HANCOCK PROSPECTING PTY LTD

Alpha Coal Project Environmental Impact Statement

05 Soils, Topography and Land Disturbance

Section 05 Soils Topography and Land Disturbance

5.1 Soils

5.1.1 Introduction

This section of the Environmental Impact Statement (EIS) describes the environmental values identified within the mine site, in terms of soil resources. The description and distribution of topsoil resources are provided and their suitability for rehabilitation assessed. The potential impacts that the proposed mining activities may have upon these landscape environmental values are assessed and any mitigation measures that may be required are outlined.

5.1.2 Description of Environmental Values

5.1.2.1 Methodology

Field surveys were conducted between August 2009 and June 2010 to collect baseline data on the soils and land suitability of the Project site (Mine Lease Application [MLA] 70426). These surveys totalled a period of 41 days and consisted of primary sampling and secondary visual assessments. Primary sampling involved the collection of soil samples at a predetermined intensity along a sampling grid. Secondary visual assessments were conducted continuously across the study area while traversing the primary sample grid. Where visual assessments indicated a change in soils conditions outside of the pre-selected sampling grid, an additional primary sample was collected.

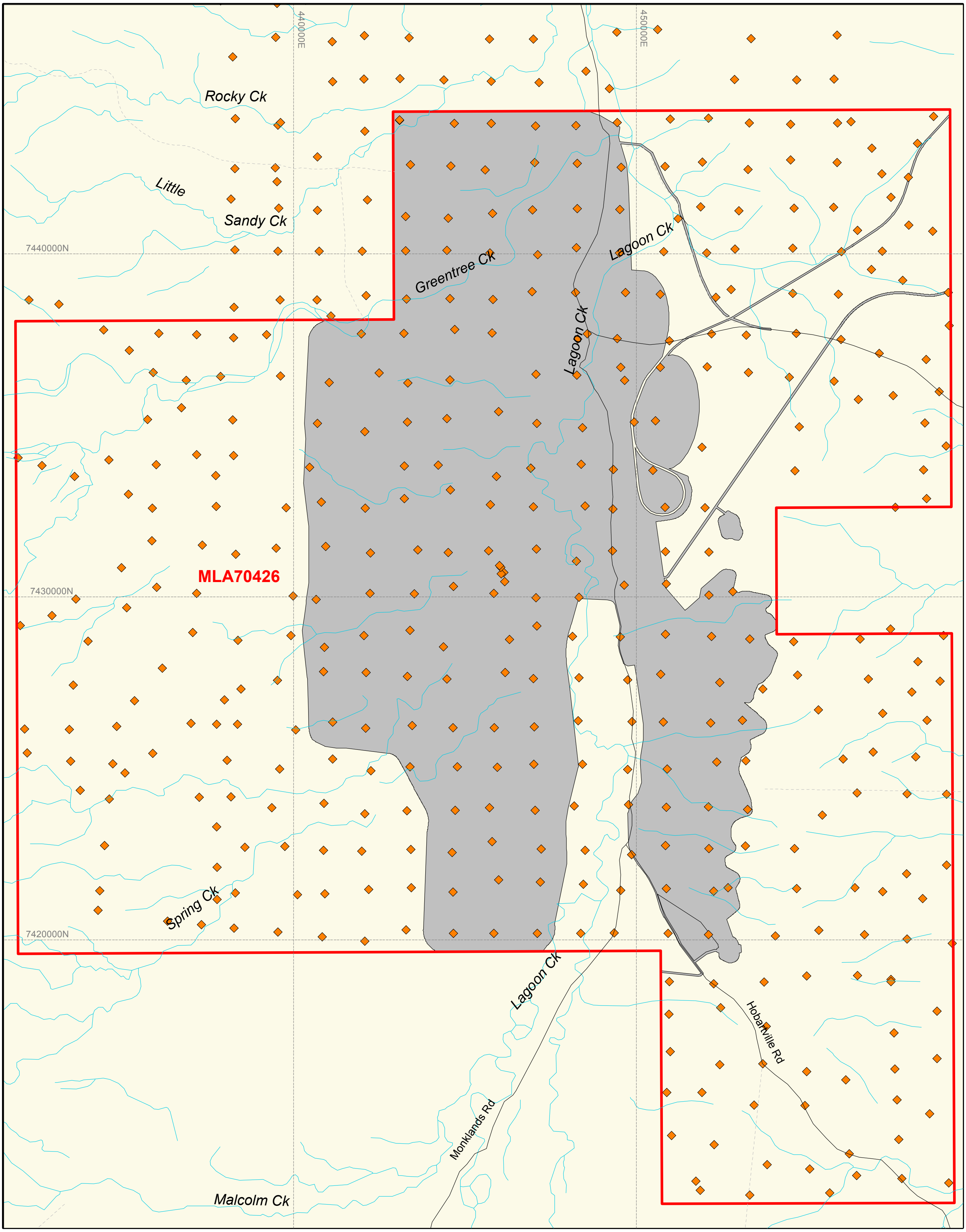
Sampling strategies and survey plans were developed in accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (Department of Minerals and Energy, 1995). Primary sampling was conducted at 484 locations within the boundaries of the Project site, with a further 71 locations outside the Projects site boundary (Figure 5-1). The location of each site was recorded using a Global Positioning System (GPS) with an accuracy of +/- 10 metres (m).

