



Soil Survey and Land Resource Assessment



Appendix 6

Anvil Hill Project:

Soil Survey and Land Resource Assessment Report



Prepared for:

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GSS ENVIRONMENTAL

Environmental, Land and Project
Management Consultants

Anvil Hill Project

Soil Survey and Land Resource Assessment Report

Prepared for **Umwelt (Australia) Pty Limited**

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1.0 INTRODUCTION

1.1 Objectives

GSS Environmental (GSSE) was commissioned by Umwelt (Australia) Pty Limited (Umwelt) to undertake a land resource assessment with respect to soils and rural land capability classification for the Proposed Disturbance Area associated with the Anvil Hill Project area (hereafter referred to as the "Project Area"). As part of the proposed open-cut mining operation, the Project Area will be subject to ground disturbance resulting from mining related activities, including the construction of industrial area infrastructure (administration buildings, coal handling and preparation plant, maintenance workshops, rail load out, etc), haul roads, rail loop and open-cut pits. This area will be referred to as the Proposed Disturbance Area. The Proposed Disturbance Area is described further in **Section 1.2** of this report. A location plan is presented as **Figure 1**. To assist with management of topsoil reserves, and planning for post-mining rural land capability, a field survey of soil materials in the Proposed Disturbance Area and classification of pre-mining rural land capability was undertaken by GSSE. The major objectives of this assessment include:

1. To describe and classify soils and land capability within the Proposed Disturbance Area;
2. Analyse the identified soil units to assess their suitability for salvage and re-use as topsoil/growth media in future land rehabilitation projects; and
3. Identify any potentially adverse soil materials requiring special management during rehabilitation of post-disturbance areas.

The following report presents the results of the field survey undertaken by GSSE and the assessment of soil resources within the survey areas. A glossary of commonly used soils terms is presented in **Appendix 1**.

1.2 Location

The Project Area is located in the Upper Hunter Valley some 20 km west of Muswellbrook. The area is bounded on all sides by agricultural and grazing land and is traversed to the north by Wybong Road. The region contains extensive coal resources at depth. The nearest operating coal operation in the vicinity is Bengalla Mine (Bengalla Mining Company) approximately 12 km to the east. Other major surface land uses in the region include beef cattle grazing, vineyards and horse studs, as well as cropping and dairying along the Hunter River alluvial plains to the south.

At the time of this survey, the detailed design for the project had not been finalised; however an outline of Proposed Disturbance Area was provided by Umwelt. The Proposed Disturbance Area is approximately 5 km east to west and 6 km north to south, and encompasses approximately 2238 ha. Much of the ground surface in the Proposed Disturbance Area has been subject to grazing related disturbance, especially in the far northern, south-eastern and

south-western corners. The area was also subject to an early logging industry, which has since ceased.

1.3 Landform and Topography

The landform in the Project Area consists mainly of undulating low hills between 140 and 210 m AHD, with natural slope gradients ranging from 1 to 6%. This undulating landform is prevalent throughout all parts of the Project Area, except the far south of the proposed rail corridor, which is situated on the alluvial plain of Sandy Creek and the Hunter River. The undulating landform is interrupted by several prominent steep outcropping hills, such as Anvil Hill, in the central part of the disturbance area and Wallaby Rocks, which forms the western boundary of the Proposed Disturbance Area. The area is also bounded to the south by a similarly formed range of hills (Limb of Addy Hill).

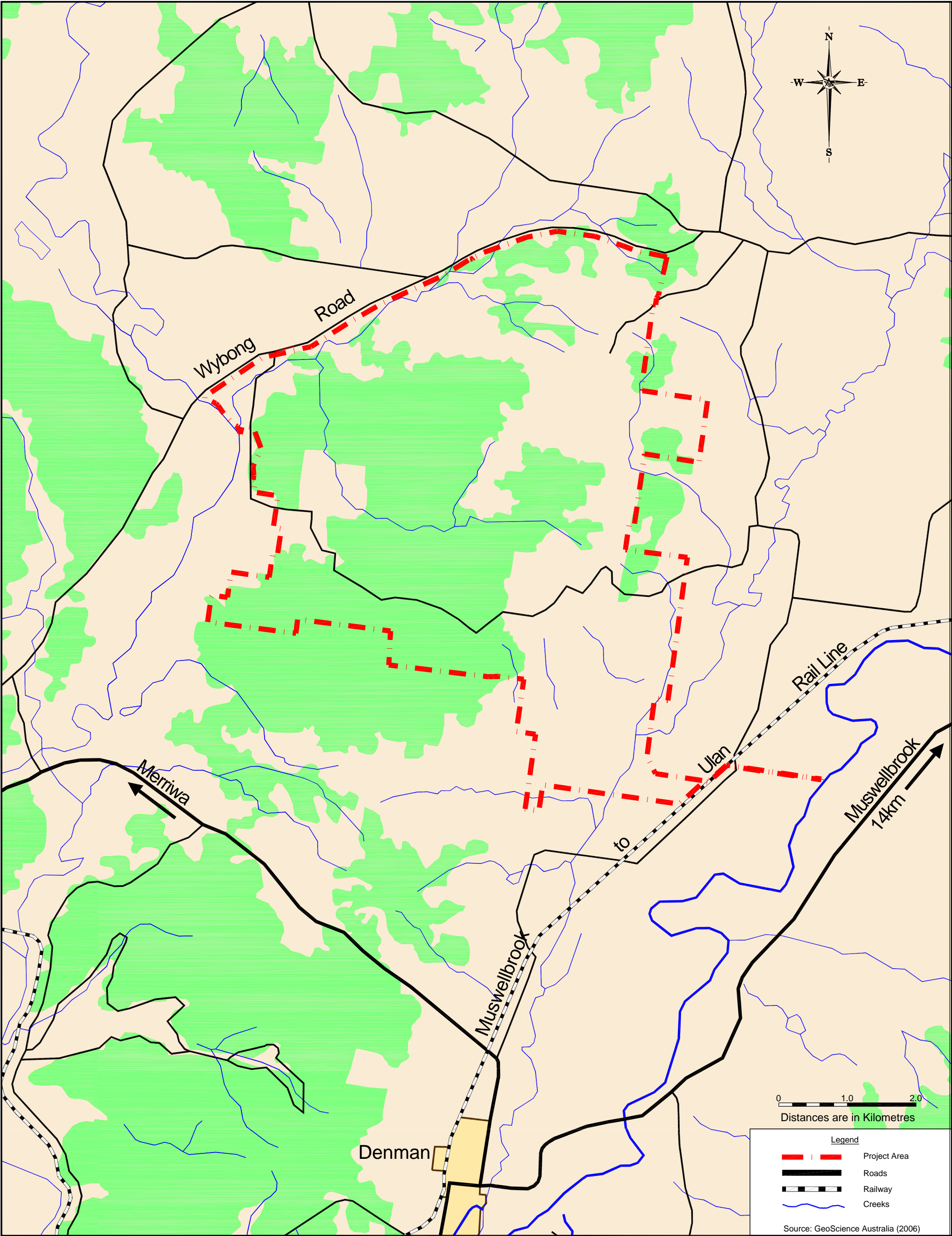
The major ephemeral stream draining the area, Big Flat Creek, traverses the northern boundary of the Project Area before flowing into Wybong Creek, which discharges into the Goulburn River. Two creeks flow westward across the survey area. Clarks Gully flows to the north of Anvil Hill and Anvil Creek to the south. The majority of the Proposed Disturbance Area is located within the Wybong Creek catchment. However, the eastern margins of the area are in a separate catchment and drain towards the south-east into Sandy Creek, which discharges into the Hunter River. Drainage lines within the survey area have been impacted by agricultural and grazing related activities, with many dams and creek crossings having been constructed and areas of gully erosion evident.

