Lucky Break Nickel Project

Soil & Land Suitability Assessment Report

Prepared for:

QLD Gold Pty Ltd

100% Subsidiary of

METALLICA MINERALS LTD

August 2006

AustralAsian Resource Consultants

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
Draft		Bob Martin, Metallica	1	10 Nov 06	Andrew Pearce	Craig McKiernan
Final		Bob Martin, Metallica	1	8 Jan 07	Andrew Pearce	Craig McKiernan

Author: Naomi Best
Project Manager: Craig McKiernan
Name of Client: QLD Gold Pty Ltd, 100% subsidiary of Metallica Minerals Limited
Name of Project: Lucky Break Nickel Project
Title of Document: Soil & Land Suitability Assessment Report
Document Version: Final

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AARC	-	AustralAsian Resource Consultants Pty Ltd
BDL	-	Below Detection Limit
CEC	-	Cation Exchange Capacity
cm	-	centimetre
DME	-	Department of Minerals and Energy
ESP	-	Exchangeable Sodium Percentage
Km	-	Kilometres
ha	-	Hectares
m	-	Metre
ML	-	Mining Lease
MLA	-	Mining Lease Application
mm	-	Millimetres
NATA	-	National Association of Testing Authorities
PAWC	-	Plant Available Water Capacity

EXECUTIVE SUMMARY

Australasian Resource Consultants Pty Ltd was commissioned by QLD Gold Pty Ltd, a 100% subsidiary of Metallica Minerals Limited, to undertake a soil and land suitability assessment of the proposed Lucky Break Nickel Project Site located approximately 100 kilometres north of Charters Towers and 140 km west of Townsville.

The assessment was undertaken in accordance with *Land Suitability Assessment Techniques* (Department of Minerals and Energy, 1995). In following the procedures outlined in this guideline, the objectives of the study were to:

- Compile a land resource inventory through classification, testing and mapping of soils, and description of the terrain;
- Determine and report on the pre-mining land suitability through the process of land resource evaluation; and
- Determine and report on topsoil stripping requirements to form part of any future Environmental Management Plan.

Soils were assessed at 21 locations within the Project Site, with a total of 41 samples collected for laboratory analysis. The location of each site was recorded using a Global Positioning System with an accuracy of +/- 10 metres. Sampling sites were selected such that all major soil types over the Project Site were sampled. Field sampling was undertaken on the 1st and 2nd of August 2006.

Samples were taken using a mechanical auger attached to the back of a tractor to a depth of 1.0 m (where possible) at each sampling location. Soil samples were collected at three depths throughout the profile; 0-10 cm, 20-30 cm and 60-70 cm. One kilogram of soil from each of these depths was placed into sample bags for analysis by a NATA accredited laboratory. All samples were subsequently analysed for a range of physical and chemical parameters that were used to assess any limiting factors the soils may have.

Most of the Project Site (91%) is covered by two alluvial soil types known as the Barkla association (63% of the Site) and the Cape association (28% of the Site). The Cape soil type is found on the lower plains around Snake Creek and the Barkla soil type is found on the slightly higher plains of the Mining Lease Application area. The Barkla soil is a greyish brown sandy loam that overlays loamy sand or loamy clay at variable depths. The Cape soil is a greyish brown silty loam over loam to clay-loam which in-turn overlays moderately sodic brownish yellow clay. The Barkla soil is of particularly low fertility and the Cape soil is of moderate fertility.

Two other soil types cover the remaining small areas of the Project Site, which include the Conolly association and the Corea association. The Conolly soil type is a shallow gravel soil and is restricted to the western edge of ML 10324. The Corea unit forms the lateritic clay outcrops of the protruding ore bodies on the Project Site.

All soil types on the Project Site have been determined to be a Land Suitability Class of 4 for beef cattle grazing. The main limiting factors preventing all soil types from being a higher Class are water availability and nutrients, with topography an additional factor exclusive to the Corea and Conolly soil types.

Land Suitability Class 4 means the land is marginally suitable for beef cattle grazing with significant inputs required to ensure sustainable use. It should be noted however, that low intensity grazing is the current land use for this area. There are no significant signs that the current use for grazing of this land is unsustainable. Notwithstanding the classifications arrived at in this report, successful cattle grazing has been undertaken within the Project Site during periods of favourable climatic conditions.

The sustainable use of the Project Site for beef cattle grazing would be largely dependent on appropriate stocking rates being employed. These stocking rates would need to take into account seasonal and annual variations in rainfall, the availability and appropriate management of water resources, the availability of land of similar quality in the immediate vicinity and implementation of appropriate management practices.

Three of the four soil types present on the Project Site are Land Suitability Class 5 for rainfed broadacre cropping. This means they are unsuitable for this purpose due to extreme limitations. The limiting factors are water availability, soil structure and topography. The remaining soil type, Soil Type 2 (the Cape association), is deemed to be Land Suitability Class 3 for rainfed broadacre cropping, which is considered moderately suitable for this land use. The limiting factors to a higher Class are also water availability, soil structure and topography.

This report provides a detailed description of each soil type, a land suitability assessment for each soil type, and recommendations on the treatment and use of soils identified during the study.

1.0 INTRODUCTION

Australasian Resource Consultants (AARC) Pty Ltd was commissioned by QLD Gold Pty Ltd, a 100% subsidiary of Metallica Minerals Limited, to undertake a soil and land suitability assessment of the proposed Lucky Break Nickel Project Site (the Project Site) located approximately 100 kilometres (km) north of Charters Towers and 140km west of Townsville.

1.1 SCOPE OF WORKS

A soil and land suitability assessment of the Project Site Soil was undertaken by AARC in accordance with the Department of Minerals and Energy's (DME) *Land Suitability Assessment Techniques* (1995). In following the procedures outlined in this guideline, the objectives of the study were to:

- Compile a land resource inventory through classification, testing and mapping of soils, and description of the terrain;
- Determine and report on the pre-mining land suitability through the process of land resource evaluation; and
- Determine and report on topsoil stripping requirements to form part of any future Environmental Management Plan.

2.0 PROJECT AND SITE DESCRIPTION

2.1 PROJECT LOCATION

The Project Site is located on Lucky Break Station, approximately 100km north of Charters Towers and 130 km by road west of the Yabulu Nickel Refinery near Townsville in North Queensland. Mining Lease (ML) 10324 covers an area of 35 hectares (ha) and the Mining Lease Application (MLA) area covers approximately 175 ha. The Site lies within the Charters Towers Mining District, the Townsville 1:250,000 sheet area and the Ewan 1:100,000 sheet.

Access to the Project Site is via the sealed all-weather Gregory Development Road, either from Greenvale or from Charters Towers approximately 100km north and south of the Site respectively. Access is also possible via the sealed all-weather Hervey Range Development Road from the Yabulu Nickel Refinery, north of Townsville (Figure 1).

Access within the Project Site and surrounding area is good, with a network of tracks throughout the Project Site. Useful facilities are available at Bluewater Springs Roadhouse, approximately 16km north of the Project Site. A homestead also exists on Lucky Break Station, approximately 1.5km south of the Project Site (Figure 2). Snake Creek lies between ML 10324 and the Mining Lease Application (MLA), which drains to the west to Stockyard Creek. This in turn drains to the Burdekin River located approximately 25km to the south-east of the Project Site.

2.2 PROJECT OVERVIEW

The proposed Project involves creating a new ML alongside the existing Dingo Dam Project on ML 10324 to facilitate the expansion of mining activities. ML 10324 is held by QLD Gold Pty Ltd and mining activities are approved under Environmental Authority MIN100338305. The Project has an initial one-year Plan of Operations to enable the extraction of bulk samples from the nickel-laterite deposit, which is due to expire in June 2007.

The proposed expanded activities include the establishment of an additional area on which a heap leach pad, processing plant, a small open cut, overburden dumps, and mine support facilities would be situated. The additional open cut called Circular Pit covers only a small area of approximately 200-250 meters (m) in diameter.

Ore will be transported from the Dingo Dam Pit on the existing ML 10324 to the processing facilities. The Dingo Dam Pit is also small and covers an area of approximately 350-400m long by 50-80m wide. Other proposed disturbances on ML 10324 are overburden dumps, topsoil stockpiles and minor internal haul roads.

The nickel-cobalt concentrate product will be transported to Townsville for further processing or exported to overseas markets. The annual Run of Mine ore will be approximately 250,000 tonnes for approximately four years.