Using a backhoe, sample holes were excavated to a depth of 100 centimetres (cm), where possible. Soil samples were collected from a minimum of four depths throughout the profile; typically 0 – 10 cm, 10 – 20 cm, 40 – 50 cm and 90 – 100 cm. Care was taken to ensure clean samples were taken from each of the four depths in order to avoid cross-contamination.

Sampling at regular intervals (to standard depth of 100 cm across all primary sample sites), allowed for quantitative comparisons between chemical and physical parameters following analysis and best met the data requirements for determining the pre-mining land use suitability in accordance with the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (Department of Minerals and Energy, 1995).

Each sample was sealed in a clean plastic zip-lock bag. The bags were labelled with the sample site number and depth of sampling. At the completion of the field survey, bagged soil samples were grouped together into similar soil types based on field observation, soil physical characteristics and the topographical and vegetation characteristics of the survey site. This arrangement, coupled with a site map outlining soil sampling locations, was used to select several representative samples of each soil type for further analysis of their chemical and physical properties. The selected samples were then packaged for transportation to a National Association of Testing Authorities (NATA) registered laboratory for chemical and physical analysis. A total of 98 sampling locations were selected for laboratory analysis.

Laboratory data, field observations and land resource information consisting of published literature (Bureau of Rural Science, 1991; Northcote *et al.* 1960 – 1968; McKenzie *et. al.* 2004; Isbell 2002) and land management manuals (eds. Thwaites and Maher 1993) were then consulted in order to help identify distinct soil management units within the Project site.



Source: AARC supplied data.

Mining Lease Application (MLA70426) Boundary
Mine Disturbance Footprint
Primary Soil Sampling Location

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PRIMARY
SOIL SAMPLING LOCATIONS

Job Number	4262 6580
Revision	A
Date	24-09-2010

Figure: 5-1

File No: 42626580-g-2086.wor

5.1.2.2 Acid Sulphate Soils Assessment

State Planning Policy 2/02 - Planning and Managing Development Involving Acid Sulphate Soils (Department of Infrastructure and Planning (DIP), 2002) sets out the State's interests concerning development involving acid sulphate soils in low-lying coastal areas. The policy applies only to certain types of development assessments in a strict list of local government areas as outlined in Annex 1 of the policy. Given that the Project falls outside of these areas, an assessment of the risk of acid sulphate soils is not relevant.