1.4 Vegetation

The majority of the vegetation within the Proposed Disturbance Area has been fragmented as a result of previous clearing for agriculture and timber extraction. The northern and eastern parts of the Proposed Disturbance Area contain examples of highly fragmented vegetation, with the central, western and southern areas being more intact. Various parts of the Proposed Disturbance Area (particularly the south eastern corner) have been almost entirely cleared, and currently exist as disturbed grassland with scattered trees. The vegetation of the Proposed Disturbance Area essentially comprises one very large remnant, together with numerous small remnants.

The general age of the vegetation within the Proposed Disturbance Area varies considerably, in response to previous clearing activities. Some areas of vegetation have been cleared (at least 67 years ago in some cases and at least 39 years ago in other areas) and then allowed to regenerate, resulting in a mosaic of regenerating vegetation of various ages, mixed with some areas of possible old-growth vegetation. Such possible old-growth vegetation is mainly located around Anvil Hill and Wallaby Rocks.

The vegetation of the Proposed Disturbance Area is dominated by woodland communities, particularly Ironbark Woodland Complex. Disturbed Grassland also dominates where previous clearing activities have permitted grazing. The riparian community Forest Red Gum Riparian Woodland is found along the major drainage channels of the Proposed Disturbance Area.



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Drawing No. ANV1-0106-09-3A

Anvil Hill Project
Locality Plan

Figure 1
Scale 1:50000

2.0 SOIL SURVEY METHODOLOGY

2.1 Introduction

A soil survey was undertaken to identify soil types, qualify the reserves of suitable topsoil material and identify soil erosion potential within the Proposed Disturbance Area. The field component of the survey was conducted during June 2005.

2.2 Mapping

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

1) Aerial photographs and topographic maps

Aerial photo and topographic map interpretation was used as a remote sensing technique, allowing detailed analysis of the landscape and mapping of features related to the distribution of soils within the survey areas.

2) Previous soil survey results

A survey of the region (including the areas surveyed in this assessment) was undertaken by Kovac and Lawrie (1991) at a scale of 1:250,000. The survey map and report present a broadscale guide to the soil and landscape unit distribution in the upper Hunter Valley Region, and provide a framework for more detailed surveys.

An unpublished soil survey conducted by a member of the local catchment management group (Hogan, unpublished) of an area that largely overlaps with the Anvil Hill Project Area was also reviewed. This survey was based on field investigations conducted by Hogan and by NSW Soil Conservation Service staff. The survey assessed soil unit distribution at a more detailed scale and was referenced as baseline information on geology and soil units most likely to be encountered within the Proposed Disturbance Area.

The alluvial materials associated with the major creeklines within the Proposed Disturbance Area were mapped on behalf of Umwelt, as part of a recent groundwater investigation (Mackie Environmental Research, 2006). The alluvial boundaries identified during this investigation were considered during this soil survey.

3) Stratified observations

Upon drafting of mapping units, surface soil exposures throughout the Proposed Disturbance Area were visually assessed to ascertain potential mapping units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigation.

2.3 Profiling

A total of sixteen (16) soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. The soil profile site locations are shown in **Figure 2**.

Subsurface exposure was undertaken by backhoe excavation of test pits to between 1.5 and 2 m deep. The test pit locations were chosen to provide representative profiles of the soil types encountered over the survey areas. The soil layers were generally distinguished on the basis of changes in texture and/or colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994).

Numerous observations of existing exposed profiles were also conducted to confirm soil units and boundaries between different soils. Shallow soils, or soils associated with sandstone outcrops, were generally identified and delineated through these observations of surface exposure (in conjunction with the map and aerial photo surveys).

2.4 Field Assessment

Soil layers at each profile site were assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing materials. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. A more detailed explanation of the Elliot & Veness procedure is presented in **Appendix 2** to this report. The system remains the benchmark for land resource assessment in the Australian coal mining industry.

2.5 Laboratory Testing

Soil samples were collected from the exposed soil profiles of major soil units within the Proposed Disturbance Area. Of the samples collected, representative samples were selected for subsequent laboratory analysis at the Department of Lands' Soil Research Centre at Scone, NSW.

Selection of samples for analysis was based on establishing the geochemical suitability of surface and near-surface soil horizons for use as topdressing in rehabilitation works. Analysis was targeted at widespread and variable soil units, such as yellow solodics and brown clays. Samples from soil units displaying little pedological variability, such as sands, were generally not selected for analysis. Samples were analysed from the following sites:

- Site 1 – 1/1 & 1/2
- Site 4 – 4/1, 4/2 & 4/3
- Site 6 – 6/1 & 6/2
- Site 7 – 7/1, 7/2 & 7/3
- Site 11 – 11/1, 11/2 & 11/3
- Site 12 – 12/1 & 12/2

- Site 13 – 13/1, 13/2 & 13/3
- Site 16 – 16/1 & 16/2
- Site 17 – 17/1, 17/2, 17/3 & 17/4

Soil layers are signified by /1, /2 and /3 in the sample ID with the surface horizon being /1 and subsoil horizons being /2, /3 & /4. Samples collected from sites 3, 5, 8, 9, 14, 15, & 18 were not analysed, as these profiles displayed similar soil characteristics to other sites already selected for analysis. Sites 2 and 10 were not excavated.

The samples were subsequently analysed for the following parameters:

- Particle Size Analysis;
- Emerson Aggregate Test (soil aggregate slaking and coherence);
- pH;
- Electrical Conductivity.

A description of the significance of each test and typical values for each soil characteristic are included in **Appendix 3**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas. The soil test results for the soil survey are provided in **Appendix 4**.

2.6 Land Capability Assessment

The land capability assessment of the Proposed Disturbance Area was conducted according to the Department of Natural Resources (DNR) (formerly the NSW Soil Conservation Service) rural land capability assessment system. The system consists of eight classes, which classify land on the basis of an increasing soil erosion hazard and decreasing versatility of use. It recognises the following three types of land uses:

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

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

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not

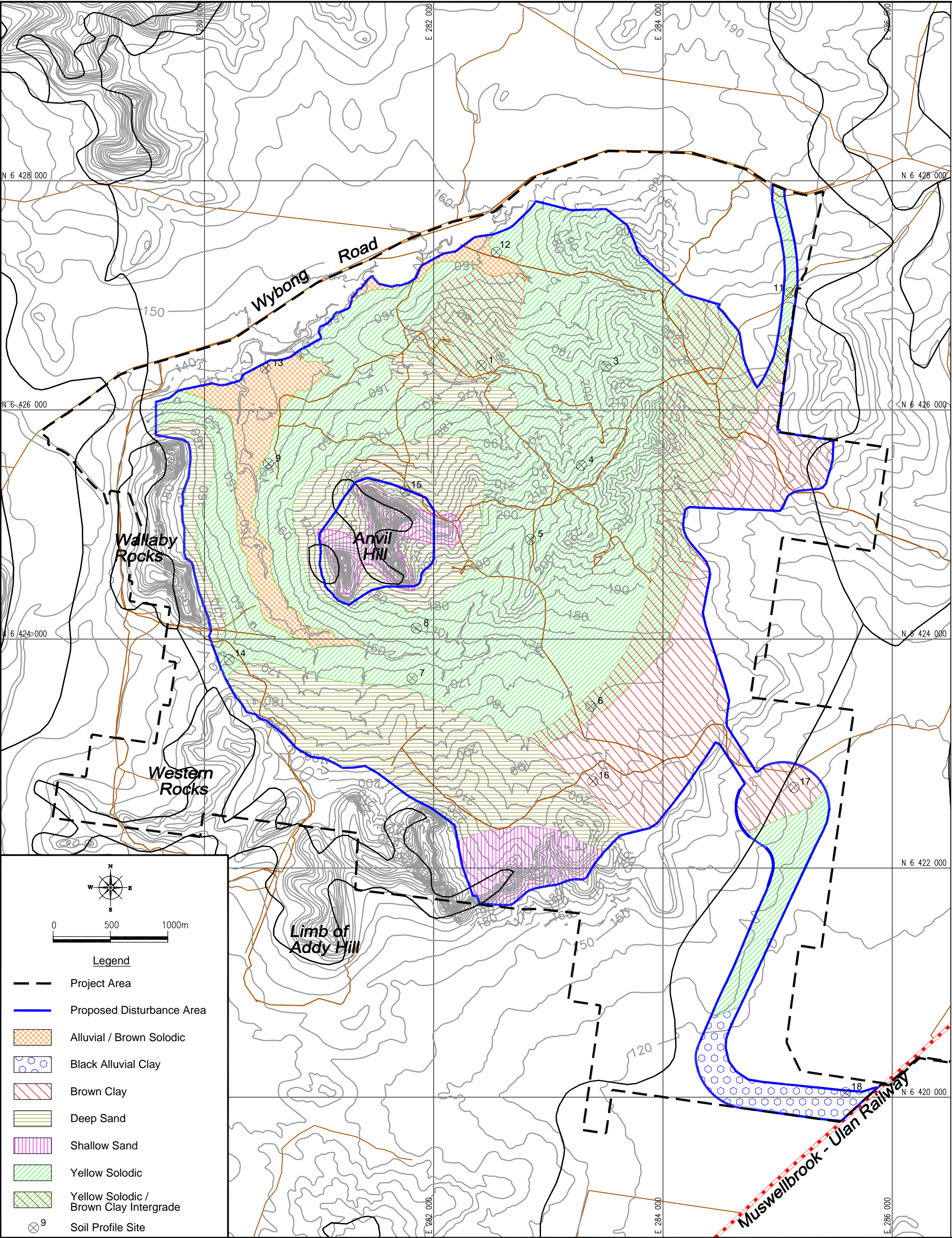
necessarily reflect the existing land use, rather it indicates the potential of the land for such uses as crop production, pasture improvement and grazing.

The system allows for land to be allocated into eight (8) possible classes (with land capability decreasing progressively from Class I to Class VIII). The classes are described in **Table 1**.

A description of land capability classification for all land within the Project Area is discussed in **Section 3.2**.

Table 1: Land Capability Classes

Rural Land Capability		
Land Class	Land Suitability	Land Definition
Class I	Regular Cultivation	No erosion control requirements
Class II	Regular Cultivation	Simple requirements such as crop rotation, minor strategic works.
Class III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways.
Class IV	Grazing, occasional cultivation	Simple practices such as stock control, fertilizer application
Class V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks
Class VI	Grazing only	Managed to ensure ground cover is maintained
Class VII	Unsuitable for rural production	Green timber maintained to control erosion
Class VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
U	Urban areas	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production
Source: Soil Conservation Service of NSW (1986).		



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Anvil Hill Project
Soil Types and
Profiles Sites

Figure 2
Scale 1:30000

3.0 RESULTS

3.1 Soils

Kovac and Lawrie (1991) identified five soil landscapes within the Proposed Disturbance Area. These five soil landscapes, along with the associated soil units observed during the GSSE soil survey, are presented in **Table 2**.

Table 2: Soil landscapes (Kovac & Lawrie, 1991), and associated soil units, within the Proposed Disturbance Area.

Soil Landscape	Location within Proposed Disturbance Area	Associated Soil Units
Sandy Hollow	Dominant soil landscape associated with drainage lines and gentle slopes throughout the Proposed Disturbance Area, except for the north-eastern corner and far south-eastern margins.	Yellow Solodic Brown Solodic Deep Sands Alluvial Soils
Castle Rock	Minor soil landscape associated with undulating low hills in north-eastern corner of Proposed Disturbance Area.	Yellow Solodics Brown Clay Alluvial Soils
Dartbrook	Minor soil landscape associated with the undulating slopes and low hills in the far eastern margin of the Proposed Disturbance Area.	Brown Clays
Lees Pinch	Minor soil landscape associated with steep outcropping sandstone hills in centre of Proposed Disturbance Area (Anvil Hill), along with far southern and western margins.	Shallow Sands (Siliceous)
Hunter	Minor soil landscape associated with flat alluvial plains of the Hunter River in the far south-eastern margins of the Proposed Disturbance Area.	Black Alluvial Clay

The yellow solodic soils, associated with the Sandy Hollow and Castle Rock soil landscapes, are the dominant soil unit and cover a majority of the Proposed Disturbance Area. However, substantial intergrading of soil unit types occur

between the yellow solodics and neighbouring soil units. An example of this is the intergrade of yellow solodics and brown clays in the eastern part of the Proposed Disturbance Area along the boundary with the Dartbrook soil landscape. Intergrades between soil units also occur relative to the surrounding landscape. For example, yellow solodics grade into lithosols and podzolic soils on upper slopes and hill crests, with alluvial intergrades situated near prominent drainage lines, such as Big Flat Creek. These associations will be described further in the sub-sections, below.

Some soils with similar physical properties have been delineated and described according to their textural characteristics. For example, the "deep sands" soil unit describes relatively uniform sandy profile, which is a combination of soloths, solodics and alluvial sandy soils.

Soils associated with the Dartbrook soil landscape (such as brown clays) were observed to be distributed over a slightly wider proportion of the Proposed Disturbance Area, extending further west than is depicted in Kovac and Lawrie (1991). This is most likely due to differences in boundary location between underlying parent bedrock material, as well as localised landscape associations. The distribution of the soil units observed during the GSSE soil survey is illustrated in **Figure 2**.

Minor areas of alluvial soils are located along the prominent drainage lines, such as Big Flat Creek and the lower reaches of Anvil creek, in the north and east of the Proposed Disturbance Area. These alluvial soils generally consist of silty to sandy clay loams, overlying sandy to medium clay. These soils are localised and confined to creek lines amongst yellow solodic dominated areas. They have not been included in the soil unit descriptions below.

Disturbed ground, associated mainly with roads, scrapes, quarries and dams, was observed throughout the Proposed Disturbance Area. Generally the disturbed ground is dispersed and fragmentary in nature and is, therefore, not shown on the soils map in **Figure 2**.

A description of each soil unit is presented in this section, with major soil unit typical soil profile descriptions presented in **Appendix 5**. **Appendix 2** provides a brief guideline to interpreting soil analytical results.

Yellow Solodic Soils

The most widespread soil unit within the Proposed Disturbance Area is the yellow solodic unit. The yellow solodics have a duplex profile, with a clear to sharp boundary between the sandy loam surface horizon and the underlying clay sub-soils. These soils are associated with the gently falling drainage lines, flat areas and gently rising slopes throughout the Proposed Disturbance Area.

As the landscape becomes more undulating towards the east and north east of Anvil Hill, the yellow solodics occupy the lower slopes, while grading to yellow podzolics on the mid to upper slopes. The soils on the hill crests and ridge tops in the north-east of the Proposed Disturbance Area grade to lithosols, displaying a shallow profile with high rock content. Site 3 is an example of a lithosolic soil profile.

