WHITEHAVEN COAL

Narrabri Coal Operations Pty Ltd

ABN: 15 129 850 139

Narrabri Coal Mine
Stage 2 Longwall Project

Soils and Land Capability Assessment of the Proposed Reject Emplacement Area, Brine Storage Area and Water Pipeline Route

Prepared by:

Geoff Cunningham Natural Resource Consultants Pty Ltd

November 2009

Specialist Consultant Studies Compendium
Volume 2, Part 9b

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November, 2009

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CONTENTS

Page

CONTENTS

Page

CONTENTS

Page

CONTENTS

Page

CONTENTS

Page

APPENDICES

TABLES

FIGURES

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EXECUTIVE SUMMARY

The soils of the proposed Reject Emplacement Area, Brine Storage Area on the Mine Site of the Narrabri Coal Mine have been sampled and subjected to field and laboratory testing.

Similarly the soils along the proposed Water Pipeline Route from the Namoi River to the Mine Site have been sampled, and field and laboratory analysed.

A single soil mapping unit [**SMU R1**] was identified at the proposed Reject Emplacement Area while at the proposed Brine Storage Area there were three soil mapping units identified [**SMUs B1, B2, B3**].

Sampling along the proposed Water Pipeline Route revealed a further three soil mapping units [**SMU P1, P2, P3**].

In all, forty soil profiles were excavated and described and the horizons analysed to provide data on their physical and chemical properties. Five of these profiles were at the proposed Reject Emplacement Area site, twenty two within the proposed Brine Storage Area and thirteen along the proposed Pipeline Route.

Laboratory analyses were undertaken on samples from all horizons in all profiles from the proposed Reject Emplacement and Brine Storage Areas. This is a departure from normal procedures as usually only a representative proportion of samples would be analysed. The additional analyses were undertaken at the request of Narrabri Coal Operations Pty Limited to ensure that the Company was fully briefed on the physical and chemical properties of the soils in these critical areas.

Soil stripping, storage and handling recommendations have been provided for all soil mapping units of the proposed Reject Emplacement and Brine Storage Areas.

As the proposed Water Pipeline Route soils would be replaced quickly after trench excavation, pipe laying and trench refilling, stripping recommendations were not provided. Instead, guidance on management of the soil materials during and after excavation and during refilling of the trench have been addressed.

Assessments of the erodibility of the soil mapping units identified within the proposed Reject Emplacement Area, Brine Storage Area and Water Pipeline Route have been undertaken using the SOILOSS computer model. Results of the assessments have been provided.

The current Land Capability and Agricultural Suitability classifications for the land proposed to be disturbed have been provided as follows.

- Proposed Reject Emplacement Area [Class III Land Capability; Class 3 Agricultural Land Suitability]
- Proposed Brine Storage Area [Class III Land Capability; Classes 3 and 4 Agricultural Land Suitability]
- Proposed Pipeline Route [Classes II and III Land Capability; Classes 2, 3 and 4 Agricultural Land Suitability]

In addition an assessment of the likely land classifications for the post-disturbance landscapes has been undertaken. The assessment is summarised as follows.

- Proposed Reject Emplacement Area [Class VI Land Capability; Class 3 Agricultural Land Suitability].
- Proposed Brine Storage Area [Class III Land Capability; Class 3 Agricultural Land Suitability].
- Proposed Pipeline Route [Classes II and III Land Capability; Classes 2, 3 and 4 Agricultural Land Suitability] – unchanged.

1 INTRODUCTION AND DESCRIPTION OF PROJECT

1.1 Introduction

The Study was undertaken for R W Corkery and Co. Pty Limited on behalf of Narrabri Coal Operations Pty Limited [the Proponent].

The soils and land capability Study Area covers three separate areas – the proposed Reject Emplacement Area near the Mine box cut, the proposed Brine Storage Area to the north of the Mine and Kurrajong Creek and the proposed route of a water pipeline from the Namoi River to the northwest of Turrawan to the Mine.

Figure 1 shows all three study areas along with the locations of the soil sample pits that were examined during the study.

Specifically the Study was carried out to provide soils and land capability information relating to the areas proposed to be disturbed by works associated with the construction of the three infrastructure facilities that are required for the Mine's operations.

Field sampling of the area was carried out on 24th, 25th, 26th and 27th August, 2009.

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

(i) the soils on the proposed Reject Emplacement Area, proposed Brine Storage Area and along the proposed Pipeline Route [*collectively referred to as the Study Area*], and;

(ii) the land capability and agricultural land suitability of these areas.

The report was required to include sufficient level of detail to satisfy NSW Industry and Investment Mining Operations Plan guidelines and to satisfy the requirements of the Department of Environment, Climate Change and Water specifications for soil surveys associated with proposed mining operations.

This report describes the soils based upon forty representative soil profiles as well as laboratory analyses of a selection of representative profiles and discusses the land capability of the Study Area.

In particular, this report provides.

- the results of the field survey and laboratory testing of samples (in the case of the proposed Reject Emplacement Area and Brine Storage Area all horizons in all of the soil profiles described were subjected to laboratory analysis);
- a discussion of the results of field survey and laboratory physical and chemical analysis in technical as well as “Plain English” terms;
- a discussion of the stripping suitability of the soil materials found at the Study Area;

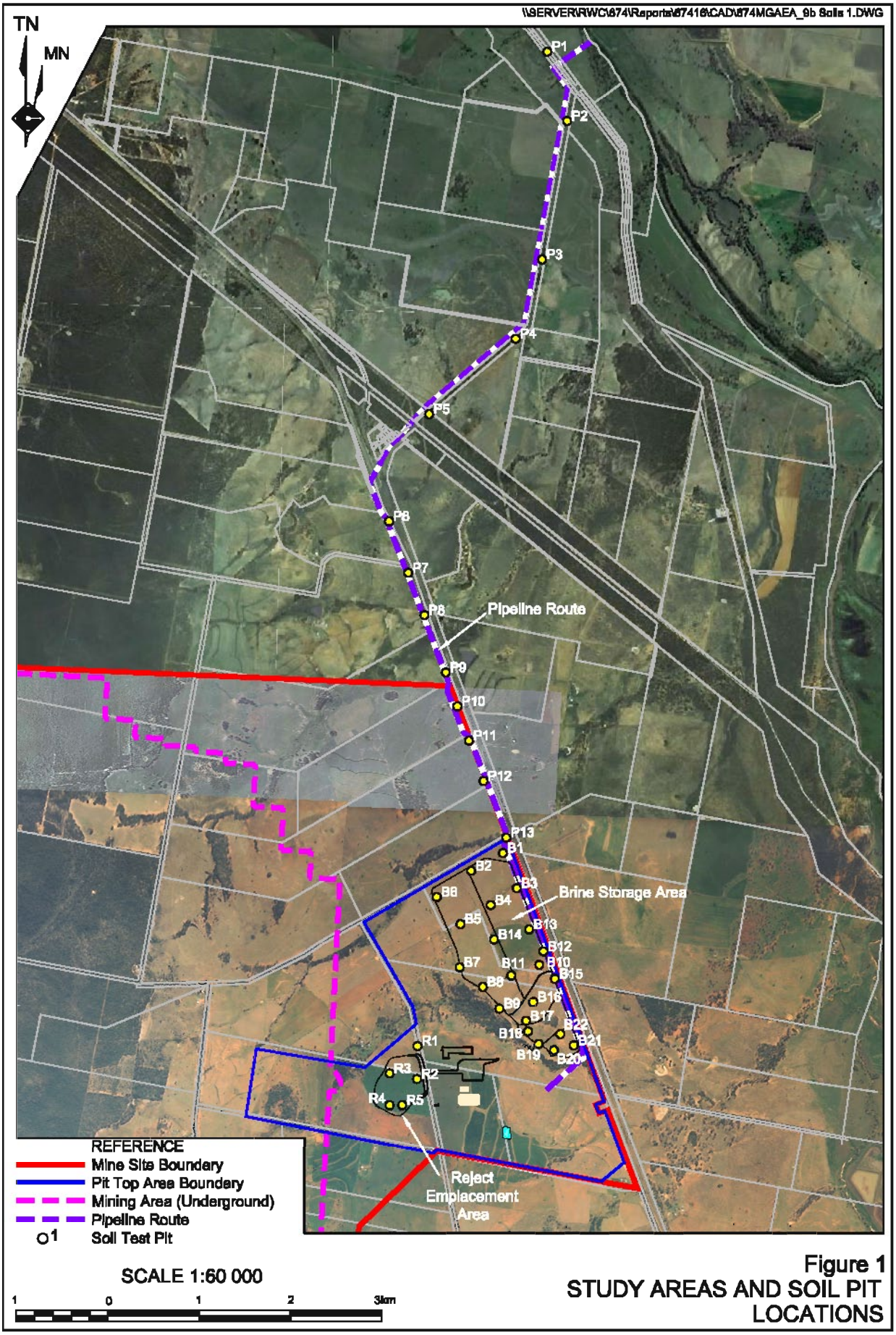

Figure 1
STUDY AREAS AND SOIL PIT LOCATIONS

- details of soil handling strategies and recommendations about soil stripping and stockpiling;
- details of the land capability and agricultural suitability at the Study Area; and
- the results of soil sampling along the route of a proposed water pipeline from the Namoi River to the Mine Site, including soil management recommendations.

1.2 Description of the Longwall Project

The Proponent's objectives for the proposed development and operation of the Stage 2 longwall mining project at the Narrabri Coal Mine are to:

i) develop and safely operate a productive longwall mine producing up to 8 million tonnes of low ash, thermal coal each year;

ii) progress to the elevated production levels, ie. greater than the approved 2.5Mtpa, at the earliest possible date to maintain the Proponent's coal production levels in the Gunnedah Basin;

iii) continue to supply international markets for the coal produced;

iv) develop and operate the mine in a manner that complies with all statutory requirements;

v) undertake all activities in an environmentally responsible manner, employing a level of control and integrating safeguards that would ensure compliance with appropriate criteria/goals and/or reasonable community expectations at all times;

vi) design and construct additional surface infrastructure that would minimise surface disturbance and would serve the mine for the foreseeable future;

vii) monitor and manage surface subsidence to ensure impacts on the local environment are minimised;

viii) monitor and manage mine ventilation to ensure a safe working environment is maintained and impacts on the local environment are minimised;

ix) maintain and increase the stimulus to the local economies of Narrabri, Boggabri and Gunnedah and their surrounding districts through employment and service supply opportunities related to the operation of the coal mine;

x) achieve the above objectives in a cost-effective manner and thereby ensure the ongoing viability of the proposed mining operation; and

xi) provide for ongoing monitoring of local environmental parameters such as groundwater, air quality and noise to ensure adverse impacts are minimised.

The Proponent proposes to convert the approved Narrabri Coal Mine from a continuous miner operation with an approved annual production rate of 2.5Mtpa to a longwall mining operation with a maximum annual production rate of 8Mtpa.

1.2.1 The Proposed Reject Emplacement Area

The ROM coal would be drawn from the ROM coal stockpiles and fed to a rotary breaker for size reduction. The broken coal would then be transferred to a dry screen with the <16mm coal transferred directly to the product coal stockpile area and the remainder transferred to the Coal Preparation Plant where the coal would be washed and coarse and fine reject screened off. The fine and ultra-fine reject would be dewatered to produce a filter cake which would be disposed of in combination with the coarse coal reject. The washed coal would be transferred to the product coal stockpile area from where it would ultimately be loaded into train wagons for transport from the Mine Site.

The Coal Preparation Plant is expected to remove up to 5% of the total ROM feed as reject, which would be predominantly rock from the floor of the mine workings. Approximately 90% of the reject would be coarse reject and the remainder comprising the filter cake, with both reject streams stockpiled within a reject pile. From the reject pile, the consolidated reject would be transferred to a Reject Emplacement Area on the north-facing side of a low ridge immediately to the west of the box cut (see **Figure 1**). The proposed maximum footprint of the Reject Emplacement Area is approximately 25ha, however, it would be constructed progressively as a series of elongated (north-south oriented) cells in a westerly direction. The emplacement would be constructed against the slope of the ridge, rising to a maximum of 15m above the natural surface level.

1.2.2 The Proposed Brine Storage Area

As groundwater seeps into the underground workings, it would be diverted to underground sumps from where it would be pumped to the surface into a dam located in the water management area within the rail loop. Some of this ‘raw’ groundwater, which is expected to be saline (Total Dissolved Solids (TDS) of up to 8 000mg/l), would be pumped from the dam for use within the Pit Top Area, ie. coal washing and dust suppression.

Water would also be required for use underground, ie. dust suppression and equipment cooling, with fresh water (TDS≤500mg/L) required for these activities.

In order to improve the water quality for use underground, the approved water conditioning plant (incorporating both micro-filtration and reverse osmosis processes) would be constructed and operated. Water discharged into Dam A1 would be pumped to the Water Conditioning Plant, with the treated water (“raffinate”) discharged to Dams C and D. The waste ‘brine’, which is expected to have a salinity approximating that of seawater, would be initially stored near the Pit Top area.

Following the completion of groundwater modelling for the Longwall Project, it became evident that the volume of groundwater in-flow would gradually increase to a level whereby the volume to be dewatered would exceed operational requirements. Furthermore, no beneficial use for the excess raw groundwater has been identified and consequently, the Proponent would process all dewatered groundwater not required for Pit Top Area activities through the Water Conditioning Plant. It is proposed to discharge the excess treated water to the Namoi River.

The additional brine, in excess of that which can be stored near the Pit Top, would be pumped to and stored within an additional storage facility to be constructed (progressively) to the north of Kurrajong Creek Tributary 2 (Brine Storage Area).

The Brine Storage Area would incorporate a series of ponds, which would be constructed as required throughout the life of the Longwall Project (see **Figure 1**). The initial three ponds which cover an area of 40ha have sufficient capacity to store the expected amount of brine that would be generated.

However, the Proponent intends to provide an additional area of Brine Storage would provide additional storage capacity in the event that amount of brine generated that predicted by groundwater modelling.

Additionally, it was identified that as the volume of groundwater to be dewatered increased in the initial years of the mine's operation there was insufficient water make to meet the operational requirements of the mine. The Proponent proposes to source additional sources of water from water licences acquired from the Namoi River, Namoi alluvium and/or the Great Artesian Basin.

At the completion of underground mining, the stored brine would be pumped back into the goaf areas and remaining gate roads of the completed longwall panels and the Brine Storage Area rehabilitated. The Proponent is also investigating the potential to progressively pump the brine into the completed goaf areas of the mine as the direction of mining progresses up-dip). This would target the transfer of all brine underground by the cessation of mining in approximately 30 years.

1.2.3 The Proposed Water Pipeline Route

The proposed pipeline would serve the purposes outlined in Section 1.2.2 in terms of allowing water to be pumped from the Namoi River for use at the Mine and at a later date for return of treated water to the River.

1.3 Rehabilitation

1.3.1 Pit Top Area infrastructure

All surface infrastructure, with the exception of the mine access road and rail infrastructure, would be decommissioned, dismantled and removed from the Mine Site. The disturbed areas of the Pit Top Area would be backfilled where appropriate, eg. box cut and underground water storage dams (after dam lining and saline material is removed), profiled, covered with available topsoil and revegetated with either pasture grass species or native tree, shrub and grass species (depending on final landform and land use requirements).

1.3.2 Reject Emplacement Area

As the permanent 14º batters of each cell of the Reject Emplacement Area are formed, they would be progressively capped with the previously stripped subsoil and topsoil. On completion of each cell to the nominated 15m height, the top surface would be profiled to create a series

of transverse (ie. east-west) drainage swales and respread with topsoil. The completed surfaces of the Reject Emplacement Area would be revegetated with a fast growing cover crop to stabilise the landform, with pasture species ultimately sown to enable a return to agriculture over this area, once mining is completed.

1.3.3 Water and Brine Storage Ponds

Following dewatering of the ponds, the black plastic liner of each pond would be removed and transported to a waste disposal facility. The salinity level of the compacted clay floor beneath the liner would be analysed to confirm that no contamination has occurred as a result of breaches in the liner. If required, appropriate remedial measures would be undertaken to remove the saline contamination. The ponds would then be backfilled, profiled, re-topsoiled and revegetated with pasture species to create a landform comparable with the surrounding topography.

1.3.4 Ventilation and Gas Drainage Infrastructure

The ventilation and gas drainage infrastructure would be rehabilitated in much the same fashion as the Pit Top Area, albeit on a smaller and more widespread scale. When facilities are no longer required, they would be progressively rehabilitated given the area required for the construction and installation of the bores required for ventilation and gas drainage greatly exceeds the area required to manage and maintain these operations.

1.3.5 Surface Cracking caused by Subsidence.

The disturbance resultant from any surface cracking caused by subsidence would be progressively rehabilitated. For smaller width cracking, the surface would simply be ripped to allow the cracks to be filled in. In some instances, the surface cracking may be too wide to be effectively in-filled by surface ripping and in these instances, material excavated from within the footprint of the Reject Emplacement Area would be used to in-fill the cracks prior to ripping and revegetation.

2 DESCRIPTION OF THE STUDY AREA

The proposed Reject Emplacement Area and Brine Storage Study Area are located adjacent to, and west of, the Gunnedah – Narrabri Railway line and the Kamilaroi Highway some 19km northwest of Baan Baa (see **Figure 1**).

The proposed Pipeline Route runs from the Mine Site along a road reserve adjoining the western side of the Gunnedah – Narrabri Railway line to Turrawan Village, before it crosses the railway line and the Kamilaroi Highway and progresses east along the road reserve of the Old Narrabri Road. The route then turns north for a short distance and then turns east again to enter 'Broadwater' property where the pump on the Namoi River would be located (see **Figure 1**).

It is proposed that two pipelines would be laid side by side in a trench approximately 1.2m deep along the proposed route. The crossings of the Kurrajong Creek tributary, the Gunnedah – Narrabri Railway, the Kamilaroi Highway and other roads would be constructed using an under-road / rail boring machine.

3 LITERATURE REVIEW

3.1 Narrabri Soil Conservation Service Technical Manual

The Narrabri Soil Conservation Service Technical Manual [Anon, 1978] shows the proposed Reject Emplacement Area and Brine Storage Area located near the boundary of the Red Brown Earth soils and the Pilliga Scrub Soils.

The proposed Pipeline Route is located within both of these broad soil types and ectending into the Brown and Grey Clays. Details of these soils are presented below.

3.1.1 Red Brown Earths

These are generally associated with gently undulating slopes and are typically hardsetting with a sandy loam to sandy clay loam A horizon overlying a sandy clay loam to light clay B horizon. The soils are predominantly red brown in colour and have a weak to moderate degree of structure. Many have an earthy appearance.

A typical profile description provided by Anon [1978] is:

0-10cm [A1 horizon] – dark brown [7.5YR8/3 moist], moderate fine blocky structure, rough ped fabric, sandy clay loam, pH 6.0; *gradual change to*:

10->100cm [B1 horizon] – brown [7.5YR4/4 moist], strong blocky structure, rough and smooth ped fabric, pH 7.5.

3.1.2 Pilliga Scrub Soils

These soil are mainly sandy solodised soils and sandy solodic soils. They possess a surface horizon of light texture that is sharply differentiated from the subsoil that has a well developed columnar structure with a sandy texture. There is usually a strongly bleached zone above the subsoil.

Other soils within this complex include deep siliceous sands, earthy sands, lithosols and red and yellow earths. Typical profiles of all of these soil types are provided by Anon [1978] and are presented below

3.1.2.1 Sandy Solodised Soils

0-2cm [A1 horizon] – dark brown [7.5YR3/3 moist], apedal, sand, pH 6.5, *sharp change to:*

2-20cm [A2 horizon] – dull brown [7.5YR5/4 dry], sporadic bleach, apedal, wormy appearance when exposed, sharp change to:

20-60cm [B1 horizon] – grayish yellow brown [10YR5/2], apedal, sand, gradual change to:

60cm+ [B2 – C horizon] – mottled red, greyish yellow sand, apedal, hardpan, pH 6.0

3.1.2.2 Sandy Solodic Soils

0-5cm [A1 horizon] – brown [7.5YR3/3 moist], sand, apedal, pH 5.5; sharp change to:

5-8cm [A2 horizon] – dull yellow orange [7.5YR7/2 dry], sand, apedal, sharp change to:

8-50cm [B1 horizon] – mottled orange yellow [dominant 7.5YR4/6 moist], clayey sand, diffuse change to

50-150cm [B2 horizon] – mottled yellow grey [dominant 10YR5/4] sandy clay, pH 6.5]

3.1.2.3 Siliceous Sands

No typical profile provided.

3.1.2.4 Earthy Sands

No typical profile provided.

3.1.2.5 Lithosols

0-25cm [A1 horizon] – loamy sand, brownish black [7.5YR3/2 moist], weak crumb structure, sandy fabric, pH 7.0, diffuse boundary to

25-60cm [C horizon] – weathering regolith of rounded large stones, orange [7.5yR6/6 moist], diffuse change to

Sandstone conglomerate parent material.

3.1.2.6 Red Earths

0-10cm [A1 horizon] – dark brown [7.5YR3/3 moist], moderate subangular blocky structure, rough ped fabric, silty clay loam, pH 6.5, gradual change to

10- 50cm [B1 horizon] – dark brown [7.5YR3/4 moist], weak subangular blocky structure, earthy appearance, silty light clay, stones present, pH 7.0

3.1.2.7 Yellow Earths

No typical profile provided.

3.1.3 Brown and Grey Clays

Anon [1978] describes the Brown Clays as uniform, brown structured clays and clay loams that typically have a thin band of recent alluvium on the surface, which may or may not crack seasonally. No description is provided for the grey clay soils.

Limited detailed profile information is provided on these soils other than to note that they have a very low permeability and that salts are retained in the profile. A typical description of the upper section of the profile of the brown clay soils is provided.

0-5cm [A1 horizon] – dark brown [7.5YR3/3] moist, weak subangular blocky structure, rough ped fabric, clay loam', pH 7.0

5-35cm [B1 horizon] – brown [7.5YR4/3] moist, strong angular blocky structure, smooth ped fabric, silty clay, pH 7.5

3.2 Soil Study for the Mine Pit Top Area, Rail Loop and Ventilation Shaft [GCNRC, 2006]

This study identified two soil mapping units on the Study Area that was associated with the current Pit Top facilities and Rail Loop. A third soil mapping unit was associated with the lands near the Ventilation Shaft. Details of these units are outlined below.

3.2.1 Pit Top / Rail Loop Area

3.2.1.1 Soils of the Floodplain of a Tributary of Kurrajong Creek

Soil to 250cm+ deep, lower slope [floodplain] location, surface condition hardsetting, some surface stone present

Topsoil to 12cm - sandy loam; many roots; pH 6.0; stones and gravel absent; brown moderately pedal [50%], weak consistence dry; not hydrophobic.

Subsoil of four layers, medium clay or medium-heavy clay in upper layers, sandy light clay at base of excavation; few roots; no lime present; no manganese present; pH 8.0 to 9.5; stones and gravel generally absent; brown or yellowish brown coloured sometimes mottled in colours of brown, yellow and grey; highly pedal very firm to very strong consistence dry; not hydrophobic.

3.2.1.2 Soils of the Slopes and Crests near the Rail Loop and Mine Facilities

Soil to 250cm deep, sometimes only 125cm; mid- to upper slope location; surface condition soft, loose or self-mulching; usually medium amounts of rounded / angular surface stone to 4cm present.

Topsoil sandy clay, sandy light clay, light clay, medium clay, medium to heavy clay, heavy clay; roots common to many; pH 5.5 to 7.0; some to much rounded angular gravel to 0.5-4cm present; not mottled; not bleached; brown coloured; highly pedal firm to very strong consistence dry; not hydrophobic.

Subsoil consisting of two to four horizons; medium clay or medium to heavy clay to heavy clay textured; stones and gravel absent or containing some to much grave and larger stones in the lower horizons; variously coloured brown, redish brown, dusky red, yellowish red; sometimes mottled in colours of grey, brown, red and yellow; highly pedal; not hydrophobic.

3.2.2 Ventilation Shaft Area

3.2.2.1 Soil of the Crests near the Ventilation Shaft

Soil to 68cm deep, crest location, surface condition firm, medium amounts of surface stone to 15cm present.

Topsoil to 15cm deep, sandy clay loam; many roots; no lime present; no manganese present; pH 4.5-5.0; some gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown [5YR3/3] moist; peds earthy-faced, moderately pedal [50%], polyhedral, 5-10mm in size; weak consistence dry; hydrophobic.