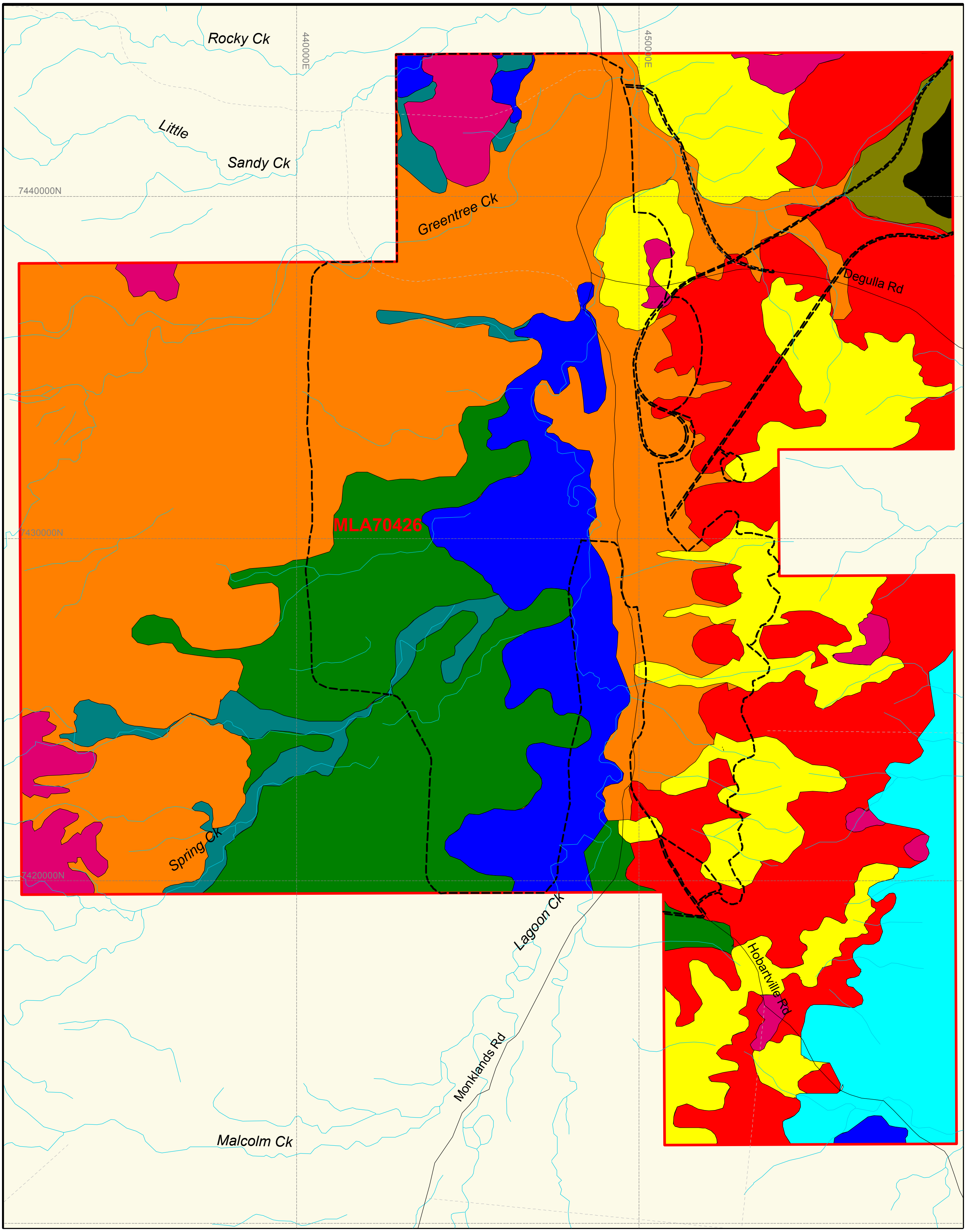
5.1.2.3 Results and Discussion

5.1.2.3.1 Soil Management Units

Based on field and laboratory assessments, ten soil management units (SMUs) were identified within the Project site. These SMUs were classified as the Britt, Waylon, Surbiton, Nelson, Malika, Rhi, Titus, Garret, Linda and Dunrobin. The distribution of these units has been mapped and presented in Figure 5-2. A description of each management unit is provided below.

Britt Soil Management Unit -

- **Australian Soil Classification:** Grey Vertosol
- **Topography and Landform Attributes:** Landscapes of the Britt SMU consist primarily of gently undulating plains which have been extensively cleared for agriculture, slopes of 0.5 to 1%.
- **Geology Unit:** The physio-chemical characteristics of this soil are consistent with the soil's development in close proximity to Tertiary basaltic geological formations.
- **Native Vegetation:** Cleared; Non-remnant.
- **Physical Attributes:** The Britt SMU consists primarily of a gray to brownish-gray medium clay, with a consistent texture maintained throughout the profile. Field observations suggest a soil with small and irregular cracking at the surface, indicating a soil that is likely to shrink (dry) and swell (wet). The soil is well structured with large (40-80 mm), friable peds. A very fine self mulch surface layer was present.
- **Chemical Analyses:** The dominant clay soil is neutral (pH 6.87) at the surface increasing steadily to moderately alkaline (pH 8.47) within 100 cm. Chemical analysis indicates a soil, which is non-saline and non-sodic at the surface. However, sodicity increases gradually with depth and soils of the lower solum are considered sodic (Exchangeable Sodium Percentage [ESP] 9.05% at 90-100 cm). Likewise, electrical conductivity increases in the lower profile to a level recognised as slightly saline for clay soils (electrical conductivity (EC) 0.415 decisiemens per metre (dS/m) at 90-100 cm). Soil chemistry indicates low to moderate levels of major soil nutrients at the surface (Nitrate Nitrogen 4 mg/kg; Phosphorus 13 mg/kg; Potassium 183 mg/kg; Organic Carbon 0.65%) and these levels halve within the surface 40-50 cm of depth. Similarly, the CEC of soils throughout the profile suggests good physical stability and nutrient availability (26.37 - 39.785 milliequivalents (mEq) / 100g).



Source: AARC supplied data.

Soils Management Legend

- Mining Lease Application (MLA70426) Boundary
- Mine Disturbance Footprint
- Dunrobin Soil Management Unit
- Surbiton Soil Management Unit
- Malika Soil Management Unit
- Rhi Soil Management Unit
- Titus Soil Management Unit
- Waylon Soil Management Unit
- Nelson Soil Management Unit
- Linda Soil Management Unit
- Garret Soil Management Unit
- Britt Soil Management Unit

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0 2 4Km

Scale 1:150 000 (A4)

Datum: GDA94, MGA Zone55

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Alpha Coal Project
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DISTRIBUTION OF SOIL MANAGEMENT UNITS WITHIN THE ALPHA MLA

