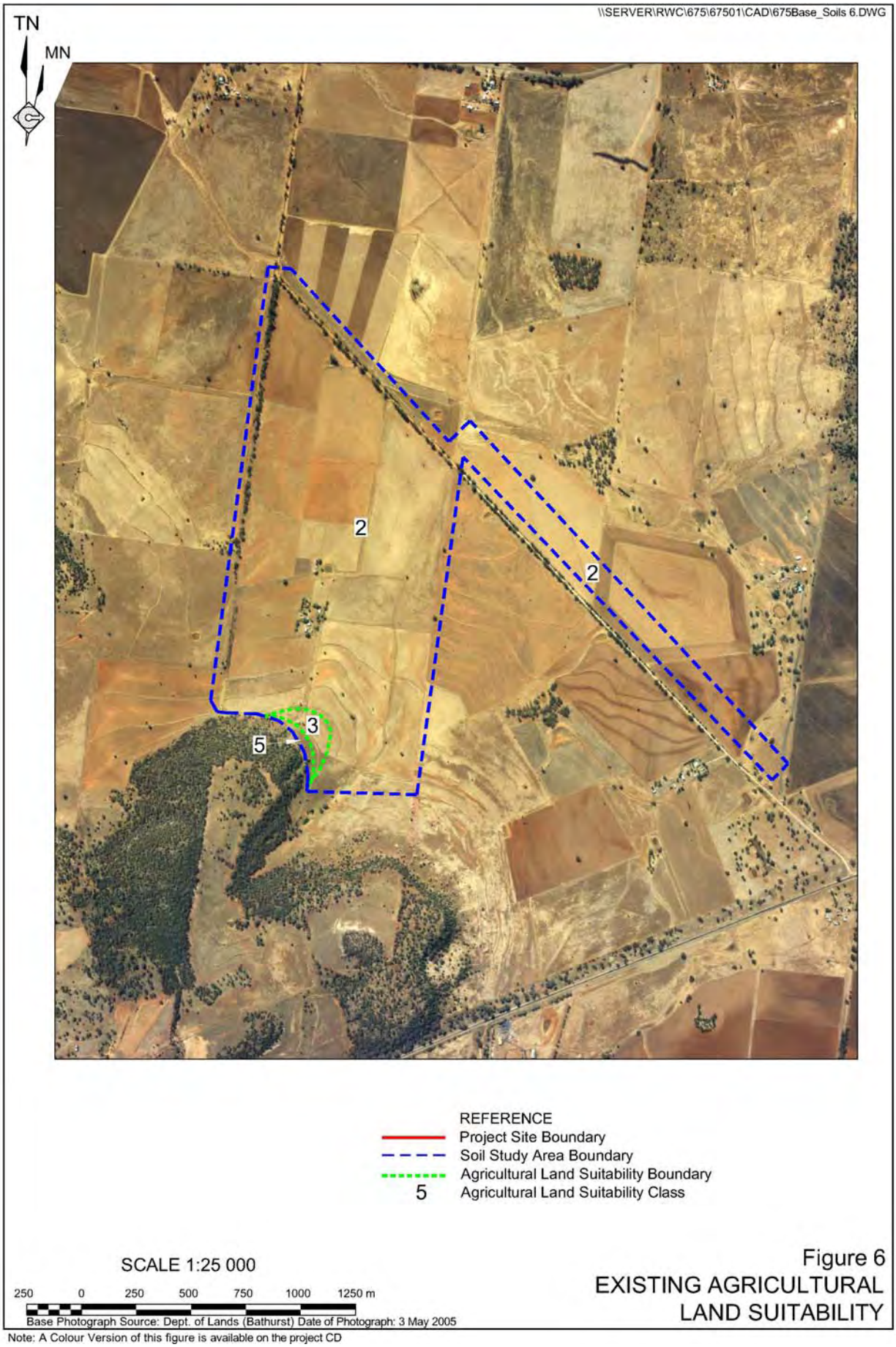


Figure 6
EXISTING AGRICULTURAL LAND SUITABILITY

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

- The depression representing the re-shaped final void.
- Those areas relatively undisturbed during the mining process which would be readily returned to agricultural use.
- The mounded area previously used for the out-of-pit emplacement.
- The shallow raised area formed by re-profiling the 15m amenity bund across the coal processing area.

The depression representing the re-shaped final void.

Figure 8 shows the post-mining land suitability classification after rehabilitation.

The backfilled open cut area would have land suitability similar to pre-mining levels.

The hill area and depression would have a land suitability classification of Class 5. This is *land not suited to agriculture or only light grazing. Agricultural production, if any, is low due to major environmental constraints.* There would be approximately 19.8ha of Class 5 land at the conclusion of rehabilitation.

10 ADDRESSING DIRECTOR-GENERAL'S REQUIREMENTS

A number of issues relating to soils and land capability have been raised in the Director-General's Requirements.

Table 8 lists the issues and indicates the section of this study where each issue is addressed.