Subsoil consisting of a single layer**,** sandy clay textured; pH 4.5-5.0; containing mainly flat and angular gravel 1-2cm and some angular sandstone to 10cm; not mottled; not bleached; red coloured; earthy fabric, massive, not hydrophobic; *bedrock.*

3.3 Soils of the Proposed Longwall Project Mining Area

This study is based on a reconnaissance survey of the 50 000 ha [approx] longwall subsidence area that would be affected by the longwall mining operation proposal that is proposed by Narrabri Coal [GCNRC, 2009].

The area surveyed is generally to the west of the current Study Area. The sampling sites were selected after a stereoscopic airphoto interpretation of the Mine Site identified that a number of different land form units were present.

These landform units were then associated with surface landforms of the three geology formations occurring over the Project Site [Garrawilla Volcanics, Pilliga Sandstones, Purlawaugh Formation] to identify suitable sites for sampling.

Each of the fourteen Geological Formation / Landform Units was then sampled in the field and the soil characteristics recorded in detail. Some of these units were sampled only once while others were sampled a number of times.

Thirty six soil profiles were excavated to a depth of 2.5m or a shallower depth if bedrock was encountered or the backhoe could not penetrate further. The individual horizons in each profile were described in detail in the field.

Based on the recorded soil attribute data, it was then possible to identify soil characteristics that might potentially cause problems on the subsidence areas – particularly those:

- on forested land,
- on cropland,
- on native and improved pasture land,
- near the subsidence cracks,
- along the drainage lines that traverse the Project Site,
- along roads and tracks,
- at farm dam and ground tank sites; and
- in areas where tank drains and soil conservation bank and waterway systems had been constructed.

Soil pH values within the sampled area were generally within the range that supports plant growth.

Soil textures vary from sandy soils generally associated with the Pilliga Sandstones, and many of the drainage lines, to more clayey soils within the other two geological formations.

Soil depth varies but in many cases it was possible to excavate the profiles to the full 250cm depth. The exceptions were usually on ridge crests and some upper slopes.

Soil dispersibility, as measured by the Dispersion % and Emerson Aggregate Test showed that many subsoils were dispersible. The potential impact of this dispersibility when associated with subsidence cracks is discussed.

Soil salinity of a slight to moderate degree was evident in some subsoils.

4 SURVEY METHODOLGY

4.1 Field Procedures

For the soil study, sampling involved the complete description of forty profiles.

The profiles in the proposed Reject Emplacement Area and the proposed Brine Storage Area exposed in a pit to a depth of 2.5m or the depth of backhoe refusal.

Five profiles were excavated within the proposed Reject Emplacement Area and twenty two profiles were examined in the proposed Brine Storage Area.

For the proposed Pipeline Route 13 profiles were excavated – generally to a depth of 180cm which is allows for characterization of the soil properties of the pipeline trench to its maximum depth.

The locations of the soil sampling sites within the Study Area are shown in **Figure 1**.

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

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" [Jacqier 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 DECCW's SPADE Soil Database.

Samples from all layers in all profiles from the proposed Reject Emplacement Area and the proposed Brine Storage Area were forwarded to the Land and Property Management Authority [Soil Conservation Service Division] 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.

Samples from three sites along the proposed Pipeline Route were also tested at the Land and Property Management Authority [Soil Conservation Service Division] laboratory.

Additional tests in relation to earthmoving related soil characteristics were also undertaken on all samples. These tests are not reported here.

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 FOR THE REJECT EMPLACEMENT AREA

5.1 Introduction

From the information gained from the detailed soil profile descriptions, one soil mapping unit [SMU] was identified.

The locations of the sampled soil profiles are shown in **Figure 1**.

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 five pits that were described in detail.

5.2 Soil Mapping Unit Descriptions

Descriptions of the layers found in the profiles of the single SMU [**SMU R1**] identified within the Reject Emplacement Area are set out below. **Figure 2** presents an interpretation of the soil mapping units of the Mine Site features and Water Pipeline Route.

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

Definitions of the technical terms used in the descriptions can be found in Appendix 3 or by consulting McDonald et al [1990] or Houghton and Charman [1986].

5.2.1 Description of SMU R1 –Soils of the Reject Emplacement Area

5.2.1.1 “Plain English” Description:

Soil to 250cm+ deep, lower to mid-slope or midslope location; surface condition loose, soft ,self mulching and cracked; some rounded and angular surface stone2-15cm present, sometimes stones up to 50cm x 30cm present.

Topsoil to 25cm - light to medium clay, medium clay; medium to heavy clay; roots common to many; no lime present; no manganese present; pH 5.5-6.0, occasionally 8.0; some to much angular gravel to 1-3cm; not mottled; not bleached; brown to reddish brown colour, moderately to highly structured; usually not hydrophobic.

Subsoil of up to four layers, light, medium clay or heavy clay texture in upper layers, indurated sandy clay loam or gravel beds at base of excavation; few to many roots; lime stains and nodules present or absent; manganese stains and concretions present or absent; pH 6.0 to pH 9.0 to 9.5-10; stones and gravel absent or some to much gravel present; some large stones and floaters present in some profiles; brown, reddish brown or yellowish brown coloured; not mottled; usually highly structured, sometimes massive with depth; not hydrophobic

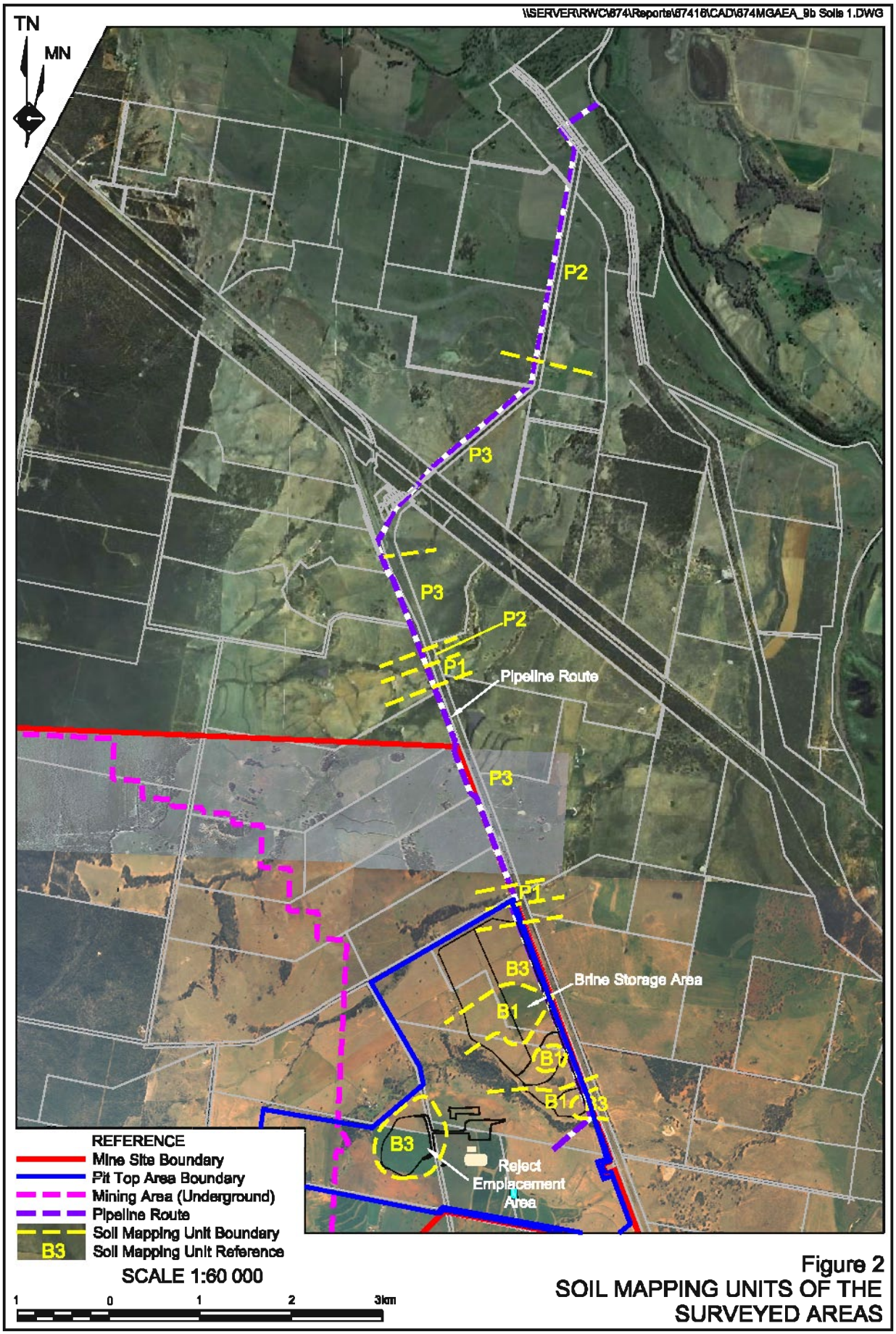

Figure 2
SOIL MAPPING UNITS OF THE SURVEYED AREAS

5.2.1.2 Technical Description [based on test pits]

a) Australian Soil Classification Name – Red and Brown Vertosols

b) Field Description:

Layer 1 [always present] [10 – 25cm thick] - light to medium clay, medium clay; medium to heavy clay; roots common to many; no lime present; no manganese present; pH 5.5-6.0, occasionally 8.0; some to much angular gravel to 1-3cm; not mottled; not bleached; dark brown [7.5YR3/4], dark reddish brown [2.5YR3/4, 5YR3/4], reddish brown [5YR4/4] dry, dark reddish brown]5YR3/3, 2.5YR3/3, 2.5YR3/4], very dark brown [7.5YR2.5/3] moist; peds rough-faced or rough- / smooth-faced, moderately [50%] to highly pedal [100%], polyhedral, <5-10 mm in size; very firm to very strong consistence dry; usually not hydrophobic, sometimes slightly so; *abrupt to:-*

Layer 2 [always present] [31-61cm thick] - light to medium clay, medium to heavy clay to heavy clay; roots few to common; no lime present or scattered lime nodules present; no manganese present; pH 6.0 to 8.0; gravel and stones absent or some to much angular or rounded gravel to 2-10cm; not mottled; not bleached; dark brown [7.5YR3/3] , dark reddish brown [5YR3/3], reddish brown [2.5YR2.5/4] dry, dark brown [7.5YR3/4], dark reddish brown [2.5YR3/4, 5YR3/2], reddish brown [5YR4/3] moist; peds rough- / smooth faced or smooth-faced, highly pedal [100%], polyhedral, <5-15mm in size; very strong consistence dry; not hydrophobic; *clear or gradual to:-*

Layer 3 [always present] [53-123cm thick] - medium to heavy clay to heavy clay; few roots; no lime present or no lime visible or many lime nodules present; no manganese present or manganese stains present; pH 8.0 to 9.5/10, occasionally pH 6.5; gravel and stones absent or some to much angular gravel to 1-2cm or scattered lenses of angular gravel to 8cm or mainly gravel / stone / rock with soil in between; not mottled; not bleached; dark reddish brown [2.5YR3/4], dark red [2.5YR3/6], reddish brown [2.5YR4/4], red [2.5YR4/6] dry, dark red [2.5YR3/6], dark reddish brown [2.5YR3/4], red [2.5YR4/6], reddish brown [2.5YR4/4] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral or polyhedral / platy,, <5-10 mm in size; very firm to very strong consistence dry; **OR** massive, fabric rough / smooth, very strong coherence dry; ; very strong consistence dry; not hydrophobic; *gradual to next layer or bedrock*

Layer 4 – [usually present] [36 – 148cm thick] - sandy loam, gritty light to medium clay, gritty medium clay; medium clay; few roots; or roots absent; no lime visible or scattered lime nodules or flecks present, no manganese present; pH 9.0 to 9.5-10 occasionally pH 7.0; gravel and stones absent or mainly angular gravel to 3cm and floaters to 30x50cm or layer of larger angular stones 20x15cm with gravel and soil between; not mottled; not bleached; brown [7.5YR5/4], red [2.5YR4/6, 2.5YR5/6] dry, red [2.5YR4/6], reddish brown [5YR4/4], strong brown [7.5YR5/6], weak red [10R4/4] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, <5-10 mm in size; very strong consistence dry; OR massive, fabric rough / smooth, very firm to very strong coherence dry; not hydrophobic; *diffuse to another layer or* decomposing rock with crystalline quartz stones to 10-15cm.

Layer 5 [rarely present] [recorded to 104 cm thick] - sandy clay loam [indurated]; few roots; no lime visible; no manganese present; pH 9.5-10; mainly stone 5 - 10 - 15cm; not mottled; not bleached; very pale brown [10YR7/4] dry, yellowish brown [10YR5/4] moist; massive, fabric rough / smooth, very strong coherence dry; not hydrophobic.

5.3 Soil Laboratory Analyses – Reject Emplacement Area

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

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.

5.3.1 Soil Physical Analyses - Reject Emplacement Area

Tables 1, 2 and **3** show the results obtained from laboratory analysis of the samples from the five pits.

5.3.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity and soil pH. This latter attribute was also measured in the field using the Raupach method. The results of the laboratory analyses are contained in **Table 3.**

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

Page 1 of 2

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
1	1	clay	0-12	47	14	11	26	37	2
	2	clay	12-43	43	15	19	23	42	<1
	3	clay	43-102	39	16	21	23	44	1
	4	clay	102-250	31	12	24	31	55	2
2	1	clay	0-20	53	17	18	12	30	<1
	2	clay	20-57	65	14	9	11	20	1
	3	clay loam	57-110	23	12	13	45	58	7
	4	clay loam	110-146	11	8	8	23	31	50
	5	loamy sand	146-250	8	14	20	41	61	17

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

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
3	1	clay	0-18	40	16	21	13	34	10
	2	clay	18-79	45	20	24	10	34	1
	3	clay	79-150	41	14	18	18	36	9
	4	loamy sand	150-250	10	13	23	53	76	1
4	1	clay loam / clay	0-25	32	20	21	12	33	15
	2	clay	25-77	59	20	12	8	20	1
	3	clay	77-140	56	18	12	13	25	1
	4	silt loam	140-250	24	20	28	26	54	2
5	1	clay	0-10	45	23	22	8	30	2
	2	clay	10-47	58	16	16	7	23	3
	3	clay loam	47-170	29	7	20	40	60	4

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

Table 2
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D%	D% level of dispersion	EAT	EAT level of dispersion
1	1	clay	0-12	22	slight	3[1]	slight
	2	clay	12-43	44	moderate	2[1]	high / moderate
	3	clay	43-102	50	moderate / high	3[1]	slight
	4	clay	102-250	76	very high	2[1]	high / moderate
2	1	clay	0-20	19	slight	5	slight
	2	clay	20-57	15	slight	4	negligible
	3	clay loam	57-110	38	moderate	4	negligible
	4	clay loam	110-146	27	slight	4	negligible
	5	loamy sand	146-250	38	moderate	4	negligible
3	1	clay	0-18	10	slight	3[1]	slight
	2	clay	18-79	12	slight	3[1]	slight
	3	clay	79-150	15	slight	3[3]	moderate
	4	loamy sand	150-250	33	moderate	3[1]	slight
4	1	clay loam / clay	0-25	9	slight	3[3]	moderate
	2	clay	25-77	16	slight	4	negligible
	3	clay	77-140	25	slight	4	negligible
	4	silt loam	140-250	20	slight	4	negligible
5	1	clay	0-10	8	slight	3[3]	moderate
	2	clay	10-47	7	slight	5	slight
	3	clay loam	47-170	15	slight	3[2]	slight

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

Table 3
Chemical Analyses Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH	EC [dS/m]#	MULTI-LIER	CALCULATED EC_e	SOIL SALINITY STATUS
1	1	clay	0-12	7.3	0.05	5.8	0.29	non-saline
	2	clay	12-43	8.7	0.19	5.8	1.10	non-saline
	3	clay	43-102	9.3	0.65	5.8	3.77	slightly saline
	4	clay	102-250	9.4	0.50	5.8	2.90	slightly saline

Table 3 [cont'd]
Chemical Analyses Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH	EC [dS/m]#	MULTI-LIER	CALCULATED EC_e	SOIL SALINITY STATUS
2	1	clay	0-20	7.7	0.04	5.8	0.23	non-saline
	2	clay	20-57	8.3	0.11	5.8	0.63	non-saline
	3	clay loam	57-110	8.6	0.09	8.6	0.77	non-saline
	4	clay loam	110-146	8.8	0.10	8.6	0.86	non-saline
	5	loamy sand	146-250	9.1	0.10	23	2.30	slightly saline
3	1	clay	0-18	6.7	0.02	5.8	0.12	non-saline
	2	clay	18-79	6.7	0.02	5.8	0.12	non-saline
	3	clay	79-150	7.1	0.01	5.8	0.06	non-saline
	4	loamy sand	150-250	7.8	0.01	23	0.23	non-saline
4	1	clay loam / clay	0-25	6.1	0.01	8.6	0.09	non-saline
	2	clay	25-77	8.3	0.11	5.8	0.64	non-saline
	3	clay	77-140	8.6	0.12	5.8	0.70	non-saline
	4	silt loam	140-250	8.9	0.11	9.5	1.05	non-saline
5	1	clay	0-10	6.3	0.03	5.8	0.17	non-saline
	2	clay	10-47	7.3	0.03	5.8	0.17	non-saline
	3	clay loam	47-170	8.3	0.02	8.6	0.17	non-saline

5.3.2.1 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 **Tables 1** and **2** are those contained in the laboratory test report.

From this data it is evident that the topsoils in both profiles contain relatively low levels of gravel and consequently the material is suitable for use in rehabilitation works.

The subsoils generally contained low amounts of gravel contents although one horizon reached the 50% level.

The texture class of each soil layer is determined by analysis of the material [fine earth fraction] that is less than 2mm in size – i.e. 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 **Tables 1 and 2**.

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

5.3.2.2 Dispersion Percentage

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

Hazelton and Murphy [in press] provide the following guides to the interpretation of D% values [**Table 4**].

Table 4
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 will be more dispersive in practice than those with a high Dispersion % value and a low clay content in the soil.

The D% values shown in **Tables 1** and **2** indicate that the topsoils all showed low levels of dispersibility.

The subsoil D% values were also usually low although some layers showed moderate to very high values.

Despite the generally low dispersibility values measured for both topsoils and subsoils, there is enough dispersible material indicated to be present requires appropriate measures to be taken to protect the stockpiles of stripped soil. The same material, when respread, should be afforded rapid protection from soil erosion in the form of vegetative cover.

5.3.2.3 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 5.**

The EAT values shown in **Tables 1** and **2** indicate that the topsoils all showed low levels of dispersibility.

The subsoil EAT values were also usually low although some layers showed moderate to very high values. These values closely mirrored the results from the D% tests.

Table 5
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].

Despite the generally low dispersibility values measured for both topsoils and subsoils, there is enough dispersible material indicated to be present requires appropriate measures to be taken to protect the stockpiles of stripped soil. The same material, when respread, should be afforded rapid protection from soil erosion in the form of vegetative cover.

5.4 Soil Chemical Attributes

Laboratory testing of the samples extended to an examination of the electrical conductivity and soil pH. The results of the laboratory analyses are contained in **Table 3.**

5.4.1 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 3** indicates that the topsoil samples tested all showed pH levels within the 4.0 to 8.5 range and generally near the pH 7.0 level.

The subsoils were generally within the acceptable range but some of the deeper samples showed values that were at or exceeded the higher acceptable level.

The pH tests indicate that the pH values of the topsoils for the tested profiles that would be stripped for use in rehabilitation are well within acceptable limits.

With the subsoils, the pH values of the upper subsoil layers is generally acceptable but there is usually a general increase in pH with depth to levels that are outside the acceptable range in some profiles.

These higher pH values would not be of concern as the mixing with lower pH soils during the stripping process would result in a composite medium of within acceptable limits.

5.4.2 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 6** [extracted from Hazelton and Murphy, in press] based on the measured soil texture.

Table 3 shows the calculated EC_e values for the samples analysed in the laboratory and shows the salinity status of the various horizons based on these EC_e values.

Table 6
Texture Class Multipliers for Calculating EC_e Values

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

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

The data in **Table 3** indicate that topsoils in all profiles are non-saline.

The lower layers of the subsoil of profiles 1 and 2 are slightly saline while the remaining subsoils [in three profiles] were non-saline.

Given these results there should not be any salinity problems associated with the storage of topsoil and subsoil material from the Reject Emplacement Area as the slightly saline material would be well mixed with non-saline material during the stripping and stockpiling processes.

5.5 Erosion Potential

The soils within the Study Area are currently generally stable except for some minor areas of sheet erosion on the slopes.

Groundcover varies over the site, but most of the area supported a low level of ground cover at the time of inspection.

It will 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.

5.6 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 two soil profiles from the Reject Emplacement Area that were tested in the laboratory.

The erodibility estimates contained in **Table 7** for these topsoils and subsoils have been calculated using part of the overall SOILOSS program capability.

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
R1 [SMU R1]	0-12cm	0.013	43-102cm	0.024	0.019	LOW
R3 [SMU R1]	0-18cm	0.017	79-150cm	0.021	0.019	LOW

The only value for which estimates were used in the calculations were those for % organic matter. After a perusal of the data for this variable for the Tally Ho Soil Landscape [**roughly equivalent to SMU R1**] within *Soil Landscapes of the Curlewis 1: 100 000 Sheet Report* [Banks, 1995], mean values of 5.5% [topsoil] and 0.98% [subsoil] for SMU R1 were chosen.

The Erodibility classes used were:

- <0.020 = LOW;
- 0.020 – 0.040 = MODERATE; and
- >0.040 = HIGH.

These two soil profiles were allotted a LOW erodibility by the SOILOSS model based on their physical characteristics.

Despite the LOW erodibility, as assessed by the SOILOSS analysis and field observations, the soils of all SMUs should be managed carefully during the stripping and rehabilitation stages to ensure that soil structure damage is minimal and that they are suitably protected by vegetation or some other medium after rehabilitation.

6 DESIGN AND OPERATIONAL SAFEGUARDS FOR THE REJECT EMPLACEMENT AREA

6.1 Stripping Suitability of the 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 4.**

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:

- soil structure.
- soil macrostructure.
- soil coherence.
- soil texture.
- the force necessary to disrupt peds.

6.2 Stripping Recommendations

6.2.1 SMU R1 Area

6.2.1.1 Layer 1

[0 - 15cm depth] - light to medium clay, medium clay; medium to heavy clay; roots common to many; no lime present; no manganese present; pH 5.5-6.5, occasionally 8.0; some to much angular gravel to 1-3cm; not mottled; not bleached; dark brown [7.5YR3/4], dark reddish brown [2.5YR3/4, 5YR3/4], reddish brown [5YR4/4] dry, dark reddish brown]5YR3/3, 2.5YR3/3, 2.5YR3/4], very dark brown [7.5YR2.5/3] moist; peds rough-faced or rough- / smooth-faced, moderately [50%] to highly pedal [100%], polyhedral, <5-10 mm in size; very firm to very strong consistence dry; usually not hydrophobic, sometimes slightly so;

Suitability Assessment [based on Elliott and Veness key]: structure grade 2 and 3; strongly coherent dry, mottles 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 topsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and should 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 should be stockpiled as topsoil provided suitable stripping and storage methods are used [see **Section 11**]. In order to maximise the regeneration of native species in the soil it is recommended that topsoil from areas currently vegetated by native and introduced species is transferred directly to areas to be revegetated whenever this is possible.
3. Topsoil stripping should be carried out on all areas that would be disturbed by the construction of the reject emplacement.

6.2.1.2 Layer 2

[15 – 100cm depth] - light to medium clay, medium to heavy clay to heavy clay; roots few to common; no lime present or no lime visible or scattered to many lime nodules present; no manganese present or manganese stains present; pH 6.0 to 8.0 sometimes pH 9.5/10 near the base, gravel and stones absent or some to much angular or rounded gravel to 2-10cm; not mottled; not bleached; dark brown [7.5YR3/3] , dark reddish brown [2.5YR3/4, 5YR3/3], reddish brown [2.5YR4/4, 2.5YR2.5/4], dark red [2.5YR3/6], reddish brown], red [2.5YR4/6] dry, dark brown [7.5YR3/4], dark reddish brown [2.5YR3/4, 5YR3/2], reddish brown [2.5YR4/4, 5YR4/3], dark red [2.5YR3/6], red [2.5YR4/6] moist; peds rough- / smooth faced or smooth-faced, highly pedal [100%], polyhedral or polyhedral / platy, <5-15mm in size; very firm to very strong consistence dry; occasionally massive, fabric rough / smooth, very strong coherence dry; not hydrophobic.

Suitability Assessment [based on Elliott and Veness key]: structure grade three; very strongly coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture suitable; sand and gravel content generally 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 organic matter, nutrient reserves and should be stockpiled and used later for rehabilitation of the final landscape or moved direct from stripped areas to areas being rehabilitated. In some sections the pH levels near the base of the stripped subsoil layer may be outside the acceptable limits but the process of stripping and mixing will ensure that the overall pH levels are suitable.