Job Number | 4262 6580
Revision | A
Date | 24-09-2010

Figure: 5-2

File No: 42626580-g-2087.wor

Waylon Soil Management Unit -

- **Australian Soil Classification:** Brown Dermosol
- **Topography and Landform Attributes:** The distribution of the Waylon SMU is restricted to along the low-lying alluvial drainage depressions within the level plains of MLA 70426. These areas are occasional incised by deep gullies but slopes generally remain below 1%.
- **Geology Unit:** Cenozoic – Quaternary era alluvium of older flood plains, sand, gravel and soil.
- **Native Vegetation:** Mostly non-remnant; Pockets of fringing riparian woodland dominated by Poplar box.
- **Physical Attributes:** The Waylon SMU consists primarily of a light brown to yellowish brown fine sandy clay. Texture generally increases slightly with depth. Surface soils often become firm to hard setting when dry, particularly in areas exposed due to grazing pressures. Soil peds throughout the profile are moderately sized (25-45 mm) and are considered firm.
- **Chemical Analyses:** Soil sodicity increases with depth, as does pH from neutral (pH 7.05 at 0-10 cm) to mildly alkaline (pH 8.0 at 90-100 cm). Soils with the upper 20 cm of the profile are considered non-sodic. Levels of exchangeable sodium increase to sodic (ESP 11.03%) by 50 cm and strongly sodic (ESP 17.4%) by 100 cm. The soil is considered non-saline. Surface soils are low in levels of major soil nutrients (Nitrate Nitrogen 2 mg/kg; Phosphorus 6 mg/kg; Potassium 198 mg/kg), CEC (7.55 mEq / 100 g) and organic carbon (Organic Carbon 0.7%). These chemical characteristics suggest a soil with poor structure and fertility, decreasing further with depth.

Surbiton Soil Management Unit -

- **Australian Soil Classification:** Grey Vertosol.
- **Topography and Landform Attributes:** Flat to slightly undulating plains which have been extensively cleared for agriculture. Slopes in these areas are generally less than <0.5%.
- **Geology Unit:** The physio-chemical characteristics of this soil are consistent with those of soils' derived from basaltic material.
- **Native Vegetation:** Cleared; Non-remnant.
- **Physical Attributes:** The Surbiton SMU consists primarily of a gray light clay extending deep into the profile. When dry, the surface is characterised by frequent surface cracking extending deep into the profile. Surface soils also exhibit a fine self mulch. This soil is considered well structured and stable when dry, but at risk of compaction if trafficked while moist.
- **Chemical Analyses:** Soil chemistry indicates a soil which is mildly to moderately alkaline in pH (pH 7.3 - 8.3). The soil is non-saline at the surface but becomes slightly saline (EC 0.45 dS/m) at 90-100 cm. Similarly, surface soils are considered non-sodic before becoming sodic (ESP 13%) at 40-50 cm and strongly sodic (ESP 15%) at 90-100 cm. At the surface the soil has mostly low lev**els of major soil nutrients (Nitrate Nitrogen 2 mg/kg; Phosphorus 8 mg/kg; Potassium 57** mg/kg) and organic carbon (0.4%) but has a moderate CEC (21 mEq / 100g).

Nelson Soil Management Unit -

- **Australian Soil Classification:** Yellow Chromosol
- **Topography and Landform Attributes:** Restricted in distribution to the gently undulating plains - low hills west of Lagoon Creek within the Project area. These areas have been mostly cleared for grazing and slopes rarely exceed 2%.
- **Geology Unit:** Cenozoic – Quaternary era alluvium of older flood plains, sand, gravel and soil.
- **Native Vegetation:** Mostly cleared; Non-remnant; Small isolated patches of remnant vegetation dominated by Brigalow and Silver-leaf Ironbark species.
- **Physical Attributes:** The Nelson SMU consists primarily of a brown to red brown clayey sand upper horizon with an abrupt change at approximately 30 cm to a brownish yellow sandy light clay lower horizon. Soil structure in the upper horizon is mostly loose granular before a clear and abrupt change to a textural B horizon. The B horizon is more compact with firm peds of 30-60 mm.
- **Chemical Analyses:** While texture changes markedly at a depth of approximately 30 cm, the soils chemical properties show little variation. Throughout the upper solum the soil maintains a slightly acidic pH (pH 6.3 between 0-50 cm) increasing to a neutral level (pH 6.7) at 90-100 cm. This soil is non-saline and non-sodic throughout the profile. Surface soils have low levels of major soil nutrients (Nitrate Nitrogen 3 mg/kg; Phosphorus 5 mg/kg; Potassium 165 mg/kg) and organic carbon (0.6%). Soils of the Nelson SMU also exhibit a very low CEC (4.6 mEq / 100 g).

Malika Soil Management Unit -

- **Australian Soil Classification:** Brown Kandosol
- **Topography and Landform Attributes:** These soils are restricted in their distribution to the steeper undulating hills (2-4%) on the Alpha Coal MLA and often only occur in small localised areas. These areas are commonly sparsely vegetated due to inadequate soil depth for root development.
- **Geology Unit:** Cenozoic –Tertiary era quartzose sandstone, conglomerate and siltstone.
- **Native Vegetation:** Sparsely vegetated with minor occurrences of Silver-leaf Ironbark.
- **Physical Attributes:** The Malika SMU is comprised of a strongly coloured, often brown, sandy clay loam over rocky substrate. In these areas rock is often encountered at depths of less than 50 cm with outcropping common. Whilst quite shallow, soils of this management unit are moderately structured with noticeably higher clay content than the soils found in adjacent areas. The shallow surface soils are moderately pedal with peds ranging in size from 20-50 mm. When dry, these soils form a very firm surface.
- **Chemical Analyses:** These soils are non-saline (EC <0.04 dS/m) and have low levels of exchangeable sodium (ESP < 4.4%). This soil exhibits a low level of major soil nutrients (Nitrate Nitrogen 3 mg/kg; Phosphorus 2.5 mg/kg; Potassium 142 mg/kg) and organic carbon (0.6%). A low CEC (7.07 mEq / 100g) is common for these soils.