Yellow solodics also exist as intergrades with neighbouring soil units throughout much of the area. In the north and west of the Proposed

Disturbance Area, they grade into alluvial soils and brown solodics as they enter the alluvial zone of Anvil Creek and Big Flat Creek. Yellow solodics also grade into brown clays along the eastern boundary of the Proposed Disturbance Area. Small dispersed areas of brown clays were also observed in the far north of the Proposed Disturbance Area (between Sites 1 and 12). Due to the difficulty in accurately delineating the brown clay and yellow solodics, these small areas have been represented as a single intergraded unit. Soil descriptions from profiles located near soil unit boundaries are likely to display characteristics of both units. For example, Site 14 is yellowish brown in the near surface horizons, while the subsurface soils exhibit a reddish colour.

Topsoil

The topsoil ranges in depth from 4cm to 40 cm and is generally brown to dark greyish brown in colour. Several sites displayed a pale brown bleached A2 horizon. The soils are weakly structured with textures ranging from clayey loams to sandy loams. These textural groups will allow for moderate infiltration and moderate to good water holding capacity, both necessary for effective vegetative growth. The topsoils are structurally stable (Emerson rating of 8/3(2) to 3(1) – slightly or non-dispersive), therefore, will not be prone to surface sealing, leading to effective infiltration and aeration for root development. The soils are non-saline (EC range of 0.01 to 0.03 dS/m) and generally neutral to mildly alkaline (pH range of 5.6 to 6.7). The sites generally displayed a surface pasture cover and root penetration in the topsoil was common, indicating potential suitability for post-mining vegetation establishment.

Subsoil

The subsoil ranges in depth, up to 110cm. It is generally yellowish brown or pale brown with a blocky to massive structure. The textures are most commonly sandy clays to medium clays. The soil is non-saline (EC range of 0.01 to 0.79 dS/m) and generally alkaline (pH range of 6.8 to 9.5). Emerson ratings are between 2 (moderately dispersive) and 3 (slightly dispersive). The constraining factors include fine texture (high clay content) and massive structure, therefore poor aeration and infiltration and inferior structural characteristics. This subsoil layer is not suitable for stripping and use as a topdressing material.

Shallow Sands

The shallow sands are a minor soil unit, occurring in proximity to the sandstone cliffs and steep hills, such as Anvil Hill and the ridgelines to the west and south of the Proposed Disturbance Area. The shallow sands were generally observed to have a uniform profile, with minimal change in texture or structure throughout the profile and displaying little pedological development.

The soils occur at the top and immediate base of the sandstone cliffs, before grading into deep sands and sandy alluvial soils. No profiles were excavated in the shallow sands, but many existing exposures were observed. Substantial variations in colour, texture and depth of horizons were observed depending on the position in the landscape and the properties of the parent sandstone material.

Topsoil

The topsoil ranges in depth from 5 cm to 15 cm. It is generally reddish brown to dark yellowish grey brown with a single grained to weak structure and textures include sands and sandy loams. Although these textural groups allow for high infiltration rates, they display very low water holding capacity, which can impede successful vegetative establishment if used as a growth medium in a relatively low rainfall environment, such as that occurring at Anvil Hill. This topsoil is not suitable for use as a topdressing material in rehabilitation due to its poor structure and low water holding capacity.

Subsoil

The subsoil varies in depth, up to 50 cm. It is generally reddish brown through to a pale yellow brown with a single grained structure, tending to massive structure at depth with increased sandstone content. The textures include sandy loams to clayey sands. The subsoil is not suitable for use as a topdressing material in rehabilitation works because of its poor structure, generally high rock content and low water holding capacity.

Deep Sands

Minor areas of deep sands are situated in the western and southern margins of the Proposed Disturbance Area, as well in the central part of the area, in the vicinity of Anvil Hill. The soils range from in-situ weathered, to colluvial and alluvial soils, resulting from the movement and deposition of sands on the lower slopes of sandstone cliffs and downslope drainage lines. A small area of deep sands is also located in the central northern part of the Proposed Disturbance Area, along the lower drainage line of Clarks Gully. The soil unit grades into shallow soils upslope and into solodic soils downslope. The soil unit may also include minor areas of soloths and sandy earths.

Depending on location in relation to parent material and landscape, the deep sands varied substantially in their profile type. However, they generally were observed to have a uniform profile, with minimal change in texture or structure throughout the profile.

Topsoil

The topsoil ranges in depth from 6 cm to 15 cm, and is light brown to reddish brown. Texture is generally sandy to sandy loam, with single grained to weak granular structure. Although these texture groups allow for moderate to high infiltration, water holding capacity is poor, thus hindering vegetative growth. Where suitable soil structure has developed, this topsoil may be suitable for stripping and use as a topdressing material. However, due to poor structure and water holding capacity, excessively sandy topsoil is not deemed to be suitable for use in rehabilitation works.

Subsoil

The subsoil was observed to exceed 1.4 m in depth, with a pale to very pale brown colour. Texture is generally clayey sand with single grained structure. Sandstone fragment content increased with depth to approximately 50% at

1.4 m. The subsoil is not suitable for use in rehabilitation due to poor structure, generally high rock content and low water holding capacity.

Brown Clay

The brown clays have a duplex profile. Surface horizons consist of clay loams to sandy clay loams, with a clear and even boundary to the underlying medium clay horizon. Minor areas of brown clay are situated in the south eastern part of Proposed Disturbance Area and in the vicinity of the proposed surface tailings dam and rail loop. The soil unit is situated on low undulating hills and gentle slopes grading down to the Hunter River alluvial plain.

The soil grades into solodic soils in the western margins of its distribution and intergrades with minor areas of non-calcic brown soils on the lower slopes towards the south. A shallow variant of the soil unit (due to shallow bedrock) was observed in the western part of its distribution within the Proposed Disturbance Area. Site 6 was situated within this area of shallow brown clay.

Topsoil

The topsoil is 10 cm to 15 cm in depth and greyish brown in colour. Texture is clay loam to sandy clay loam, with a weak blocky structure. This texture will allow for moderate infiltration and water holding capacity. With Emerson ratings of 3(1) and 8/3(3), this topsoil is non-dispersive to slightly dispersive and is structurally stable (note: a rating of 8/3 indicates heterogeneity within the soil sample). As a result, the topsoil will not be prone to surface sealing leading to effective infiltration and aeration for root development. The topsoil of Site 16 displayed an Emerson rating of 2(3), which indicates moderate instability. This area would need to be investigated further during the production of a detailed topsoil stripping plan, as required during preparation of a Mining Operations Plan (MOP), to identify patches of poor topsoil quality not suitable for recovery. The topsoil is mildly alkaline (pH of 5.6 to 7.4) and non-saline (EC of 0.01 to 0.32). This topsoil is suitable for stripping and use in post-mining vegetation establishment.

Subsoil

The subsoil ranges up to 45 to 65 cm in depth and is a very dark grey brown. Texture is medium clay with a moderate to strong blocky structure. The subsoil is alkaline (pH of 7.6 to 9.1) and of low to moderate salinity (EC of 0.64 to 1.04). Stability declines in the lower subsoils, with Emerson ratings of between 1 and 2(1). This indicates that the subsoils are highly dispersive and the potential for surface sealing and erosion is high if left exposed. The brown clay subsoil at Site 6 contained up to 50% rock fragment content. Due to the alkalinity, highly dispersive nature and localised high rock content, this subsoil is not considered suitable for use as topdressing material in rehabilitation. This material should not be left exposed, unmanaged, or as a surface horizon in the post-mine landform.

Black Alluvial Clay

Minor areas of black alluvial clay were observed in the far southern margins of the Proposed Disturbance Area, in the vicinity of the proposed rail corridor. Limited disturbance, associated with construction of a rail link, is proposed in this area. The soil unit is confined to the alluvial plain of the Hunter River. The area has generally been cultivated for cropping. The black alluvial clay was observed to have a uniform profile, with little development in structure or texture throughout the profile.