Recommendations for Layer 2 Materials.

Strip all of the Layer 2 subsoil to a depth of 100cm below the current soil surface [ie a layer 85cm thick] over the whole reject emplacement area. Layer 2 material should be stockpiled as subsoil provided suitable stripping and storage methods are used. [See **Section 11**] or moved direct from stripped areas to areas being rehabilitated whenever this is possible.

6.2.1.3 Layer 3 [Remainder of the Profile]

Do not strip unless required for use in forming a cover over the reject material before the subsoil is spread during rehabilitation of the emplacement.

Recommendations for Layer 3 Materials

Leave in situ or strip, if necessary, and stockpile for use in rehabilitation as a layer over the final reshaped landform prior to re-spreading of subsoil and topsoil.

7 RESULTS FOR THE BRINE STORAGE AREA

7.1.1 Introduction

From the information gained from the detailed soil profile descriptions, three soil mapping units [SMUs] were identified (see **Figure 2**).

The first SMU [**SMU B1**] comprises Clay Soils that are generally medium to heavy clay textured for the whole of the excavated profile or which may have a coarser textured layer at the base. These soil occur near the Kurrajong Creek tributary as well as on level areas further to the north.

The second [**SMU B2**] is limited to a single profile that has a sandy textured profile throughout. The occurrence suggests that the profile may be associated with a prior stream bed but no other similar profiles were encountered and there were no surface indications that the profile was in any way different from the surrounding soils.

The third [**SMU B3**] is comprised of duplex soils that have a sandy surface texture overlying the remaining profile of clay material. Some profiles comprise a single coarser textured layer overlying the clay material while others have two or three distinct layers of sandy material overlying the clay.

The locations of the twenty two sampled soil profiles are shown in **Figure 1**.

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 2 contains detailed information of the layers present in the twenty two pits that were described in detail.

7.2 Soil Mapping Unit Descriptions

Descriptions of the layers found in the profiles of the three SMUs [**SMU B1, SMU B2, SMU B3**] identified within the Brine Storage 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].

7.2.1 Description of SMU B1 – Clay Soils

7.2.1.1 "Plain English" Description:

Soil to 250cm+ deep, lower slope [floodplain] location; surface condition hardsetting; some surface stone present.

Topsoil to 20cm - silty clay; light clay; gritty light to medium clay, light to medium clay; medium clay, medium to heavy clay; roots common to many; no lime present; no manganese present; pH 5.0 to7.5; gravel and stones usually absent, sometimes flat angular gravel <5mm to 4cm present; not mottled; not bleached; brown to reddish brown coloured moderately structured or sometimes massive; usually not hydrophobic.

Subsoil of up to four layers, silty clay to heavy clay textured; roots absent to many; no lime present or no lime visible or scattered to many large lime nodules present; no manganese present or small manganese stains and concretions present; pH 5.0 to 7.5 or pH 9.0 to 9.5/10; gravel and stones usually absent, some profiles with layers of rounded water-washed gravel to 5-6cm gravel and stones to 20cm;coloured brown, red or yellow; usually not mottled; highly structured; not hydrophobic

7.2.1.2 Technical Description [based on test pits]

[a] Australian Soil Classification Name – Red and Brown Vertosols

[b] Field Description:

Layer 1 [always present] [10-20cm thick] - silty clay; light clay; gritty light to medium clay, light to medium clay; medium clay, medium to heavy clay; roots common to many; no lime present; no manganese present; pH 5.0 to7.5; gravel and stones usually absent, sometimes flat angular gravel <5mm to 4cm present; not mottled; not bleached; brown [7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4], reddish brown [5YR4/3] dry, dark brown [7.5YR3/2, 7.5YR3/3, 7.5YR4/2], dark reddish brown [5YR3/2], very dark brown [7.5YR2.5/2] moist; mostly structured; peds rough-faced or rough- / smooth-faced, moderately pedal [70%] to highly pedal [100%], polyhedral, <5-15 mm in size; weak to strong consistence dry; sometimes massive, fabric rough, firm to strong coherence dry; usually not hydrophobic; *abrupt to clear to:*

Layer 2 [always present] [17-79cm thick] - silty clay, sticky light to medium clay, medium clay, medium to heavy clay, heavy clay; roots common to many; no lime present; no manganese present; pH 5.5 to 7.5 or pH 9.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/2, 7.5YR4/3, 7.5YR5/4], dark reddish brown [5YR3/2], dusky red [10R3/2, reddish brown [5YR4/3, 5YR4/4] dry, dark brown [7.5YR3/3], dark reddish brown [5YR3/2, 5YR3/3], dusky red [10R3/2] moist; peds rough- / smooth-faced, highly pedal [100%],angular blocky or polyhedral; <5-20 mm in size; strong consistence dry; not hydrophobic; a*brupt, clear or gradual to:-*

Layer 3 [always present] [34-112cm thick] - medium clay, medium to heavy clay; heavy clay; few to many roots; no lime present or no lime visible to scattered to many lime stains and nodules present; ; no manganese present or some managanese concretions present; Usually pH 8.5 to 9.5/10, sometimes pH 7.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/2, 7.5YR4/4], reddish brown [2.5YR5/4, 5YR4/4], strong brown [7.5YR4/6], yellowish brown [10YR5/4] dry, brown [7.5YR4/3, 7.5YR4/4], dark brown [7.5YR3/3], dark yellowish brown [10YR4/4], reddish brown [2.5YR4/3, 2.5YR4/4], strong brown [7.5YR4/6], yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [80% - 100%], polyhedral, <5-20 mm in size; firm to strong consistence dry; not hydrophobic; *clear to gradual to:-*

Layer 4 – [always present] [36-118cm thick] - sandy clay, medium clay, medium to heavy clay heavy clay, heavy clay; roots usually absent, rarely roots common; no lime present or no lime visible or some to many lime nodules present; no manganese present or manganese staining and concretions common; pH often 9.5/10, sometimes pH 6.0 to 6.5; gravel and stones usually absent, some profiles with layers of rounded water-washed gravel to 5-6cm gravel and stones to 20cm; not bleached; usually whole coloured brown [10YR4/3, 7.5YR4/4,7.5YR5/3, 7.5YR5/4] [sometimes with a reddish tinge], strong brown [7.5YR5/6] dry, brown [7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4] [sometimes with a reddish tinge], dark brown [10YR3/3] moist; rarely mottled yellowish red [5YR4/6], brown [10YR5/3] dry, brown [7.5YR4/4], brown [10YR5/3] moist; peds smooth-faced or usually rough- / smooth-faced , highly pedal [100%], polyhedral, <5-15 mm in size; strong consistence dry; not hydrophobic; *layer continues or gradual or diffuse to:-*

Layer 5 [usually present but sometimes as a layer of water-washed gravel and stones to 20cm] [40-161cm thick] - sandy medium clay [indurated], sandy light to medium clay, light to medium clay, medium clay, medium to heavy clay; roots absent; no lime present or no lime visible or scattered to many large lime nodules present; no manganese present or small manganese stains and concretions present; usually pH 9.5/10, sometimes pH 4.5; gravel and stones absent or some small gravel <5mm to 1cm or comprised of decomposing rock; not bleached; sometimes whole coloured brown [7.5YR5/3, 7.5YR5/4], yellowish brown [10YR5/4] with red stains dry, brown [7.5YR4/4, 7.5YR5/3], yellowish brown [10YR5/4] with red stains moist; at times mottled brown [7.5YR5/3], light grey [10YR7/2], pale brown [10YR6/3], reddish yellow [7.5YR6/6], strong brown [7.5YR4/6], yellowish red[5YR4/6] dry, brown [7.5YR4/2, 10YR5/3], grey [7.5YR6/2], strong brown [7.5YR4/6, 7.5YR5/6], yellowish red[5YR4/6] moist; sometimes structured with peds smooth- faced or rough- / smooth-faced, highly pedal [100%], polyhedral,<5-15 mm in size; sometimes massive, fabric rough, very firm to strong coherence dry; strong consistence dry; not hydrophobic.

7.2.2 Description of SMU B2 – Deep Sandy Soils

7.2.2.1 "Plain English" Description:

Soil to 250cm+ deep, *level plain location; surface condition firm; surface stone absent*

Topsoil sandy loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; yellowish brown coloured; weakly structured; not hydrophobic.

Subsoil consisting of two horizons; clayey sand , sandy loam textured; no lime visible; no manganese present; pH 6.5 to 8.0; not mottled; sometimes bleached; grey, brown and yellowish brown coloured; massive to highly structured; not hydrophobic.

7.2.2.2 Technical Description [based on one test pit]

[a] Australian Soil Classification Names –Brown Kandosol

[b] Field Description:

Layer 1 [40cm thick] - sandy loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, dark yellowish brown [10YR4/4] moist; peds rough- faced, weakly pedal [15%], polyhedral, 5-15 mm in size; weak consistence dry; not hydrophobic; *gradual to:*

Layer 2 [70cm thick] - clayey sand; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; bleached; light grey [10YR7/2] dry, brown [7.5YR5/3] moist; massive; fabric rough; firm coherence dry; not hydrophobic; *abrupt to:*

Layer 3 [140cm thick] - fine sandy clay loam; few roots; no lime visible; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; brownish yellow 10YR6/6] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-15 mm in size; firm consistence dry; not hydrophobic.

7.2.3 Description of SMU B3 – Duplex Soils

7.2.3.1 "Plain English" Description:

- **Soil** to250cm+ deep; level plain, depression, level crest, mid and upper slope locations ; surface condition loose, firm or hardsetting , sometimes cracked; surface stone absent or some rounded / angular surface stone to 2-10cm [sometimes to 15cm] present.

- **Topsoil to 34cm deep,** clayey sand, sandy loam, sandy clay loam, fine sandy clay loam; roots common to many; no lime present; no manganese present; pH 4.5 to 6.5; gravel and stones usually absent, occasionally small angular and round gravel to 1-2cm present; not mottled; not bleached; brown, yellowish brown or reddish brown coloured; usually weakly to highly structured, sometimes massive not hydrophobic.

- **Subsoil** consisting of up to six layers**,** clayey sand, sandy clay, sandy light clay, medium clay, sandy medium clay, gritty medium to heavy clay, heavy clay; roots absent to common; pH 4.5 to 7.0 or pH 9.0 to 9.5/10; no lime present or no visible lime present or scattered lime nodules present; usually no manganese present, sometimes some manganese stains present; usually whole coloured in shades of brown, red, yellow and grey; sometimes mottled in similar tones; usually weakly to highly structured, sometimes massive; rarely hydrophobic.

7.2.3.2 Technical Description [based on test pits]

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

[b] Field Description:

Layer 1 [always present] [10-34cm thick] - clayey sand, sandy loam, sandy clay loam, fine sandy clay loam; roots common to many; no lime present; no manganese present; pH 4.5 to 6.5; gravel and stones usually absent, occasionally small angular and round gravel to 1-2cm present; not mottled; not bleached; brown [7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4], light yellowish brown [10YR6/4], reddish brown [5YR4/3], strong brown [7.5YR4/6], yellowish brown [10YR5/4] dry, dark brown [7.5YR3/2, 10YR3/3, 7.5YR3/3, 5YR3/4, 7.5YR3/4], dark reddish brown [5YR3/3, 2.5YR3/3], dark yellowish brown [10YR4/4] moist; usually structured peds rough- faced, weakly pedal [15%-30%], moderately pedal [40%-50% or highly pedal [80%-100%], polyhedral, 5-15 mm in size; weak to strong consistence dry; sometimes massive; fabric rough; weak to firm coherence dry; not hydrophobic, *sharp, abrupt [usually], clear or gradual to:-*

NOTE: *Layers 2 and 3 are usually not present and the profiles comprise layer above layer 4 and subsequent layers*

Layer 2 [occasionally present] [4-48cm thick] - clayey sand, sandy clay loam; roots common to many; no lime present; no manganese present; pH 6.0 to 7.5; gravel and stones absent or some rounded gravel to 2cm present; not mottled; sometimes bleached; brown [7.5YR5/3], light brown [7.5YR6/4], pinkish grey [7.5YR7/2] dry, brown [7.5YR4/3, 7.5YR4/4, 7.5YR5/4] moist; massive; fabric rough; weak, firm or strong coherence dry; not hydrophobic; *sharp, abrupt or clear to:-*

Layer 3 [rarely present] [one profile – 21] [27cm thick] - clayey sand; few roots; no lime present; no manganese present; pH 7.5; angular and rounded gravel to 4cm; not mottled; not bleached; red [5YR4/6] dry, red [5YR4/6] moist; massive, fabric rough, weak coherence dry ; not hydrophobic; *clear to:-*

Layer 4 [always present] [23-66cm thick] - sandy clay, sandy light clay, medium clay, sandy medium clay, gritty medium to heavy clay, heavy clay; roots few to common; no lime present or no visible lime present or scattered lime nodules present; usually no manganese present, sometimes some manganese stains present; pH 4.5 to 7.0 or pH 9.0 to 9.5/10; gravel and stones usually absent, sometimes some rounded gravel to 2cm present; not bleached; usually whole coloured brown [7.5R4/4, 7.5YR4/3, 7.5YR5/4, 10YR5/3], brownish yellow [10YR6/6], dark reddish brown [5YR3/3], reddish brown [2.5YR4/4, 5YR4/3, 5YR4/4], yellow [10YR5/4] dry, brown [7.5YR4/4, 7.5YR5/4], dark brown [7.5YR5/4], dark reddish brown [5YR2.5/2], dark

yellowish brown [10YR4/4, 10YR4/6], reddish brown [2.5YR4/4, 5YR4/3, 5YR4/4], yellow [10YR5/4] moist; rarely mottled light reddish brown [5YR6/3], reddish brown [2.5YR4/4, 2.5YR5/4]; peds rough- / smooth-faced, highly pedal [80% - 100%], polyhedral, <5-20 mm in size; weak to strong consistence dry; not hydrophobic; *clearor gradual to:-*

Layer 5 [always present] 18-110cm thick] - medium clay, medium to heavy clay, heavy clay, rarely clayey sand; few roots; no lime present or no lime visible or scattered to many lime concretions present; manganese stains and concretions sometimes present; pH 5.5 to 6.5 or pH 9.5/10; gravel and stones absent or some to much small [0.5-1.5cm] or large gravel [4-8cm] present; not bleached; usually whole coloured brown [7.5YR5/3, 7.5YR5/4], brownish yellow [10YR6/6], reddish brown [5YR5/4], yellowish red [5YR5/6] dry, brown [7.5YR4/3, 7.5YR5/3, 7.5YR5/4], reddish brown [5YR4/4, yellowish brown [10YR5/6, 5YR4/6] moist; sometimes mottled pale brown [10YR6/3] red [10YR4/6], reddish brown [5YR5/4, 7.5YR4/6], strong brown [7.5YR5/6], very pale brown [10YR7/3], yellowish red [10YR5/6] dry, brown [7.5YR4/4, 7.5YR5/4], greyish brown [10YR5/2], pale brown [10YR6/3], strong brown [7.5YR4/6], weak red [10R4/4], yellowish red [10YR5/6] moist; peds rough- / smooth-faced, occasionally rough-faced, highly pedal [100%], polyhedral, <5-20 mm in size; strong consistence dry; rarely hydrophobic; *clear or gradual to bedrock or underlying horizon:-*

Layer 6 [often present][30-139cm thick] - medium clay, medium to heavy clay, heavy clay, rarely sandy clay loam; few roots or roots absent; no lime visible or some to many lime flecks and / or nodules present; ; no manganese present or some to many manganese stains and small concretions common; pH 8.0 to 9.5/10; rarely pH 6.5; gravel and stones usually absent, occasionally scattered rounded and angular gravel to 5cm present; not bleached; usually whole coloured brown [10YR5/3, 7.5YR5/4], brownish yellow [10YR6/6[, dark yellowish brown [10YR4/4], light brown [7.5YR6/4], light brownish grey [2.5Y6/2], strong brown [7.5YR5/6], yellowish brown [10YR5/4], yellowish red [5YR4/6] dry, brown [7.5YR5/3, 7.5YR5/4], dark yellowish brown [10YR4/6], light brown [7.5YR6/4], light brownish grey [2.5Y6/2], pale brown [10YR6/3], reddish brown [5YR4/4], strong brown [7.5YR4/6], yellowish brown [10YR5/4] moist; sometimes mottled brownish yellow [10YR6/6], light brownish grey [10YR6/2], light grey [10YR7/2], light yellowish brown [10YR6/4], pinkish grey [7.5YR6/2], yellowish red [5YR5/6] dry, brown [10YR5/3], light brown [7.5YR6/4], light brownish grey [10YR6/2], light grey [10YR7/2], weak red [10R4/4], yellowish brown [10YR5/6] moist; usually structured peds rough- / smooth-faced, highly pedal [100%], polyhedral or polyhedral / platy, <5-15mm in size; very firm to strong consistence dry; sometimes massive, smooth, rough or rough / smooth fabric, strong coherence dry; not hydrophobic; *bedrock / refusal or horizon continues or gradual / diffuse to next horizon:-*

Layer 7 [occasionally present] [58-120cm thick] – sandy light clay, heavy clay, gritty heavy clay, rarely sandy clay loam; few roots or roots absent; no lime visible or some to many lime concretions present; no manganese present or present; some manganese stains present; no lime present; no manganese present; manganese stains and small concretions common; pH 9.0 to 9.5/10; gravel and stones usually absent, sometimes some gravel to 5cm present or material is decomposing rock; usually whole coloured brown [7.5YR5/4], light brown [7.5YR6/4] with light grey staining, light yellowish brown [10YR6/4, 2.5Y6/3], reddish brown [7.5YR5/4] dry, brown [7.5YR5/4], dark brown [7.5YR3/4], light brownish grey [2.5Y6/2], strong brown [7.5YR4/6], yellowish brown [10YR5/4] moist; occasionally mottled light yellowish brown [10YR6/4], brown [7.5YR5/3, 7.5YR5/4], reddish brown [5YR5/3], dry, light yellowish brown [10YR6/4], brown [7.5YR5/3, 7.5YR5/4] reddish brown [5YR5/3], moist; peds rough- /

smooth-faced, highly pedal [90%], polyhedral, angular blocky or polyhedral / platy, <5-20 mm in size; very firm to strong consistence dry; occasionally massive, fabric rough, strong coherence dry; not hydrophobic.

7.3 Soil Laboratory Analyses – Brine Storage Area

All samples from twenty two soil profiles were selected for laboratory analysis at the Land and Property Management Authority [Soil Conservation Service Division] Soil and Water testing Laboratory at Scone.

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.

7.3.1 Soil Physical Analyses - Brine Storage Area

Tables 7 and **8** show the results obtained from laboratory analysis of the samples from the five pits.

Table 8
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

Page 1 of 3

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
1	1	loamy sand	0-25	9	8	37	46	83	0
	2	loamy sand	25-40	77	8	36	49	85	0
	3	clay	40-66	48	5	19	28	47	<1
	4	clay	66-120	38	6	24	32	56	0
	5	clay	120-250	38	9	27	25	52	1
2	1	sand	0-40	7	5	32	56	88	<1
	2	sand	40-110	5	5	28	62	90	<1
	3	sandy loam	110-250	18	11	28	43	71	<1
3	1	loamy sand	0-23	9	8	39	44	83	<1
	2	clay	23-72	40	7	24	29	53	<1
	3	clay	72-114	45	8	22	25	47	<1
	4	clay	114-174	44	13	20	23	43	<1
	5	loamy sand	174-260	10	16	21	53	74	<1
4	1	sandy loam	0-20	16	8	34	42	76	<1
	2	sandy clay loam	20-64	28	7	31	34	65	<1
	3	clay	64-106	39	6	25	30	55	<1
	4	clay	106-192	39	9	24	28	52	<1
	5	clay	192-250	40	14	23	17	40	6
5	1	loamy sand	0-24	9	11	35	45	80	0
	2	clay	24-39	48	5	19	28	47	<1
	3	clay	39-75	43	3	23	31	54	<1
	4	clay	75-130	46	6	22	26	48	<1
	5	sandy clay loam	130-250	21	4	22	53	75	<1

Table 8 [cont'd]
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
6	1	loamy sand	0-34	9	8	33	50	83	0
	2	sandy clay loam	34-81	21	5	31	43	74	<1
	3	clay	81-160	48	3	20	29	49	0
	4	clay	160-260	39	4	23	33	56	1
7	1	sandy clay / clay	0-20	34	6	30	30	60	0
	2	clay	20-37	34	7	27	32	59	<1
	3	clay	37-85	40	8	24	28	52	<1
	4	clay	85-137	43	9	22	26	48	<1
	5	sand clay loam	137-260	28	5	23	44	67	<1
8	1	sandy loam	0-15	12	5	35	47	82	1
	2	sandy clay loam / clay loam	15-50	30	5	28	36	64	1
	3	clay	50-96	29	4	14	31	45	22
	4	sandy clay loam	96-210	29	6	26	39	65	<1
9	1	sandy clay loam	0-15	20	4	31	38	69	7
	2	clay	15-47	38	5	23	32	55	2
	3	clay	47-121	39	5	19	27	46	10
	4	clay	121-260	41	18	0	38	38	3
10	1	sandy loam	0-10	12	5	41	41	82	1
	2	sandy clay loam	10-30	29	3	35	33	68	<1
	3	sandy clay loam	30-48	28	3	35	33	68	1
	4	clay	48-85	34	7	29	30	59	<1
	5	clay	85-154	36	11	25	28	53	<1
11	1	loam	0-10	17	12	32	38	70	1
	2	clay loam	10-31	28	8	28	36	64	<1
	3	clay	31-102	35	10	23	32	55	<1
	4	clay	102-191	33	8	25	34	59	0
	5	clay loam	191-250	30	11	35	24	59	<1
12	1	sandy loam	0-16	13	7	36	43	79	1
	2	sandy clay loam	16--61	24	8	30	38	68	<1
	3	clay	61-107	40	7	26	27	53	<1
	4	clay	107-180	39	10	25	26	51	<1
	5	clay	180-250	35	10	28	27	55	<1
13	1	sandy clay loam	0-15	21	6	34	39	73	<1
	2	sandy clay	15-38	34	4	27	35	62	<1
	3	clay	38-70	33	6	29	32	61	<1
	4	sandy clay loam	70-160	27	3	33	36	69	1
	5	sandy clay loam	160-250	21	2	17	60	77	<1
14	1	clay loam	0-18	30	5	34	31	65	<1
	2	clay	18-50	42	6	24	27	51	1
	3	sandy clay loam	50-99	27	1	45	27	72	<1
	4	clay	99-170	42	13	22	23	45	<1
	5	clay	170-250	35	10	23	32	55	<1

Table 8 [cont'd]
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
15	1	loam / sandy loam	0-16	11	8	34	47	81	<1
	2	sandy loam	16-20	16	11	33	40	73	<1
	3	clay loam	20-70	30	8	28	34	62	<1
	4	clay	70-180	38	8	26	28	54	<1
	5	sandy laom / loamy sand	180-210	11	7	34	48	82	<1
16	1	sandy loam	0-10	13	10	35	42	77	<1
	2	clay loam	10-29	29	10	26	34	60	1
	3	clay loam	29-63	30	10	26	33	59	1
	4	clay	63-99	35	9	24	32	56	<1
	5	clay	99-260	34	7	24	35	59	<1
17	1	sand	0-14	10	3	42	45	87	<1
	2	sandy clay loam	14-56	25	6	33	36	69	<1
	3	sandy clay / clay	56-93	32	6	28	34	62	<1
	4	sandy clay / sandy clay loam	93-180	30	5	25	40	65	0
	5	sandy loam	180-250	31	8	24	33	57	4
18	1	loam	0-10	16	16	40	28	68	0
	2	clay loam	10-68	31	22	34	13	47	0
	3	clay loam	68-180	28	9	39	24	63	0
	4	loam	180-220	9	2	6	34	40	49
19	1	loam	0-16	18	24	36	22	58	0
	2	clay	16-63	44	14	30	12	42	0
	3	clay	63-173	39	17	28	15	43	1
	4	sandy clay loam	173-245	23	9	32	36	68	0
	5	loam	245-260	17	6	18	30	48	29
20	1	sandy loam	0-18	15	12	38	35	73	0
	2	clay	18-97	40	13	32	15	47	0
	3	sandy clay loam	97-192	25	4	36	35	71	<1
	4	sandy clay loam	192-250	14	1	12	39	51	34
21	1	sand	0-12	7	1	36	54	90	2
	2	sand	12-60	3	0	18	44	62	35
	3	sand	60-87	5	0	10	40	50	45
	4	clay	87-153	37	15	24	24	48	0
	5	sandy clay loam	153-250	19	2	18	61	79	0
22	1	loam	0-14	17	20	39	24	63	0
	2	loam	14-44	20	24	36	20	56	<1
	3	clay	44--79	41	22	23	14	37	0
	4	clay loam	79-197	33	17	29	21	50	0
	5	sandy clay loam	197-250	23	8	11	58	69	<1