Rhi Soil Management Unit -

- **Australian Soil Classification:** In the steeper ridgeline areas within the Rhi SMU (where the underlying substrate breaches the surface or soils are very shallow and the underlying substrate impedes soil development) this soil type is best described as a Leptic Rudosol.
- **Topography and Landform Attributes:** Most commonly restricted to the upper ridgelines of the steeper hills in the west of the Project site. These areas are intersected by numerous deep gullies, usually with signs of erosion. Slopes in these areas are often in the range of 6-8%.
- **Geology Unit:** Joe Joe Formation and Colinlea Sandstone geological formations.
- **Native Vegetation:** Sparsely vegetated or wooded areas dominated by Gidgee. Smaller areas dominated by Weeping bottlebrush species.
- **Physical Attributes:** The Rhi SMU is comprised primarily of a light pale coloured sandy material of limited pedological development. These soils are mostly very shallow and their development impeded by substrate intrusion. In a large portion of the area, this substrate is exposed at the surface forming rocky outcrops. Surface soils are generally light gray, with a mostly granular structure. When dry they exhibit extensive a hard-setting surface crusting.

  In very isolated area, soils of similar topsoil characteristics have also been identified in areas which runoff these shallow ridgeline outcrops and are sometimes underlain by very pale brown sandy clay subsoils. These subsoils are weakly pedal with occasional firm peds between 20 mm – 40 mm. These soils have been grouped as a single management unit due to their strong association, limited distribution, similarities in topsoil characteristics and the inherent management limitations.
- **Chemical Analyses:** These shallow soils tend to be sodic within the top 20 cm (ESP 7% at 10-20 cm) increasing steadily to strongly sodic (ESP 16%) by 100 cm. Such high levels of sodicity and poor soil stability is evident in these areas with common gully erosion. Surface soils (0-20 cm) are considered strongly acidic (pH 5.3) with acidity decreasing slightly with depth (pH 6.5 at 90-100 cm). When present, weakly developed subsoils are considered slightly saline below 40 cm (EC 0.13 dS/m at 40-50 cm). These soils are considered to have poor fertility (CEC 2.33 mEq / 100g) and very low levels of major soil nutrients (Nitrate Nitrogen 1.7 mg/kg; Phosphorus 3.8 mg/kg; Potassium 82 mg/kg; Organic Carbon 0.62%).

Titus Soil Management Unit -

- **Australian Soil Classification:** Brown Kandosol
- **Topography and Landform Attributes:** These soils are found interspersed with the Rhi SMU along the steeper undulating hills in the west of the Alpha Coal MLA. Slopes in these areas are often in the range of 2-4%.
- **Geology Unit:** Joe Joe Formation and Colinlea Sandstone geological formations
- **Native Vegetation:** Queensland Yellow Jacket; Silver-leaf Ironbark; Poplar box.
- **Physical Attributes:** The Titus SMU consists of a strong brown to brownish-red fine sandy loam. Soils of the Titus SMU are often very deep and weakly structured with minimal colour or texture changes throughout the profile. In some areas, red spherical aggregates (approximately 10 mm in diameter) are encountered at depths of between 40 – 90 cm. Surface soils are loose when dry.

- **Chemical Analyses:** Findings of the chemical analysis indicate a soil which is non-sodic and non-saline. Soil pH increases with depth but the profile is considered slightly acidic (pH 5.9 - 6.4).Surface soils are considered to have low levels of major soil nutrients (Nitrate Nitrogen 3.7 mg/kg; Phosphorus 2.78 mg/kg; Potassium 137 mg/kg) and organic carbon (0.5%). The soil is also considered to have a poor CEC (3.3 mEq / 100g).

Garret Soil Management Unit –

- **Australian Soil Classification:** Brown Kandosol
- **Topography and Landform Attributes:** Located on the gently undulating plains intersected by Sandy Creek in the west of the Project site. In these areas slopes rarely exceed 2%.
- **Geology Unit:** Cenozoic – Quaternary era alluvium of older flood plains, sand, gravel and soil.
- **Native Vegetation:** These areas are mostly forested with Silver-leaf Ironbark and mixed eucalyptus species.
- **Physical Attributes:** The Garret SMU comprises of a red-brown to yellow-brown clayey sand. These soils have limited structure and are of loose consistence. When dry, the surface maintains a loose consistence. Pedal development is limited, with small weak peds of between 10 mm and 30 mm forming in the lower horizon. Whilst being slightly coherent, the surface horizon is mostly granular in structure.
- **Chemical Analyses:** Soils of the Garret Management Unit tend to be non-sodic and non-saline. Soils are slightly acidic throughout the profile (pH 5.9 - 6.4). Low levels of major plant nutrients are present in the surface soils (Nitrate Nitrogen 4.9 mg/kg; Phosphorus 5.6 mg/kg; Potassium 120 mg/kg) and these levels decrease further with depth. The sandy nature of the soil results in a very low CEC (3.0 mEq / 100g) and the surface soil also exhibits low levels of organic carbon (0.5%).