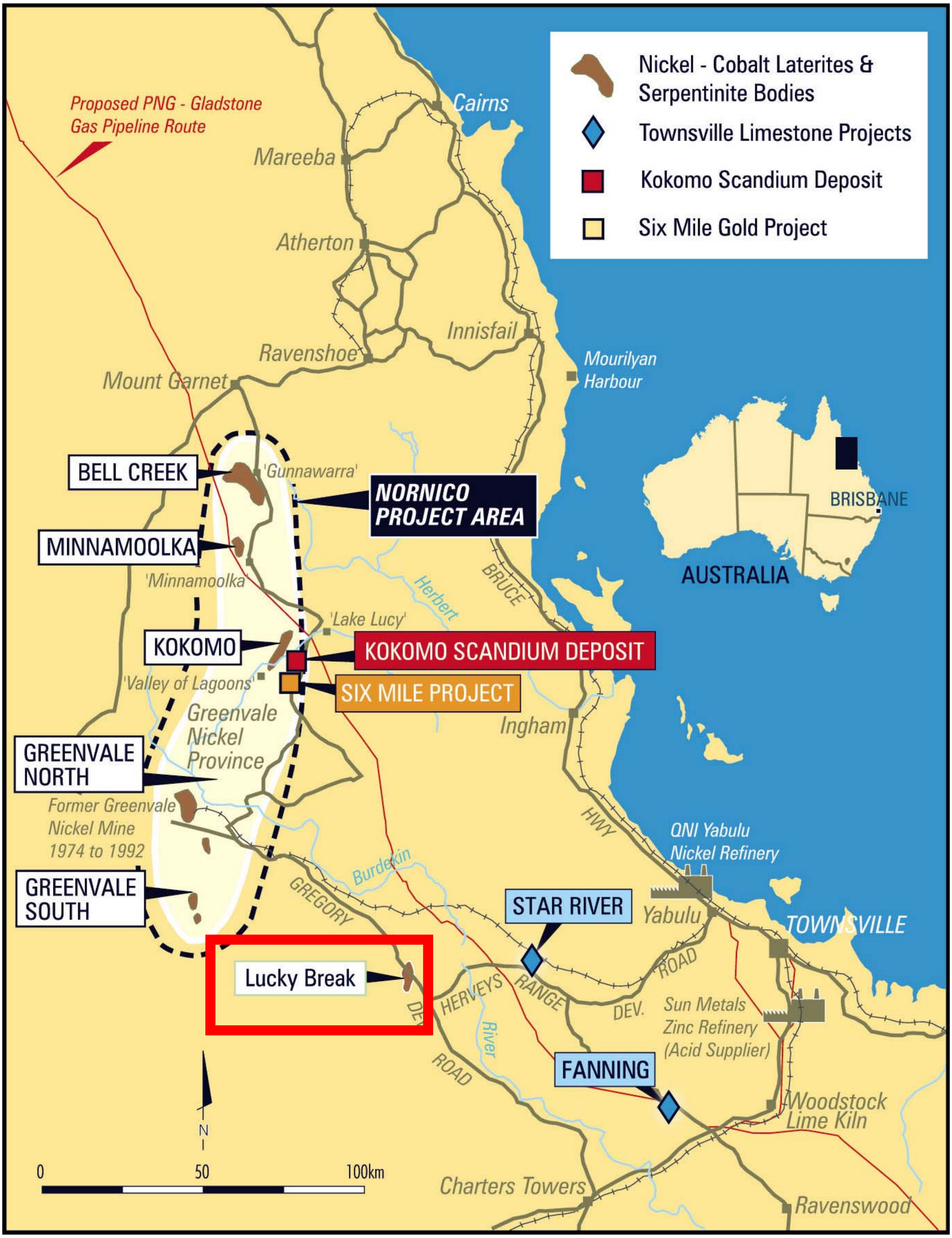

Figure 1: Regional Location of the Lucky Break Nickel Project

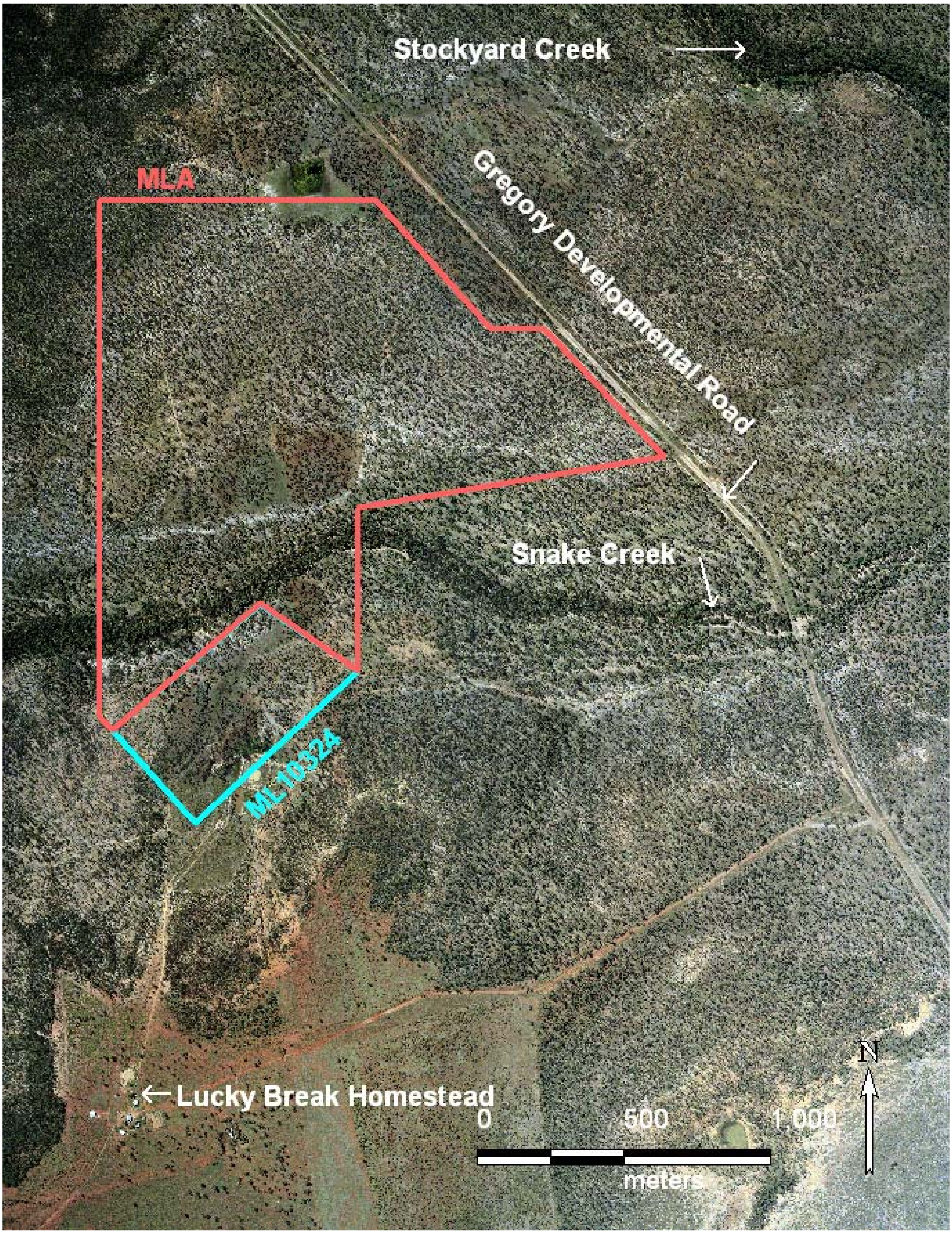

Figure 2: Local Location of the Project Site

2.3 REGIONAL CLIMATE

This climatic description of the region in which the Project Site is located has been compiled using data collected from the Charters Towers Airport by Australian Bureau of Meteorology (http://www.bom.gov.au/). The Charters Towers weather monitoring station is approximately 100km to the south of the Project Site.

The data indicates that mean annual rainfall for the region is approximately 579 millimetres (mm). Figure 3 shows that rainfall is typically highly seasonal, with the dry season peaking between July and September and the wet season peaking in January and February.

Figure 4 shows that the coldest mean daily temperatures occur in June and July, with eight of the remaining ten months having a mean daily temperature between 30 and 35°C.

Light to moderate winds up 20km/h from the east or north-east are dominant from September through to January. From February through to August winds are of a similar strength but tend to come from the east or south-east.