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

Table 9
Physical Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D%	D% level of dispersion	EAT	EAT level of dispersion
1	1	loamy sand	0-25	42	moderate	3[2]	slight
	2	loamy sand	25-40	60	high	3[1]	slight
	3	clay	40-66	68	high	2[3]	very high
	4	clay	66-120	72	very high	2[3]	very high
	5	clay	120-250	53	high	2[3]	very high
2	1	sand	0-40	40	moderate	3[1]	slight
	2	sand	40-110	50	moderate / high	3[1]	slight
	3	sandy loam	110-250	20	slight	3[1]	slight
3	1	loamy sand	0-23	33	moderate	3[1]	slight
	2	clay	23-72	88	very high	2[3]	very high
	3	clay	72-114	78	very high	2[3]	very high
	4	clay	114-174	37	moderate	3[3]	moderate
	5	loamy sand	174-260	17	slight	3[1]	slight
4	1	sandy loam	0-20	22	slight	3[2]	slight
	2	sandy clay loam	20-64	80	very high	2[3]	very high
	3	clay	64-106	53	high	2[2]	high
4	4	clay	106-192	65	high / very high	2[3]	very high
	5	clay	192-250	71	very high	2[1]	high / moderate
5	1	loamy sand	0-24	33	moderate	3[1]	slight
	2	clay	24-39	84	very high	2[2]	high
	3	clay	39-75	75	very high	2[2]	high
	4	clay	75-130	57	high	2[1]	high / moderate
	5	sandy clay loam	130-250	45	moderate	2[1]	hiugh / moderate
6	1	loamy sand	0-34	29	moderate	3[1]	slight
	2	sandy clay loam	34-81	8	slight	5	slight
	3	clay	81-160	4	negligible	5	slight
	4	clay	160-260	58	high	2[1]	high / moderate
7	1	sandy clay / clay	0-20	18	slight	3[2]	slight
	2	clay	20-37	39	moderate	3[1]	slight
	3	clay	37-85	29	slight	4	negligible
	4	clay	85-137	36	moderate	2[1]	high / moderate
	5	sand clay loam	137-260	62	high	2[1]	high / moderate
8	1	sandy loam	0-15	21	slight	3[1]	slight
	2	sandy clay loam / clay loam	15-50	48	moderate	3[2]	slight
	3	clay	50-96	21	slight	4	negligible
	4	sandy clay loam	96-210	53	high	2[1]	high / moderate
9	1	sandy clay loam	0-15	29	slight	8/3[1]	negligible / slight
	2	clay	15-47	19	slight	4	negligible
	3	clay	47-121	45	moderate	4	negligible
	4	clay	121-260	56	high	2[1]	high / moderate
10	1	sandy loam	0-10	29	slight	3[1]	slight
	2	sandy clay loam	10-30	83	very high	2[2]	high
	3	sandy clay loam	30-48	86	very high	2[2]	high
	4	clay	48-85	43	moderate	2[1]	high / moderate
	5	clay	85-154	42	moderate	2[1]	high / moderate
11	1	loam	0-10	30	slight / moderate	3[2]	slight
	2	clay loam	10-31	33	moderate	3[3]	moderate
	3	clay	31-102	56	high	3[1]	slight
	4	clay	102-191	88	very high	2[3]	very high
	5	clay loam	191-250	69	very high	2[3]	very high
12	1	sandy loam	0-16	23	slight	3[2]	slight
	2	sandy clay loam	16--61	62	high	2[1]	high / moderate
	3	clay	61-107	37	moderate	2[1]	high / moderate
	4	clay	107-180	45	moderate	2[1]	high / moderate

Table 9 [cont'd]
Physical Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D%	D% level of dispersion	EAT	EAT level of dispersion
	5	clay	180-250	72	very high	2[3]	very high
13	1	sandy clay loam	0-15	19	slight	3[1]	slight
	2	sandy clay	15-38	67	very high	2[3]	very high
	3	clay	38-70	84	very high	2[2]	high
	4	sandy clay loam	70-160	69	very high	2[1]	high / moderate
	5	sandy clay loam	160-250	80	very high	2[1]	high / moderate
14	1	clay loam	0-18	34	moderate	3[3]	moderate
	2	clay	18-50	35	moderate	2[1]	high / moderate
	3	sandy clay loam	50-99	80	very high	2[1]	high / moderate
	4	clay	99-170	93	very high	2[3]	very high
	5	clay	170-250	76	very high	2[3]	very high
15	1	loam / sandy loam	0-16	29	slight	3[2]	slight
	2	sandy loam	16-20	82	very high	2[3]	very high
	3	clay loam	20-70	94	very high	2[3]	very high
	4	clay	70-180	80	very high	2[3]	very high
	5	sandy laom / loamy sand	180-210	7	slight	3[1]	slight
16	1	sandy loam	0-10	25	slight	3[2]	slight
	2	clay loam	10-29	71	very high	2[3]	very high
	3	clay loam	29-63	75	very high	2[1]	high / moderate
	4	clay	63-99	63	very high	2[1]	high / moderate
	5	clay	99-260	94	very high	2[2]	high
17	1	sand	0-14	9	slight	3[1]	slight
	2	sandy clay loam	14-56	35	moderate	3[1]	slight
	3	sandy clay / clay	56-93	22	slight	2[2]	high
	4	sandy clay / sandy clay loam	93-180	60	high	2[1]	high / moderate
	5	sandy loam	180-250	94	very high	2[1]	high / moderate
18	1	loam	0-10	27	slight	8/3[1]	negligible / slight
	2	clay loam	10-68	58	high	2[2]	high
	3	clay loam	68-180	83	very high	2[2]	high
	4	loam	180-220	100	very high	2[2]	high
19	1	loam	0-16	31	moderate	3[2]	slight
	2	clay	16-63	26	slight	3[3]	moderate
	3	clay	63-173	20	slight	3[1]	slight
	4	sandy clay loam	173-245	28	slight	3[2]	slight
	5	loam	245-260	31	slight	3[2]	slight
20	1	sandy loam	0-18	28	slight	3[1]	slight
	2	clay	18-97	17	slight	4	negligible
	3	sandy clay loam	97-192	27	slight	4	negligible
	4	sandy clay loam	192-250	81	very high	2[2]	high
21	1	sand	0-12	43	moderate	3[1]	slight
	2	sand	12-60	25	slight	2[1]	high / moderate
	3	sand	60-87	56	high	2[2]	high
	4	clay	87-153	92	very high	2[2]	high
	5	sandy clay loam	153-250	80	very high	2[1]	high / moderate
22	1	loam	0-14	25	slight	3[3]	moderate
	2	loam	14-44	36	moderate	3[3]	moderate
	3	clay	44--79	81	very high	2[3]	very high
	4	clay loam	79-197	51	high	2[2]	high
	5	sandy clay loam	197-250	78	very high	2[3]	very high

7.3.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity and soil pH. The results of the laboratory analyses and the field pH measurements are contained in **Table 10.**

Table 10
Chemical Laboratory Analysis Data for Selected Soil Profiles

Page 1 of 3

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH	EC [dS/m]#	MULTI-LIER	CALCULATED EC_e	SOIL SALINITY STATUS
1	1	loamy sand	0-25	6.4	<0.01	23	<0.23	non-saline
	2	loamy sand	25-40	6.7	<0.01	23	<0.23	non-saline
	3	clay	40-66	7.7	0.02	5.8	0.12	non-saline
	4	clay	66-120	7.0	0.06	5.8	0.35	non-saline
	5	clay	120-250	9.4	0.23	5.8	1.33	non-saline
2	1	sand	0-40	7.2	<0.01	23	<0.23	non-saline
	2	sand	40-110	7.8	<0.01	23	<0.23	non-saline
	3	sandy loam	110-250	8.8	0.01	14	0.14	non-saline
3	1	loamy sand	0-23	7.0	0.02	23	0.46	non-saline
	2	clay	23-72	7.6	0.12	5.8	0.70	non-saline
	3	clay	72-114	8.7	0.24	5.8	1.39	non-saline
	4	clay	114-174	8.9	0.26	5.8	1.51	non-saline
	5	loamy sand	174-260	9.5	0.14	23	3.22	slightly saline
4	1	sandy loam	0-20	6.3	<0.01	14	<0.14	non-saline
	2	sandy clay loam	20-64	8.7	0.05	9.5	0.48	non-saline
	3	clay	64-106	9.6	0.26	5.8	1.51	non-saline
	4	clay	106-192	9.5	0.35	5.8	2.03	slightly saline
	5	clay	192-250	9.6	0.42	5.8	2.44	slightly saline
5	1	loamy sand	0-24	5.9	<0.01	23	<0.23	non-saline
	2	clay	24-39	6.9	0.13	5.8	0.75	non-saline
	3	clay	39-75	7.1	0.29	5.8	1.68	non-saline
5	4	clay	75-130	8.7	0.45	5.8	2.61	slightly saline
	5	sandy clay loam	130-250	9.1	0.35	9.5	3.33	slightly saline
6	1	loamy sand	0-34	6.6	<0.01	23	<0.23	non-saline
	2	sandy clay loam	34-81	5.6	<0.01	14	<0.14	non-saline
	3	clay	81-160	6.0	<0.01	5.8	<0.06	non-saline
	4	clay	160-260	7.8	0.01	5.8	0.06	non-saline
7	1	sandy clay / clay	0-20	7.1	0.02	8.6	0.17	non-saline
	2	clay	20-37	8.6	0.08	5.8	0.46	non-saline
	3	clay	37-85	9.5	0.71	5.8	4.12	moderately saline
	4	clay	85-137	9.4	0.85	5.8	4.93	moderately saline
	5	sand clay loam	137-260	9.0	0.58	9.5	5.51	moderately saline
8	1	sandy loam	0-15	6.6	0.01	14	0.14	non-saline
	2	sandy clay loam / clay loam	15-50	8.7	0.25	9.5	2.38	slightly saline
	3	clay	50-96	9.3	0.87	5.8	5.05	moderately saline
	4	sandy clay loam	96-210	9.4	0.75	9.5	7.13	moderately saline

Table 10 [cont'd]
Chemical Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH	EC [dS/m]#	MULTI-LIER	CALCULATED EC_e	SOIL SALINITY STATUS
9	1	sandy clay loam	0-15	7.2	0.02	9.5	0.19	non-saline
	2	clay	15-47	9.1	0.14	5.8	0.89	non-saline
	3	clay	47-121	9.7	0.40	5.8	2.32	slightly saline
	4	clay	121-260	9.6	0.74	5.8	4.29	moderately saline
10	1	sandy loam	0-10	6.3	<0.01	14	<0.14	non-saline
	2	sandy clay loam	10-30	7.2	0.12	9.5	1.14	non-saline
	3	sandy clay loam	30-48	6.9	0.17	9.5	1.62	non-saline
	4	clay	48-85	8.7	0.50	5.8	2.90	slightly saline
	5	clay	85-154	9.4	0.72	5.8	4.18	moderately saline
11	1	loam	0-10	6.6	0.02	9.5	0.19	non-saline
	2	clay loam	10-31	8.9	0.09	8.6	0.77	non-saline
	3	clay	31-102	9.7	0.64	5.8	3.71	slightly saline
	4	clay	102-191	7.5	0.72	5.8	4.18	moderately saline
	5	clay loam	191-250	5.0	0.52	8.6	4.47	moderately saline
12	1	sandy loam	0-16	6.3	0.01	14	0.14	non-saline
	2	sandy clay loam	16--61	8.5	0.15	9.5	1.43	non-saline
	3	clay	61-107	9.3	0.70	5.8	4.06	moderately saline
	4	clay	107-180	9.3	0.90	5.8	5.22	moderately saline
	5	clay	180-250	8.5	0.68	5.8	3.94	slightly saline
13	1	sandy clay loam	0-15	7.1	0.05	9.5	0.48	non-saline
	2	sandy clay	15-38	8.1	0.04	8.6	0.34	non-saline
	3	clay	38-70	9.5	0.66	5.8	3.83	slightly saline
	4	sandy clay loam	70-160	9.1	0.65	9.5	6.18	moderately saline
	5	sandy clay loam	160-250	9.0	0.60	9.5	5.70	moderately saline
14	1	clay loam	0-18	7.0	0.02	8.6	0.17	non-saline
	2	clay	18-50	8.9	0.17	5.8	0.99	non-saline
	3	sandy clay loam	50-99	9.4	0.76	9.5	7.22	moderately saline
	4	clay	99-170	6.5	0.82	5.8	4.76	moderately saline
	5	clay	170-250	4.9	0.60	5.8	3.48	slightly saline
15	1	loam / sandy loam	0-16	5.9	0.02	14	0.28	non-saline
	2	sandy loam	16-20	7.6	0.07	14	0.98	non-saline
	3	clay loam	20-70	8.7	0.41	8.6	3.53	slightly saline
	4	clay	70-180	8.6	0.60	5.8	3.48	slightly saline
	5	sandy loam / loamy sand	180-210	8.1		23	5.75	moderately saline
16	1	sandy loam	0-10	6.4	<0.01	14	<0.14	non-saline
	2	clay loam	10-29	7.8	0.10	8.6	0.86	non-saline
	3	clay loam	29-63	8.7	0.40	8.6	3.44	slightly saline
	4	clay	63-99	9.2	0.58	5.8	3.36	slightly saline

Table 10 [cont'd]
Chemical Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH	EC [dS/m]#	MULTI-LIER	CALCULATED EC_e	SOIL SALINITY STATUS
	5	clay	99-260	9.4	0.74	5.8	4.29	moderately saline
17	1	Sand	0-14	7.0	0.02	23	0.46	non-saline
	2	sandy clay loam	14-56	7.4	0.02	9.5	0.19	non-saline
	3	sandy clay / clay	56-93	8.8	0.06	8.6	0.52	non-saline
	4	sandy clay / sandy clay loam	93-180	9.4	0.19	9.5	1.79	non-saline
	5	sandy loam	180-250	9.8	0.35	8.6	3.01	slightly saline
18	1	loam	0-10	6.3	0.02	9.5	0.19	non-saline
	2	clay loam	10-68	9.0	0.11	8.6	0.95	non-saline
	3	clay loam	68-180	9.4	0.26	8.6	2.24	slightly saline
	4	loam	180-220	9.4	0.15	9.5	1.43	non-saline
19	1	loam	0-16	6.5	0.01	9.5	0.10	non-saline
	2	clay	16-63	7.4	<0.01	5.8	<0.06	non-saline
	3	clay	63-173	7.9	0.04	5.8	0.23	non-saline
	4	sandy clay loam	173-245	8.6	0.03	9.5	0.29	non-saline
	5	loam	245-260	8.6	0.03	9.5	0.29	non-saline
20	1	sandy loam	0-18	6.4	0.01	14	0.14	non-saline
	2	clay	18-97	8.5	0.10	5.8	0.58	non-saline
	3	sandy clay loam	97-192	8.6	0.07	14	0.98	non-saline
	4	sandy clay loam	192-250	9.4	0.09	14	0.85	non-saline
21	1	sand	0-12	6.4	<0.01	23	<0.23	non-saline
	2	sand	12-60	8.0	<0.01	23	<0.23	non-saline
	3	sand	60-87	8.0	0.03	23	0.69	non-saline
	4	clay	87-153	8.8	0.19	5.8	1.10	non-saline
	5	sandy clay loam	153-250	9.4	0.14	14	1.96	non-saline
22	1	loam	0-14	6.1	<0.01	9.5	<0.10	non-saline
	2	loam	14-44	6.9	0.01	9.5	0.10	non-saline
	3	clay	44--79	6.8	0.09	5.8	0.52	non-saline
	4	clay loam	79-197	8.6	0.07	8.6	0.60	non-saline
	5	sandy clay loam	197-250	8.0	0.06	9.5	0.57	non-saline

7.4 Discussion of Soil Analyses

7.4.1 Physical Attributes

The laboratory analysis results contained in **Tables 8** and **9** are important in assessing the erodibility of the soil units found within the Brine Storage Area.

The three tests [Particle Size Analysis, Dispersion %, Emerson Aggregate Test] carried out on samples from each of the horizons within the twenty two 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.

7.4.1.1 Particle Size Analysis

The results shown in **Table 8** are those contained in the laboratory test report.

From this data it is evident that the topsoils in most profiles contain relatively low levels of gravel and consequently the material is suitable for use in rehabilitation works.

The subsoils generally contained low amounts of gravel contents although some horizons included up to 50% gravel.

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 8**.

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

7.4.1.2 Dispersion Percentage

The D% values shown in **Table 9** indicate that the topsoils all showed variable levels of dispersibility with many having slight dispersibility and others having moderate dispersibility. One profile [No. 4] near the northern end of the proposed Brine Storage Area showed a high to very high reading.

The subsoil D% values were usually moderate to very high with an occasional slight or negligible reading.

Despite the generally low dispersibility values measured for the topsoils, there is enough dispersible material indicated to be present requires appropriate measures to be taken to protect the stockpiles of stripped soil. The same material, when respread, should be afforded rapid protection from soil erosion in the form of vegetative cover.

The subsoils on the proposed Brine Storage Area are a different situation and because of their generally high dispersibility care needs to be taken to stabilize stockpiles of this material to prevent erosion. It is suggested that the stockpiles be seeded [hydroseeded] and covered with an additional bitumen / hay mulch a soon as construction is complete to provide maximum protection against erosion – particularly during intense summer storms.

7.4.1.3 Emerson Aggregate Test

The EAT values shown in **Table 9** indicate that the topsoils generally showed slight levels of dispersibility although some showed moderate to very high values.

The subsoil EAT values were usually moderate to very high with an occasional slight or negligible reading.

Despite the generally low dispersibility values measured for the topsoils, there is enough dispersible material indicated to be present requires appropriate measures to be taken to protect the stockpiles of stripped soil. The same material, when respread, should be afforded rapid protection from soil erosion in the form of vegetative cover.

The subsoils on the proposed Brine Storage Area are a different situation and because of their generally high dispersibility care needs to be taken to stabilize stockpiles of this material.to prevent erosion. It is suggested that the stockpiles be seeded [hydroseeded] and covered with an additional bitumen / hay mulch a soon as construction is complete to provide maximum protection against erosion – particularly during intense summer storms.

7.5 Soil Chemical Attributes

Laboratory testing of the samples extended to an examination of the electrical conductivity and soil pH. The results of the laboratory analyses and the field pH measurements are contained in **Table 10.**

7.5.1 Soil pH

Perusal of the data in the pH column in **Table 10** indicates that almost all of the topsoil samples tested all showed pH levels within the 4.0 to 8.5 range and generally around the pH 7.0 level. There was one aberrant value above 8.5.

The upper subsoils were generally within the acceptable range but most of the deeper samples showed values that were at or exceeded the higher acceptable level.

The pH tests indicate that the pH values of the topsoils for the tested profiles that would be stripped for use in rehabilitation are well within acceptable limits

With the subsoils, the pH values of the upper subsoil layers are generally acceptable but there is usually a general increase in pH with depth to levels that are outside the acceptable range in some profiles.

There are also some deeper subsoils that have pH values in the 4.5 to 5.0 range.

These higher pH values would not be of concern as the mixing with lower pH soils during the stripping process would result in a composite medium of within acceptable limits.

7.5.2 Electrical Conductivity

The data in **Table 9** indicate that all but one of the topsoils tested were non-saline. The remaining horizon [No.5] showed slight salinity.

Many of the lower layers of the subsoils were slightly to moderately saline although others were non-saline. There appeared to be a trend for the profile closer to Kurrajong Creek to be lower in salinity than those in more elevated areas.

Salinity is not a concern for the topsoils tested from the Brine Storage Area.

However, the levels of subsoil salinity revealed by these tests are a cause for some concern in terms of their ability to be provided with an adequate vegetative cover during the stockpile phase.

The subsoil stockpiles should be seeded [hydroseeded] with a mix of pasture species that are salt tolerant and then covered with an additional hay / bitumen mulch as has been recommended to overcome the potential dispersibility problems that may be encountered with these soils.

7.6 Erosion Potential

The soils within the Brine Storage Area are currently generally stable except for some minor areas of sheet and cully erosion on the slopes and some scalding and historic drift on the lower terrace near Kurrajong Creek.

Groundcover varies over the site, but most of the area supported a low to moderate level of ground cover at the time of inspection with that on the scalded areas being patchy.

It will be essential, if erosion is to be prevented, to maintain an adequate groundcover on the existing landscape prior to basin construction and on any stockpiles / bunds during the proposed period of use and then on the reformed landscapes after rehabilitation work is carried out.

7.7 SOILOSS Program

Table 11 provides details of the calculated erodibility values [K] and erodibility ratings for topsoils and subsoils from five of the twenty two soil profiles from the proposed Brine Storage Area that were tested in the laboratory.

Table 11
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
B7 [SMU B1]	0-20cm	0.022	37-88cm	0.019	0.021	MODERATE
B18 [SMU B1]	0-10cm	0.041	68-100cm	0.029	0.035	MODERATE
B2 [SMU B2]	0-40cm	0.015	40-110cm	0.022	0.019	LOW
B9 SMU B3]	0-15cm	0.022	47-121cm	0.017	0.019	LOW
B17 [SMU B3]	0-14cm	0.021	56-93cm	0.024	0.023	MODERATE

The erodibility estimates contained in **Table 11** for profiles from the three SMUs recorded from the proposed Brine Storage Area [**SMU B1, SMU B2, SMU B3**]have been calculated using part of the overall SOILOSS program capability and the Particle Size Analysis information obtained from laboratory testing and other data.

The only values for which estimates were used in the calculations were those for organic matter %. After a perusal of the data for this variable for the Yarraman [equivalent to SMU B1] and Trinkey Forest [equivalent to SMUs B2 and B3] Soil Landscapes within *Soil Landscapes of the Curlewis 1: 100 000 Sheet Report* [Banks, 1995], mean values of 1.65% [topsoil] and 2.1% [subsoil] for SMU B1 and 3.5.0% [topsoil] and 0.33% [subsoil] for SMUs B2 and B3 were chosen.

The soil from the three SMUs were allotted a LOW to MODERATE erodibility by the SOILOSS model based on their physical characteristics (the Erodibility classes used were previously provide in Section 5.6).

Because of the generally MODERATE erodibility, as assessed by the SOILOSS analysis and field observations, the soils of all three SMUs should be managed carefully during the stripping, bund construction and rehabilitation stages to ensure that soil structure damage is minimal and that they are suitably protected by vegetation or some other medium after rehabilitation.

8 DESIGN AND OPERATIONAL SAFEGUARDS FOR THE BRINE STORAGE AREA

8.1 Stripping Suitability of the 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 4.**

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; and

e) the force necessary to disrupt peds.

8.2 Stripping Recommendations

8.2.1 SMU B1 Area

8.2.1.1 Layer 1

[0 - 15cm depth] - silty clay; light clay; gritty light to medium clay, light to medium clay; medium clay, medium to heavy clay; roots common to many; no lime present or occasionally some lime present near base; no manganese present; pH 5.0 to7.5, occasionally pH9.0 at base, gravel and stones usually absent, sometimes flat angular gravel <5mm to 4cm present; not mottled; not bleached; brown [7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4], reddish brown [5YR4/3], dusky red [10R3/2] dry, dark brown [7.5YR3/2, 7.5YR3/3, 7.5YR4/2], dark reddish brown [5YR3/2], very dark brown [7.5YR2.5/2], dusky red [10R3/2] moist; mostly structured; peds rough-faced or rough- / smooth-faced, moderately pedal [70%] to highly pedal [100%], polyhedral or angular blocky, <5-20 mm in size; weak to strong consistence dry; sometimes massive, fabric rough, firm to strong coherence dry; usually not hydrophobic;

Suitability Assessment [based on Elliott and Veness key]: structure grade 2 and 3; strongly coherent dry, mottles 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 topsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and should be used initially to topsoil the constructed bund and after the cessation of use of the Brine Storage reclaimed , stockpiled and then used as soon as possible in topsoiling the rehabilitated surface.

Recommendations for Layer 1 Materials

1. Strip all of the Layer 1 material to a depth of 15cm.
2. Layer 1 materials should be stockpiled as topsoil until the subsoil from the section of the brine storage area being constructed is stripped and used as the core of the bund surrounding that particular brine storage compartment. The topsoil should then be spread over the subsoil core and revegetated. If an excess of topsoil is removed then it should be stripped and stored in accord with the suitable stripping and storage methods detailed in **Section 11**. If possible, in order to maximise the regeneration of native species in the soil it is recommended that topsoil from areas currently vegetated by native and introduced species is transferred directly to areas to be revegetated.
3. Topsoil stripping should be carried out on all areas that would be disturbed by the construction of the brine storage area.