Linda Soil Management Unit -

- **Australian Soil Classification:** Gray Vertosol
- **Topography and Landform Attributes:** Restricted in its distribution to the alluvial plains along Lagoon Creek. These areas are generally very flat, with slopes of less than 1%.
- **Geology Unit:** The Tertiary (equivalent Wondoola Beds) sediments comprising silt, clay, sandy clay material.
- **Native Vegetation:** .These areas are most commonly cleared for grazing or support remnant patches of Brigalow and Gidgee scrub
- **Physical Attributes:** The Linda SMU consists of a firm brown-gray to gray silty clay. This soil type is characterised by minor surface cracking and extensive melon-hole development covering approximately 70% of the surface area. Melon-holes are quite deep (between 60 and 80 cm) and are darker in colour than the adjacent 'mound' soil. Surface soils, when dry, display fine self mulching tendencies. This soil is considered moderately to well structured and stable when dry. Pedal development is moderate. Peds are between 50 - 100 mm in size and very firm in

consistence. Field observations suggest a degree of compaction from extensive grazing and being trafficked while moist.

- **Chemical Analyses:** Soil chemical properties display some variation (attributed to melon-hole development) but the soil is typically non-sodic on the surface before becoming sodic (ESP 10%) within the first 20 cm and strongly sodic (ESP 19%) by 40-50 cm. Soils are considered moderately saline (EC 0.76 dS/m) below 40 cm). Alkalinity increase steadily with depth, with neutral pH (pH 6.8), recordings at the surface increasing to mildly alkaline pH 7.7) by 100 cm. The clay mineralogy results in a soil with a moderate CEC (14 mEq / 100g) and reasonable structure. Levels of major soil nutrients vary greatly (Nitrate Nitrogen 1.4 mg/kg; Phosphorus 21.4 mg/kg; Potassium 345 mg/kg; Organic Carbon 0.9%) but diminish with depth.

Dunrobin Soil Management Unit -

- **Australian Soil Classification:** Brown Dermosol
- **Topography and Landform Attributes:** Restricted in its distribution to the gently undulating plains of the Native Companion Creek catchment area in the southeast corner of the Project site. These areas have been extensively cleared for agriculture. Slopes in these areas do not exceed 3%.
- **Geology Unit:** Cenozoic – Quaternary era alluvium of older flood plains, sand, gravel and soil.
- **Native Vegetation:** Non-remnant; Cleared.
- **Physical Attributes:** The Dunrobin SMU consists of a mostly brown to yellow-brown clay soil. The texture of these soils generally increases slightly with depth, while colour transitions to a lighter brown than the surface soils. These soils are weakly pedal with a weak consistence and peds ranging in size from 20-50 mm. In extensively grazed areas field observations suggest a degree of compaction from frequent trafficking while moist.
- **Chemical Analyses:** Chemical analysis indicates a slightly acidic (pH 6.24) surface soil with pH increasing gradually to moderately alkaline (pH 8.0) by 100 cm. Levels of exchangeable sodium also increase with depth. Surface soils are considered non-sodic before sodicity increases to a classification of sodic (ESP 9.7%) by 50 cm and strongly sodic (ESP 14%) by 100 cm. Levels of major soil nutrients in the topsoil layer were generally very low (Nitrate Nitrogen 1.5 mg/kg; Phosphorus 1.1 mg/kg; Potassium 115 mg/kg; Organic Carbon 0.43%), as was the CEC (5 mEq / 100g) and presence of organic carbon (0.43%).The soil is considered non-saline.

It should be noted that the results of the chemical analysis indicate significant variation in subsoil sodicity across the Dunrobin SMU. These laboratory results were confirmed by field observations. In some areas, significant gully erosion was observed within mid to upper slope drainage lines. However, seemingly identical adjacent and down slope areas, this degree of soil dispersion was not evident.

5.1.2.3.2 Depth and Quality of Useable Topsoil Resources

Useable soil resources are mainly confined to the surficial horizons and locally in the upper part of the subsurface horizons, which contain seed-stock, micro-organisms and nutrients necessary for plant growth. Soil microbial activity, organic matter content and other parameters affecting soil fertility tend to decrease with depth.

For each SMU both the quality of the topsoil resource and depth of topsoil suitable for rehabilitation were determined. These recommendations were made by assessing the physical and chemical properties of each soil type. If required for rehabilitation, topsoil will be stripped to the following depths (in order of suitability for rehabilitation):