Table 8
Director-General's Requirements

ORGANISATION	ISSUE	SECTION WHERE ADDRESSED
Department of Environment and Conservation [Planning Focus Meeting Minutes]	• Assess land capability • Identify any soil constraints to rehabilitation	Sections 9.1, 9.2 Whole of Sections 6 and 7
DPI Mineral Resources [Planning Focus Meeting Minutes]	No net loss of Class 3 land Management of soils using best practice	Section 9 Whole of Sections 6 and 7
Director-General's Requirements	Rehabilitation	Section 7
Department of Natural Resources	Description of Soil Types and Hazards	Section 5, Appendix 1
	Mitigation of Soil Impacts	Sections 7, 8
Department of Primary Industries	Soil Stripping Recommendations	Section 7
	Land Capability and Agricultural Land Suitability Assessment	Section 9

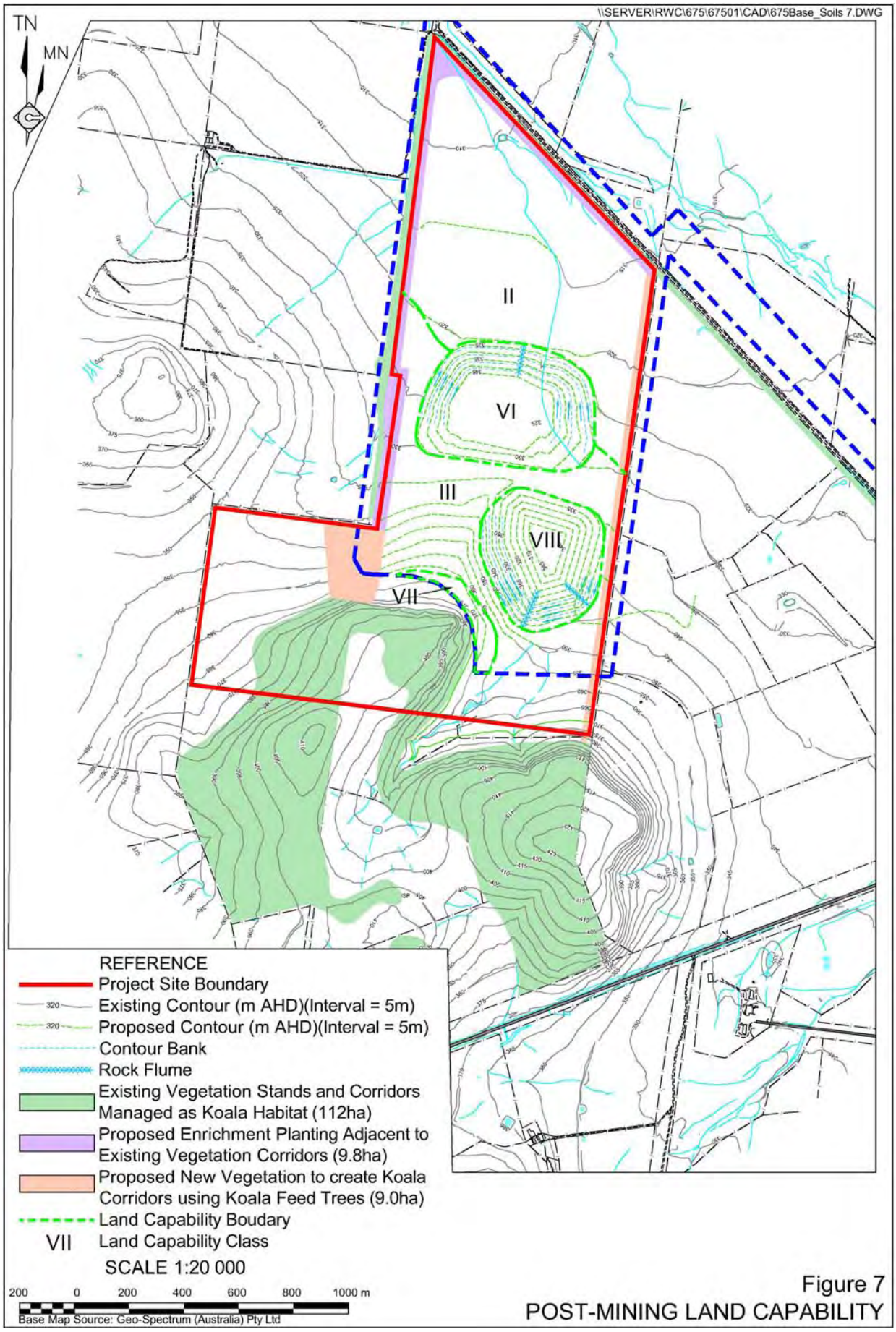


Figure 7
POST-MINING LAND CAPABILITY

Note: A colour version of this figure is presented on the Project CD

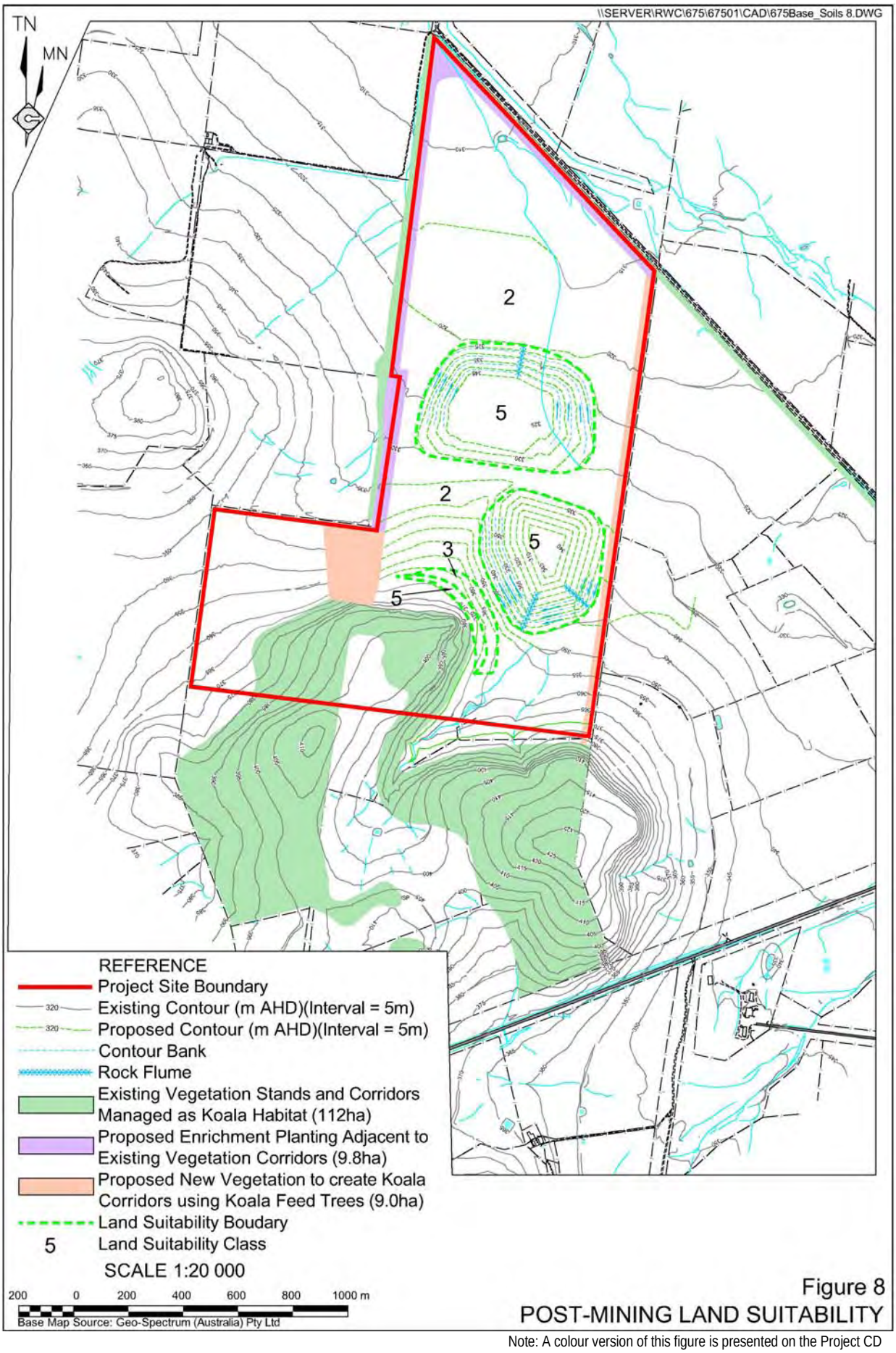


Figure 8
POST-MINING LAND SUITABILITY

Note: A colour version of this figure is presented on the Project CD

11 CONCLUSION

Soils in the Study Area have been described and three 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 soils are currently relatively stable but have a generally **moderate** erodibility rating as determined using the laboratory data obtained from samples from the Study Area in the SOILOSS computer model and field observations;
- topsoils from both SMU 1 and SMU 2 exhibit slight dispersibility while the subsoil from both SMUs show a generally similar slight dispersibility for the layers that would be stripped and stockpiled for use in rehabilitation of disturbed areas;
- despite this generally low dispersibility and there still remains a need for rapid protection of stockpiled material and newly-rehabilitated areas by mulches and vegetation cover;