8.2.1.2 Layer 2

[15 – 100cm depth] - silty clay, sticky light to medium clay, medium clay, medium to heavy clay, heavy clay; roots few, common or many; no lime present or no lime visible to scattered to many lime stains and nodules present; no manganese present or some manganese concretions or staining present; pH 5.5 to 7.5 or pH 8.5 to pH 9..5/10; gravel and stones

absent; not mottled; not bleached; brown [7.5YR4/2, 7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4, 10YR4/3], dark reddish brown [5YR3/2], dusky red [10R3/2, reddish brown [2.5YR5/4, 5YR4/3, 5YR4/4], strong brown [7.5YR4/6], yellowish brown [10YR5/4] dry, brown [7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4], dark brown [7.5YR3/3, 10YR3/3], dark reddish brown [5YR3/2, 5YR3/3], dusky red [10R3/2], dark yellowish brown [10YR4/4], reddish brown [2.5YR4/3, 2.5YR4/4], strong brown [7.5YR4/6], yellowish brown [10YR5/4] moist; peds smooth- faced or rough- / smooth-faced, highly pedal [80 - 100%],angular blocky or polyhedral; <5-20 mm in size; firm to strong consistence dry; not hydrophobic;

Suitability Assessment [based on Elliott and Veness key]: structure grade 2 and 3; strongly coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture suitable; sand and gravel content generally 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 organic matter, nutrient reserves and should be used as the core of the bund surrounding the particular section of the brine storage area that is being constructed. Any excess soil should be stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining.In some sections the pH levels near the base of the stripped subsoil layer may be outside the acceptable limits but the process of stripping and mixing will ensure that the overall pH levels are suitable.

Recommendations for Layer 2 Materials

Strip all of the Layer 2 subsoil to a depth of 100cm below the current soil surface [ie a layer 85cm thick] from the section of the brine storage area being constructed, mix with the subsoil from the other two SMUs and use as the core of the bund surrounding that particular brine storage compartment. Any excess soil should be stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining.

This excess Layer 2 material should be stockpiled in the meantime as subsoil using suitable storage methods. [See **Section 11**]

8.2.1.3 Layer 3 [Remainder of the Profile]

Do not strip.

Recommendations for Layer 3 Materials

Do not strip.

8.2.2 SMU B2 Area

8.2.2.1 Layer 1

[0-15cm depth] - sandy loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, dark yellowish brown [10YR4/4] moist; peds rough- faced, weakly pedal [15%], polyhedral, 5-15 mm in size; weak consistence dry; not hydrophobic; *gradual to:*

Suitability Assessment [based on Elliott and Veness key]: structure grade 1; weakly coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture marginal; sand and gravel content generally unsuitable; pH levels generally suitable; salt content suitable.

This material is not really suitable for topsoiling on the basis of the Elliott and Veness key but the area of occurrence is small and the sandy material will be mixed with a much greater quantity of suitable material during the stripping operation. It contains valuable seed, organic matter, nutrient reserves and should be used initially to topsoil the constructed bund and after the cessation of use of the Brine Storage reclaimed , stockpiled and then used as soon as possible in topsoiling the rehabilitated surface.

Recommendations for Layer 1 Materials

1. Strip all of the Layer 1 material to a depth of 15cm at the same time as the other two SMUs are being stripped [ie. do not stockpile separately].

2. Layer 1 materials should be stockpiled as **topsoil** until the subsoil from the section of the brine storage area being constructed is stripped and used as the core of the bund surrounding that particular brine storage compartment. The topsoil should then be spread over the subsoil core and revegetated. If an excess of topsoil is removed then it should be stripped and stored in accord with the suitable stripping and storage methods detailed in Section 11. If possible, in order to maximise the regeneration of native species in the soil it is recommended that topsoil from areas currently vegetated by native and introduced species is transferred directly to areas to be revegetated.

3. Topsoil stripping should be carried out on all areas that would be disturbed by the construction of the brine storage area.

8.2.2.2 Layer 2

[15 – 100cm depth] - clayey sand, sandy loam; roots common; no lime present; no manganese present; pH 6.0 to 6.5; gravel and stones absent; not mottled; sometimes bleached; light yellowish brown [10YR6/4], light grey [10YR7/2] dry, dark yellowish brown [10YR4/4], brown [7.5YR5/3] moist; peds rough- faced, weakly pedal [15%], polyhedral, 5-15 mm in size; weak consistence dry; OR massive; fabric rough; firm coherence dry; not hydrophobic;

Suitability Assessment [based on Elliott and Veness key]: structure grade 1; weakly coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture marginal; sand and gravel content generally unsuitable; pH levels generally suitable; salt content suitable

This material is suitable for not really subsoiling on the basis of the Elliott and Veness key but the area of occurrence is small and the sandy material will be mixed with a much greater quantity of suitable material during the stripping operation. The subsoil I contains valuable organic matter, nutrient reserves and should be used as the core of the bund surrounding the particular section of the brine storage area that is being constructed. Any excess soil should be

stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining.

Recommendations for Layer 2 Materials

Strip all of the Layer 2 subsoil to a depth of 100cm below the current soil surface [ie a layer 85cm thick] from the section of the brine storage area being constructed, mix with the subsoil from the other two SMUs and use as the core of the bund surrounding that particular brine storage compartment. Any excess soil should be stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining. Any excess soil should be stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining.

This excess Layer 2 material should be stockpiled in the meantime as subsoil using suitable storage methods. [**See Section 11**]

8.2.2.3 Layer 3 [Remainder of the Profile]

Do not strip.

Recommendations for Layer 3 Materials

Do not strip.

8.2.3 SMU B3 Area

8.2.3.1 Layer 1

[0 - 15cm depth] - sandy loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, dark yellowish brown [10YR4/4] moist; peds rough- faced, weakly pedal [15%], polyhedral, 5-15 mm in size; weak consistence dry; not hydrophobic; *gradual to:-*

Suitability Assessment [based on Elliott and Veness key]: structure grade 1; weakly coherent dry, mottles absent; macrostructure suitable; force to disrupt peds suitable; texture suitable; sand and gravel content generally suitable; pH levels suitable; salt content suitable.

This material is suitable for topsoiling on the basis of the Elliott and Veness key and contains valuable seed, organic matter, nutrient reserves and This material is suitable for topsoiling on the basis of the Elliott and Veness key. It contains valuable seed, organic matter, nutrient reserves and should be used initially to topsoil the constructed bund and after the cessation of use of the Brine Storage reclaimed , stockpiled and then used as soon as possible in topsoiling the rehabilitated surface.

Recommendations for Layer 1 Materials

1. Strip all of the Layer 1 material to a depth of 15cm at the same time as the other two SMUs are being stripped [ie. do not stockpile separately].

2. Layer 1 materials should be stockpiled as topsoil until the subsoil from the section of the brine storage area being constructed is stripped and used as the core of the bund surrounding that particular brine storage compartment. The topsoil should then be spread over the subsoil core and revegetated. If an excess of topsoil is removed then it should be stripped and stored in accord with the suitable stripping and storage methods detailed in **Section 11**. If possible, in order to maximise the regeneration of native species in the soil it is recommended that topsoil from areas currently vegetated by native and introduced species is transferred directly to areas to be revegetated.

3. Topsoil stripping should be carried out on all areas that would be disturbed by the construction of the brine storage area.

8.2.3.2 Layer 2

[15-100cm depth] - clayey sand, sandy clay loam; medium clay; medium to heavy clay; heavy clay; roots absent, few, common or many; no lime present or no lime visible or some lime flecks or concretions present; no manganese present or manganese stains and concretions present; pH 6.0 to 7.5; or pH 9.0; pH 9.5/10 at lower levels; gravel and stones usually absent or angular and rounded gravel to 4cm present; sometimes bleached; usually whole coloured brown [7.5YR4/3, 7.5YR5/3, 7.5YR5/4], light brown [7.5YR6/4], pinkish grey [7.5YR7/2], red [5YR4/6], yellowish red [5YR4/6], dark yellowish brown [10YR4/4] dry, brown [7.5YR4/3, 7.5YR4/4, 7.5YR5/3, 7.5YR5/4], red [5YR4/6], reddish brown [5YR4/4] moist; rarely mottled very pale brown [10YR7/3], yellowish red [10YR5/6] dry, pale brown [10YR6/3], yellowish red [10YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; strong consistence dry; rarely massive; fabric rough; weak, weak, firm or strong coherence dry; not hydrophobic.

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

This material is suitable for not really subsoiling on the basis of the Elliott and Veness key but the area of occurrence is small and the sandy material will be mixed with a much greater quantity of suitable material during the stripping operation. The subsoil I contains valuable organic matter, nutrient reserves and should be used as the core of the bund surrounding the particular section of the brine storage area that is being constructed. Any excess soil should be stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining.

Recommendations for Layer 2 Materials

Strip all of the Layer 2 subsoil to a depth of 100cm below the current soil surface [ie a layer 85cm thick] from the section of the brine storage area being constructed, mix with the subsoil from the other two SMUs and use as the core of the bund surrounding that particular brine storage compartment. Any excess soil should be stockpiled and used later for rehabilitation of the final landscape or used in filling subsidence cracks following longwall mining.

The excess Layer 2 material should be stockpiled in the meantime as subsoil using suitable storage methods. [See **Section 11**].

8.2.3.3 Layer 3 [Remainder of the Profile]

Do not strip.

Recommendations for Layer 3 Materials

Do not strip.

9 THE PROPOSED PIPELINE ROUTE

9.1 Introduction

Sampling depth along the proposed Pipeline Route was generally 180cm, although P1 profile was sampled to 250cm. The shallower sampling was undertaken as the proposed twin pipelines are to be laid in a trench approximately 120cm deep. Thirteen soil sample pits were excavated along the section of the proposed pipeline route away from the Mine Facilities Area and the proposed Brine Storage Area.

Once the pipeline reaches the proposed Brine Storage Area it bifurcates and one line travels along the eastern boundary of the Brine Storage Area and the other along its western boundary. They rejoin on the southern side of the Brine Storage Area and continue to the Mine Facilities Area.

Relevant soil information obtained for these sections of the proposed Pipeline Route is contained in the section of this assessment dealing with the proposed Brine Storage Area.

The remaining section of the proposed Pipeline Route between the southern side of the proposed Brine Storage Area [at the Kurrajong Creek tributary] and the Mine Facilities Area is covered by the soils information provided in the 'Soil Study for the Mine Pit Top Area, Rail Loop and Ventilation Shaft' at Narrabri Coal Mine [GCNRC, 2006]

From the information gained from the detailed soil profile descriptions, three soil mapping units [SMUs] were identified along the section of the proposed Pipeline Route to the north and west of the proposed Brine Storage Area.

The first SMU [SMU P1] is a deep clay soil unit that occurs in the floodplain area of the Namoi River, while the second SMU [SMU P2] has deep sandy accumulations above a clay base and occurs in drainage depressions that would be traversed by the proposed pipeline

The third SMU [SMU P3] is associated with the slightly more elevated country that comprises the remainder of the pipeline route away from the River. This unit comprises duplex soils with a sand topsoil overlying a clay suboil.

The location of the thirteen sampled soil profiles and the boundaries of the three SMUs are shown in **Figure 1**.

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 2 contains detailed information of the layers present in the 13 pits that were described in detail.

9.2 Soil Mapping Unit Descriptions

Descriptions of the layers found in the profiles of the three SMUs identified along the proposed pipeline route are set out below (see **Figure 2**).

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].

9.2.1 Description of SMU 1 – Soils of the Drainage Depressions

9.2.1.1 "Plain English" Description:

Soil sampled to approximately 180cm; *drainage depression location; surface condition firm to hardsetting; surface stone absent.*

Topsoil to 22cm – clayey sand, sandy loam to sandy clay loam; roots common to many; no lime present; no manganese present; pH 6.0; some or much round or angular gravel to 1-2cm; not mottled; not bleached; brown coloured; massive; sometimes hydrophobic.

Subsoil of four layers, the upper one or two layers clayey sand or sandy clay loam textured and occurring to a depth of 60-110cm ; pH 6.0; gravel and stones absent or some rounded and angular gravel or layers of waterwashed stone present; brown coloured; massive or well structured; not hydrophobic overlying light to medium clay horizons; brown or yellowish brown coloured , sometimes slightly mottled in these colours; highly structured or massive; one profile with a base of indurated sand; not hydrophobic.

9.2.1.2 Technical Description [based on test pits]

a) Australian Soil Classification Name – Brown Chromosols

b) Field Description

Layer 1 [always present] [10-22cm thick] - clayey sand to sandy loam; roots common to many; no lime present; no manganese present; pH 6.0; some or much round or angular gravel to 1-2cm; not mottled; not bleached; brown [7.5YR4/2. 7.5YR5/4] dry, brown [7.5YR4/3], dark

brown [7.5YR3/2] moist; massive, fabric rough, weak to very firm coherence dry; sometimes hydrophobic; *abrupt to*

Layer 2 [always present] 22-52cm thick] - clayey sand; sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; round and angular gravel to 5-10cm present or odd small gravel to 5mm; not mottled; not bleached; brown [7.5R5/3] dry, dark brown [7.5YR3/3] moist; peds rough-faced or rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; weak to strong consistency dry; not hydrophobic; *abrupt or :clear to:-*

Layer 3 [always present] [28-37cm thick] - clayey sand; few roots; no lime present; no manganese present; pH 6.0; gravel and stones absent or a layer of rounded gravel present, some waterwashed; not mottled; sometimes bleached;
brown [7.5YR4/3], pink [7.5YR7/3] dry, brown [7.5YR4/4], reddish brown [5YR4/3] moist; massive, fabric rough or rough / smooth,, firm to strong coherence dry; not hydrophobic; *abrupt to clear to:-*

Layer 4 [always present] [39-50cm thick] - gritty light clay, medium clay; few roots; no lime present; sometimes manganese stains present; pH 6.0 to 7.5; gravel and stones absent or some gravel fragments to 1cm present; not bleached; **sometimes whole coloured** brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; sometimes mottled; 95% pale brown [10YR6/3], 5% yellowish brown [10YR5/6] dry, 95% brown [10YR5/3], 5% strong brown [7.5YR4/6] moist; peds rough-faced or rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistency dry; not hydrophobic; *clear to- gradual to:-*

Layer 5 [Always present] [60-70cm thick] - indurated sand, gritty medium clay; few roots, no lime present or no lime visible; no manganese present; pH 7.5 – 8.0; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3], yellowish brown [10YR5/4] dry, brown [10YR5/3], yellowish brown [19YR5/4] moist; structured ; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; strong consistency dry OR massive, fabric rough, very strong coherence dry; not hydrophobic.

9.2.2 Description of SMU P2 – Soils of the Namoi River Floodplain

9.2.2.1 "Plain English" Description:

Soil sampled to approximately 180cm - *floodplain / depression locations; surface condition soft, firm or self mulching and cracked; surface stone absent or some small surface gravel present.*

Topsoil light to medium clay, medium clay; many roots; no lime present; no manganese present; pH 6.5; gravel and stones absent or some small gravel or round and angular gravel to 5-10cm present; not mottled; not bleached; brown, reddish brown or greyish brown coloured; highly structured; sometimes hydrophobic.

Subsoil consisting of three layers – sandy clay loam to medium to heavy clay textured; brown to reddish brown coloured, sometimes slightly mottled in these same colours; pH 6.5 to 7.5 near surface , increasing to 9.5/10 at the base; gravel and stones usually absent; highly structured; not hydrophobic.

9.2.2.2 Technical Description [based on test pits]

a) Australian Soil Classification Names – Brown Vertosol

b) Field Description:

Layer 1 [always present] [15-30cm thick] - light to medium clay, medium clay; many roots; no lime present; no manganese present; pH 6.5; gravel and stones absent or some small gravel or round and angular gravel to 5-10cm present; not mottled; not bleached; brown [7.5YR4/3, 7.5YR5/3], dark reddish brown [5YR3/5], very dark greyish brown [10YR3/2] dry, brown [7.5YR4/3], dark brown [7.5YR3/3], dark reddish brown [5YR2.5/2], very dark greyish brown [10YR3/2] moist; peds rough- faced or rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; firm consistency to very strong consistency dry; sometimes hydrophobic; *abrupt to clear to:-*

Layer 2 [always present] [52-85cm thick] -- medium to heavy clay heavy clay;
roots few to common; often no lime present or lime flecks present; no manganese present; pH 6.5 to 7.5, occasionally pH 9.5-10; gravel and stones usually absent, sometimes some rounded and angular gravel to 3cm present; not mottled; not bleached; brown [7.5R4/2, [7.5YR4/3, [7.5YR4/4] dry, brown [7.5R4/2, [7.5YR4/3, [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral,<5-15 mm in size; very firm to very strong consistency dry; not hydrophobic; *gradual to:-*

Layer 3 [always present] [73-88cm thick] - sandy clay loam, medium clay, heavy clay; few roots; no lime present or no lime visible or lime flecks present; no manganese present; pH 8.0 to pH 9.5/10, occasionally pH 6.5; gravel and stones absent; not bleached; usually whole coloured brown [7.5YR4/3, 7.5YR5/3], yellowish brown [10YR5/4] dry, brown [7.5YR4/3, 7.5YR4/4] moist; brown [] moist sometimes mottled 80% brown [7.5YR5/3], 20% brown [7.5YR4/2] dry, 80% brown [7.5YR5/3], 20% brown [7.5YR4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-20 mm in size; very firm to very strong consistency dry; not hydrophobic; *gradual to a deeper layer or continues:-*

9.2.3 Description of SMU 3 – Duplex Soils of the Slightly Elevated Section of the Proposed Pipeline Route

9.2.3.1 "Plain English" Description:

Soil sampled to approximately 180cm - *lower slope, upper slope or crest location; surface condition soft, firm or hardsetting; surface stone usually absent, occasionally some surface gravel or stone present.*

Topsoil 10-24cm deep, clayey sand, sandy clay loam, fine sandy clay loam,; roots common to many; no lime present; no manganese present; pH 4.5 to 7.5; gravel and stones absent or some small rounded gravel to 0.5 to 2cm; not mottled; not bleached; brown to black coloured; usually massive, sometimes highly structured; usually not hydrophobic.

Subsoil consisting of a up to five layers; sometimes with an upper bleached clayey sand layer above a number of clay layers that vary in texture from light to medium clay to heavy clay; pH 6.0 to 7.5 in upper layers to pH 8.0 to 9.5/10 below; no lime present or no lime visible; no manganese present or some manganese stains and concretions present; coloured brown, reddish brown or yellowish brown, sometimes slightly mottled in similar colours; gravel and stones absent or some rounded and angular gravel to 4cm present; highly structured, not hydrophobic.

9.2.3.2 Technical Description [based on test pits]

a) Australian Soil Classification Names – Red and Brown Chromosols

b) Field Description:

Layer 1 [always present] [10-24cm thick] – clayey sand, sandy clay loam, fine sandy clay loam, light to medium clay [most likely a road grader deposit]; roots common to many; no lime present; no manganese present; pH 4.5 to 7.5; gravel and stones absent or some small rounded gravel to 0.5 to 2cm; not mottled; not bleached; brown [7.5YR5/3, 7.5YR5/4] dry, black [5YR2.5/2], dark brown [7.5YR3/3, 7.5YR3/4], very dark brown [7.5YR2.5/3] moist; usually massive, fabric rough, very firm coherence dry; massive, fabric rough or rough / smooth, very weak to very firm coherence dry; occasionally structured , peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; very firm consistency dry; usually not hydrophobic; *sharp or abrupt to:-*

Layer 2 [sometimes present] [15-22cm thick] - clayey sand, sandy loam; roots common; no lime present; no manganese present; pH 6.0 to 6.5; gravel and stones usually absent, sometimes gravel to 5mm present; not mottled; occasionally bleached; pink [7.5YR7/3], pinkish grey [5YR6/2], brown [7.5YR5/3] dry, brown [7.5YR5/3, 7.5YR5/4] moist; dark reddish grey [5YR4/2] moist; often massive, fabric rough or rough / smooth, very firm coherence dry; sometimes structured, peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistency dry; not hydrophobic; *sharp, abruptor- clear to:-*

Layer 3 [always present] 19-64cm thick] - sandy light to medium clay, light to medium clay, medium clay, medium to heavy clay; roots few to many; no lime present or no lime visible; no manganese present or some manganese stains and concretions present; usually pH 8.0 to 9.5/10, sometimes pH 6.0 to 7.5; gravel and stones absent or some rounded and angular gravel to 2cm present; not mottled; not bleached; brown [7.5YR4/4, 7.5YR5/4], dark reddish brown [2.5YR3/3], light brown [7.5R6/4], reddish brown [5YR4/4, 5YR5/4], yellowish brown [10YR5/4] dry, brown [7.5YR4/4, 7.5YR5/3], dark brown [7.5YR3/2, 7.5YR3/4], reddish brown [5YR4/3, 5YR4/4], yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistency dry; not hydrophobic; *clear to gradual to:-*

Layer 4 [always present] [29-97cm thick] - ;medium clay, medium to heavy clay;
roots few to common; no lime present; no manganese present; or lime flecks and nodules and some manganeses stains and concretions present; usually pH 9.5/10 occasionally pH 7.5; gravel and stones usually absent, sometimes some angular or rounded gravel to 0.5 to1cm present; not bleached; **usually whole coloured** brown [10YR5/3, 7.5YR5/4], reddish brown

[2.5YR4/4, 5YR4/4], strong brown [7.5YR4/6], yellowish brown [10YR5/4] dry, brown [7.5YR4/4, 7.5YR5/4], light yellowish brown [10YR6/4], reddish brown [2.5YR4/4, 5YR4/4], yellowish brown [10YR5/4] moist; occasionally mottled 95% brown [10YR5/3], 5% brownish yellow [10YR6/8] dry, 95% pale brown 10YR6/3], 5% strong brown [7.5YR5/6 moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral or polyhedral / platy, 5-15 mm in size; strong consistency dry; not hydrophobic; *clear or gradual or horizon continuing to:-*

Layer 5 [always present] [40-73cm thick] - medium clay, medium to heavy clay, heavy clay; roots few to common; no lime visible, no manganese present or present many lime nodules and stains and some manganese stais and concretions present;
usually pH 9.0 to 9.5/10, sometimes pH 6.0; gravel and stones usually absent or
some rounded and angular gravel to 4cm present; not bleached**;** usually whole coloured brown [7.5YR5/4], light yellowish brown [10YR6/4], reddish brown [5YR4/4], yellowish brown [10YR5/4] dry, brown [7.5YR5/4], pale brown [10YR6/3], reddish brown [5YR4/4], yellowish brown [10YR5/4] moist; sometimes mottled brown [7.5YR5/4, 10YR5/3], pale brown [10YR6/3] ,brownish yellow [10YR6/8] dry, pale brown 10YR6/3], strong brown [7.5YR5/6], light brownish grey [2.5Y6/2] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-15 mm in size; very firm to strong consistency dry; not hydrophobic; *clear to or horizon continuing.*

Layer 6 [sometimes present] [80cm thick] - medium to heavy clay; few roots; no lime present; manganese stains present; pH; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistency dry; not hydrophobic.

9.3 Soil Laboratory Analyses – Pipeline Route

Twelve samples from three soil profiles [Nos.P3, P4 and P13] were selected for laboratory analysis at the Land and Property Management Authority [Soil Conservation Service Division] Soil and Water testing Laboratory at Scone.

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

9.3.1 Soil Physical Analyses – Pipeline Route

Tables 12 and **13** show the results obtained from laboratory analysis of the samples from the three pits.