Topsoil

The topsoil is 5 cm to 25 cm deep and dark greyish brown in colour. Texture is clay loam to sandy clay loam. This texture will allow for moderate infiltration and water holding capacity, both necessary for effective vegetative growth. Structure is weak and blocky, and was observed to experience surface cracking in dry conditions. This topsoil is suitable for stripping and use as topdressing material in post-mine vegetation establishment.

Subsoil

The subsoil is 80 cm deep, and is very dark grey to black. Texture is medium clay with a moderate blocky structure. Ped size increased from 20-50 mm at 25 cm depth, to 200-500 mm at 1.7 m. No roots were observed to have penetrated to the sub-surface horizons. The heavy structure (large peds) and fine texture (high clay content) of this material indicates that it is largely impermeable and poorly aerated for root development. However, due to the high agricultural value (Class II land capability) and heterogeneity of these alluvial soils, further investigation during the MOP preparation will be required to ascertain whether the suitability of this subsoil for stripping and use in rehabilitation.



Plate 1: Yellow Solodic at Site 5, displaying duplex soil profile.



Plate 2: Shallow lithosolic soil (Site 3).



Plate 3: Deep Sands at Site 15, displaying uniform soil profile.



Plate 4: Brown Clay excavated from Site 17.

3.2 Land Capability

Historically, the Proposed Disturbance Area has been used for low intensity cattle grazing, with some minor areas of cultivation in the far south-east. The native vegetation within the area has also supported small logging operations, which have long since ceased. Grazing continues over much of the Proposed Disturbance Area and is the dominant land use within the area.

The majority of the land within the Proposed Disturbance Area is limited to Class VI (including yellow solodics and deep sands). The land is generally suitable for grazing with intensive management measures. The land is not suitable for cultivation owing to a combination of limitations of slope, soil alkalinity, subsoil instability and potential for dispersion and gully erosion. Soil conservation practices such as pasture improvement, stocking rate control, application of fertilizer and re-establishment of permanent pasture are also recommended. Provided that environmental controls (particularly erosion & sediment controls) are in place and operating effectively during development and operation of the proposed mine, there will be no adverse effects on the land's capability to support the desired post-mine land uses suitable to Class VI land.

A small area of Class VIII land occurs as rock outcrop on "Anvil Hill" in the centre of the Project Area. Similarly, some Class VII land ie steep rocky areas occur in the south of the Project Area.

The black alluvial clays and selected areas of the brown clays, in the south-east of the Proposed Disturbance Area, are of relatively high agricultural value and are classified as Class II land. Disturbance in this area will involve construction of the rail loop.

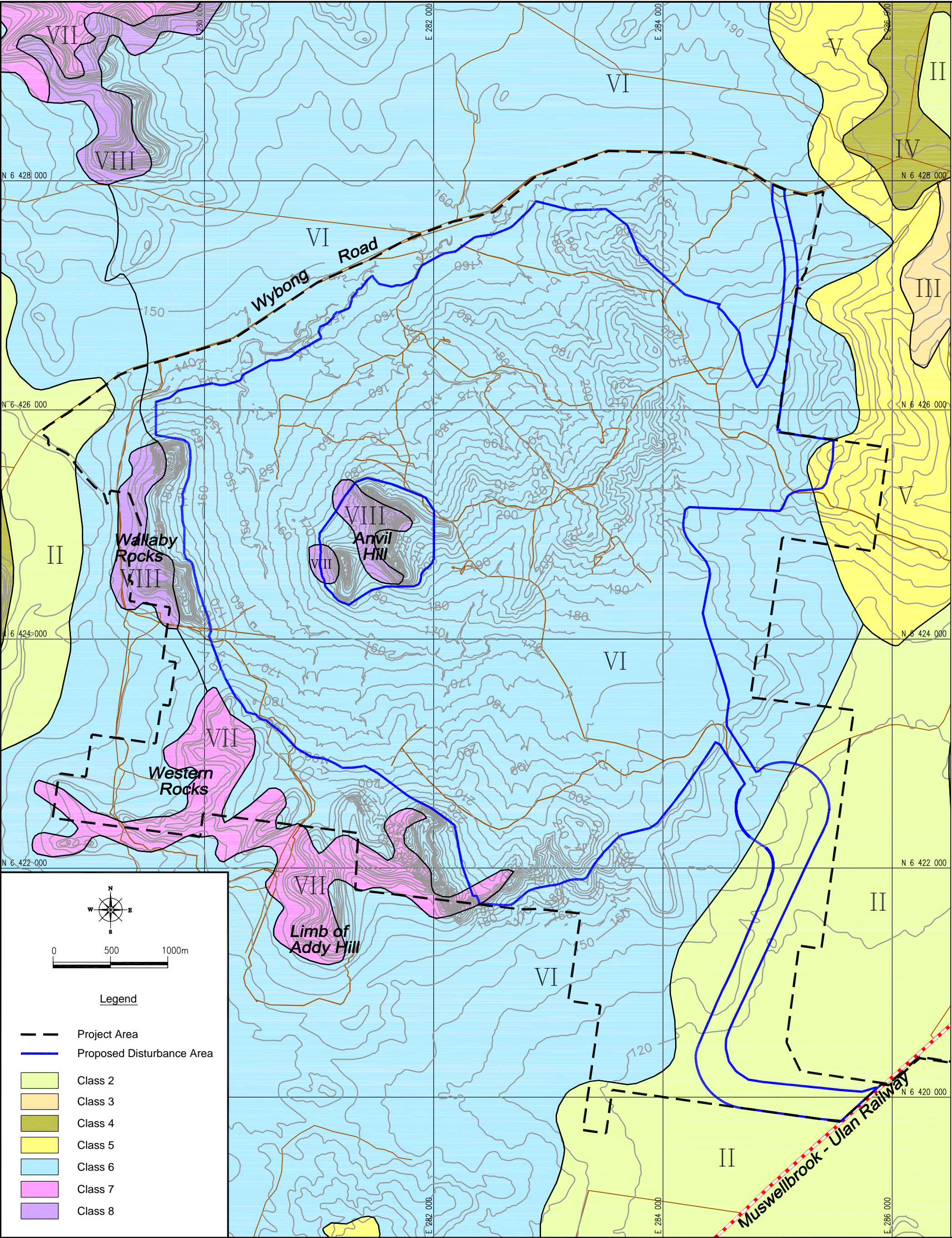
A description of land capability classification is provided in **Table 3**. The land capability classes for the Project Area are presented in **Figure 3**.

Land capability within the Proposed Disturbance Area will be very slightly modified after mining. **Figure 4** provides the proposed post-mining landform and the associated land capability classification of the landform. A small increase in Class VIII land, corresponding with the location of the final voids (positioned in the south-west corner of the Proposed Disturbance Area), is the only change to the pre-mining land capability classification of the area.

The boundary of the Class VIII land, as shown in **Figure 4**, represents the projected equilibrium water levels in the voids. Some 58 ha of pre-mining Class VI land will be converted to Class VIII land. This represents less than 3% of the total Proposed Disturbance Area.

Table 3: Land capability classes for the Anvil Hill Proposed Disturbance Area.