- the topsoil materials from both SMUs could be stored in the same stockpiles – ie. there is no need for segregation of the topsoils from the two units;
- the subsoil materials from both SMUs could also be stored in the same stockpiles – ie. there is no need for segregation of the subsoils from the two units;
- the soils have a generally moderate to high structure grade and so can be stripped and respread using scrapers without major impacts on soil structure;
- the topsoil material from the entire area to be disturbed would be stripped to a depth of 15cm from the present land surface;
- the subsoil material over the whole area to be disturbed would be stripped for a further 50cm to an overall depth of 65cm below the present land surface;
- should mottled soil material or weathered rock be encountered stripping would cease on such areas – particularly within SMU 1;
- none of the soil material tested from both SMUs showed any saline tendencies;
- all soils would be subject to structural degradation if worked when too moist;
- the topsoil from SMU 3 which is associated with an endangered ecological community – Native Vegetation on Cracking Clay Soils of the Liverpool Plains – would be stripped to 15cm depth and stockpiled; and
- any further soil that is required to be stripped during construction of the transport route would be held in a separate stockpile and respread during the rehabilitation phase before respreading of the topsoil.

No laboratory measurements were undertaken for the SMU soil sample because of the small area that would be disturbed to a minimal degree. Recommendations have been provided along with advice on stabilising the soil stockpiles in the period between stripping and respreading.