Table 12
Physical Laboratory Analysis Data for Selected Soil Profiles
[Whole Soil Particle Size Analysis]

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	PSA % CLAY	PSA % SILT	PSA % FINE SAND	PSA% COARSE SAND	PSA % TOTAL SAND	PSA % GRAVEL
3	1	clay loam	0-20	32	22	33	13	46	<1
	2	clay	20-82	51	16	26	7	33	<1
	3	clay	82-180	47	20	27	5	32	1
4	1	loam	0-16	22	14	36	27	63	1
	2	clay	16-62	43	16	19	22	41	<1
	3	clay	62-100	42	16	18	23	41	1
	4	clay	100-170	39	15	20	25	45	1
13	1	sandy loam	0-10	16	7	8	61	69	8
	2	clay loam	10-32	25	16	22	37	59	0
	3	loamy sand	32-60	8	7	38	47	85	<1
	4	clay	60-110	38	8	22	32	54	0
	5	clay	110-180	38	16	22	24	46	<1

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

Table 13
Physical Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	D%	D% level of dispersion	EAT	EAT level of dispersion
3	1	clay loam	0-20	19	slight	3[2]	slight
		clay	20-82	15	slight	3[1]	slight
		clay	82-180	16	slight	4	negligible
4	1	loam	0-16	31	moderate	2[1]	high / moderate
	2	clay	16-62	70	very high	2[2]	high
	3	clay	62-100	51	moderate	2[2]	high
	4	clay	100-170	62	high	2[1]	high / moderate
13	1	sandy loam	0-10	28	slight	8/3[1]	negligible / slight
	2	clay loam	10-32	30	slight / moderate	3[1]	slight
	3	loamy sand	32-60	63	high	3[1]	slight
	4	clay	60-110	76	very high	2[2]	high
	5	clay	110-180	97	very high	2[3]	very high

9.3.2 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity and soil pH. The results of the laboratory analyses and the field pH measurements are contained in **Table 14.**

Table 14
Chemical Laboratory Analysis Data for Selected Soil Profiles

PIT No.	LAYER	TEXTURE [fine earth]#	DEPTH [cm]	pH	EC [dS/m]#	MULTI-LIER	CALCULATED EC_e	SOIL SALINITY STATUS
3	1	clay loam	0-20	7.0	0.05	8.6	0.43	non-saline
		clay	20-82	7.1	0.04	5.8	0.23	non-saline
		clay	82-180	8.5	0.25	5.8	1.4	non-saline
4	1	loam	0-16	6.2	0.04	9.5	0.38	non-saline
	2	clay	16-62	8.0	0.20	5.8	1.16	non-saline
	3	clay	62-100	9.0	1.05	5.8	6.09	moderately saline
	4	clay	100-170	9.4	0.83	5.8	4.81	moderately saline
13	1	sandy loam	0-10	7.0	0.06	14	0.84	non-saline
	2	clay loam	10-32	7.0	0.02	8.6	0.17	non-saline
	3	loamy sand	32-60	6.7	<0.01	23	<0.23	non-saline
	4	clay	60-110	6.4	0.14	5.8	0.81	non-saline
	5	clay	110-180	8.2	0.31	5.8	1.80	non-saline

9.4 Discussion of Soil Analyses

9.4.1 Physical Attributes

The laboratory analysis results contained in **Tables 12** and **13** are important in assessing the erodibility of the soil units found within the Reject Emplacement Study Area.

The three tests [Particle Size Analysis, Dispersion %, Emerson Aggregate Test] carried out on samples from each of the horizons within the twenty two 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.

9.4.1.1 Particle Size Analysis

The results shown in **Table 12** are those contained in the laboratory test report.

From this data it is evident that the topsoils in most profiles contain relatively low levels of gravel and consequently the material is suitable for use in rehabilitation works. Some topsoils contained no discernable gravel, while in the profiles where gravel was recorded, it varied in size from very small to relatively large.

The subsoils generally contained low amounts of gravel although there was generally a mix of horizons in individual profiles where some contained gravel and others did not.

The texture class of each soil layer is determined by analysis of the material [fine earth fraction] that is less than 2mm in size – i.e. 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 12**.

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

9.4.1.2 Dispersion Percentage

The D% values shown in **Table 13** indicate that the topsoils showed slight to moderate levels of dispersibility.

The subsoil D% values varied from slight to moderate to very high**.**

As the pipeline trench will be refilled as soon as the pipes are laid there should be no problems associated with stockpiling dispersible soils.

The only likely problems would occur if the excavated profile was inverted during refilling. To overcome the likelihood of such an event occurring, extreme care should be taken to ensure that the topsoil is stockpiled on one side of the trench and the subsoil on the other with the side for each remaining constant to avoid error.

Refilling the trench should also involve replacing the subsoil first and then the topsoil on the surface.

9.4.1.3 Emerson Aggregate Test

The EAT values shown in **Table 14** indicate that the topsoils generally showed negligible/ slight to high to moderate levels of dispersibility.

The subsoil D% values varied from slight to moderate to very high**.**

Again, as the pipeline trench will be refilled as soon as the pipes are laid there should be no problems associated with stockpiling dispersible soils.

The only likely problems would occur if the excavated profile was inverted during refilling. To overcome the likelihood of such an event occurring, extreme care should be taken to ensure that the topsoil is stockpiled on one side of the trench and the subsoil on the other with the side for each remaining constant to avoid error.

Refilling the trench should also involve replacing the subsoil first and then the topsoil on the surface.

9.5 Soil Chemical Attributes

Laboratory testing of the samples extended only to an examination of the electrical conductivity and soil pH. The results of the laboratory analyses are contained in **Table 14**.

9.5.1 Soil pH

Perusal of the data in the pH column in **Table 14** indicates that the three topsoil samples tested all showed pH levels within the 4.0 to 8.5 range and generally around the pH 7.0 level. Similar results were obtained during the field testing of the topsoils of all thirteen profiles.

The upper subsoils were generally within the acceptable range but some of the deeper samples showed values that were at, or exceeded, the higher acceptable level. Field tests on the thirteen pipeline profiles indicated that while the upper subsoils had pH values within the acceptable range, some of the deeper subsoils had values outside the higher limit. In addition there were some of the deeper subsoils that had almost mid-range values.

Higher pH values in the deeper subsoils will not be of concern as the trench will be refilled after pipe laying is complete.

However, as with the dispersibility issue, the only likely problems would occur if the excavated profile was inverted during refilling. To overcome the likelihood of such an event occurring, extreme care should be taken to ensure that the topsoil is stockpiled on one side of the trench and the subsoil on the other with the side for each remaining constant to avoid error.

Refilling the trench should also involve replacing the subsoil first and then the topsoil on the surface.

9.5.2 Electrical Conductivity

The data in **Table 14** indicate that all of the topsoils tested were non-saline.

However, in one of the profiles [No. 4], the subsoil horizons were moderately saline. This should not cause any corrosion problems with the "plastic" pipe being used and should not result in any other issues so long as the profile is not inverted during refilling of the trench.

To overcome the likelihood of such an event occurring, extreme care should be taken to ensure that the topsoil is stockpiled on one side of the trench and the subsoil on the other with the side for each remaining constant to avoid error.

Refilling the trench should also involve replacing the subsoil first and then the topsoil on the surface.

9.6 Erosion Potential

The soils along the proposed Pipeline Route are currently generally stable except for some minor areas of sheet and gully erosion on sloping land.

Groundcover varies over the site, but most of the area supported a low to moderate level of ground cover at the time of inspection.

It will be essential, if erosion is to be prevented, to ensure that the seed-bank containing topsoil is replaced in the correct order and that on sloping areas small check banks are located at regular intervals along the refilled trench line to divert runoff water and prevent it exposing the pipes.

9.7 SOILOSS Program

Table 15 provides details of the calculated erodibility values [K] and erodibility ratings for topsoils and subsoils from the three soil profiles along the proposed Pipeline Route that were tested in the laboratory.

Table 15
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
P13 [SMU P1]	0-20cm	0.034	20-82cm	0.021	0.028	MODERATE
P3 [SMU P2]	0-16cm	0.022	62-100cm	0.018	0.020	LOW TO MODERATE
P4 [SMU P3]	0.10cm	0.008	60-110cm	0.021	0.015	LOW

The erodibility estimates contained in **Table 15** for the three SMUs recorded from along the proposed Pipeline Route have been calculated using part of the overall SOILOSS program capability and the Particle Size Analysis and other data.

The only values for which estimates were used in the calculations were those for organic matter %. After a perusal of the data for this variable for the Yarraman [equivalent to SMU B1] and Trinkey Forest [equivalent to SMUs B2 and B3] Soil Landscapes within *Soil Landscapes of the Curlewis 1: 100 000 Sheet Report* [Banks, 1995], mean values of 1.65% [topsoil] and 2.1% [subsoil] for SMU B1 and 3.5.0% [topsoil] and 0.33% [subsoil] for SMUs B2 and B3 were chosen.

The soils from the three SMUs were allotted a LOW to MODERATE erodibility ratings by the SOILOSS model based on their physical characteristics (the Erodibility classes used are provided in Section 5.6).

Despite the LOW erodibility for SMU P3, as assessed by the SOILOSS analysis and field observations, the soils of all SMUs should be managed carefully during the stripping and rehabilitation stages to ensure that soil structure damage is minimal and that they are suitably protected by vegetation or some other medium after rehabilitation.

10 DESIGN AND OPERATIONAL SAFEGUARDS FOR THE PROPOSED PIPELINE ROUTE

10.1 Stripping Suitability of the 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 4.**

This method has been used in the sections of this assessment that deal with the Reject Emplacement Are and the Brine Storage Area. However, there is little value in conducting the suitability test proposed by Elliott and Veness [1981] for the pipeline route soils as the materials will not be stockpiled and later respread but have to be replaced at the sites from which they have been excavated.

10.2 Stripping Recommendations

These stripping recommendations are provided for ALL SMUs as the nature of the project dictates that the stripping process would be linear and that a variety of soil materials will be encountered along the route.

The recommendations take into account the information obtained in the sampling along the proposed Pipeline Route to the north and east of the proposed Brine Storage Area, the information gained in relation to the soils of the proposed Brine Storage Area and the soils data contained in the 'Soil Study for the Mine Pit Top Area, Rail Loop and Ventilation Shaft at Narrabri Coal Mine' [GCNRC, 2006]

Basically the stripping and windrowing will ensure that the topsoil and subsoil materials are stored in separate windrows on opposite sides of the trench and that the appropriate material will be replaced in the trench at a position very close to where they originated.

Perusal of the topsoil depth data from all profiles in all SMU's indicates that removal of a top layer of material 15cm deep will ensure that more fertile topsoil material with its accumulated seedbank will be readily available for replacement over the trench after the subsoil covers the pipes to ensure rapid rehabilitation.

Topsoil should only be removed from the immediate vicinity of the trench where subsoil excavation is to occur. As stated previously the topsoil and subsoil material should not be mixed and should be placed on opposite sides of the trench.

The subsoil should only be removed from the trench after completion of excavation of the topsoil.

The topsoil should always be placed on the same side of the trench [eg. the western side] to avoid operator error during trench filling and rehabilitation. The same procedure should apply for subsoils with these materials being always placed on the same side of the trench.

It should be the trenching and pipelaying contractor's responsibility to establish these soil placement "rules" with the machine operators and to ensure that they are complied with.

It is essential that profile inversion is STRICTLY AVOIDED. The dispersibility of many of the subsoils may well result in soil erosion that exposes the buried pipeline in wet periods if profile inversion occurs. This phenomenon was observed during the construction of the Moomba – Sydney Gas Pipeline in the 1970s when profile inversion occurred. The resulting damage was extremely costly.

In addition to the normal reasons for avoiding profile inversion there are soil salinity issues in some lower horizons of some the soil profiles examined that are likely to be avoided by returning the subsoil to the trench first.

It is recognised that construction of a pipeline requires many vehicles to travel along the line. However, given the relative fragility of some of the sandy topsoils travel in the immediate vicinity of the trench such travel should be minimized.

This should be readily achievable as the proposed Pipeline Route outside the Mine area follows public roads for almost the whole of its length. These roads should be used for access as much as possible.

10.3 Precautions During Stripping and Windrowing Along the Proposed Pipeline Route

Excessive handling of the materials during the stripping and windrowing operations and handling when the soils are wet should be avoided to protect any structure that may have developed.

The topsoil stripping operation could be undertaken using machines with narrow angled blades. The subsoil would need to be removed using a backhoe or excavator.

Driving of machinery on the topsoil and subsoil windrows should be kept to an absolute minimum to maximise soil aggregation and prevent compaction, particularly when the stockpiles are moist.

Windrows may have to be protected from soil erosion in some places along he route and sections of the trench that pass through drainage lines may need to have the windrow discontinuous to facilitate passage of water.

In such instances it would be appropriate to breach the continuous windrow and push the material from the breached section into a slightly higher and wider windrow at each side of the breach. This will ensure that the material from the trench in the breached section is not taken too far from its source and place it in an inappropriate section of the trench during rehabilitation.

It should be reiterated here that stripping / windrowing and trenching should not be allowed to progress too far in front of the pipe laying teams to reduce the amount of open trench and consequent potential for soil erosion.

This will require detailed and careful project planning and in-field management.

10.4 Required Soil Conservation Measures

Measures should be taken to minimise loss of soil materials from the windrows, especially in the period before they are stabilized – for example, using geotextile “silt fences” or lines of straw / hay bales, small check banks etc.

Rehabilitation work in the public road reserve areas and areas of remnant native vegetation should avoid introduction of non native species. If stripping / windrowing and rehabilitation work is undertaken carefully and any sloping sections of the rehabilitated route is suitably protect by soil conservation measures, the native seeds in the topsoils should relatively quickly re-establish cover.

On the open cleared country, it would be appropriate for the rehabilitated areas to be sown with suitable pasture / cereal species as recommended by a local agronomist.

11 GENERAL RECOMMENDATIONS ON HANDLING STRIPPED SOILS – ALL AREAS

11.1 Introduction

Stripping and stockpiling of soil materials is proposed for the proposed Reject Emplacement Area and the proposed Brine Storage Area.

The recommended approach to managing the stripping and related tasks along the proposed Piepline Route is covered in **Section 10**.

This section outlines the recommended techniques for handling the soil materials that are to be stripped, stockpiled and then respread during the rehabilitation phase on the proposed Reject Emplacement Area and the proposed Brine Storage Area.

The recommendations are based on an interpretation of the results of a 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.

11.2 Stripping and Stockpiling

11.2.1 Earthmoving Procedures

The soils that would be disturbed [particularly topsoils] are often relatively weakly structured and so excessive handling of the materials during the stripping and stockpiling operation and handling when the soils are wet should 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 should be taken also 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, should be kept to an absolute minimum to maximise soil aggregation and prevent compaction, particularly when the stockpiles are moist. Ideally, the topsoil stockpiles should be no greater than 1m high but, if necessary, higher dumps can be used. These should not exceed about 2m in height. The subsoil stockpiles should not exceed 3m in height.

These stockpiles would need to be positioned to prevent sediment-laden runoff from entering the local watercourses that take their source within and adjacent to the study area.

11.2.2 Soil Conservation Measures

Measures should 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 should 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 should 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 should be progressively stabilised.

12 IMPACT ASSESSMENT

Adherence to the recommended soil stripping, windrowing, handling and storage procedures would result in a minimal impact from a soils and land capability viewpoint within the proposed Reject Emplacement Area, the proposed Brine Storage Area and along the proposed Pipeline Route between the proposed Brine Storage Are and the Namoi River.

13 CURRENT LAND CAPABILITY AND AGRICULTURAL LAND SUITABILITY

It should be noted that both the NSW Department of Environment, Climate Change and Water's [DECCW] Land Capability mapping and the Industry and Investment NSW – Agriculture [I&INSW] Land Suitability mapping 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.

13.1 Land Capability

13.1.1 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 DECCW].

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 I] through to land that is unsuitable for agricultural or pastoral production [Class VIII].

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 5**.

13.1.2 Land Capability as Mapped by DECCW for the Study Area

The 1: 100 000 scale Land Capability maps of the Baan Baa map sheet area prepared by the former Soil Conservation Service of NSW [DECCW, Parramatta - GIS] shows that the proposed Reject Emplacement Area and the proposed brine Storage Area are mapped as **Class III** lands (see **Figure 3**).

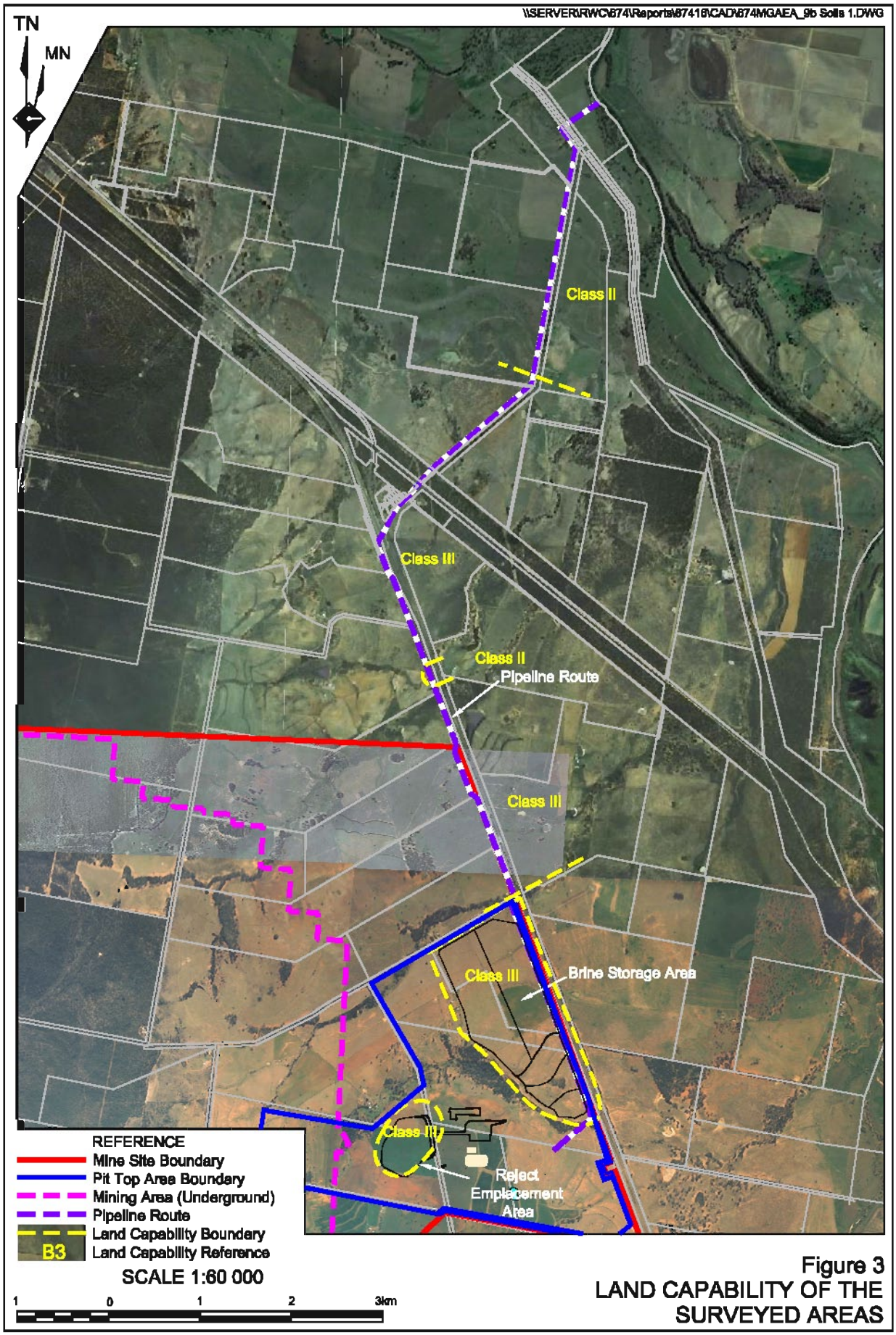

Figure 3
LAND CAPABILITY OF THE SURVEYED AREAS

The proposed Pipeline Route also traverses mainly **Class III** lands from the Mine to a point northeast of Turrawan where it enters the **Class II** lands associated with the Namoi River floodplain.**Class II** land *is land suitable for regular cultivation. It requires the use of soil conservation practices such as strip cropping, conservation tillage and adequate crop rotation to maintain its fertility and stability*.

Class III land *is land that is suitable for regular cultivation but requires construction of **s**tructural soil conservation works such as graded banks, waterways and diversion banks, together with soil conservation practices such as conservation tillage and adequate crop rotation.*

13.1.3 Current Assessment

13.1.3.1 Proposed Reject Emplacement Area

After field assessments during the soil survey, it is evident that this area is Class III land.

13.1.3.2 Proposed Brine Storage Area

After field assessments during the soil survey, it is evident that this area is Class III land.

13.1.3.3 Proposed Pipeline Route

After field assessments during the soil survey, it is evident that this Route passes through both Class II and Class III lands as indicated by the existing Land Capability Mapping.

13.2 Agricultural Land Suitability Classification

13.2.1 I&INSW - Agriculture Assessment

Information supplied by NSW Department of Primary Industries [Agriculture] at Orange indicates that the Department has classified the some of the lands along the proposed pipeline route 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 3** land over the Reject Emplacement Area and mainly **Class 3** land with a small area of **Class 4** land on the proposed Brine Storage Area (see **Figure 4**).

The proposed Pipeline Route runs through mainly **Class 3** and **Class 4** land until close to the Namoi River where it passes through a small section of **Class 2** land (see **Figure 4**).

These Agricultural Land Suitability classes are described as follows:

- **Class 2** – 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.

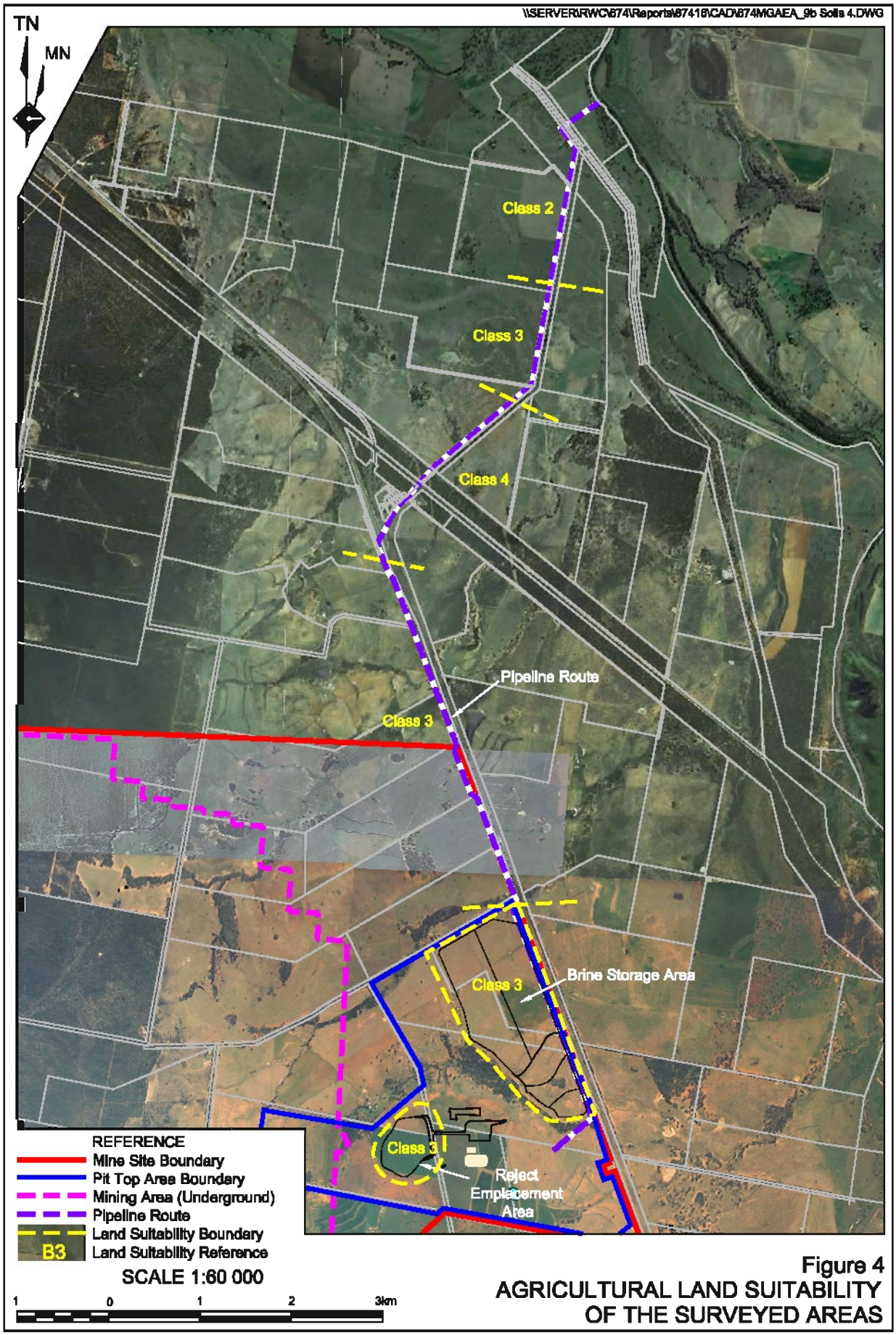

Figure 4
AGRICULTURAL LAND SUITABILITY OF THE SURVEYED AREAS

- **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]'.

13.2.2 Current Assessment

13.2.2.1 Proposed Reject Emplacement Area

After field assessments during the soil survey, it is evident that this area is Class 3 land.

13.2.2.2 Proposed Brine Storage Area

After field assessments during the soil survey, it is evident that this area is mainly Class 3 land with a small area of Class 4 land..