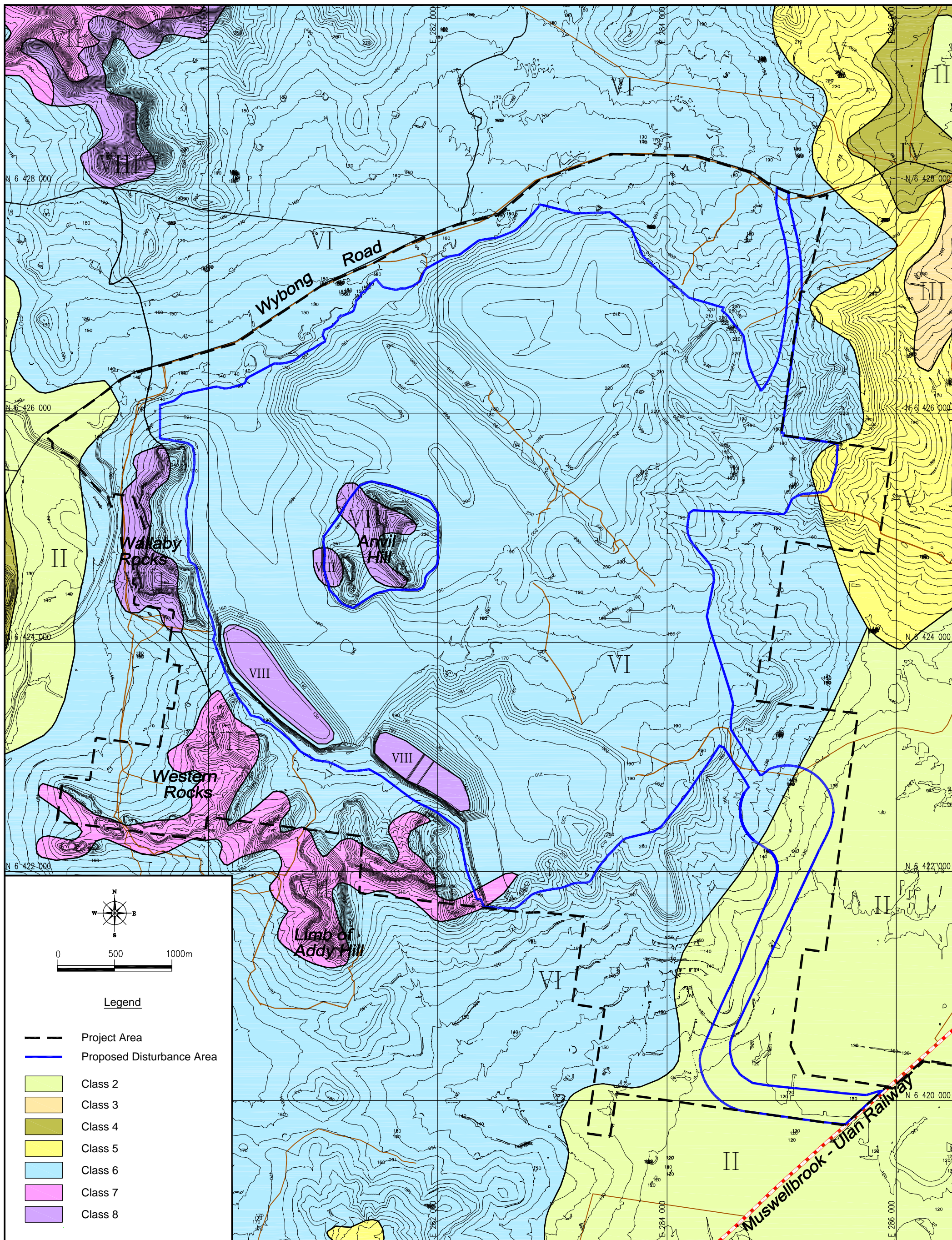
Land Capability Class	Description
II	Usually gently sloping land suitable for a wide variety of agricultural uses. Has a high potential for production of crops on fertile soils similar to Class I, but increasing limitations to production due to site conditions. Includes "prime agricultural land".
VI	Productivity will vary due to the soil depth and the soil fertility. Comprises the less productive grazing lands
VII	Generally comprises areas of steep slopes, shallow soils and/or rock outcrop. Adequate ground protection must be maintained by limiting grazing and minimising damage by fire. Destruction of trees is not generally recommended, but partial clearing for grazing purposes under strict management controls can be practised on small areas of low erosion hazard. Where clearing of these lands as occurred in the past, unstable soil and terrain sites should be returned to timber cover.
VIII	Land unusable for agricultural or pastoral uses. Recommended uses are those compatible with the preservation of the natural vegetation, namely: water supply catchments, wildlife refuges, national and state parks, and scenic areas.
Source: Soil Conservation Service of NSW (1986).	



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Environmental, Land and Project
Management Consultants
Project No. ANV1-0106-09
Drawing No. ANV1-0106-09-1A

Anvil Hill Project
Pre-Mining Rural Land
Capability Classification

Figure 3
Scale 1:30000



GSS ENVIRONMENTAL
 Environmental, Land and Project
 Management Consultants
 Project No. ANV1-0106-09
 Drawing No. ANV1-0106-09-2A

Anvil Hill Project
 Post-Mining Rural Land
 Capability Classification

Figure 4
Scale 1:30000

4.0 TOPSOIL SUITABILITY

Details of the soil test results (refer **Appendix 4**) were used in conjunction with the field assessment (refer **Appendix 2**) to determine the depth or thickness of soil materials that are suitable for stripping and re-use as a surface cover in the rehabilitation of disturbed areas. Suitable stripping depths for each soil unit are provided in **Table 4**.

The suitable stripping depth for the yellow solodics is approximately 15 cm. Although generally weak in structure, the surface horizons of the soil unit consist of sandy loams, are relatively stable, and generally of neutral to slightly alkaline pH. Shallow, lithosolic profiles, such as those observed on the hill crests in the north-east of the study area, should not be used for topdressing due to poor structure and high rock content. Instability in the subsoil horizons, combined with high pH, indicate high dispersion potential and erodibility are major constraints in the material's value as a surface cover material. Therefore, the subsoil (>15 cm depth) has been deemed unsuitable for re-use in the rehabilitation of the post-mining landform.

The suitable topsoil stripping depth for the deep sands is 15 cm. The soil unit has a weakly structured sandy loam surface horizon and is suitable for recovery and re-use. Due to poor structure and water holding capacity, the subsurface horizons (>15 cm) are considered unsuitable for recovery and re-use as a topdressing medium.

Due to their poor structure and location in the landscape (associated with steep slopes and cliff features), shallow sands are not suitable for recovery and use as a topdressing material in rehabilitation works. Where operationally allowable, it is preferable that these soils not be disturbed.

Brown clays are suitable to be stripped to 15 cm for re-use as topdressing material. Below this depth, the subsoil displayed high alkalinity, low stability and high potential for dispersion and erodibility. However, Site 16 displayed a moderate potential for dispersion in the surface horizons, indicating that surface soil quality may vary within the brown clay unit. During production of a detailed stripping plan, further investigations will be required to identify areas of high dispersion and erosion potential within the brown clay topsoil.

Based on the observations made during this survey, the suitable stripping depth for the black alluvial clays, located in the southern end of the proposed rail corridor, is 25 cm. However, due to the heterogeneity and high agricultural value of these soils, further investigations will be required as part of a detailed stripping plan in all areas where proposed mining related activities will disturb the soils of the Hunter River alluvial plain.

Where encountered, alluvial soil and brown solodics along Big Flat Creek should be stripped to 15 cm. Underlying clay subsurface horizons are believed to be characterised by similar poor structure and instability parameters as the yellow solodics and are deemed unsuitable as topdressing media.