- **Britt Soil Management Unit 400 mm**
  There are few limitations which prevent the stripping of this soil unit to depths further than approximately 400 mm. However, below this depth levels of exchangeable sodium increases to a level considered sodic (ESP 6.15%) and soil pH steadily increases to levels considered outside the preferred pH range for most plant species by a depth of 900 mm (pH 8.47).
- **Titus Soil Management Unit 500 mm**
  There are no chemical limitations which restrict the stripping of this soil to depths greater that 500 mm, if required. Soil chemistry indicates that levels of major soil nutrients decrease with depth. The presence of gravel in localised areas may impede stripping at depths greater than approximately 500 mm.
- **Garret Soil Management Unit 200 mm**
  There are few physiochemical limitations which restrict the stripping of this soil to depths greater that 200 mm, if required. Levels of major plant nutrients, particularly nitrogen, decrease markedly within the first 200 mm and this would limit the suitability of the soil as a medium for rehabilitation.
- **Waylon Soil Management Unit 200 mm**
  Stripping depths will generally be limited to 200 mm because of the increased risk of soil dispersion due to high levels of exchangeable sodium and issues associated with plant development in sodic soils.
- **Nelson Soil Management Unit 300 mm**
  There are no changes in the chemical properties of the soil which prevent stripping to depths greater than approximately 300 mm. However, soil structure degrades below the 200-300 mm deep topsoil layer.
- **Dunrobin Soil Management Unit 200 mm**
  Stripping depths will generally be limited to 200 mm because of the increased risk of degradation in soil structure due to elevated levels of exchangeable sodium. Levels of major plant nutrients also decline below the top 100 mm of the soil profile.
- **Surbiton Soil Management Unit 200 mm**
  Stripping depths will generally be limited to 200 mm as there is an increased risk of degradation in soil structure due to elevated levels of exchangeable sodium.. Soil pH increases to levels considered outside the preferred pH range for most plant species by a depth of 400 mm. Note that this soil is at risk from compaction if trafficked whist moist.

- **Linda Soil Management Unit 100 mm**
  Stripping depths will generally be limited to 100 mm due to very high levels of exchangeable sodium and the associated risks of soil dispersion and poor plant growth. Any stripping attempts may be impeded by melonhole development and care will be taken to not disturb soils below this 100 mm threshold.
- **Malika Soil Management Unit 0 mm**
  While soil chemical characteristics would not inhibit the suitability of this topsoil for rehabilitation, rock outcropping is present which would impede stripping operations. If required, further surveys could be undertaken to determine the precise depth and location of rock intrusion into the topsoil layer. Stripping to 200 mm in localised areas could occur.
- **Rhi Soil Management Unit 0 mm**
  This soil is mostly void of major plant nutrients, is dispersive due to high level of exchangeable sodium, and is poorly structured. Therefore it will not be used for stripping and rehabilitation efforts.

The approximate volumes of topsoil available for rehabilitation are presented in Table 5-1. These calculations take into consideration the disturbance footprint of the Project, underlying soil type and stripping depth.

Table 5-1: Approximate Volumes of Topsoil Available for Rehabilitation

Soil Management Unit	Surface Area (Total Project Site) (ha)	Approximate Surface Area to be Disturbed (ha)	Percentage of Total Disturbance Area (%)	Stripping Depth (m)	Approximate Volume of Topsoil Available for Rehabilitation (m^3)
Britt	670	36.4	0.2	0.4	**145,600**
Titus	11,040	1220.9	5.4	0.5	**6,104,500**
Garret	23,720	9,628.5	42.8	0.2	**19,257,000**
Waylon	1,620	750.4	3.3	0.2	**1,500,800**
Nelson	8,690	4,632.0	20.6	0.3	**13,896,000**
Dunrobin	3,400	0	0.0	0.2	**0**
Surbiton	270	0	0.0	0.2	**0**
Linda	4,930	3,708.0	16.5	0.1	**3,708,000**
Malika	2,300	858.6	3.8	0	**0**
Rhi	8,190	1,664.7	7.4	0	**0**
Total	**64,830**	**22,500**	**100**	**-**	**44,611,900**

5.1.3 Potential Impacts and Mitigation Measures

The potential impacts may occur from erosion of soil on the Project site. Areas that have been exposed through vegetation removal are more susceptible to erosion. Specific areas of the Project site that may potentially be impacted on due to exposed soils include the following:

- Areas cleared for vegetation;
- Waste dumps;

- Stockpiles;
- Dams, banks and waterway crossings;
- The mine site including the mine infrastructure area;
- Access roads, railways areas and associated infrastructure areas; and
- Areas under rehabilitation.

Environmental values may potentially be impacted on by soil erosion, due to factors such as increased sediments in waterways, further loss of vegetation, loss of future production potential and a general decrease in waterway quality.

5.1.3.1 Erosion Potential and Soil Stability

Field surveys have found that localised areas, primarily within the Rhi and Dunrobin SMUs, exhibit moderately to severe sheet and gully erosion. These areas are mostly restricted to the minor drainage lines which originate from the upper slopes of the minor ridge, formed along the Colinlea Sandstone and Joe Joe Formation outcrops.

Soils within the Rhi and Dunrobin SMUs have instances of hard setting surficial horizons and sodic soil layers within close proximity to the surface. Accordingly, in cleared areas these soils are likely to be prone to locally severe occurrences of sheet, rill and gully erosion due to uncontrolled surface water runoff from the hard setting surface soils. Over time this will inevitably lead to exposure of the more strongly dispersive subsoil layers which will exacerbate the effects and severity of the gully erosion.

Whilst also displaying high levels of exchangeable sodium, soils of the Linda SMU are at less of a risk of dispersion due to the relief of the mostly flat plains on which they occur.