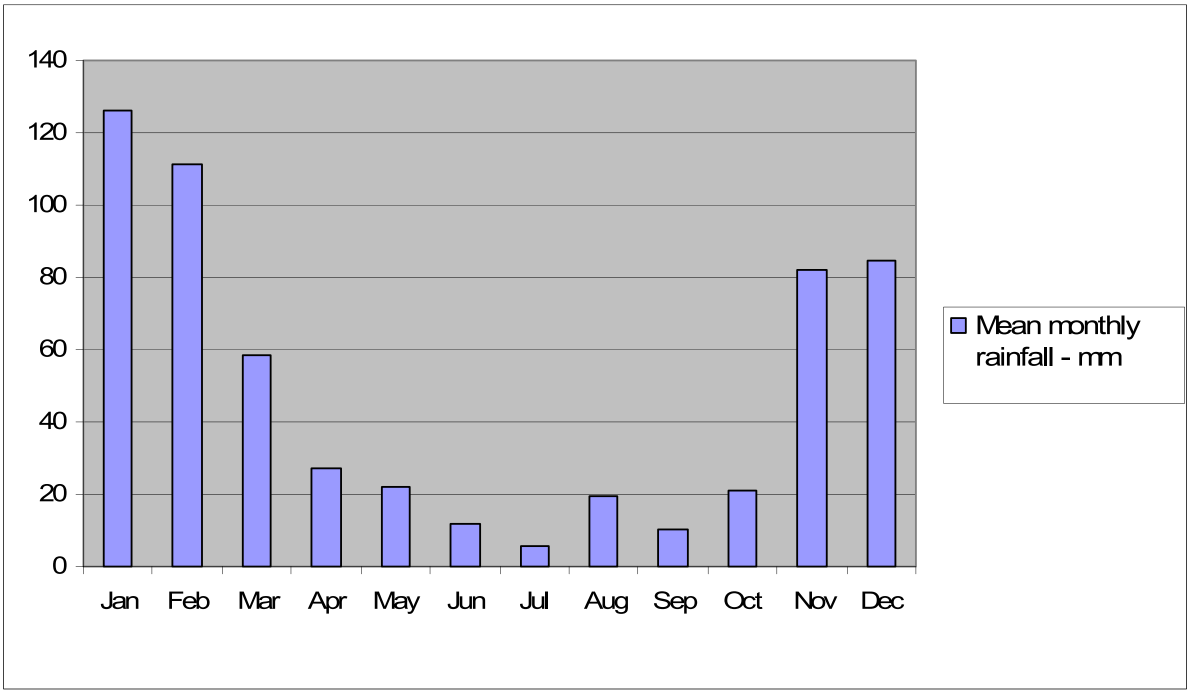

Figure 3: Mean Monthly Rainfall (mm) for the Charters Towers Region

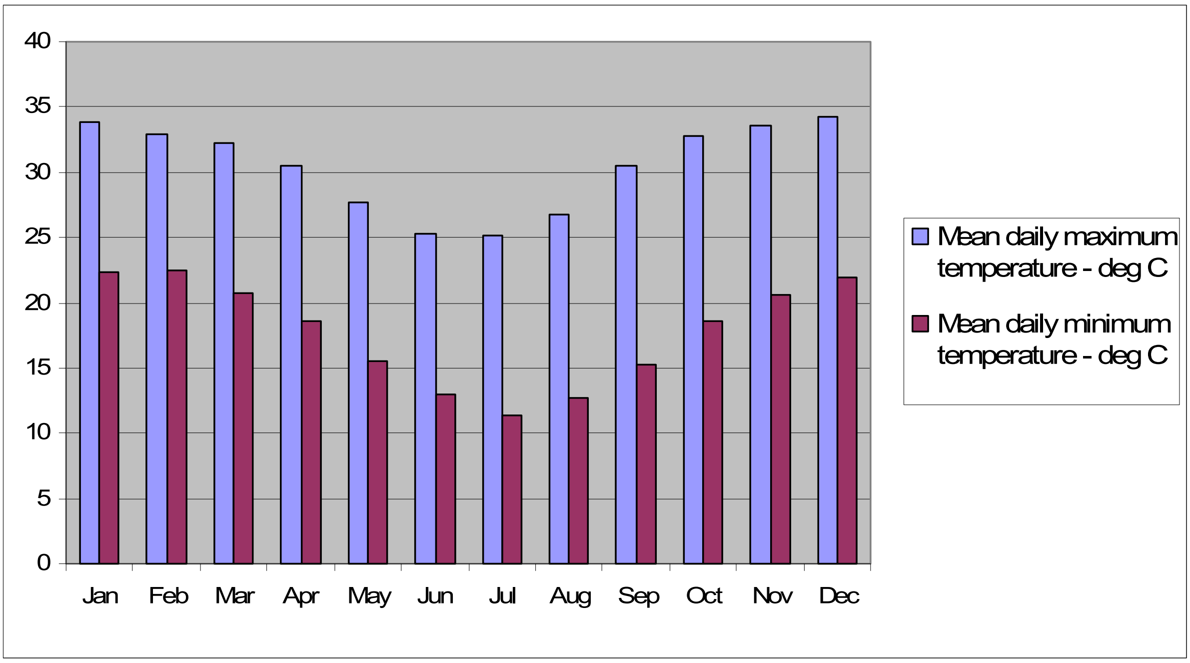

Figure 4: Mean Monthly Temperature (degrees C) for the Charters Towers Region

2.4 SURFACE WATER AND DRAINAGE

In a regional context, the Project Site is located within the north-central section of the Burdekin River catchment. The Burdekin River catchment covers a total area of approximately 130,000km^2 and has peak flows from December to April and lower to no flow from May to November.

Locally, the site is situated within the lower reaches of Snake Creek catchment which covers an area of approximately 160km^2. Snake Creek is located between ML 10324 and the MLA site. With the exception of a narrow transport corridor between the sites, Snake Creek is entirely avoided by mining activities and is outside the boundaries of the Project Site. The proposed transport corridor is located within the corridor presently used by the land owner to cross Snake Creek.

Most of the land on the Project Site slopes gently towards Snake Creek. Snake Creek drains to Stockyard Creek less than 5 km south-east of the Project Site. Stockyard Creek then drains into the Basalt River approximately 20km further to the south-east. The Basalt River travels a short distance from its confluence with Stockyard Creek before discharging into the Burdekin River.

Snake Creek is highly ephemeral, with no permanent ponds being present in the vicinity of the Project Site. The creek is between 10m and 20m wide with the bed consisting of course sand interspersed with tall Eucalypts, Melaleucas and Casuarinas. The banks are short and steep to a height of approximately 3-4m in some locations. Rubber vine dominates the understorey along much of creek-bed and its banks. The upper banks of Snake Creek form an alluvial plain of soils consisting of silty-sand.

3.0 METHODOLOGY

3.1 LITERATURE REVIEW

The primary reference document for soils of the region in which the Project Site is located is the Queensland Government publication *Land Resources of the Dalrymple Shire* (Rogers *et al*, 1999). The report is designed to provide information on property planning and pasture management to achieve sustainable beef cattle production. It is based on soil mapping through field assessment and laboratory analysis. It provides detailed soil descriptions and issues concerning land degradation. Information contained in the report is used in conjunction with AARC's field survey results.

Additionally, soil maps and brief soil descriptions were sourced from the Atlas of Queensland Soils on the Interactive Resource and Tenure Maps (http://www.nrm.qld.gov.au).

3.2 FIELD SURVEY

Soils were assessed at 21 locations within the Project Site (Figure 5), with a total of 41 samples collected for laboratory analysis. The location of each site was recorded using a Global Positioning System with an accuracy of +/- 10m. Sampling sites were selected such that all major soil types over the Project Site were sampled. Field sampling was undertaken on the 1st and 2nd of August 2006.

Samples were taken using a mechanical auger attached to the back of a tractor to a depth of 1.0m (where possible) at each sampling location. Soil samples were collected at three depths throughout the profile; 0-10 centimetres (cm), 20-30 cm and 60-70 cm. One kilogram of soil from each of these depths was placed into sample bags for chemical and physical analysis by a NATA accredited laboratory.

All samples were subsequently analysed for pH (1:5 water and 1:5 $CaCl_2$); Organic Carbon; Nitrate as N; Total N; Sulphate; Phosphorous; Potassium; Calcium; Magnesium; Sodium; Chloride; Electrical Conductivity (EC); Copper; Zinc; Manganese; Iron; Boron; Percent Moisture Content; Cation Exchange Capacity (CEC); Calcium to Magnesium ratio; and Exchangeable Sodium Percentage (ESP).