13.2.2.3 Proposed Pipeline Route

After field assessments during the soil survey, it is evident that this Route passes through mainly Class 3 and Class 4 and a small area of Class 2 lands as indicated by the existing Agricultural Land Suitability Mapping.

After field inspection during the soil survey, it is evident that, the I&INSW assessment of the agricultural land suitability of the Study Area is generally correct.

14 POST-DISTURBANCE LAND CAPABILITY AND AGRICULTURAL LAND SUITABILITY

14.1 Land Capability

14.1.1 Proposed Reject Emplacement Area

Given that this area would have a very different landform to that which currently exists. The rehabilitated emplacement would have sloping batters and a top surface with a series of drainage channels to remove rain water quickly to minimize infiltration below the capping material.

The Land Capability of the rehabilitated former Reject Emplacement Area would be Class VI.

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

14.1.2 Proposed Brine Storage Area

It is proposed that this area would be returned to its former landform as much as possible by replacing the subsoil and topsoils after decommissioning. However, there will be an expansion in volume of soil material associated with the earthmoving activity and it is likely that the land surface may well be more undulating than it now is.

The probable Land Capability of the rehabilitated Brine Storage Area would be Class V.

Class V land is land suitable for grazing with occasional cultivation and which requires structural soil conservation works such as absorption banks, diversion banks and contour ripping and conservation practices such as pasture improvement, stock control, application of fertiliser and minimal cultivation for the establishment or re-establishment of permanent pasture.

14.1.3 The Proposed Pipeline Route

The Land Capability of the Pipeline Route is unlikely to change as a result of the disturbance associated with the laying of the proposed pipeline and so will remain the same as outlined in the current assessment.

14.2 Agricultural Land Suitability

14.2.1 Proposed Reject Emplacement Area

Given that this area would have a very different landform to that which currently exists. The rehabilitated emplacement would have sloping batters and a top surface with a series of drainage channels to remove rain water quickly to minimise infiltration below the capping material.

The Agricultural Land Suitability of the rehabilitated former Reject Emplacement Area would be Class 5.

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'*.

14.2.2 Proposed Brine Storage Area

It is proposed that this area would be returned to its former landform as much as possible by replacing the subsoil and topsoils after decommissioning. However, there will be an expansion in volume of soil material associated with the earthmoving activity and it is likely that the land surface may well be more undulating than it now is.

The probable Land Capability of the rehabilitated Brine Storage Area would be Class 3.

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*'.

14.2.3 The Proposed Pipeline Route

The Agricultural Land Suitability of the Pipeline Route is unlikely to change as a result of the disturbance associated with the laying of the proposed pipeline and so will remain the same as outlined in the current assessment.

15 ADDRESSING THE DIRECTOR-GENERAL'S REQUIREMENTS

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

Table 16 lists the issues and indicates the section of this study where each issue is addressed.

Table 16
Director-General's Requirements

Government Agency	Paraphrased Requirement	Relevant Section
NCMA	Land use change and post-mining land use	Section 14
DPI	Details of post-mining land use	Section 14
DoP	Potential soil erosion	Sections 10 & 11

16 CONCLUSION

The soils of the proposed Reject Emplacement Area, Brine Storage Area at the Narrabri Coal Mine have been sampled and subjected to field and laboratory testing.
Similarly the soils along the proposed Pipeline Route from the Namoi River to the Narrabri Coal Mine have been sampled and filed and laboratory analysed.

A single soil mapping unit [SMU R1] was identified at the proposed Reject Emplacement Area while at the proposed Brine Storage Area there were three soil mapping units identified [SMUs B1, B2, B3].

Samplng along the proposed Pipeline Route revealed a further three soil mapping units [SMU P1, P2, P3].

In all, forty soil profiles were excavated and described and the horizons analysed to provide data on their physical and chemical properties. Five of these profiles were at the proposed Reject Emplacement Area site, twenty two within the proposed Brine Storage Area and thirteen along the proposed Pipeline Route.

Laboratory analyses were undertaken on samples from all horizons in all profiles from the proposed Reject Emplacement and Brine Storage Areas. This is a departure from normal procedures as usually only a representative proportion of samples would be analysed.

The additional analyses were undertaken at the request of Narrabri Coal Operations Pty Limited to ensure that the Company was fully briefed on the physical and chemical properties of the soils in these critical areas.

Soil stripping, storage and handling recommendations have been provided for all SOIL Mapping Units on the proposed Reject Emplacement and Brine Storage Areas.

As the proposed Pipeline Route soils would be replaced quickly after trench excavation, pipelaying and trench refilling, stripping recommendations as such were not provided. Instead, guidance on management of the soil materials during and after excavation and during refilling of the trench have been addressed.

Assessments of the erodibility of the soil mapping units identified within the proposed Reject Emplacement Area, Brrine Storage Area and Pipeline Route have been undertaken using the SOILOSS computer model. Results of the assessments have been provided.

The current Land Capability and Agricultural Suitability classifications for the land proposed to be disturbed have been provided as follows:

- proposed Reject Emplacement Area [Class III Land Capability; Class 3 Agricultural Land Suitability];
- proposed Brine Storage Area [Class III Land Capability; Classes 3 and 4 Agricultural Land Suitability]; and
- proposed Pipeline Route [Classes II and III Land Capability; Classes 2, 3 and 4 Agricultural Land Suitability].

In addition an assessment of the likely land classifications for the post-disturbance landscapes has been undertaken. The assessment is summarized as follows:

- proposed Reject Emplacement Area [Class VI Land Capability; Class 3 Agricultural Land Suitability];
- proposed Brine Storage Area [Class III Land Capability; Class 3 Agricultural Land Suitability]; and
- proposed Pipeline Route [Classes II and III Land Capability; Classes 2, 3 and 4 Agricultural Land Suitability] – unchanged.

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Appendix 1

Reject Emplacement Soil Profile Descriptions from Backhoe Test Pits - Field Descriptions

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Profile R1 [SMU R1] - *lower to mid-slope location; surface condition loose;some rounded and angular surface stone 5-15cm present;*

0-12cm - light to medium clay; many roots; no lime present; no manganese present; pH 6.5; some angular gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/4] dry, dark reddish brown]5YR3/3] moist; peds rough- / smooth faced, moderately pedal [50%], polyhedral, <5-10 mm in size; very firm consistence dry; slightly hydrophobic; *abrupt to:-*

12-43cm - heavy clay; roots common; scattered lime nodules present; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; dark reddish brown [5YR3/3] dry, dark reddish brown [5YR3/2] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

43-102cm - medium to heavy clay; few roots; many lime nodules present; no manganese present; pH 9.5/10; 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, 5-10 mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

102-250cm - gritty light to medium clay; few roots; scattered lime nodules present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; red [2.5YR4/6] dry, weak red [10R4/4] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral,<5-10 mm in size; very strong consistence dry; not hydrophobic.

Profile R2 [SMU R1] - *midslope location; surface condition self mulching and cracked; medium amounts of rounded / angular surface stone 2-10cm and up to 50cm x 30cm present*

0-20cm - medium clay; roots common; no lime visible; no manganese present; pH 8.0; some angular gravel to 2cm;not mottled; not bleached; dark reddish brown [2.5YR3/4] dry, dark reddish brown [2.5YR3/3] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, 5-10mm in size; very strong consistence dry; not hydrophobic; *abrupt to:-*

20-57cm - medium to heavy clay; roots common; no lime visible; no manganese present; pH 8.5; some angular gravel to 2cm; not mottled;not bleached; dark reddish brown 5YR3/3] dry; dark reddish brown [2.5YR3/4] moist, peds smooth-faced, highly pedal [100%], polyhedral, 5-15mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

57-110cm - medium to heavy clay; few roots;no lime visible; no manganese present; pH 9.0; some angular gravel to 2cm; not mottled; not bleached; red [2.5YR4/6] dry, red [2.5YR4/6] moist; massive, fabric rough / smooth, very strong coherence dry; not hydrophobic; *gradual to:-*

110-146cm - gritty medium clay; few roots; no lime visible; no manganese present; pH 9.5-10; mainly angular gravel to 3cm, floaters to 30x50cm ; not mottled; not bleached;red [2.5YR5/6] dry, red [2.5YR4/6] moist; massive, fabric rough / smooth, very strong coherence dry; not hydrophobic; *diffuse to:-*

146-250cm - sandy clay loam [indurated]; few roots; no lime visible; no manganese present; pH 9.5-10; mainly stone 5 - 10 - 15cm; not mottled; not bleached; very pale brown [10YR7/4] dry, yellowish brown [10YR5/4] moist; massive, fabric rough / smooth, very strong coherence dry; not hydrophobic.

Profile R3 [SMU R1] - *mid-slope location;surface condition self mulching and cracked; large amounts of angular surface stone to 10cm present*

0-18cm - light to medium clay; many roots; no lime present; no manganese present; pH 6.0; much angular gravel to 3cm; not mottled; not bleached; dark reddish brown [2.5YR3/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, <5-10 mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

18-79cm - light to medium clay; roots common; no lime present; no manganese present; pH 6.0; much angular gravel to 1-2cm; not mottled; not bleached; reddish brown [2.5YR2.5/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

79-150cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 6.5; scattered lenses of angular gravel to 8cm; not mottled; not bleached; dark red [2.5YR3/6] dry, dark red [2.5YR3/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; very firm consistence dry;not hydrophobic; *gradual to:-*

150-250cm - sandy loam; roots absent; no lime present; no manganese present; pH 7.0; layer of larger angular stones 20x15cm with gravel and soil between; not mottled; not bleached; red [2.5YR4/6] dry, reddish brown [5YR4/4] moist;massive, fabric rough / smooth, very firm coherence dry; not hydrophobic.

Profile R4 [SMU R1 - *mid-slope location; surface condition soft; large amounts of rounded / angular surface stone 2 to 10cm present;*

0-25cm - light to medium clay; many roots; no lime present; no manganese present; pH 5.5; much angular gravel to 2cm; not mottled; not bleached; dark reddish brown [5YR3/4] dry, dark reddish brown [5YR3/3] moist; peds rough-faced, moderately pedal [60%], polyhedral, <5-10 mm in size; very strong consistence dry; not hydrophobic; *abrupt to:-*

25-77cm - heavy clay; few roots; no lime present; no manganese present; pH 7.5; much angular gravel to 3cm; not mottled; not bleached; dark reddish brown [5YR3/3] dry, reddish brown [5YR4/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

77-140cm - heavy clay; few roots; no lime visible; no manganese present; pH 9.0; much small angular gravel to 1cm; not mottled; not bleached; dark red [2.5YR3/6] dry, dark red [2.5YR3/6] moist; peds smooth-faced, highly pedal [100%], polyhedral,
<5-10 mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

140-220cm - medium clay; roots absent; some lime flecks present; no manganese present; pH 9.0; much rock with gravel to 1cm; not mottled; not bleached; brown [7.5YR5/4] dry, strong brown [7.5YR5/6] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-10 mm in size; very strong consistence dry; not hydrophobic; *diffuse to:-*

220-250cm - decomposing rock with crystalline quartz stones to 10-15cm; roots absent; not sampled.

Profile R5 [SMU R1] - *midslope location; surface condition cracked; medium to high amounts of rounded and angular surface stone 2-10cm present*

0-10cm - medium to heavy clay; many roots; no lime present; no manganese present; pH 6.0; much gravel to 1cm; not mottled; not bleached; dark brown [7.5YR3/4] dry, very dark

brown [7.5YR2.5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; very strong consistence dry; not hydrophobic; *abrupt to:-*

10-47cm - heavy clay; few roots; no lime present; no manganese present; pH 7.0; much round and angular gravel to 10cm; not mottled; not bleached; dark brown [7.5YR3/3] dry, dark brown [7.5YR3/4] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; very strong consistence dry; not hydrophobic; *clear to:-*

47-170cm - medium to heavy clay; few roots; no lime visible; manganese stains present; pH 8.0; mainly gravel / stone / rock with soil in between; not mottled; not bleached; dark reddish brown [2.5YR3/4] dry, dark reddish brown [2.5YR3/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral / platy, <5 mm in size; very strong consistence dry; not hydrophobic

170+ cm;bedrock

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Appendix 2

Water Pipeline Soil Profile Descriptions from Backhoe Test Pits - Field Descriptions

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Profile P1 [SMU P2] - *crest location; surface condition soft; surface stone absent*

0-30cm - light to medium clay; many roots; no lime present; no manganese present; pH 6.5; some small gravel and some rounded stone to 10cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough- faced, highly pedal [100%], polyhedral, <5-10mm in size; firm consistence dry; not hydrophobic; *clear to:-*

30 - 82cm - medium to heavy clay; roots common; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

82-179cm - sandy clay loam; few roots; no lime visible; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20 mm in size; very firm consistence dry; not hydrophobic; *gradual to:-*

179-290cm - sandy clay loam; few roots; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; strong brown [7.5YR4/6] dry, dark yellowish brown 10YR4/4] moist; massive, fabric rough, firm coherence dry; not hydrophobic.

Profile P2 [SMU P2] - *floodplain location; surface condition self mulching and racked; surface stone absent*

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

15-92cm - medium to heavy clay; few roots; lime flecks present; no manganese present; pH 9.5-10; gravel and stones absent; not mottled; not bleached; brown [7.5R4/2] dry, brown [7.5R4/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; very firm consistence dry; not hydrophobic; *gradual to:-*

92-180cm - heavy clay; few roots; lime flecks present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; very strong consistence dry; not hydrophobic;

Profile P3 [SMU P2] - *depression location; surface condition firm; some small surface gravel present*

0-20cm - medium clay; many roots; no lime present; no manganese present; pH 6.5; some small angular gravel; not mottled; not bleached; brown [7.5YR4/3] dry, dark brown [7.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; hydrophobic; *clear to:-*

20-82cm - heavy clay; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

82-180cm - medium clay; few roots; no lime visible; no manganese present; pH 8.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P4 [SMU P3] - *lower slope location; surface condition firm; surface stone absent*

0-16cm - sandy clay loam; many roots; no lime present; no manganese present; pH 5.5; some small rounded gravel to 2cm; not mottled; not bleached; brown [7.5YR5/3] dry, black [5YR2.5/2] moist; massive, fabric rough, very firm coherence dry; not hydrophobic; *abrupt to:-*

16-62cm - medium to heavy clay; roots common; no lime present; no manganese present; pH 9.5/10; some small rounded gravel to 2cm; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

62-100cm - medium clay; roots common; occasional lime nodules present; some manganese concretions present; pH 9.5/10; some angular gravel to 1cm; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

100-170cm - medium to heavy clay; few roots; many lime nodules present; no manganese present; pH 9.5/10; some rounded and angular gravel; not mottled; not bleached; yellowish brown [10YR5/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P5 [SMU P3] - *upper slope location; surface condition soft; surface stone absent*

0-24cm - sandy clay loam; many roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/4] moist; massive, fabric rough, very weak coherence dry; not hydrophobic; *sharp to:-*

24-39cm - clayey sand; roots common; no lime present; no manganese present; pH 6.0; some gravel to 5mm; not mottled; bleached; pink [7.5Yr7/3] dry, brown [7.5YR5/4] moist; massive, fabric rough, very firm coherence dry; not hydrophobic; *sharp to:-*

39-103cm - light to medium clay; few roots; no lime visible; flecks of manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; light brown [7.5R6/4] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

103-200cm - medium to heavy clay; few roots; zone of lime nodule accumulation; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not leached; brown [10YR5/3] dry, light yellowish brown [10YR6/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; very firm consistence dry; not hydrophobic.

Profile P6 [SMU P2] - *depression location; surface condition self mulching and cracked; surface stone absent*

0-22cm - medium clay; many roots; no lime present; no manganese present; pH 6.5; round and angular gravel to 5-8cm; not mottled; not bleached; dark reddish brown [5YR3/5] dry, dark reddish brown [5YR2.5/2] moist; peds rough- / smooth-faced, highly pedal [100%], olyhedral, <5-15 mm in size; very strong consistence dry; not hydrophobic; *abrupt to clear to:-*

22-107cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 6.5; some rounded and angular gravel to 3cm; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; very strong consistence dry; not hydrophobic; *gradual to:-*

107-180cm - heavy clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; mottled; not bleached; 80% brown [7.5YR5/3, 20% brown [7.5YR4/2] dry, 80% brown [7.5YR5/3, 20% brown [7.5YR4/2] moist; peds smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; very strong consistence dry; not hydrophobic.

Profile P7 [SMU P3] - *lower slope location; surface condition hard setting; surface stone absent*

0-11cm - sandy clay loam; many roots; no lime present; no manganese present; pH; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry,dark brown [7.5YR3/3] moist; massive, fabric rough, weak coherence dry; slightly hydrophobic; *clear to:-*

11-30cm - light to medium clay; many roots; no lime present; no manganese present; pH; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; firm consistence dry; not hydrophobic; *clear to:-*

30-59cm - medium clay; few roots; no lime present; some manganese concretions present; pH; 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, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

59-100cm - medium to heavy clay; few roots; no lime present; no manganese present; pH; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

100-180cm - medium to heavy clay; few roots; no lime present; manganese stains present; pH; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P8 [SMU PP1] - *depression location; surface condition hardsetting; surface stone absent*

0-22cm - sandy loam; many roots;no lime present; no manganese present; pH 6.0; some round gravel to 2cm; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR4/3] moist; massive, fabric rough, weak coherence dry; not hydrophobic; *abrupt to:-*

22-74cm - clayey sand; roots common; no lime present; no manganese present; pH 6.0; round and angular gravel to 5-10cm present; not mottled; not bleached; brown [7.5YR5/3] dry,

dark brown [7.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; weak consistence dry; not hydrophobic; *clear to:-*

74-111cm - clayey sand; few roots; no lime present; no manganese present; pH 6.0; layer of rounded gravel, some waterwashed; not mottled; not bleached; brown [7.5YR4/3] dry, reddish brown [5YR4/3] moist; massive, fabric rough, strong coherence dry; not hydrophobic; *clear to:-*

111-150cm - medium clay; few roots; no lime present; some manganese stains present; pH 7.5; gravel and stones absent; mottled; not bleached; 95% pale brown [10YR6/3], 5% yellowish brown [10YR5/6] dry, 95% brown [10YR5/3], 5% strong brown [7.5YR4/6] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

150-210cm - indurated sand; few roots; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; pale brown [10YR6/3] dry, yellowish brown [19YR5/4] moist; massive, fabric rough, very strong coherence dry; not hydrophobic.

Profile P9 [SMU P3] - *crest location; surface condition soft; surface stone absen;*

0-19cm - clayey sand; many roots; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, very dark brown [7.5YR2.5/3] moist; massive, fabric rough / smooth, slightly hydrophobic; *abrupt to:-*

19-41cm - clayey sand; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; pinkish grey [5YR6/2] dry, dark reddish grey [5YR4/2] moist; massive, fabric rough / smooth, not hydrophobic; *abrupt to:-*

41-60cm - light to medium clay; few roots; no lime visible; no manganese present; pH 9.0; some round and angular gravel to 2cm;not mottled; not bleached; yellowish brown [10YR5/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

60-135cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 7.5; gravel and stones absent; mottled; not bleached; 95% brown [10YR5/3], 5% brownish yellow [10YR6/8] dry, 95% pale brown 10YR6/3], 5% strong brown [7.5YR5/6 moist; peds rough- / smooth faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

135-180cm - medium clay; few roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; mottled; not bleached; 95% brown [10YR5/3], 5% brownish yellow [10YR6/8] dry, 95% pale brown 10YR6/3], 5% strong brown [7.5YR5/6 moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P10 [SMU P3] - *upper slope location; surface condition soft; surface stone absent*

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

10-31cm - sandy loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/3]

moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

31-60cm - sandy light to medium clay; many roots; no lime present; no manganese present; pH 8.0; some rounded gravel <5mm; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

60-107cm - medium to heavy clay; roots common; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

107-180cm - medium clay; roots common; many lime nodules and stains present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, pale brown [10yR6/3] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P11 [SMU P3] - *crest location; surface condition loose to firm; some surface gravel present*

0-20cm - fine sandy clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/4] moist; massive, fabric rough, very firm coherence dry; not hydrophobic; *abrupt to:-*

20-50cm - medium to heavy clay; many roots; no lime present; some manganese stains and concretions present; pH 7.5; gravel and stones absent; not mottled; not bleached; dark reddish brown [2.5YR3/3] dry, dark brown [7.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

50-140cm - medium clay; few roots; lime concretions present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; strong brown [7.5YR4/6] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

140-180cm - medium to heavy clay; few roots; major zone of lime accumulation, many nodules present; some manganese stains present; pH 9.5/10; some angular gravel to 4cm; mottled; not bleached; 50% brown [7.5YR5/4], 50% pale brown [10YR6/3] dry, 50% pale brown [10YR6/3], 50% light brownish grey [2.5Y6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P12 [SMU P3] - *level area on crest location; surface condition firm; surface stone absent*

0-10cm - fine sandy clay loam; roots common; no lime present; no manganese present; pH 4.5; some rounded and angular gravel to 1cm; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/4] moist; massive, fabric rough / smooth, firm coherence dry; slightly hydrophobic; *sharp to:-*

10-50cm - medium clay; few roots; no lime present; no manganese present; pH 6.0; some small angular gravel to 5mm; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish

brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

50-117cm - medium to heavy clay; few roots; occasional scattered flecks and nodules of lime present; some manganese stains present; pH 9.5/10; some small rounded gravel to 5mm; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral / platy, 5-15mm in size; strong consistence dry; not hydrophobic; *clear to:-*

117-190cm - heavy clay; few roots; major zone of lime nodules; some small manganese nodules present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth- faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic.

Profile P13 [SMU P1] - *drainage line location; surface condition firm; surface stone absent*

0-10cm - clayey sand; roots common; no lime present; no manganese present; pH 6.0; much angular gravel to 1cm; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; massive, fabric rough, very firm coherence dry; hydrophobic; *abrupt to:-*

10-32cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; odd small gravel to 5mm; not mottled; not bleached; brown [7.5YR4/3] dry, dark brown [7.5YR3/3] moist; peds rough-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *abrupt to:*

32-60cm - clayey sand; few roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; bleached; pink [7.5YR7/3] dry, brown [7.5YR4/4] moist; massive, fabric rough / smooth, firm coherence dry; not hydrophobic; *abrupt to:*

60-110cm - gritty light clay; few roots; no lime present; no manganese present; pH 6.0; some gravel fragments to 1cm; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

110-180cm - gritty medium clay; few roots; no lime visible; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, brown [10YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; strong consistence dry; not hydrophobic.

Appendix 3

Brine Storage Area Soil Profile Descriptions from Backhoe Test Pits - Field Descriptions

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Profile B1 [SMU B3]- *level plain location; surface condition loose; surface stone absent*

0-25cm - sandy clay loam; roots common; no lime present; no manganese present; pH 5.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, dark brown [7.5YR3/3] moist; massive; fabric rough; firm coherence dry; not hydrophobic; *clear to:-*

25-40cm - clayey sand; many roots; no lime present; no manganese present; pH 6.0; some small rounded gravel to 5mm; not mottled; bleached; pinkish grey [7.5YR7/2] dry, brown [7.5YR5/4] moist; massive; fabric rough; firm coherence dry; not hydrophobic; *sharp to:-*

40-66cm - medium clay; few roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; yellow [10YR5/4] dry, yellow [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

66-120cm - medium clay; few roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; mottled; not bleached; 90% very pale brown [10YR7/3], 10%yellowish red [10YR5/6] dry, 90% pale brown [10YR6/3], 10% yellowish red [10YR5/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

120-250cm - medium clay; few roots; many lime nodules present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, pale brown [10YR6/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic.

Profile B2 [SMU B2] - *level plain location; surface condition firm;surface stone absent*

0-40cm - sandy loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; light yellowish brown [10YR6/4] dry, dark yellowish brown [10YR4/4] moist; peds rough- faced, weakly pedal [15%], polyhedral, 5-15 mm in size; weak consistence dry; not hydrophobic; *gradual to:-*

40-110cm - clayey sand; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; bleached; light grey [10YR7/2] dry, brown [7.5YR5/3] moist; massive; fabric rough; firm coherence dry; not hydrophobic; *abrupt to:-*

110-250cm - fine sandy clay loam; few roots; no lime visible; no manganese present; pH 8.0; gravel and stones absent; not mottled; not bleached; brownish yellow 10YR6/6] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-15 mm in size; firm consistence dry; not hydrophobic.