Table 4: Suitable topsoil stripping depths for soil types

Soil Unit Type	Suitable Stripping Depth (cm)
Yellow solodics	15
Shallow Sands	Not suitable for stripping
Deep sands	15
Brown Clay	>15 (after further investigation)
Black Alluvial Clay	>25 (after further investigation)

4.1 Topsoil Stripping and Handling

The following topsoil stripping and stockpiling techniques are appropriate to prevent excessive soil deterioration:

- Strip material to the depths stated in **Table 4**, subject to further investigation in the areas noted. Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Grading or pushing soil into windrows with graders or dozers for later collection by elevating scrapers, or for loading into rear dump trucks by front-end loaders, are examples of less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by dump trucks may be placed directly into storage. Soil transported by bottom dumping scrapers is best pushed to form stockpiles by other equipment (eg dozer) to avoid tracking over previously laid soil by the scraper.
- The surface of soil stockpiles should be left in a rough a condition as possible in order to promote infiltration and minimise erosion until vegetation is established to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile depth of 3 m. Clayey soils should be stored in lower stockpiles for shorter periods of time compared to sandier soils.
- If long-term stockpiling is planned, seed and fertilise stockpiles as soon as possible.

- Prior to re-spreading stockpiled topsoil onto reshaped overburden (particularly onto designated tree seeding areas), an assessment of weed infestation (particularly *Galenia secunda*) on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and / or "scalping" of weed species prior to topsoil spreading.

Topsoil Respreading

Where possible, suitable topsoil should be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil should be spread to a minimum depth of 200 mm on all regraded spoil. Topsoil should be spread, treated and seeded in one consecutive operation. To prevent loss of topsoil to wind and water erosion, topsoil should not be left spread and untreated/unseeded, where possible.

5.0 CONCLUSION

During the land resource assessment conducted by GSSE for the Proposed Disturbance Area associated with the Anvil Hill Project, the area was observed to be dominated by duplex yellow solodic soils on the lower slopes; alluvial soils in the major drainage lines; sandy soils associated with the steep sandstone features; brown clays associated with the Dartbrook soil landscape in the eastern margins; and black alluvial clays in the far south.

The current land use for most of the Proposed Disturbance Area was identified as predominantly cattle grazing, with small areas of cultivation associated with the better soils in the far south. Land capability for most of the Proposed Disturbance Area was identified as Class VI, generally suitable for grazing; whilst small areas of the south were identified as being of higher value (Class II - III). The landscapes associated with the steep sandstone features within the Proposed Disturbance Area, such as Anvil Hill, were identified as Class VII – VIII.

The majority of soils within the Proposed Disturbance Area (deep sands and yellow solodics) are suitable for stripping to a depth of approximately 15 cm for use for rehabilitation topdressing purposes. Below this depth, the subsoils have been identified as being of unsuitable structure and texture (too sandy or too clayey) or exhibiting a high potential for dispersion, erosion and hard settingness. Areas of shallow, rocky soils are not stripping for stripping and re-use in post-mining rehabilitation. The shallow sands associated with the steep sandstone features are also not suitable for stripping. The brown clay topsoil within the Proposed Disturbance Area was observed to be of variable quality, however, based on the findings of this survey, stripping to a depth of 15 cm is considered suitable. Further investigations will be required during the production of a Mining Operations Plan to produce a more detailed topsoil stripping plan. Similarly, further investigation will be required to characterise topsoil quality in the southern end of the rail corridor, where proposed disturbance intersects with high value agricultural soils.

Generally, the subsurface soils of the yellow solodics and the brown clay soil units were observed to consist of medium clays with moderate to high alkalinity and moderate to high dispersion potential. This indicates that these soils have a high potential for erosion and hardsetting surfaces if left exposed and, therefore, should not be used as a surface cover in the rehabilitated post-mining landscape. Measures should also be implemented during the mining process, to ensure these subsoils are not exposed for prolonged periods and any surface runoff from exposed subsoils is suitably managed.

Those soils exhibiting excessive sand content (shallow sands or creekline alluvial sands) or rock content in the surface horizons (hill crest/ridgeline lithosols in north-east corner) are not suitable for use as topdressing media. Soils within low-lying areas prone to seasonal inundation (creeklines in the north-west of the Proposed Disturbance Area) should also be assessed for salinity and sodicity, and appropriate management measures, prior to disturbance.

6.0 REFERENCES

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Appendix 1 – Glossary

A Horizon

The original top layer of mineral soil divided into A₁ (typically from 5 to 30 cm thick; generally referred to as topsoil

Alluvial Soils

Soils developed from recently deposited alluvium, normally characterise little or no modification of the deposited material by soil forming processes, particularly with respect to soil horizon development.

Brown Clays

Soil determined by high clay contents. Typically, moderately deep to very deep soils with uniform colour and texture profiles, weak horizonation mostly related to structure differentiation.

Consistence

The attribute of the soil material that is expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

Electrical Conductivity

The property of the conduction of electricity through water extract of soil. Used to determine the soluble salts in the extract, and hence soil stability.

Emmerson Aggregate Test (EAT)

A classification of soil based on soil aggregate coherence when immersed water. Classifies soils into eight classes and assists in identifying whether soils will slake, swell or disperse.

Gravel

The >2 mm materials that occur on the surface and in the A₁ horizon and include hard, coarse fragments.

Lithosols

Stony or gravelly soils lacking horizon and structure development. They are usually shallow and contain a large proportion of fragmented rock. Textures usually range from sands to clay loams.

Loam

A medium, textured soil of approximate composition 10 - 25% clay, 25 - 50% silt and <50% sand.

Mottling

The presence of more than one soil colour in the same soil horizon, not including different nodule or cutan colours.

Particle Size Analysis (PSA)

The determination of the amount of the different size fractions in a soil sample such as clay, silt, fine sand, coarse sand and gravel.

Pedality

The relative proportion of peds in the soil (as strongly pedal, weakly pedal or non-pedal).

pH

A measure of the acidity or alkalinity of a soil.

Solodic Soils

Strong texture differentiation with a very abrupt wavy boundary between A and B horizons, a well-developed bleached A2 horizon and a medium to coarse blocky clay B horizon.

Soloths

Similar to a solodic soil but acidic throughout the profile. Tends to be a more typical soil of the humid regions where the exchangeable cations in the B Horizon of the solodised soils have been leached out.

Podzolics

Podzolic soils are acidic throughout and have a clear boundary between the topsoil and subsoil. The topsoils are loams with a brownish grey colour. The lower part of the topsoil has a pale light colour and may be bleached with a nearly white, light grey colour.

Ped

An individual, natural soil aggregate.

Sodicity

A measure of exchangeable sodium in the soil. High levels adversely affect soil stability, plant growth and/or land use.

Soil mantle

The upper layer of the Earth's mantle, between consolidated bedrock and the surface, that contains the soil. Also known as the regolith.

Appendix 2 – Field Assessment Procedure

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

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

Mottling

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

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

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

Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behaviour and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.