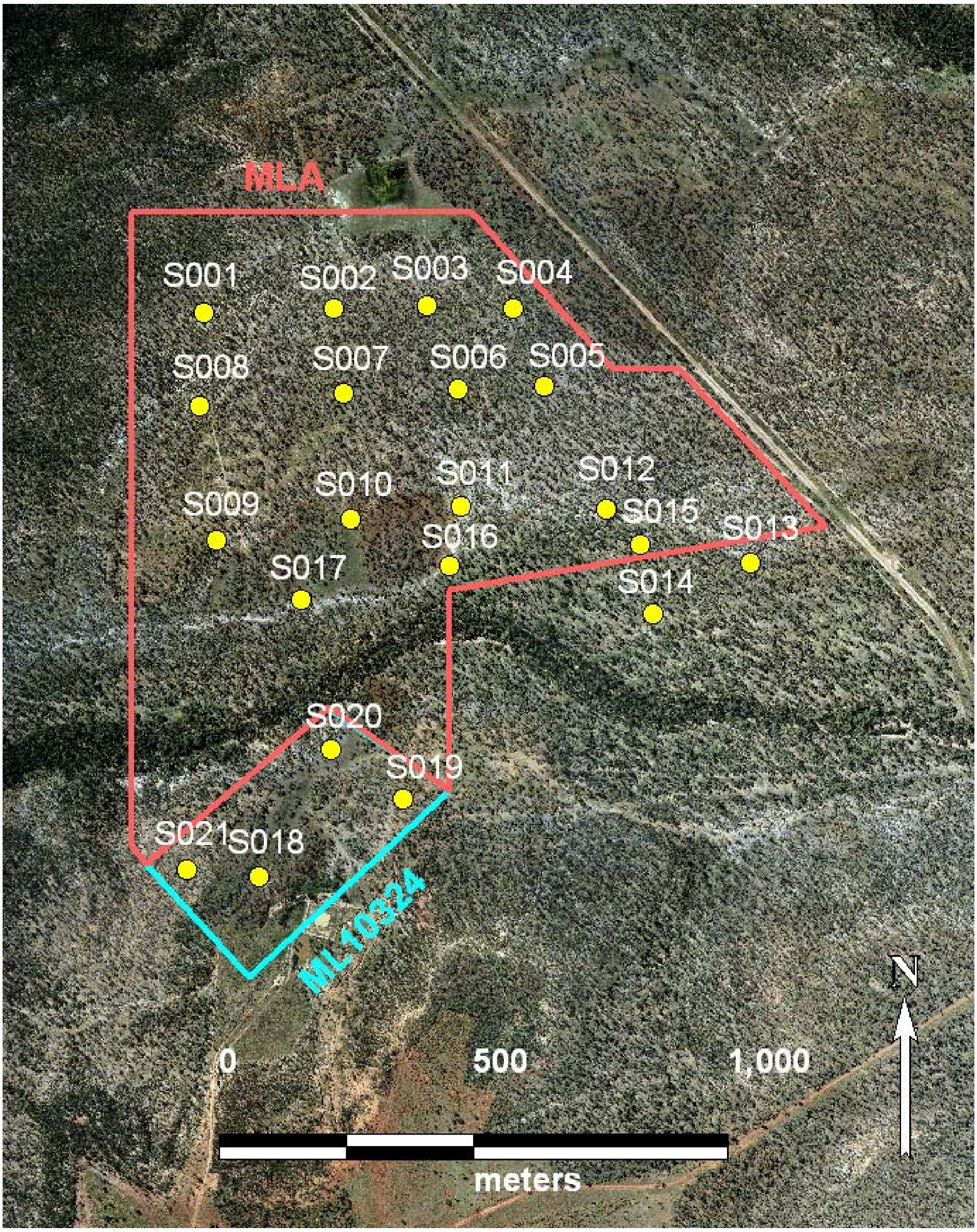

Figure 5: Soil Sampling Locations

4.0 RESULTS

4.1 SOIL TYPES

Mapping presented in Rogers *et al* (1999), and on the Interactive Resource and Tenure Maps website suggests that four soil types exist on the Project Site. This was confirmed by the AARC field survey when the distribution of soils on the Project Site was mapped and soil samples collected. The distribution of soil units is shown in Figure 6. Soil association names are sourced from Rogers *et al* (1999).

Figure 6 shows that the majority of the Project Site is covered by two alluvial soil types known as the Barkla association (Soil Type 1) and the Cape association (Soil Type 2). Both soil types form on alluvial plains, with the Cape unit found on the lower plains around Snake Creek and the Barkla unit found on the slightly higher plains on the MLA.

Two other soil types cover the remaining small areas of the Project Site, which include the Conolly association (Soil Type 3) and the Corea association (Soil Type 4). The Conolly unit is restricted to the western edge of ML 10324 and the Corea unit forms the lateritic clay outcrops of the protruding ore bodies on the Project Site.

A description of each soil type is provided below and a summary of the chemical characteristics of each soil type is attached in Appendix A.

Soil Type 1: Barkla

This soil is a greyish brown sandy loam that overlays loamy sand or loamy clay at variable depths. A strong texture contrast is sometimes evident (refer to Photo Plate 1).

The low fertility soils are slightly acid (average pH 5.97, 0-10cm), are low in organic Carbon, Nitrogen, CEC and Phosphorous. They occur on gently sloping alluvial plains that are occasionally dissected by washouts.

The Barkla soil type covers 175ha of the Project Site (63% of the Site).

Photo Plate 1: Example of strong texture contrast in the Barkla soil type

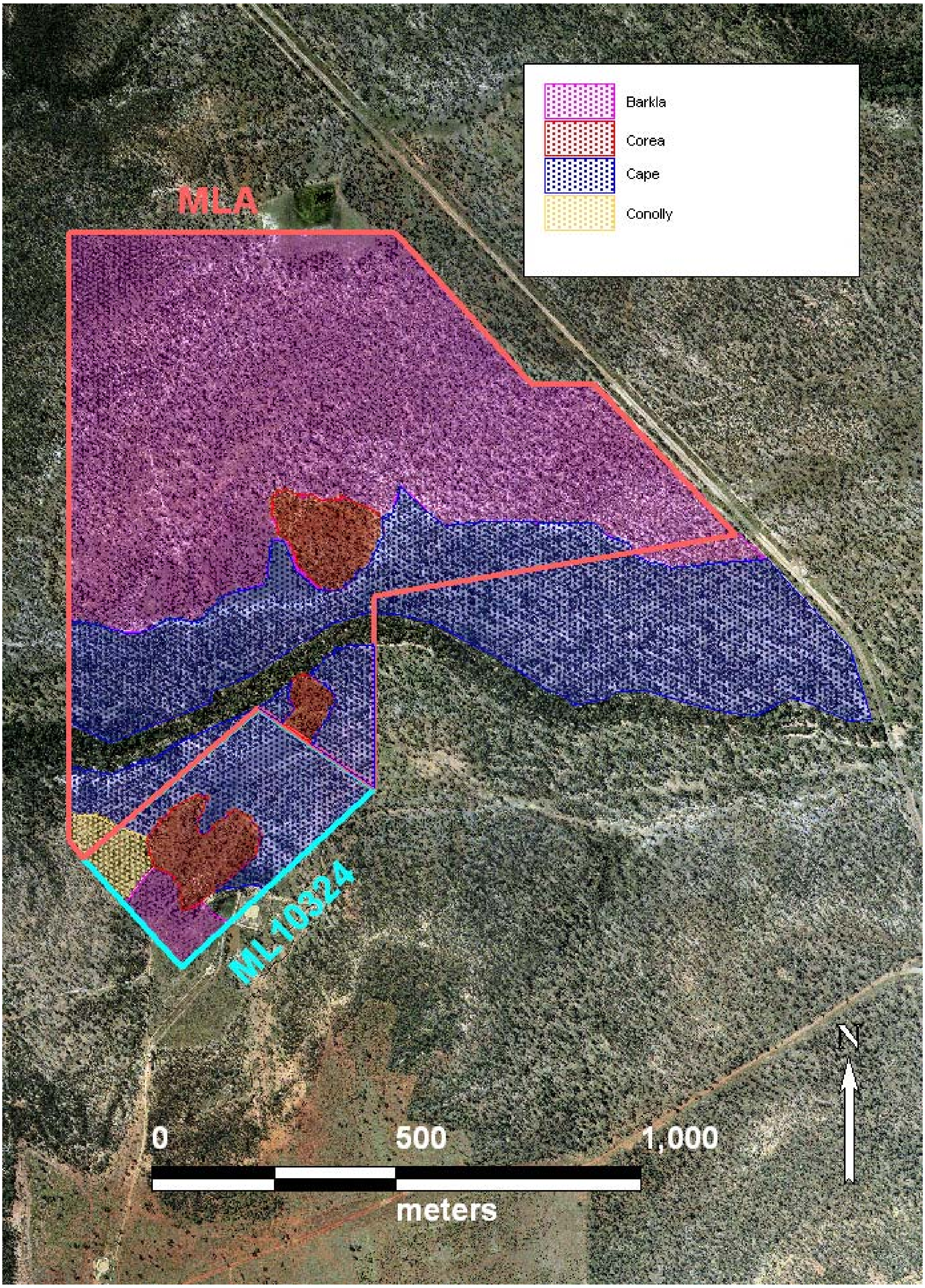

Figure 6: Distribution of Soils on the Project Site

Soil Type 2: Cape

This soil is a greyish brown silty loam over loam to clay loam over moderately sodic brownish yellow clay. The soil is of moderate fertility, but nutrient levels, particularly phosphorous, fall significantly below the upper 200mm. The moderately sodic subsoils may be highly dispersive.