Profile B3 [SMU B3] - *level plain location; surface condition loose;surface stone absent*

0-23cm - sandy loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; strong brown [7.5YR4/6] dry, dark brown [7.5YR3/4] moist; peds rough-faced, weakly pedal [10%], polyhedral, 5-10 mm in size; weak consistence dry; not hydrophobic; *abrupt to:-*

23-72cm - sandy light clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; mottled; not bleached; 70% reddish brown [2.5YR4/4], 30%light reddish brown [5YR6/3] dry, 70% reddish brown [2.5YR5/4], 30% light reddish brown [5YR6/3 moist;

peds rough-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

72-114cm - heavy clay; few roots; no lime visible; manganese stains present; pH 9.0; gravel and stones absent; not mottled; not bleached; yellowish red [5YR5/6] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral / platy, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

114-174cm - heavy clay; few roots; no lime visible; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; strong brown [7.5YR5/6] dry, strong brown [7.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral / platy, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

174-260cm - sandy clay loam; few roots; no lime visible; no manganese present; pH 9.5/10; some angular gravel to 5cm; not mottled; not bleached; light brown [7.5YR6/4] with light grey staining dry, strong brown [7.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [90%], polyhedral, up to 5 mm in size; very firm consistence dry; not hydrophobic.

Profile B4 [SMU B3] - *level plain location; surface condition firm; some water worn and rounded / angular surface stone present*

0-20cm - fine sandy clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/4] moist; peds rough-faced, highly pedal [80%], polyhedral, 10-15 mm in size; weak consistence dry; not hydrophobic; *abrupt to:-*

20-64cm - heavy clay; few roots; no lime visible; some manganese stains present; pH 9.0; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

64-106cm - medium to heavy clay; few roots; scattered lime stains present; some manganese stains present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; reddish brown [5YR5/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

106-192cm - heavy clay; roots absent; many large lime nodules present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brownish yellow [10YR6/6 dry, dark yellowish brown [10YR4/6] moist; massive, rough / smooth fabric, strong coherence dry; not hydrophobic; *gradual to:-*

192-250cm - heavy clay; roots absent; many large lime nodules present; some manganese concretions present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; reddish brown [7.5YR5/4] dry, dark brown [7.5YR3/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral / platy, <5-10 mm in size; strong consistence dry; not hydrophobic.

Profile B5 [SMU B3] - *level plain location; surface condition firm; surface stone absent*

0-24cm - sandy clay loam; roots common; no lime present; no manganese present; pH 4.5; rounded and angular gravel to 5mm present; not mottled; not bleached; brown [7.5YR4/4] dry, dark reddish brown [2.5YR3/3] moist; massive, rough fabric, weak coherence dry; not hydrophobic; *abrupt to:-*

24-39cm;gritty medium to heavy clay; few roots; no lime present; no manganese present; pH 6.0; some rounded gravel to 1cm; not mottled; not bleached; brown [7.5YR5/4] dry, brown 7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

39-75cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; mottled; not bleached; 50% strong brown [7.5YR5/6], 50% red [10YR4/6] dry, 50% strong brown [7.5YR4/6], 50% weak red [10R4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

75-130cm - heavy clay;roots absent; some lime concretions present; manganese stains and concretions present; pH 9.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

130-250cm - sandy light clay; roots absent; some lime concretions present; no manganese present; pH 9.5/10; decomposing rock; not mottled; not bleached; light yellowish brown [10YR6/4] dry, yellowish brown [10YR5/4] moist; massive, fabric rough, strong coherence dry; not hydrophobic.

Profile B6 [SMU B3] - *level plain location; surface condition hardsetting; surface stone absent*

0-34cm - sandy clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, dark brown [10YR3/3] moist; massive, fabric rough, firm coherence dry; not hydrophobic; *clear to:-*

34-81cm - gritty medium to heavy clay; roots common; no lime present; no manganese present; pH 4.5; gravel and stones absent; not mottled; not bleached; brownish yellow [10YR6/6] dry, dark yellowish brown [10YR4/6] moist; peds rough-faced, highly pedal [80%], polyhedral, 5-20 mm in size; weak consistence dry; not hydrophobic; *gradual to:-*

81-160cm - medium clay; few roots; no lime present; no manganese present; pH 5.5; rounded and angular decomposing gravel to 4cm; not mottled; not bleached; brownish yellow [10YR6/6] dry, yellowish brown [10YR5/6] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-20 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

160-260cm - medium to heavy clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; mottled; not bleached; 60% brownish yellow [10YR6/6], 40% light brownish grey [10YR6/2] dry, 60%yellowish brown [10YR5/6], 40% light grey [10YR7/2] moist; massive, fabric smooth, strong coherence dry; not hydrophobic.

Profile B7 [SMU B1] - *crest location; surface condition firm; surface stone absent*

0-20cm - medium to heavy clay ;roots common; no lime present; no manganese present; pH 5.5; 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, 5-10 mm in size; very firm consistence dry; slightly hydrophobic; *abrupt to:-*

20-37cm - heavy clay; roots common; no lime present; no manganese present; pH 6.0; 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%], angular blocky; 10-20 mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

37-85cm - heavy clay; few roots; many lime nodules present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

85-137cm - heavy clay; roots absent; many lime nodules present present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds smooth- faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

137-250cm - medium clay; roots absent; scattered large lime nodules present; small manganese stains and concretions present; pH 9.5/10; pockets of decomposing rock exposed in base of pit; mottled; not bleached; 95% pale brown [10YR6/3], 5% reddish yellow [7.5YR6/6] dry, 95% brown [10YR5/3], strong brown [7.5YR5/6] moist; peds smooth- faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic.

Profile B8 [SMU B3] - *crest location; surface condition hardsetting and cracked; some rounded / angular surface stone to 4-10cm present*

0-15cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/4] moist; peds rough-faced, moderately pedal [50%], polyhedral, 5-15 mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

15-50cm - heavy clay;roots common; no lime visible; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; brown [7.5R4/4] dry, dark brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

50-96cm - heavy clay; few roots; many lime nodules present; no manganese present; pH 9.5/10; much round gravel to 8cm; not mottled; not bleached; reddish brown [5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

96-210cm - heavy clay; few roots; scattered lime nodules present; no manganese present; pH 9.5/10; probably decomposing rock material; mottled; not bleached; 50% light grey [10YR7/2], 50% pinkish grey [7.5YR6/2] dry, 50% light brownish grey [10YR6/2], 50% light brown [7.5YR6/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic.

Profile B9 [SMU B3] - *mid-slope location; surface condition hardsetting; medium amounts of rounded / angular surface stone 5-20cm present*

0-15cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.5; small angular and round gravel to 1-2cm present; not mottled; not bleached; brown [7.5YR4/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, moderately pedal [40%], polyhedral, 5-10 mm in size; very firm consistence dry; slightly hydrophobic; *abrupt to:-*

15-47cm - heavy clay; roots common; no lime visible; many manganese stains present; pH 9.0; rounded gravel to 2cm; not mottled; not bleached; reddish brown [5YR4/3] dry, reddish

brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

47-121cm - heavy clay;few roots; many lime concretions present; some manganese concretions present; pH 9.5/10; some scattered round and angular gravel to 4cm; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

121-260cm - medium to heavy clay; roots absent; many lime concretions present; some manganese stains present; pH 9.5/10; scattered rounded and angular gravel to 5cm; not mottled; not bleached; light brownish grey [2.5Y6/2] dry, light brownish grey [2.5Y6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile B10 [SMU B3] - *upper slope location; surface condition hardsetting; some rounded / angular surface stone 2-10cm present*

0-10cm - sandy loam; roots common; no lime present; no manganese present; pH 5.5; some rounded gravel to 1cm; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/3] moist; peds rough-faced, moderately pedal [50%], polyhedral, 10-15 mm in size; weak consistence dry; not hydrophobic; *abrupt to:-*

10-30cm - medium clay; roots common; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; reddish brown 5YR4/4] dry, reddish brown [5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-20 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

30-48cm - medium clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, yellowish brown [5YR4/6] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20 mm in size; strong consistence dry; slightly hydrophobic; *gradual to:-*

48-85cm - medium clay; few roots; some lime flecks present;no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; yellowish red [5YR4/6] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

85-154cm - heavy clay; roots absent; no lime present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry; brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

154-195cm - decomposing rock - not sampled.

Profile B11 [SMU B1] - *crest location; surface condition firm;some rounded / angular surface stone to 10cm present*

0-10cm - medium clay; roots common; no lime present; no manganese present; pH 6.5; occasional angular gravel <5mm; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/2] moist; peds rough- faced, moderately pedal [70%], polyhedral, 5-10 mm in size; firm consistence dry; not hydrophobic; *abrupt to:-*

10-31cm - medium clay; roots common; no lime visible; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; dusky red [10R3/2] dry, dusky red [10R3/2] moist; peds rough- / smooth-faced, highly pedal [100%], angular blocky; 15-20 mm in size; strong consistence dry; not hydrophobic; *abrupt to:-*

31-102cm - heavy clay; few roots; many lime stains and nodules present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; reddish brown [2.5YR5/4] dry, reddish brown [2.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; very firm consistence dry; not hydrophobic; *clear to:-*

102-191cm - heavy clay; roots absent; no lime present; some manganese stains present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

191-250cm - medium clay; roots absent; no lime present; no manganese present; pH 4.5; gravel and stones absent; mottled; not bleached; 50% yellowish red [5YR4/6],. 50% light grey [10YR7/2] dry, 50% yellowish red [5YR4/6], 50% pinkish grey [7.5YR6/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-15 mm in size; strong consistence dry; not hydrophobic.

Profile B12 [SMU B3] – *lower slope / depression location; surface condition firm; some rounded / angular surface stone 2-5cm present*

0-16cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; some rounded gravel to 1.5cm; not mottled; not bleached; reddish brown [5YR4/3] dry, dark reddish brown [5YR3/3] moist; peds rough- faced, moderately pedal [50%], polyhedral, 5-10 mm in size; weak consistence dry; not hydrophobic; *abrupt to:-*

16-61cm - heavy clay; few roots; scattered lime nodules present; no manganese present; pH 9.5/10; 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, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

61-107cm - heavy clay; few roots; no lime present; some manganese stains present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, reddish brown [5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

107-180cm - heavy clay; roots absent; no lime visible; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; light brown [7.5YR6/4] dry, light brown [7.5YR6/4] moist; peds rough- / smooth-faced, highly pedal 100%], polyhedral, <5-10 mm in size; very firm consistence dry; not hydrophobic; *gradual to:-*

180-250cm - heavy clay; roots absent; some lime concretions present; some manganese stains present; pH 9.0; gravel and stones absent; mottled; not bleached; 60% light yellowish brown [10YR6/4], 40% brown [7.5YR5/4] dry, 60% light yellowish brown [10YR6/4], 40% brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic.

Profile B13 [SMU B3] - *depression location; surface condition soft and cracked; surface stone absent*

0-15cm - sandy clay loam; many roots; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, weakly pedal [10%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

15-38cm - sandy clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; dark reddish brown [5YR3/3] dry, dark reddish brown [5YR2.5/2] moist; peds rough-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

38-70cm - medium clay; few roots; lime nodules present; some manganese stains present; pH 9.5/10; some small angular gravel <1cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

70-160cm - medium to heavy clay; few roots; lime nodules present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; dark yellowish brown [10YR4/4] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

160-250cm - gritty heavy clay; roots absent; no lime visible; no manganese present; pH 9.0; gravel and stones absent; mottled; not bleached; 70% reddish brown [5YR5/3], 30% brown [7.5YR5/3] dry, 70% reddish brown [5YR5/3], 30% brown [7.5YR5/3] moist; massive, fabric rough, strong coherence dry; not hydrophobic.

Profile B14 [SMU B1] - *mid-slope of depression location; surface condition hardsetting and cracked; some rounded / angular surface stone to 8cm present*

0-18cm- medium clay; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/3] dry, very dark brown [7.5YR2.5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

18-50cm - medium to heavy clay; few roots; no lime visible; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; dark reddish brown [5YR3/2] dry, dark reddish brown [5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

50-99cm - medium to heavy clay; few roots; some lime concretions present; manganese stains present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; reddish brown [5YR4/4] dry, reddish brown [2.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

99-170cm - heavy clay; roots absent; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced,highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

170-250cm - light to medium clay; roots absent; no lime present; no manganese present; pH 4.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/3] moist; peds smooth-faced, highly pedal [100%], polyhedral, <5-15 mm in size; strong consistence dry; not hydrophobic.

Profile B15 [SMU B3] - *upper slope of main creek line location;surface condition firm; some rounded surface stone to 5cm present*

0-16cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/3] moist; massive, fabric rough, weak coherence dry; not hydrophobic; *sharp to:-*

16-20cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; massive, fabric rough, strong coherence dry; not hydrophobic; *abrupt to:-*

20-70cm - medium clay; roots common; no lime visible; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-20 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

70-180cm - medium to heavy clay; few roots; scattered lime concretions present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR5/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

180-210cm - sandy clay loam; roots absent; no lime visible; extensive manganese staining present; pH 8.0; gravel and stones absent; mottled; not bleached; 50% light yellowish brown [10YR6/4], 50% yellowish red [5YR5/6] dry, 50% brown [10YR5/3], 50% weak red [10R4/4] moist; massive, fabric rough, strong coherence dry; not hydrophobic.

Profile B16 [SMU B1] - *mid-slope location; surface condition hardsetting; some surface stone present, rounded, some chert;*

0-10cm - gritty light to medium clay; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [80%], polyhedral, <5-10 mm in size; weak consistence dry; slightly hydrophobic; *abrupt to:-*

10-29cm - medium clay; roots common; no lime present; no manganese present; pH 6.5; 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%], angular blocky; 10-20 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

29-63cm - medium clay; roots common; no lime visible; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; strong brown [7.5YR4/6] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

63-99cm -medium to heavy clay; few roots; some lime concretions present; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/3] with reddish tinge dry, brown [7.5YR5/3] with reddish tinge moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

99-260cm - medium to heavy clay; few roots;many lime concretions present; no manganese present; pH 9.5/10; occasional rounded gravel to 1cm; not mottled; not bleached; yellowish brown [10YR5/4] with red stains dry, yellowish brown [10YR5/4] with red stains moist; peds

rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic.

Profile B17 [SMU B3] - *mid-slope location; surface condition hardsetting; some rounded / angular surface stone to 15cm present*

0-14cm - sandy clay loam; roots common; no lime present; no manganese present; pH 6.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [5YR3/4] moist; peds rough-faced, weakly pedal [30%], polyhedral, 5-15 mm in size; very firm consistence dry; not hydrophobic; *abrupt to:-*

14-56cm;sandy medium clay; few roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [10YR5/3] dry, dark yellowish brown [10YR4/4] moist; peds rough- / smooth-faced, highly pedal [90%], polyhedral, 10-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

56-93cm - medium to heavy clay; few roots; no lime visible; no manganese present; pH 9.0; some rounded gravel to 1.5cm; not mottled; not bleached; brown [7.5YR5/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 10-20 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

93-180cm - heavy clay; few roots; scattered lime nodules present; manganese stains and small concretions common; pH 9.5/10; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20 mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

180-250cm - heavy clay; roots absent; many lime concretions present; manganese stains and small concretions common; pH 9.5/10; gravel and stones absent; not mottled; not bleached; light yellowish brown [2.5Y6/3] dry, light brownish grey [2.5Y6/2] moist; peds rough- / smooth-faced, highly pedal [100%], angular blocky; 5-20 mm in size; strong consistence dry; not hydrophobic.

Profile B18 [SMU B1] - *floodplain location; surface condition firm; some round and rounded / angular surface stone to 20cm present*

0-10cm - light clay; many roots; no lime present; no manganese present; pH 6.5; flat angular gravel to 4cm present; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR4/2] moist; massive, fabric rough, firm coherence dry; not hydrophobic; *abrupt to:-*

10-68cm - heavy clay; many roots;some lime present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

68-180cm - medium to heavy clay;few roots; no lime visible; no manganese present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, yellowish brown [10YR5/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

120-180cm - sandy clay;roots absent; no lime visible; manganese common; pH 9.5/10; layer of rounded waterwashed sandstone to 20cm present; not mottled; not bleached; brown

[7.5YR5/4] dry, brown [7.5YR5/4] moist, peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *diffuse to:-*

180-220cm - layer of waterwashed sandstone stones to 20cm.

Profile B19 [SMU B1] - *floodplain location; surface condition hardsetting; surface stone absent;*

0-16cm - silty clay; many roots; no lime present; no manganese present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, dark brown [7.5YR3/2] moist; massive, fabric rough, strong coherence dry; not hydrophobic; *abrupt to:-*

16-63cm - medium to heavy clay; many roots; no lime present; no manganese present; pH 7.5; 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, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

63-173cm - medium clay; many roots; no lime visible; no manganese present; pH 8.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, strong brown [7.5YR4/6] moist; peds rough- / smooth-faced, highly pedal [80%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

173-245cm - heavy clay; roots absent; no lime present; no manganese present; pH 9.5/10; rounded stones to 10cm present; not mottled; not bleached; strong brown [7.5YR5/6] dry, brown [7.5YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

245+cm; sandy light to medium clay; roots absent; no lime visible; no manganese present; pH 9.5/10; decomposing rock; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR4/4] moist; massive, fabric rough, very firm coherence dry; not hydrophobic.

Profile B20 [SMU B1] - *floodplain location; surface condition firm; surface stone absent;*

0-18cm - light to medium clay; many roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/2] moist; peds rough-faced, highly pedal [80%], polyhedral, 5-10 mm in size; weak consistence dry; not hydrophobic; *abrupt to:-*

18-97cm - sticky light to medium clay; many roots; scattered lime stains present; no manganese present; pH 9.0; gravel and stones absent; not mottled; not bleached;
brown [7.5YR4/2] dry, dark brown [7.5YR3/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

97-192cm - medium clay; few roots; scattered lime stains present; some small manganese concretions present; pH 9.5/10; gravel and stones absent; not mottled; not bleached; yellowish brown [10YR5/4] dry, dark yellowish brown [10YR4/4] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-20 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

192-250cm - sandy clay; roots absent; no lime visible; many manganese concretions present; pH 9.5/10; rounded water-washed gravel to 5-6cm; mottled; not bleached; 50% yellowish red [5YR4/6], 50% brown [10YR5/3] dry, 50% brown [7.5YR4/4], 50% brown [10YR5/3] moist;

peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic.

Profile B21 [SMU B3] - *floodplain location; surface condition firm; surface stone absent;*

0-12cm - clayey sand; many roots; no lime present; no manganese present; pH 5.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/3] moist; peds rough-faced, weakly pedal [20%], polyhedral, 5-10 mm in size; weak consistence dry; not hydrophobic; *abrupt to:-*

12-60cm - clayey sand; roots common; no lime present; no manganese present; pH 7.5; some rounded gravel to 2cm; not mottled; not bleached; light brown [7.5YR6/4] dry, brown [7.5YR4/4] moist; massive, fabric rough, weak coherence dry; not hydrophobic; *clear to:-*

60-87cm - clayey sand; few roots; no lime present; no manganese present; pH 7.5; angular and rounded gravel to 4cm; not mottled; not bleached; red [5YR4/6] dry, red [5YR4/6] moist; massive, fabric rough, weak coherence dry ; not hydrophobic; *clear to:-*

87-153cm - medium clay; few roots; no lime visible; many manganese stains present; pH 9.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/3] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

153-215cm - clayey sand; few roots; no lime visible; no manganese present; pH 9.5/10; some small gravel <5mm; mottled; not bleached; 90% strong brown [7.5YR4/6], 10% pale brown [10YR6/3] dry, 90% brown [7.5YR4/4], 10% greyish brown [10YR5/2] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-15 mm in size; strong consistence dry; not hydrophobic.

Profile B22 [SMU B1] - *floodplain location; surface condition hardsetting; surface stone absent*

0-14cm - medium clay; roots common; no lime present; no manganese present; pH 7.5; gravel and stones absent; not mottled; not bleached; brown [7.5YR4/4] dry, dark brown [7.5YR3/3] moist; massive, fabric rough, strong coherence dry; not hydrophobic; *abrupt to:-*

14-44cm - silty clay; roots common; 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 [5YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *clear to:-*

44-79cm - medium clay; few roots; no lime present; no manganese present; pH 7.0; gravel and stones absent; not mottled; not bleached; brown [7.5YR5/4] dry, brown [7.5YR4/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, <5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

79-197cm - medium clay; roots common; no lime present; much manganese staining present; pH 6.5; gravel and stones absent; not mottled; not bleached; brown [10YR4/3] dry, dark brown [10YR3/3] moist; peds rough- / smooth-faced, highly pedal [100%], polyhedral, 5-10 mm in size; strong consistence dry; not hydrophobic; *gradual to:-*

197-250cm - sandy medium clay [indurated]; roots absent; no lime present; no manganese present; pH 8.0; some small gravel <5mm; mottled; not bleached; 50% brown [7.5YR5/3], 50% strong brown [7.5YR4/6] dry, 50% brown [7.5YR4/2], 50% strong brown [7.5YR4/6] moist; massive, fabric rough, strong coherence dry; not hydrophobic.

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Appendix 4

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

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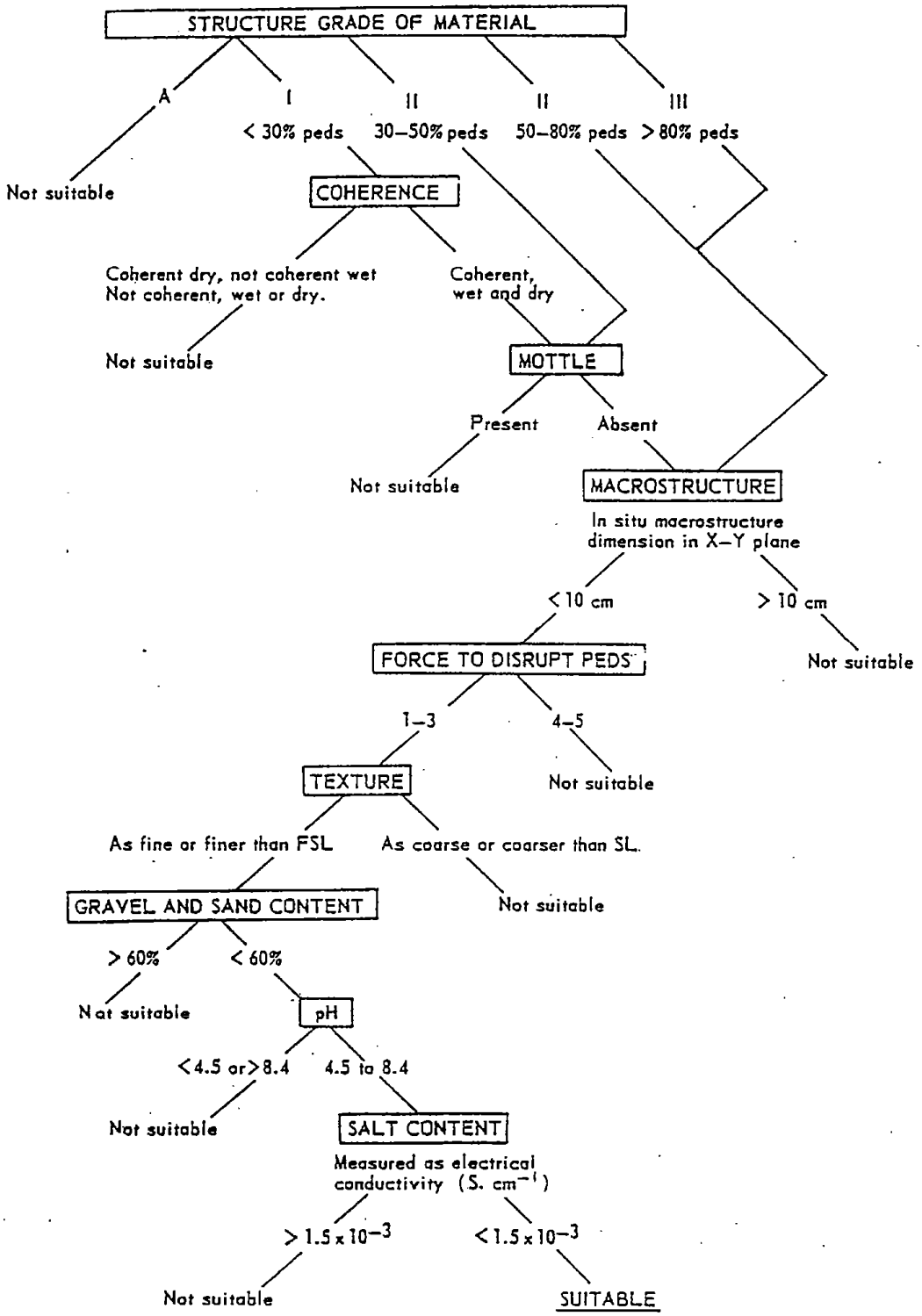
Procedure for the selection of material for use in topdressing of disturbed areas.



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