The pre-disturbance Land Capability [**Classes II, III and VII**] and Agricultural Land Suitability [**Classes 2, 3, 4 and 5**] of the Study Area have been determined. Post mining there are areas of Land Capability Class VI (16.7ha) and Class VIII(18.4ha) established. There would be 19.8ha of Land Suitability Class 5 established.

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APPENDICES

(No. of pages excluding this page = 13)

Appendix 1 **Soil Profile Descriptions from Backhoe Test Pits – Field Descriptions**

Appendix 2 **Topsoil Stripping Suitability Key [after Elliott and Veness, 1981]**

Appendix 3 **Basis of Land Capability Classification [after Emery, undated]**

Appendix 4: **Glossary**

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Appendix 1

Soil Profile Descriptions from Backhoe Test Pits - Field Descriptions

(No. of pages excluding this page = 10)

Soil Profile Descriptions

Profile 1 [SMU 2] *Upper slope location; surface condition firm; some surface stone present;*

0-13cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; some gravel to 1.5cm; not mottled; not bleached; brown [7.5YR4/3] dry, dark reddish brown [5YR3/3] moist; massive to weakly pedal [10%], peds rough-faced, polyhedral, 5-15mm in size; weak consistency dry; slightly hydrophobic; *abrupt to:-*

13-70cm; loam fine sandy; few roots; no lime present; no manganese present; pH 7.0; some gravel to 1.5cm; not mottled; not bleached; reddish brown [5YR5/4] dry, dark reddish brown [2.5YR3/4] moist; highly pedal [100%], peds rough-faced, polyhedral, <5-10mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

70-204cm; light clay; few roots; no visible lime present; manganese concretions common; pH 9.0; some gravel <1cm; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR4/4] moist; highly pedal [100%], peds rough-faced, polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

204-260cm; heavy clay; few roots; some lime present; some manganese stains present; pH 9.5-10; gravel to 5cm common, stones to 15cm present; not mottled; not bleached; strong brown [7.5YR4/6] dry, strong brown [7.5YR4/6] moist; highly pedal [100%]; peds rough- faced, polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic.

Profile 2 [SMU 1] -*Upper slope location; surface condition firm; medium amounts of surface stone present, rounded / angular to 10cm*

0-21cm; loam fine sandy; roots common; no lime present; no manganese present; pH 6.5; rounded / angular gravel to 1cm present; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/3] moist; highly pedal [100%], peds rough-faced, polyhedral, 5-15mm in size; strong consistency dry; hydrophobic; *gradual to:-*

21-65cm; medium to heavy clay; roots common; no lime present; no manganese present; pH 8.0; much rounded gravel to 5cm; not mottled; not bleached; weak red [7.5YR4/4] dry, dark red 10R3/4] moist; highly pedal [100%], peds rough-faced,
polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *abrupt to:-*

65-145cm; gritty light clay; few roots; no lime present; no manganese present; pH 8.5; mainly decomposing rock, much gravel to 8cm ; not mottled; not bleached; pinkish white [7.5YR8/2] dry, very pale brown [10YR7/4] moist; massive; fabric rough- / smooth; not hydrophobic

Profile 3 [SMU 2] - *Mid slope location; surface condition firm; some surface stone present, rounded, to 5-10cm*

0-18cm; loam fine sandy; many roots; no lime present; no manganese present; pH 5.5; gravel absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/4] moist; massive to weakly pedal [20%], peds rough-faced, polyhedral, <5-20mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

18-63cm; sandy clay; many roots; no lime present; no manganese present; pH 6.5; some rounded gravel to 2cm; not mottled; not bleached; yellowish red [5YR4/4]] dry, dark reddish brown [5YR3/4] moist; highly pedal [100%], peds rough-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *abrupt to:-*

63-175cm; silty clay; few roots; no lime present; manganese stains common; pH 9.0;
some small gravel to 1cm; mottled; not bleached; 50% brown [7.5YR5/4, 50% reddish brown [5YR4/4] dry, 50% strong brown [7.5YR4/6], 50% yellowish red [5YR4/6 moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *gradual to:-*

175-260cm; medium clay; few roots; lime nodules present; manganese stains present; pH 9.5; gravel absent; not mottled; not bleached; brown [7.5YR4/4] dry, brown [7.5YR4/4] moist; highly pedal [100%], peds smooth-faced, polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic;

Profile 4 [SMU 2] - *Mid slope location; surface condition firm; moderate amounts of surface stone present, angular, to 5cm*

0-14cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; some gravel and stones present; not mottled; not bleached; brown [7.5YR4/4] dry, very dark brown [7.5YR2.5/2] moist; massive to weakly pedal [20%], peds rough-faced, polyhedral, 5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14-75cm; light to medium clay; many roots; no visible lime present; occasional manganese concretion present; pH 8.0; occasional small gravel, <1cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

75-134cm; light to medium clay; few roots; no visible lime present; no manganese present; pH 8.5; layer of rounded / angular gravel and stones 2-15cm; not mottled; not bleached; reddish brown [5YR4/4] dry, yellowish red [5YR4/6] moist; highly pedal [100%], peds rough-/smooth-faced, polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