The Cape soils occur on gently sloping alluvial plains that form the upper levee of Snake Creek. Washouts dissecting this soil unit are common.

The Cape soil type covers 78ha of the Project Site (28% of the Site).

Photo Plate 2: Example of 1m soil profile of the Cape soil type

Soil Type 3: Conolly

The Conolly soil type is gravely sand formed from granite on dense brown clay at a depth of less than 300mm.

The soil unit has steep slopes up to 30% and is heavily dissected by gullies. There is very little soil development and nutrient levels and vegetation cover are low.

The Conolly soil type covers 4.5ha of the Project Site (2% of the Site). It is understood there will be no or minimal disturbance to this soil unit.

Photo Plate 3: Soil surface within the Conolly soil type

Soil Type 4: Corea

The Corea soil type forms lateritic clay outcrops of the protruding ore bodies on the Project Site. This soil type is a massive reddish-brown clay with the surface often consisting of greater than 60% rock.

The soil unit has gentle to steep slopes up to 40% and the soils are non-acid and non-sodic with low nutrient levels.

The Correa soil type covers 17.5ha of the Project Site (7% of the Site).

Photo Plate 4: Surface of the Corea Soil Type

5.0 LAND SUITABILITY ASSESSMENT

5.1 ASSESSMENT AIMS

This land suitability assessment aims to evaluate, according to *Land Suitability Assessment Techniques* (DME, 1995), the land suitability of the Project Site prior to mining.

5.2 LAND SUITABILITY CLASSES

An interpretation of data collected on the physical, chemical and nutritional characteristics of the soil is made to rank the land according to a five-class system that applies to grazing, rainfed cropping and conservation.

The classes are described as:

Class 1 *Suitable land with negligible limitations which is highly productive requiring only simple management practises to maintain economic production.*

Class 2 *Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.*

Class 3 *Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.*

Class 4 *Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production).*

Class 5 *Unsuitable land with extreme limitations that preclude its use for the proposed purpose.*

5.3 CURRENT LAND USES

The current land use of the Project Site is mineral exploration and low intensity cattle grazing for beef produce. Water for stock is provided by a pastoral dams located to the immediate north and south of the Project Site. The Project Site also runs directly adjacent to Snake Creek and crosses the creek at the south-western boundary for access to the existing ML 10324.

5.4 PRE MINING LAND SUITABILITY

The suitability of the land at the Project Site to sustain beef cattle grazing, rainfed broadacre cropping and conservation is described below in Sections 5.4.1 to 5.4.3.

5.4.1 Beef Cattle Grazing

Limitations used to assess land suitability for beef cattle grazing at the Project Site are as follows:

- Water availability;
- Nutrient deficiency;
- Soil physical factors;
- Salinity;
- Rockiness;
- Micro relief;
- pH;
- ESP;
- Wetness;
- Water erosion; and
- Flooding.

These limitations as they relate to the suitability for beef cattle grazing are discussed individually below for each soil type present at the Project Site.

5.4.1.1 Water Availability

The plant available water capacity (PAWC) for the soil types on the Project Site have been estimated by reference to Table 2.3 from *Land Suitability Assessment Techniques* (DME, 1995), and are presented in Table 1. PAWC cut-off levels for beef cattle grazing for each of the land suitability classes are as follows:

Class 1: 125 mm

Class 2: 100-125 mm

Class 3: 75-100 mm

Class 4: 50-75 mm

Class 5: <50 mm

These cut-off levels are not based on a particular type of pasture (for instance Buffel Grass), but on pasture as a general land use.

Table 1: Land Suitability Classes for Beef Cattle Grazing Based on PAWC

Soil Type	*PAWC	Land Suitability Class
1: Barkla	PAWC – 50-75 mm	4
2:Cape	PAWC – 100-125 mm	2
3: Conolly	PAWC – 50-75 mm	4
4: Corea	PAWC – 50-75 mm	4

* Specific PAWC for each soil sourced from Rogers *et al* (1999)

5.4.1.2 Nutrient Deficiency

The impact of nutrient deficiencies on the land suitability class of the soils on the Project Site has been assessed against Table 2.2 of *Land Suitability Assessment Techniques* (DME, 1995). The land suitability class for beef cattle grazing identified for each soil is presented in Table 2.

Table 2: Land Suitability Classes for Beef Cattle Grazing Based on Nutrient Status

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Bicarbonate P ≤4 ppm	4
2:Cape	Bicarbonate P ≤4 ppm	4
3: Conolly	Bicarbonate P ≤4 ppm	4
4: Corea	Bicarbonate P ≤4 ppm	4

5.4.1.3 Soil Physical Factors

The land suitability class identified for each soil type based on soil physical factors is presented in Table 3.

Table 3: Land Suitability Classes for Beef Cattle Grazing Based on Soil Physical Factors

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Rigid soil with a hard setting surface when dry	2
2:Cape	Rigid soil with a hard setting surface when dry	2
3: Conolly	Gravel with minimal soil features	3
4: Corea	Crust forms on the surface	3

5.4.1.4 Salinity

A root zone of 50cm is assumed for the root zone of pasture species. The land suitability classes identified for each soil type based on salinity are presented in Table 4.

Table 4: Land Suitability Classes for Beef Cattle Grazing Based on Salinity

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Rootzone EC <0.15 mS/cm	1
2:Cape	Rootzone EC <0.15 mS/cm	1
3: Conolly	Rootzone EC <0.15 mS/cm	1
4: Corea	Rootzone EC <0.15 mS/cm	1

5.4.1.5 Rockiness

The land suitability class identified for each soil type based on rockiness is presented in Table 5.

Table 5: Land Suitability Classes for Beef Cattle Grazing Based on Rockiness

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	<20% coarse surface gravel	1
2:Cape	<20% coarse surface gravel	1
3: Conolly	>90% surface gravel	4
4: Corea	50-90% surface cobble	3

5.4.1.6 Microrelief

All areas within the Project Site have been assigned a Class 1 rating for microrelief as melonholes cover less than 20% of all soil types on the Project Site.

5.4.1.7 pH

The land suitability class identified for each soil type based on pH is presented in Table 6.

Table 6: Land Suitability Classes for Beef Cattle Grazing Based on pH

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	pH in rootzone 5.6-6.6	1
2:Cape	pH in rootzone 6.6-8.0	2
3: Conolly	pH in rootzone 5.0-5.6	4
4: Corea	pH in rootzone 6.6-8.0	2

5.4.1.8 Exchangeable Sodium Percent (30cm)

ESP is a measure used to determine the erosion potential of soils. The land suitability classes identified for each soil type based on ESP in the upper 300mm is presented in Table 7.

Table 7: Land Suitability Classes for Beef Cattle Grazing Based on ESP

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	ESP <5.0	1
2:Cape	ESP 5.0-10.0	2
3: Conolly	ESP 5.0-10.0	2
4: Corea	ESP 5.0-10.0	2

5.4.1.9 Wetness

The limiting factor of wetness describes the adverse affects of excess water on pasture production through a reduction in plant growth. The land suitability class identified for each soil type based on wetness is presented in Table 8.

Table 8: Land Suitability Classes for Beef Cattle Grazing Based on Wetness

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Gently undulating elevated plains	1
2:Cape	Low lying level plains	2
3: Conolly	Undulating terrain	1
4: Corea	Undulating terrain	1

5.4.1.10 Topography

The land suitability class identified for each soil type based on topography is presented in Table 9.