Appendix 3 – Soil Information

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1	-	very dispersible soils with a high tunnel erosion susceptibility.
Class 2	-	moderately dispersible soils with some degree of tunnel erosion susceptibility.
Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

- (1) slight milkiness, immediately adjacent to the aggregate
- (2) obvious milkiness, less than 50% of the aggregate affected
- (3) obvious milkiness, more than 50% of the aggregate affected
- (4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (dS/cm), on plants are:

0 to 1 negligible.	very low salinity, effects on plants mostly
1 to 2 restricted.	low salinity, only yields of very sensitive crops are
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

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

EC

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

pH

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

Appendix 4 – Soil Test Results

SOIL TEST REPORT

Page 1 of 3

Scone Research Service Centre

REPORT NO: SCO05/158R1

REPORT TO: Rod Masters
GSS Environmental
PO Box 3214
Wamberal 2260

REPORT ON: Twenty four soil samples
Ref: GSS0605-AH
Anvil Hill Project

PRELIMINARY RESULTS

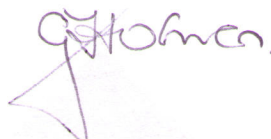
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 29 June 2005

METHODS: Information on test procedures can be obtained from Scone
Research Service Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL



G Holman
(Technical Officer)

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Page 2 of 3

Report No: SCO05/158R1
 Client Reference: Rod Masters
 GSS Environmental
 PO Box 3214
 Wamberal 2260

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH
1	Anvil Hill 1/1	17	14	19	19	31	3(2)	0.02	6.5
2	Anvil Hill 1/2	37	14	17	22	10	2(1)	0.35	8.3
3	Anvil Hill 4/1	11	14	25	26	24	3(1)	0.01	6.4
4	Anvil Hill 4/2	7	7	9	12	65	3(1)	0.01	6.7
5	Anvil Hill 4/3	33	3	6	14	44	2(2)	0.79	7.6
6	Anvil Hill 6/1	9	29	38	19	5	3(1)	0.02	5.7
7	Anvil Hill 6/2	36	18	30	7	9	2(1)	0.64	7.6
8	Anvil Hill 7/1	7	10	23	49	11	5	0.01	5.6
9	Anvil Hill 7/2	5	8	20	40	27	5	0.01	6.0
10	Anvil Hill 7/3	5	8	22	36	29	5	0.01	6.8
11	Anvil Hill 11/1	32	13	36	19	<1	3(2)	0.03	5.8
12	Anvil Hill 11/2	53	10	23	14	<1	3(2)	0.16	8.3
13	Anvil Hill 11/3	32	17	19	32	<1	2(2)	0.54	9.5

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Page 3 of 3

Report No: SCO05/158R1
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Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH
14	Anvil Hill 12/1	36	13	22	25	4	2(3)	0.30	8.6
15	Anvil Hill 12/2	43	13	22	20	2	2(3)	0.95	9.4
16	Anvil Hill 13/1	19	27	34	18	2	8/3(2)	0.02	6.3
17	Anvil Hill 13/2	43	23	22	11	1	2(3)	0.20	7.1
18	Anvil Hill 13/3	39	22	27	11	1	1	0.82	9.3
19	Anvil Hill 16/1	46	14	17	17	6	2(3)	0.32	7.4
20	Anvil Hill 16/2	44	15	19	19	3	1	0.67	8.7
21	Anvil Hill 17/1	25	20	30	25	<1	8/3(3)	0.09	6.7
22	Anvil Hill 17/2	40	19	21	20	<1	3(3)	0.25	8.1
23	Anvil Hill 17/3	35	17	22	24	2	2(1)	1.04	9.1
24	Anvil Hill 17/4	60	21	12	7	<1	1	1.42	8.8

G. Hoffman

END OF TEST REPORT

Appendix 5 – Soil Profile Descriptions

SOIL UNIT: YELLOW SOLODIC		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.15	Brown to dark greyish brown (10YR 5/3, 10YR 4/2) sandy loam to clay loam. Weak to very weak consistence with weak, angular to sub-angular peds. Generally <10% stones and roots commonly occur in the layer. The lower boundary is clear and even to layer 2.
2	0.15 – 0.40	Several profiles display bleached light yellowish brown to very pale brown (2.5Y 6/3, 10YR 8/2) silty to sandy clay A2 horizon. Apedal single grained, or weakly pedal angular blocky, rough-faced 10-50mm peds with weak consistence. Few roots present. Clear to gradual boundary to layer 3.
3	0.15 – 1.10	Pale Yellow, through yellowish brown to dark greyish brown (5Y 7/3, 2.5YR 8/2, 2.5YR 8/3) sandy to medium clay. Moderate to strong consistence and generally apedal massive. Few to no roots and <10% stones. The lower boundary is gradual to diffuse to layer 4.
4	1.10 - 1.65+	Olive yellow to yellowish brown (2.5Y 6/8, 10YR 5/8) medium clay with 30% grey mottle. Strong to moderate consistence and apedal massive with no roots.

SOIL UNIT: SHALLOW SANDS		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.15	Yellowish brown (10 YR 5/4) sandy loam. Weak consistence and weak pedality with sandy crumbly 2-10 mm peds. Few roots and the lower boundary is clear and even to layer 2.
2	0.15 – 0.25	Pale brown (10YR 6/3) sandy loam. Apedal single grained. Few roots penetrate this layer. The boundary is clear and even to layer 3.
3	0.25 – 0.50+	Yellowish brown (10YR 5/4) loamy sand. Apedal single grained. Few roots penetrate this layer. 10-20% strongly weathered, sub-angular sedimentary fragments, 6-20mm in diameter.

SOIL UNIT: DEEP SANDS		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.06	Light brown (2.5Y 4/3) sandy loam. Very weak consistence and weak pedality with sandy sub-angular blocky 5-10 mm peds. Roots are few and no stones. The lower boundary is sharp and even to layer 2.
2	0.06 – 0.28	Pale brown (10YR 6/3) clayey sand. Apedal single grained. Few roots penetrate this layer. 10-20% strongly weathered, sub-rounded to sub-angular sedimentary stones, 2-60mm in diameter. The boundary is gradual and even to layer 3.
3	0.28 – 1.40+	Very pale brown (10YR 7/3) clayey sand. Apedal single grained. No roots penetrate this layer. 20-50% strongly weathered, sub-rounded to sub-angular sedimentary stones and fragments, 6-60mm in diameter.

SOIL UNIT: BROWN CLAY		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.15	Dark grey to greyish brown (2.5Y 4/1, 10 YR 5/2) clayey loam. Weak to moderate consistence and weak pedality with rough-faced angular blocky peds 5-20mm. Few roots and <2% stones. The lower boundary is clear and even to layer 2.
2	0.15 – 0.45	Dark grey (2.5Y 4/1) light to medium clay. Strong consistence and weak pedality with rough-faced sub-angular blocky peds 20-100mm. Few roots and <2% stones. The lower boundary is clear and wavy to layer 3.
3	0.45 – 0.65	Very dark grey to very dark brown (2.5Y 3/1, 10YR 3/2) heavy clay. Strong consistence and the layer is apedal massive. No roots and <2% stones. The boundary is gradual and wavy to layer 4.
4	0.65 – 1.90+	Very dark grey to black (2.5Y 3/1, 10YR 2/1) medium to heavy clay. Moderate consistence and the layer is apedal massive. No roots and <2% stones.

SOIL UNIT: BLACK ALLUVIAL CLAY		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.05	Dark greyish brown (2.5Y 4/2) sandy clay. Very weak consistence and weak pedality with sandy sub-angular blocky peds 5-10 mm. Roots are common and the lower boundary is sharp and even to layer 2.
2	0.05 – 0.25	Very dark grey (10YR 3/1) medium clay. Strong consistence and moderate pedality with rough-faced, sub-angular blocky peds 20-50mm. Few roots penetrate this layer and no stones observed. The boundary is clear and wavy to layer 3.
3	0.25 – 0.80	Black (2.5Y 2.5/1) medium clay. Strong consistence and moderate pedality with rough-faced, sub-angular blocky peds 100-200mm. Few roots penetrate this layer and no stones observed. The boundary is diffuse to layer 4.
4	0.80 – 1.70+	Dark yellowish brown (10YR 4/4) silty clay. Moderate consistence and moderate pedality with rough-faced, angular blocky peds 200-500mm. No roots or stones observed in this layer.



Centennial Hunter Pty Limited

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