134-250cm; medium to heavy clay; few roots; no visible lime present; some manganese concretions present; pH 8.5; occasional rounded stones to 15cm; not mottled; not bleached; brown [7.5YR4/4] dry, strong brown [7.5YR4/6] moist; highly pedal [100%], peds rough-/smooth-faced, polyhedral, <5-15mm in size; very strong consistency dry; not hydrophobic

Profile 5 [SMU 2] - *surface condition loose;some surface stone present, angular, 1-15cm*

0-14cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; massive to weakly pedal [20%], peds rough-faced, polyhedral, 5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

14-76cm; light to medium clay; few roots; no lime present; no manganese present; pH 8.5; occasional rounded gravel to 2cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough-faced, polyhedral; 5-20mm in size; strong consistency dry; not hydrophobic; *diffuse to:-*

76-174cm; silty clay; few roots; no lime present; no manganese present; pH 8.5; occasional rounded gravel to 1cm; not mottled; not bleached; yellowish red [5YR5/6] dry, reddish brown [5YR4/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic; *diffuse to:-*

174-250cm; medium to heavy clay; few roots; no lime present; no manganese present; pH 8.5; round and angular gravel common, to 10cm; not mottled; not bleached; strong brown [7.5YR5/6] dry, strong brown [7.5YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-10mm in size; very strong consistency dry; not hydrophobic

Profile 6 [SMU 1] - *Upper slope location; surface condition firm; large amounts of surface gravel and tone present, rounded / angular, 1-15cm;*

0-13cm; sandy clay to silty clay; many roots; no lime present; no manganese present; pH 6.0; some rounded and angular gravel 1-3cm; not mottled; not bleached; brown [7.5YR4/4] dry, very dark brown [7.5YR2.5/3] moist; highly pedal [100%], peds rough- faced, polyhedral, 5-15mm in size; weak consistency dry; not hydrophobic; *abrupt to:-*

13-80cm; heavy clay; roots common; no lime present; no manganese present; pH 6.0; some rounded gravel to 2cm; not mottled; not bleached; red 10R4/6] dry, red 10R4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

80-145cm; heavy clay; few roots; no lime present; no manganese present; pH 8.0; some angular gravel to 1-2cm; mottled; not bleached; 90% light grey [10YR7/2], 10% yellowish red [5YR4/6] dry, 90% light brownish grey [10YR6/2], 10% yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; firm consistency dry; not hydrophobic; *diffuse to:-*

145-167cm; weathered rock; pH 8.5;

Profile 7 [SMU 1] - *Upper slope location; surface condition loose to firm; moderate amounts of surface stone present, rounded / angular to 15cm*

0-13cm; medium to heavy clay; many roots; no lime present; no manganese present; pH 6.0; some rounded and angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; <5-15mm in size; firm consistency dry; slightly hydrophobic; *gradual to:-*

13-56cm; heavy clay; few roots; no lime present; no manganese present; pH 8.0; some rounded and angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral to angular blocky, <5-10mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

56-118cm; weathered rock; few roots.

Profile 8 [SMU 2]- *Midslope location; surface condition firm; surface stone absent*

0-19cm; loam fine sandy; many roots; no lime present; no manganese present; pH 5.5; some small gravel to 1cm; not mottled; not bleached; yellowish red 5YR5/6] dry, dark reddish brown [5YR3/3] moist; highly pedal [100%], peds rough-faced, polyhedral; <5-10mm in size; weak consistency dry; not hydrophobic; *abrupt to:-*

19-103cm; light to medium clay; roots common; no lime present; no manganese present; pH 6.0; pockets of gravel, generally <10cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

103-156cm; medium clay; roots common; no lime present; no manganese present; pH 8.0; pockets of rounded gravel to 3cm; not mottled; not bleached; red [2.4YR4/8] dry, red [2.5YR4/8] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

156-240cm; medium to heavy clay; few roots; no lime present; no manganese present; pH 8.0; pockets of rounded gravel to 2cm; not mottled; not bleached; red [2.5YR5/6] dry, red [2.5YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-10mm in size; strong consistency dry; not hydrophobic

Profile 9 [SMU 2] - *Midslope location; surface condition loose; some surface stone present, rounded to 3cm*

0-18cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; some rounded gravel to 2cm; not mottled; not bleached; strong brown [7.5YR4/6] dry, very dark brown [7.5YR 2.5/3] moist; highly pedal [100%], peds rough-faced, polyhedral, 5-10mm in size; weak consistency dry; slightly hydrophobic; *gradual to:-*

18-58cm; medium clay; roots common; no lime present; no manganese present; pH 6.0; pockets of angular gravel to 3cm; not mottled; not bleached; red [2.5YR4/8] dry, dark red [2.5YR3/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

58-85cm; heavy clay; few roots; no lime present; no manganese present; pH 8.0; some gravel to 1cm; not mottled; not bleached; red [2.5YR4/6] dry, dark red [2.5YR3/6] moist; highly pedal [100%], peds smooth-faced, polyhedral, 5-20mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

85-150cm; medium clay; few roots; no lime present; some manganese concretions present; pH 8.0; pockets of rounded gravel to 1cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistency dry; not hydrophobic; *gradual to:-*