Table 9: Land Suitability Classes for Beef Cattle Grazing Based on Topography

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Slopes less than 15%	1
2:Cape	Slopes less than 15%	1
3: Conolly	Many deep gullies. Slopes >15%	4
4: Corea	Slopes >15%	4

5.4.1.11 Water Erosion

The land suitability class identified for each soil type based on water erosion is presented in Table 10.

Table 10: Land Suitability Classes for Beef Cattle Grazing Based on Water Erosion

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Slopes < 3% on non-sodic soils	1
2:Cape	Slopes < 1% on soils with sodic sub-soil	1
3: Conolly	Slopes 12-20% on non-sodic soils	3
4: Corea	Slopes 12-20% on non-sodic soils	3

5.4.1.12 Flooding

All soil types have been assigned Land Suitability Class 2 with flooding expected in every 50-100 year cycle.

5.4.1.13 Summary of Land Suitability for Beef Cattle Grazing

As summarised in Table 11 below, all soil types are classified as Land Suitability Class 4 for Beef Cattle Grazing. The main limiting factors preventing all soil types from being a higher land suitability class are water availability and nutrients, with topography an additional factor exclusive to the Corea and Conolly soil types.

Land Suitability Class 4 means the soils are marginally suitable for beef cattle grazing with major inputs required to ensure sustainable use. It should be noted however that low intensity grazing is the current land use for this area. There are no significant signs that the current use for grazing of this land is unsustainable. Notwithstanding the classifications arrived at in this report, successful cattle grazing has been undertaken within the Project Site during periods of favourable climatic conditions.

The sustainable use of the Project Site for beef cattle grazing would be largely dependent on appropriate stocking rates being employed. These stocking rates would need to take into account seasonal and annual variations in rainfall, availability of and appropriate management of water resources, the availability of land of similar quality in the immediate vicinity and implementation of appropriate management practices.

Table 11: Summary of Land Suitability Limitations for Beef Cattle Grazing

Parameter	Barkla	Cape	Conolly	Corea
PAWC	4	2	4	4
Nutrients	4	4	4	4
Physical	2	2	3	3
Salinity	1	1	1	1
Rockiness	1	1	4	3
Micro- relief	1	1	1	1
pH	1	2	4	2
ESP	1	2	2	2
Wetness	1	2	1	1
Topography	1	1	4	4
Erosion	1	1	3	3
Flooding	2	2	2	2
Overall Suitability Rating	**4**	**4**	**4**	**4**

5.4.2 Rainfed Broadacre Cropping

Limitations used to assess land suitability for rainfed broadacre cropping at the Project Site are as follows:

- Water availability;
- Nutrient deficiency;
- Soil physical factors;
- Soil workability;
- Salinity;
- Rockiness;
- Microrelief;
- Wetness;
- Topography;
- Water Erosion; and
- Flooding.

These limitations are discussed below for each soil type present at the Project Site.

5.4.2.1 Water Availability

The PAWC for each soil type on the Project Site (Table 12) has been estimated using Table 2.3 from *Land Suitability Assessment Techniques* (DME, 1995) as a guide. PAWC cut-off levels for each land suitability class for rainfed broadacre cropping are as follows:

Class 1: >150 mm

Class 2: 125-150 mm

Class 3: 100-125 mm

Class 4: 75-100 mm

Class 5: <75 mm

Table 12: Land Suitability Classes for Rainfed Broadacre Cropping Based on PAWC

Soil Type	*PAWC	Land Suitability Class
1: Barkla	PAWC <75 mm	5
2:Cape	PAWC 100-125 mm	3
3: Conolly	PAWC <75 mm	5
4: Corea	PAWC <75 mm	5

* Specific PAWC for each soil sourced from Rogers *et al* (1999)

5.4.2.2 Nutrient Deficiency

The impact of nutrient deficiencies on the land suitability class of soils on the Project Site has been assessed against Table 2.2 of *Land Suitability Assessment Techniques* (DME, 1995). Results are presented in Table 13.

Table 13: Land Suitability Classed for Rainfed Broadacre Cropping Based on Nutrient Status

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Bicarbonate P ≤10 ppm and Exchangeable K $\leq$ 0.3meq/100g; and Exchangeable Ca <3meq/100g	4
2:Cape	Exchangeable K > 0.3meq/100g	2
3: Conolly	Bicarbonate P ≤10 ppm and Exchangeable K $\leq$ 0.3meq/100g; and Exchangeable Ca <3meq/100g	4
4: Corea	Exchangeable K > 0.3meq/100g	2

5.4.2.3 Soil Physical Factors

The land suitability class for rainfed broadacre cropping identified for each soil type based on soil physical factors is presented in Table 14.

Table 14: Land Suitability Classes for Rainfed Broadacre Cropping Based on Soil Physical Factors

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Rigid soil with a hard setting surface when dry	3
2:Cape	Rigid soil with a hard setting surface when dry	3
3: Conolly	Gravel with minimal soil features	5
4: Corea	Rigid soil with a hard setting surface when dry	3

5.4.2.4 Soil Workability

The land suitability class for rainfed broadacre cropping determined for each soil type based on soil workability is presented in Table 15.

Table 15: Land Suitability Classed for Rainfed Broadacre Cropping Based on Soil Workability

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Rigid soil with a hard setting surface when dry	2
2:Cape	Rigid soil with a hard setting surface when dry	2
3: Conolly	Gravel with minimal soil features	5
4: Corea	Hard setting crusting surface	3

5.4.2.5 Salinity

A root zone of 90cm is assumed for the root zone of rainfed cropping species. The land suitability class identified for each soil type is presented in Table 16.

Table 16: Land Suitability Classed for Rainfed Broadacre Cropping Based on Salinity

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Rootzone EC <0.15 mS/cm	1
2:Cape	Rootzone EC <0.15 mS/cm	1
3: Conolly	Rootzone EC <0.15 mS/cm	1
4: Corea	Rootzone EC <0.15 mS/cm	1

5.4.2.6 Rockiness

The land suitability class identified for each soil type based on rockiness is presented in Table 17.

Table 17: Land Suitability Classes for Rainfed Broadacre Cropping Based on Rockiness

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	<10% coarse surface gravel	1
2:Cape	<10% coarse surface gravel	1
3: Conolly	>90% surface gravel	5
4: Corea	50-90% surface cobble	4

5.4.2.7 Microrelief

All areas within the Project Site have been assigned to Land Suitability Class 1 for microrelief as melonholes cover less than 10% of the Project Site.

5.4.2.8 Wetness

The limitation of wetness describes the adverse affects of excess water on cropping through a reduction in plant growth. The land suitability class identified for each soil type based on wetness is presented in Table 18 below.

Table 18: Land Suitability Classes for Rainfed Broadacre Cropping Based on Wetness

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Gently undulating elevated plains	1
2:Cape	Low lying level plains	2
3: Conolly	Undulating terrain	1
4: Corea	Undulating terrain	1

5.4.2.9 Topography

The land suitability class identified for each soil type based on topography is presented in Table 19.

Table 19: Land Suitability Classes for Rainfed Broadacre Cropping Based on Topography

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Occasional gullies present	2
2:Cape	Gullies would impede cultivation	3
3: Conolly	Abundant deep gullies would prevent cultivation	5
4: Corea	Slopes would force major changes to cultivation practices	4

5.4.2.10 Water Erosion

The land suitability class identified for each soil type based on water erosion is presented Table in 20.

Table 20: Land Suitability Classes for Rainfed Broadacre Cropping Based on Water Erosion

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	Slopes < 1% on non-sodic soils	1
2:Cape	Slopes < 1% on soils with sodic sub-soil	1
3: Conolly	Slopes >5% on non-sodic soils	5
4: Corea	Slopes >5% on non-sodic soils	5

5.4.2.11 Flooding

The land suitability class identified for each soil type based on flooding is presented in Table 21.

Table 21: Land Suitability Classes for Rainfed Broadacre Cropping Based on Flooding

Soil Type	Limiting Features	Land Suitability Class
1: Barkla	<1 flood per 100yrs	1
2:Cape	Rare flooding (every 50-100yrs)	2
3: Conolly	<1 flood per 100yrs	1
4: Corea	<1 flood per 100yrs	1

5.4.2.12 Summary of Land Suitability for Rainfed Broadacre Cropping

Three of the four soil types present on the Project Site are Land Suitability Class 5 for rainfed broadacre cropping. This means they are unsuitable for this purpose due to extreme limitations. The limiting factors are water availability, soil structure and topography. The remaining soil type, Soil Type 2 (the Cape association), is deemed to be Land Suitability Class 3 for rainfed broadacre cropping, which is considered moderately suitable for this land use. The limiting factors to a higher Class are also water availability, soil structure and topography.