Soil loss estimates have been computed to enable effective erosion and sediment control measures to be put in place during project development and to aid mitigation measure to reduce the erosion potential of post-mining landforms.

The computed soil loss results for the Project site for each soil management unit range from 48 – 97 tonnes/ha/yr and 201 - 435 tonnes/ha/yr for the flat and sloping rehabilitated landforms, respectively, with a bare soil surface. The Titus management unit has the highest erodibility ranking and is expected to generate the largest soil loss and erosion mitigation considerations are of particular importance for this soil unit. The computed soil loss rates will be significantly reduced during vegetation establishment. The theoretical soil loss rates will reduce by 65 to 85% with vegetative covers of 25 to 50%, respectively.

Soil loss (A) has been computed using the Revised Universal Soil Loss Equation (RUSLE) in accordance with Managing Urban stormwater: Soils and Construction Volume 1 – Appendix A (2004). The RUSLE is designed to predict the long term annual soil loss from the project site due to erosion and this equation models five factors: rainfall erosivity (R), soil erodibility (K), slope length/gradient (LS), erosion control practice (P) and ground cover/management factor (C).

The estimated soil loss for each SMU for both flat and sloping post-mining landforms with a bare soil surface is quantified below in Table 5-2.

Table 5-2: RUSLE Results (bare soil)

	Britt	Waylon	Surbiton	Nelson	Malika	Rhi	Titus	Garret	Linda	Dunr-obin
R	2210	2210	2210	2210	2210	2210	2210	2210	2210	2210
K	0.015	0.017	0.025	0.025	0.025	0.015	0.030	0.025	0.025	0.025
LS - flat	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82
LS - slope	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59
P	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
C	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A (flats) = (ton/h/yr)	**48**	**55**	**80**	**80**	**80**	**48**	**97**	**80**	**80**	**80**
A (slopes) = (ton/h/yr)	**201**	**228**	**335**	**335**	**335**	**201**	**403**	**335**	**335**	**335**

5.1.3.2 Erosion Management

A detailed ESCP will be developed prior to the commencement of construction works. The principle objectives of the ESCP are outlined in Volume 2, Section 25.

One of the primary design aspects of the Project is the minimisation of clean water in ephemeral drainage channels entering the active disturbance area. This will be achieved through the use of levees, cut-off drains, dams and diversions, as well as the containment of dirty water in sediment dams within the active areas of the Project to limit any uncontrolled runoff.

Effective erosion and sediment control for the Project site will require appropriate activities to be carried out over the life of the Project including:

- Construction;
- Operations; and
- Rehabilitation and Closure.

The effectiveness of erosion and sediment controls during the operational and closure stages will be optimised through effective mine planning and design.

Sediment dams will be provided to intercept as much runoff from the overburden dump as practical. The eastern portion of the overburden dump drains east, and sediment dams will intercept dirty runoff before it reaches Lagoon Creek. The eastern sediment dams overflow to a drain running along the western side of the main haul road. The overflow drain discharges to a final sediment dam, which can discharge into Lagoon Creek under optimum conditions. The western portion of the overburden dump drains to the pits, and sediment dams have been provided to intercept dirty runoff before it reaches the pit. Water captured in the western sediment dams (SD11 to SD20) will be pumped back to the eastern sediment dams. However, the western sediment dams will overflow to the pit during large storm events (Volume 2, Section 11).

A total of 21 sediment dams are proposed to manage runoff from the site over the life of the project. The proposed sediment dam locations have been selected so that runoff from disturbed areas will be intercepted and appropriately managed before release into the creek system.

5.1.3.3 Erosion Monitoring

Regular erosion monitoring of the rehabilitation areas will be required during the vegetation establishment period, to demonstrate whether the objectives of the rehabilitation strategy are being achieved and whether a sustainable landform has been provided.

In addition to rehabilitated areas, reference sites will be monitored to allow a comparison of the development and success of the rehabilitation against a control. Reference sites indicate the condition of surrounding un-mined areas that the mine site must replicate.

The proposed rehabilitation monitoring program details, including relevant erosion monitoring aspects, are provided in the Environmental Management Plan (Volume 5, Appendix P).

5.1.4 Conclusions

Based on field and laboratory assessments, ten SMUs were identified within the Project site. These were classified as the Britt, Waylon, Surbiton, Nelson, Malika, Rhi, Titus, Garret, Linda and Dunrobin SMUs.

The Surbiton, Linda and Dunrobin SMUs all posses a non-sodic surface layer before levels of exchangeable sodium increase to sodic or strongly sodic within the upper 50 cm of the profile. Salinity also increases within these profiles, but only to levels considered slightly saline by 90-100 cm. An exception to this is the Linda SMU which becomes sodic within the first 20 cm and strongly sodic by 40-50 cm.

With the exception of the Malika and Rhi SMUs, the soils of the Project site are all considered suitable for stripping and stockpiling of the topsoil layer for post mine rehabilitation efforts. All soils present on the Project site are considered largely deficient of major soil nutrients. As such, it is recommended that topsoil stockpiles be ripped and seeded to maintain soil biota and a viable seed bank. An application of an appropriate fertiliser will be used to enhance the growing medium where required.