150-250cm; medium clay; few roots; no lime present; some manganese concretions present; pH 8.0; much rounded gravel to 2cm; not mottled; not bleached; red [2.5YR5/6] dry, reddish brown [2.5YR4/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral; 5-15mm in size; firm to very firm consistency dry; not hydrophobic

Profile 10 [SMU 2] - *Midslope location; surface condition hardsetting; some surface stone present, angular to 10cm*

0-24cm; loam fine sandy; many roots; no lime present; no manganese present; pH 5.5; gravel not recorded; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/2] moist; massive to moderately pedal [40%], peds rough- faced, polyhedral, 5-15mm in size; firm consistency dry; not hydrophobic; *abrupt to:-*

24-54cm; medium clay; many roots; no lime present; no manganese present; pH 6.0; gravel not recorded; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [5YR3/2] moist; highly pedal [100%], peds rough-faced, polyhedral, 5-20mm in size; very firm to strong weak consistency dry; not hydrophobic; *gradual to:-*

54-187cm; medium clay; few roots; no lime present; trace of manganese staining present; pH 7.0; occasional rounded gravel to 1-2cm; not mottled; not bleached; strong brown [7.5YR5/6] dry, strong brown [7.5YR5/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-10mm in size; very firm consistency dry; not hydrophobic; *gradual to:-*

187-230cm; light to medium clay; few roots; no lime present; much manganese staining present; pH 7.5; occasional rounded gravel to 1-2cm; not mottled; not bleached; weak red [10R4/4] dry, weak red [10R4/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; very strong consistency dry; not hydrophobic

Profile 11 [SMU 2] - *Lower slope location; surface condition hardsetting; some surface stone present, angular to 5cm, including petrified wood*

0-16cm; loam fine sandy to sandy clay loam; many roots; no lime present; no manganese present; pH 7.0; occasional rounded gravel, <1cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/2] moist; highly pedal [100%], peds rough- faced, polyhedral, 5-15mm in size; weak to firm consistence dry; not hydrophobic; *abrupt to:-*

16-48cm; light clay; many roots; no lime present; no manganese present; pH 8.0; occasional angular gravel to 2cm; not mottled; not bleached; red [2.5YR4/6] dry, dark reddish brown [2.5YR3/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral; 5-15mm in size; very firm consistence dry; not hydrophobic; *gradual to:-*

48-177cm; medium clay; many roots; no lime present; no manganese present; pH 8.0; some small rounded gravel to <1cm; not mottled; not bleached; red [2.5YR4/6] dry, dark reddish brown [2.5YR3/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-10mm in size; strong consistence dry; not hydrophobic;
gradual to:-

177-240cm; heavy clay; roots few; no lime present; no manganese present; pH 8.0; some small rounded gravel to <1cm; not mottled; not bleached; weak red [10R4/4] dry, dusky red 10R3/4] moist; highly pedal [100%], peds smooth-faced, polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic

Profile 12 [SMU 2] - *Lower slope location; surface condition firm; some surface stone present, rounded to 1cm*

0-16cm; light clay; many roots; no lime present; no manganese present; pH 5.5; occasional gravel, rounded to <1cm; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; moderately pedal [50%], peds rough- faced, polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

16-80cm; light clay; roots common; no lime present; no manganese present; pH 8.0; some gravel, rounded to <1cm; not mottled; not bleached; yellowish red [5YR5/6] dry, reddish brown [2.5YR4/4] moist; highly pedal [100%], peds rough-faced, polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

80-170cm; medium to heavy clay; roots few; no lime present; manganese stains present; pH 8.0; some rounded gravel to 2cm; mottled; not bleached; 50% red [2.5YR4/6], 50% reddish brown [2.5YR4/4] dry, 50% strong brown [7.5YR4/6], 50% dark yellowish brown [10YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

170-250cm; heavy clay; roots few; no lime present; much manganese staining present; pH 8.0; some rounded gravel to 2cm; not mottled; not bleached; strong brown [7.5YR5/6] with a hint of red [2.5YR4/4] dry, strong brown [7.5YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic

Profile 13 [SMU 2] - *Lower slope location; surface condition firm; surface stone absent*

0-19cm; loam fine sandy; many roots; no lime present; no manganese present; pH 5.5; some gravel, round, <5mm; not mottled; not bleached; brown [7.5yr5/4] dry, dark brown [7.5YR3/4] moist; moderately pedal [60%], peds rough- faced, polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

19-57cm; light to medium clay; roots common; no lime present; no manganese present; pH 6.0; some gravel, rounded to 1cm; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/4] moist; highly pedal [100%], peds rough- faced, polyhedral, 5-10mm in size; very firm consistence dry; not hydrophobic; *gradual to:-*

57-149cm; light to medium clay; roots few; no lime present; no manganese present; pH 8.0; some gravel, rounded to 3cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, <5-10mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

149-264cm; heavy clay; roots few; no lime present; no manganese present; pH 8.0; some rounded gravel to 1.5 - 2cm; not mottled; not bleached; reddish brown [2.5Yr4/4] dry, dark reddish brown 2.5YR3/4] moist; highly pedal [100%], peds smooth-faced, polyhedral, <5-15mm in size; strong consistence dry; not hydrophobic