The overall land suitability class for rainfed broadacre rainfed cropping for each soil type is presented in Table 22.

Table 22: Summary of Land Suitability Limitations for Rainfed Broadacre Cropping

Parameter	Barkla	Cape	Conolly	Corea
PAWC	5	3	5	5
Nutrients	4	2	4	2
Physical	3	3	5	3
Soil Workability	2	2	5	3
Salinity	1	1	1	1
Rockiness	1	1	5	4
Micro- relief	1	1	1	1
Wetness	1	2	1	1
Topography	2	3	5	4
Erosion	1	1	5	5
Flooding	1	2	1	1
Overall Suitability Rating	**5**	**3**	**5**	**5**

5.4.3 Conservation

The suitability class for conservation at the Project Site is Land Suitability Class 4. The lands contain limited conservation values pre-mining and/or are incapable of being effectively restored post-mining to any alternative conservation use which provides similar benefits. The area could however be restored to provide a stable landform of use that does not impact on surrounding conservation values (DME 1995).

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 SOIL TYPES

The majority of the Project Site is covered by two alluvial soil types known as the Barkla association (Soil Type 1) and the Cape association (Soil Type 2). Both soil types form on alluvial plains, with the Cape unit found on the lower plains around Snake Creek and the Barkla unit found on the slightly higher plains on the MLA area.

Two other soil types cover the remaining small areas of the Project Site, which include the Conolly association (Soil Type 3) and the Corea association (Soil Type 4). The Conolly unit is restricted to the western edge of ML 10324 and the Corea unit forms the lateritic clay outcrops of the protruding ore bodies on the Project Site.

6.2 LAND SUITABILITY

All soil types on the Project Site are classified as Land Suitability Class 4 for Beef Cattle Grazing. The main limiting factors preventing all soil types from being a higher Class are water availability and nutrients, with topography an additional factor exclusive to the Corea and Conolly soil types.

This means all soils are marginally suitable for beef cattle grazing with major inputs required to ensure sustainable use. It should be noted however that low intensity grazing is the current land use for this area. There are no significant signs that the current use for grazing of this land is unsustainable. Notwithstanding the classifications arrived at in this report, successful cattle grazing has been undertaken within the Project Site during periods of favourable climatic conditions.

The sustainable use of the Project Site for beef cattle grazing would be largely dependent on appropriate stocking rates being employed. These stocking rates would need to take into account seasonal and annual variations in rainfall, availability of and appropriate management of water resources, the availability of land of similar quality in the immediate vicinity and implementation of appropriate management practices.

Three of the four soil types present on the Project Site are Land Suitability Class 5 for rainfed broadacre cropping. This means they are unsuitable for this purpose due to extreme limitations. The limiting factors are water availability, soil structure and topography. The remaining soil type, Soil Type 2 (the Cape association), is deemed to be Land Suitability Class 3 for rainfed broadacre cropping, which is considered moderately suitable for this land use. The limiting factors to a higher Class are also water availability, soil structure and topography.

6.3 TOPSOIL STRIPPING

As described throughout this report, Soil Type 3 (the Conolly association) lacks soil structure, is low in nutrients and has other characteristics unfavourable for use in the Project's rehabilitation program. Therefore, if areas within Conolly soil unit are to be disturbed, stripping and storage of topsoil is not recommended. Instead, it is recommended that additional topsoil is stripped from Soil Types 1 or 2 to account for any rehabilitation activities occurring in the area covered by Soil Type 3.

Based on mine disturbance plans, most of the areas to be disturbed within Soil Type 4 (the Corea association) constitute the ore body proposed to be mined. Topsoil will therefore be unavailable for storage and later use in the rehabilitation program. This being the case, if the voids are to be backfilled and revegetated it is recommended that the required topsoil be stripped from Soil Types 1 or 2.

Prior to land disturbance in Soil Types 1 and 2, it is recommended that topsoil be stripped and stored for use in the Project rehabilitation program. The following guidelines are recommended for the topsoil stripping program:

- Topsoil on the Project Site is of sufficient depth and quality to enable stripping to occur to a depth of 300mm, where available;

- Stripping can occur below this depth in Soil Type 1, but nutrient levels are reduced and additional fertilising will be required when the soil is used for rehabilitation,

- Stripping below 300mm is not recommended in Soil Type 2 due to increasing sodicity with depth; and

- Once stripped, topsoil should be stored in windrows no larger than 2m high and 5m wide. If revegetation cover does not occur after 1 year the stockpiles should be seeded with legume and grass species used locally for grazing in the area.

6.4 TOPSOIL TREATMENTS FOR REHABILITATION

To maximise the potential of soils used in the rehabilitation program, the following treatments are recommended:

- Topsoil should be spread to a depth of 200mm at areas being rehabilitated. Where possible, ripping of the surface should occur prior to spreading topsoil to ensure a pan does not form under the topsoil layer;

- Where possible, topsoil should be replaced to locations as near as possible to its point of origin. This will minimise transport costs and maximise the potential for germination from within the soil seed bank. The exception to this is when topsoil from Soil Types 1 and 2 are used in areas covered by Soil Types 3 and 4 (refer to Section 6.3);

- A phosphorous based fertiliser should be applied to topsoils after respreading to assist in the establishment of self-sustaining plant communities. This is necessary due to the low phosphorous levels in all soils present at the Site. This is particularly important two to three years after revegetation, as nutrients stored in the soil will be depleted by growth experienced in the first year of revegetation. Monitoring should be performed to determine ongoing fertiliser needs; and

- Where practicable, plants species known to succeed for grazing purposes in the local area should be used in the rehabilitation program.

7.0 BIBLIOGRAPHY & REFERENCES

Barker D.E. (1991) Interpreting Soil Analyses from Soil Surveys Conducted in Queensland in *Land Resource Bulletin QB91001*. Queensland Department of Primary Industries.

Barker D.E. & V.J Eldershaw (1993) Interpreting Soil Analysis for Agricultural Land Use in Queensland. Queensland Department of Primary Industries.

Department of Minerals and Energy (1995) *Land Suitability Assessment Techniques*. Queensland Government

Rogers L.G., Cannon M.G. & Barry E.V. (1999) *Land Resources of the Dalrymple Shire.* Queensland Government.

Appendix A: Summary of Chemical Analysis of Soils

Soil Type 1: Barkla

Colour and Texture: Brown Sandy Loam to Clay Loam

Parameter	Units	0-10cm			20-30cm			60-70cm		
		AVERAGE	STDEV	N=	AVERAGE	STDEV	N=	AVERAGE	STDEV	N=
EC [Elect. Conductivity]	dS/m	0.013	0.005	7	0.019	0.009	7	0.070	0.113	6
pH [pH (1:5 Water)]		5.971	0.243	7	6.157	0.391	7	7.300	0.626	6
pH2 [pH (1:5 CaCl2)]		4.629	0.256	7	4.829	0.457	7	5.850	0.826	6
Organic C [Organic Carbon]	%	0.366	0.102	7	0.217	0.119	7	0.200	0.059	6
Cl [Chloride]	mg/kg	BDL			BDL			63.000	116.241	6
NO3 [Nitrate Nitrogen]	mg/kg	BDL			1.214	0.524	7	BDL		
N [Total Nitrogen]	%	BDL			BDL			BDL		
S [Sulfate Sulfur (MCP)]	mg/kg	2.271	1.219	7	4.100	2.790	7	4.833	5.024	6
Carbonate	%	BDL			BDL			BDL		
Ca_meq [Calcium (Amm-acet.)]	meq/100g	1.536	1.140	7	1.681	1.470	7	1.858	1.865	6
K_meq [Potassium (Amm-acet.)]	meq/100g	0.306	0.102	7	0.223	0.042	7	0.208	0.102	6
Mg_meq [Magnesium (Amm-acet.)]	meq/100g	1.424	1.765	7	1.871	2.419	7	2.705	2.696	6
Na_meq [Sodium (Amm-acet.)]	meq/100g	0.059	0.063	7	0.117	0.075	7	1.349	2.346	6
Al_meq [Aluminium (KCl)]	meq/100g	0.149	0.124	7	0.166	0.124	7	0.100	0.000	2
CEC [Cation Exch. Cap.]	meq/100g	3.473	2.982	7	4.053	3.859	7	6.148	5.608	6