Profile 14 [SMU 2] - *Midslope location; surface condition loose; surface stone absent*

0-14cm; sandy clay loam to clay loam; many roots; no lime present; no manganese present; pH 5.5; some gravel, rounded to 1cm; not mottled; not bleached; reddish brown [5YR4/5] dry, dark reddish brown [5YR2.5/2] moist; highly pedal [100%], peds rough- faced, polyhedral / platy, 5-10mm in size; very firm consistence dry; hydrophobic; *abrupt to:-*

14-42cm; light to medium clay; many roots; no lime present; no manganese present; pH 6.0; occasional gravel, rounded <1cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR2.5/2] moist; highly pedal [100%], peds rough-faced, polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

42-122cm; medium clay; roots few; no lime present; no manganese present; pH 8.5; occasional gravel, rounded <1cm; not mottled; not bleached; yellowish red [5YR4/6] dry, reddish brown [5YR4/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral / platy, 5-15mm in size; very firm consistence dry; not hydrophobic; *gradual to:-*

122-260cm; heavy clay; roots few; no lime present; some manganese stains and small concretions present; pH 8.5; some gravel, rounded <1cm; mottled; not bleached; 80% weak red [10R4/4], 20% yellowish red [5YR5/6] dry, 80% weak red [10R4/4], 20% yellowish red [5YR4/6] moist, highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic

Profile 15 [SMU 2] - *Lower slope location; surface condition loose; surface stone absent*

0-19cm; silty clay; many roots; no lime present; no manganese present; pH 5.5; gravel absent; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral / platy, 5-15mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

19-41cm; light to medium clay; many roots; no lime present; no manganese present; pH 6.5; some gravel, angular 1-5 to 2cm; not mottled; not bleached; yellowish red [5YR4/6] dry, dark reddish brown [5YR3/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

41-122cm; medium to heavy clay; roots few; no lime present; occasional manganese stains present; pH 8.0; occasional gravel to <1cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] dry, highly pedal [100%], peds rough- / smooth-faced, polyhedral / platy, 5-10mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

122-240cm; medium to heavy clay; roots few; no lime present; manganese stains common; pH 8.5; some gravel to 2cm; not mottled; not bleached; red [2.5YR4/6] dry, reddish brown [2.5YR4/4] moist; highly pedal [100%], peds rough- / smooth-faced, polyhedral, 5-15mm in size; very firm consistence dry; not hydrophobic

Profile 16 SMU 2] - *Level plain location; surface condition loose to firm; surface stone absent*

0-15cm; loam fine sandy; many roots; no lime present; no manganese present; pH 6.0; occasional angular gravel to 7mm; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [[7.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10mm in size; weak consistence dry; not hydrophobic; *clear to:-*

15-100cm; medium clay; many roots; no lime present; no manganese present; pH 7.5; gravel and stone absent; not mottled; not bleached; weak red [10R4/4] dry, weak red [10R4/4] moist; peds smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

100-150cm; medium clay; roots absent; many lime nodules and stains present; many small manganese nodules present; pH 9.0; pockets of rounded gravel to 1cm; not mottled; not bleached; reddish brown [10R4/4] dry, reddish brown [10R4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5.20mm in size; very strong consistence dry; not hydrophobic; *diffuse to:-*

150-250cm; medium clay; roots absent; many lime nodules and stains present; many small manganese nodules present; pH 9.0; pockets of rounded gravel to 1cm; not mottled; not bleached; yellowish red [5YR5/6] dry, yellowish red [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic;

Profile 17 [SMU 2] - *Level plain location; surface condition loose; occasional surface stones present, square to 10cm*

0-14cm; light to medium clay; many roots; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [100%], polyhedral; <5-10 mm in size; firm consistence dry; slightly hydrophobic; *abrupt to:-*

14-85cm; medium to heavy clay; roots common; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/3] dry, dark brown [7.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

85-173cm; light to medium clay; roots few; some lime stains present; no manganese present; pH 8.5; pockets of rounded gravel 1-3cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *diffuse to:-*

173-250cm; light to medium clay; roots absent; lime stains and nodules present; many small manganese nodules present; pH 9.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-20mm in size; very strong consistence dry; not hydrophobic.

Profile 18 [SMU 2] - *Level plain location; surface condition; 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; brown [7.5YR5/4] dry, dark reddish brown [5YR3/2] moist; eds rough-faced, highly pedal [100%], polyhedral; <5-15 mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

16-62cm; medium clay; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; <5-10mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

62-110cm; heavy clay; roots few; many lime stains present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

110-184cm; medium clay; roots few; many lime nodules present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *diffuse to:-*

184-280cm; medium to heavy clay; roots absent; many lime nodules present; some manganese stains present; pH 9.0; gravel and stones absent; not mottled; not bleached; reddish brown [2.5YR4/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; very strong consistence dry; not hydrophobic.

Profile 19 [SMU 3] - *Depression location; surface condition self mulching and cracking; surface stone absent*

0-19cm; heavy clay; many roots; some lime stains present; no manganese present; pH 8.0-9.0; gravel and stones absent; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

19-64cm; heavy clay; many roots; many small lime nodules present; no manganese present; pH 9.0-9.5; occasional rounded gravel to 1cm; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dusky red [2.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-15mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

64-104cm; heavy clay; roots few; many lime stains and nodules present; no manganese present; pH 9.0-9.5; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; very firm to strong consistence dry; not hydrophobic; *diffuse to:-*

104-260cm; medium to heavy clay; roots few; many lime stains and nodules present; many manganese stains present; pH 9.0-9.5; gravel and stones absent; not mottled; not bleached; reddish brown [2.5YR4/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral; 5-10mm in size; strong consistence dry; not hydrophobic.

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Appendix 2

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

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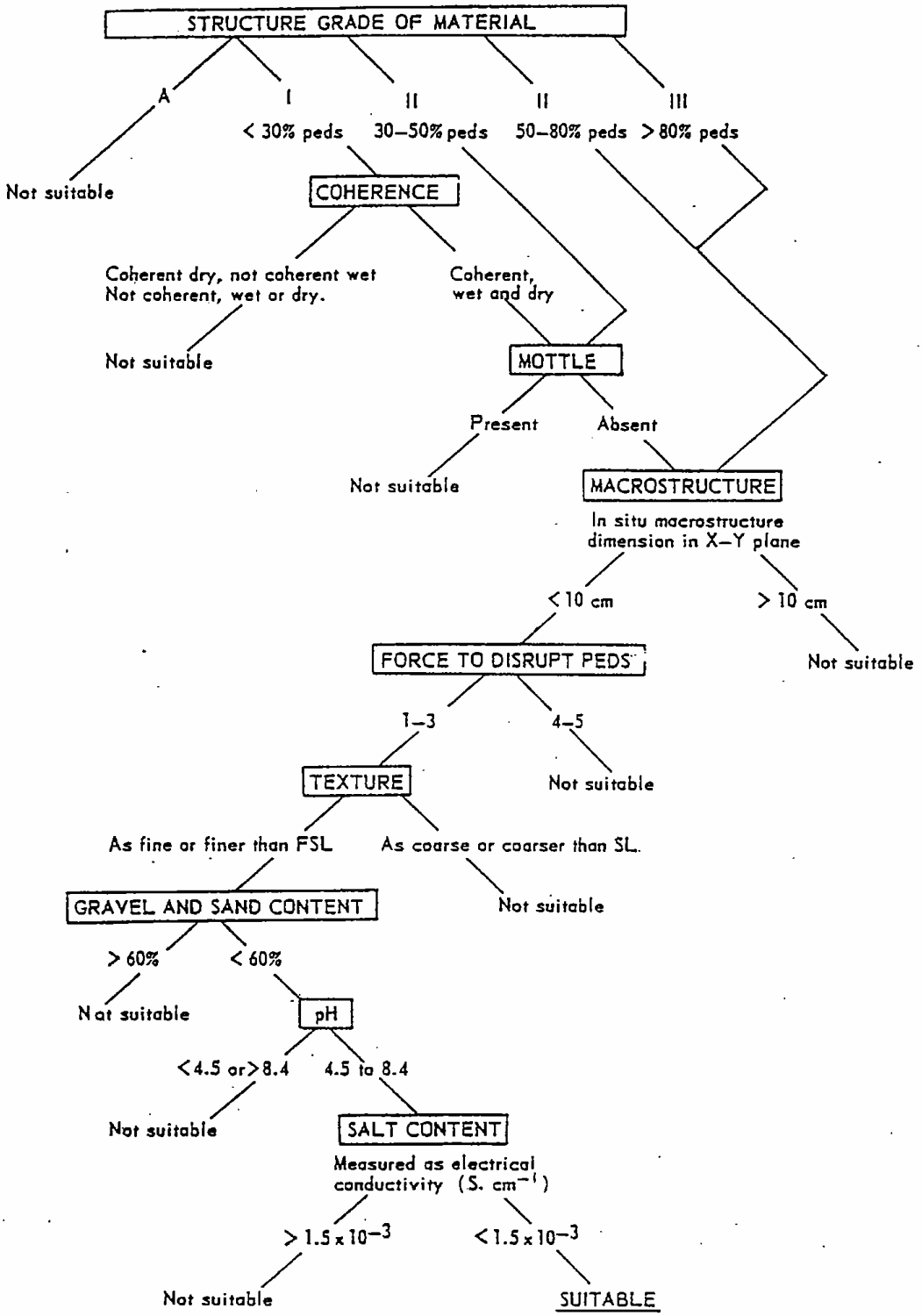
Procedure for the selection of material for use in topdressing of disturbed areas.



Appendix 3

Basis of Land Capability Classification [after Emery, undated]

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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	Soil conservation practices such as pasture improvement, stock control, application of fertilizer and minimal cultivation for the establishment or re-establishment of permanent pasture.	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	Structural soil conservation works such as absorption banks, diversion banks and contour ripping, together with the practices as in Class IV.	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	Soil conservation practices including limitation of stock, broadcasting of seed and fertilizer, prevention of fire and destruction of vermin. May include some isolated structural works.	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	
		M	Mining and quarrying areas.	

CLASS SUBSCRIPTS	SPECIAL USES
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.

Appendix 4

Glossary

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Glossary of Terms

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.

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.