Parameter	Units	0-10cm			20-30cm			60-70cm		
		AVERAGE	STDEV	N=	AVERAGE	STDEV	N=	AVERAGE	STDEV	N=
Ca/Mg Ratio [Calcium/Magnesium Ratio]		1.530	0.620	7	1.253	0.589	7	0.860	0.482	6
Na% of Cations [Sodium % of Cations (ESP)]	%	1.649	0.936	7	3.563	1.980	7	17.317	16.475	6
Al% of Cations [Aluminium Saturation %]	%	7.000	8.145	7	6.673	6.334	7	3.500	1.273	2
Cu [Copper (DTPA)]	mg/kg	0.234	0.120	7	0.260	0.180	7	0.306	0.248	6
Fe [Iron (DTPA)]	mg/kg	19.857	7.862	7	17.714	11.818	7	12.333	8.894	6
Mn [Manganese (DTPA)]	mg/kg	10.343	3.503	7	11.121	13.163	7	6.323	6.922	6
Zn [Zinc (DTPA)]	mg/kg	0.103	0.055	7	0.047	0.018	7	0.057	0.032	6
B [Boron (Hot CaCl2)]	mg/kg	0.170	0.059	7	0.197	0.064	7	0.657	0.750	6
P [Phosphorus (Colwell)]	mg/kg	BDL			BDL			BDL		

BDL – Below detection limit used for all samples when a majority of results were below detection limit, in all other cases detection limit was used for averages

Soil Type 2: Cape

Colour and Texture: Brown to Grey Silty Loam to Clay Loam

Parameter	Units	0-10cm			20-30cm			60-70cm		
		AVERAGE	STDEV	N=	AVERAGE	STDEV	N=	AVERAGE	STDEV	N=
EC [Elect. Conductivity]	dS/m	0.05	0.04	6	0.06	0.07	6	0.10	0.10	4
pH [pH (1:5 Water)]		6.53	0.79	6	6.80	1.34	6	7.28	1.24	4
pH2 [pH (1:5 CaCl2)]		5.12	0.95	6	5.48	1.43	6	6.00	1.49	4
Organic C [Organic Carbon]	%	0.77	0.39	6	0.32	0.29	6	BDL		
Cl [Chloride]	mg/kg	19.67	17.21	6	42.50	67.65	6	77.50	86.17	4
NO3 [Nitrate Nitrogen]	mg/kg	1.85	1.09	6	1.05	0.12	6	BDL		
N [Total Nitrogen]	%	0.06	0.02	6	BDL			BDL		
S [Sulfate Sulfur (MCP)]	mg/kg	2.17	0.68	6	2.45	1.37	6	2.35	1.22	4
Carbonate	%	BDL			BDL			BDL		
Ca_meq [Calcium (Amm-acet.)]	meq/100g	6.94	10.92	6	7.34	11.98	6	8.50	15.01	4
K_meq [Potassium (Amm-acet.)]	meq/100g	0.41	0.19	6	0.28	0.15	6	0.20	0.12	4
Mg_meq [Magnesium (Amm-acet.)]	meq/100g	5.43	8.80	6	5.81	9.65	6	7.16	12.57	4
Na_meq [Sodium (Amm-acet.)]	meq/100g	0.55	0.62	6	1.04	1.53	6	1.18	1.63	4
Al_meq [Aluminium (KCl)]	meq/100g	0.17	0.11	5	0.42	0.21	3	0.12	0.02	2
CEC [Cation Exch. Cap.]	meq/100g	13.48	19.87	6	14.66	21.78	6	17.08	27.67	4
Ca/Mg Ratio [Calcium/Magnesium Ratio]		1.70	0.60	6	1.39	0.46	6	1.27	0.76	4

Parameter	Units	0-10cm			20-30cm			60-70cm		
		AVERAGE	STDEV	N=	AVERAGE	STDEV	N=	AVERAGE	STDEV	N=
Na% of Cations [Sodium % of Cations (ESP)]	%	7.04	7.51	6	9.12	10.92	6	14.90	23.45	4
Al% of Cations [Aluminium Saturation %]	%	5.26	6.58	5	22.13	11.57	3	8.00	1.27	2
Cu [Copper (DTPA)]	mg/kg	0.92	1.01	6	0.70	0.77	6	0.64	0.98	4
Fe [Iron (DTPA)]	mg/kg	36.17	28.18	6	16.83	7.91	6	9.98	2.52	4
Mn [Manganese (DTPA)]	mg/kg	12.05	7.99	6	5.95	5.38	6	2.80	2.01	4
Zn [Zinc (DTPA)]	mg/kg	0.34	0.30	6	0.06	0.03	5	0.03	0.01	4
B [Boron (Hot CaCl2)]	mg/kg	0.31	0.18	6	0.35	0.28	6	0.47	0.48	4
P [Phosphorus (Colwell)]	mg/kg	5.65	0.93	6	BDL			BDL		

BDL – Below detection limit used for all samples when a majority of results were below detection limit, in all other cases detection limit was used for averages

Soil Type 3: Conolly

Colour and Texture: Sandy Loam to Gravel over granite rock

SAMPLE SITE		S021	S021	S021
Soil Depth		0-10cm	20-30cm	60-70cm
Texture		Sandy Loam	Loam	Sand
Colour [Colour (Munsell)]		Brown	Brown	Yellow-Orange
EC [Elect. Conductivity]	dS/m	0.98	0.2	0.44
pH [pH (1:5 Water)]		5.1	5.9	6
pH2 [pH (1:5 CaCl2)]		4.1	4.3	4.4
Organic C [Organic Carbon]	%	1.1	<0.15	<0.15
Cl [Chloride]	mg/kg	76	20	18
NO3 [Nitrate Nitrogen]	mg/kg	<1.0	<1.0	<1.0
N [Total Nitrogen]	%	0.069	<0.040	<0.040
S [Sulfate Sulfur (MCP)]	mg/kg	10	1.6	2.3
Carbonate	%	<2.0	<2.0	<2.0
Ca_meq [Calcium (Amm-acet.)]	meq/100g	1.55	0.55	0.55
K_meq [Potassium (Amm-acet.)]	meq/100g	0.22	0.07	0.05
Mg_meq [Magnesium (Amm-acet.)]	meq/100g	2	0.83	0.92
Na_meq [Sodium (Amm-acet.)]	meq/100g	0.4	0.16	0.2
Al_meq [Aluminium (KCl)]	meq/100g	0.47	0.24	0.17
CEC [Cation Exch. Cap.]	meq/100g	4.63	1.85	1.88

Ca/Mg Ratio [Calcium/Magnesium Ratio]		0.78	0.66	0.6
Na% of Cations [Sodium % of Cations (ESP)]	%	9	9	10
Al% of Cations [Aluminium Saturation %]	%	10	13	9
Cu [Copper (DTPA)]	mg/kg	1.7	0.46	0.31
Fe [Iron (DTPA)]	mg/kg	160	36	31
Mn [Manganese (DTPA)]	mg/kg	9.1	1.4	2.3
Zn [Zinc (DTPA)]	mg/kg	1	0.014	0.14
B [Boron (Hot CaCl2)]	mg/kg	0.23	0.05	0.06
P [Phosphorus (Colwell)]	mg/kg	<5.0	<5.0	<5.0

Soil Type 4: Corea

Colour and Texture: Yellow-red sandy clay over massive structured clay

SAMPLE SITE		S019	S019	S019
Depth		0-10cm	20-30cm	60-70cm
Texture		Clay Loam	Sandy ClayL	Sandy Clay
Colour [Colour (Munsell)]		Yellow-Red	Yellow-Red	Yellow-Red
EC [Elect. Conductivity]	dS/m	0.12	0.07	0.05
pH [pH (1:5 Water)]		6.9	7.8	8.2
pH2 [pH (1:5 CaCl2)]		6.1	6.8	7
Organic C [Organic Carbon]	%	0.66	0.33	0.21
Cl [Chloride]	mg/kg	85	35	22
NO3 [Nitrate Nitrogen]	mg/kg	15	7.4	4.4
N [Total Nitrogen]	%	0.042	<0.040	<0.040
S [Sulfate Sulfur (MCP)]	mg/kg	3.8	2.4	2.3
Carbonate	%	<2.0	<2.0	<2.0
Ca_meq [Calcium (Amm-acet.)]	meq/100g	4.7	2.7	3
K_meq [Potassium (Amm-acet.)]	meq/100g	0.33	0.16	0.1
Mg_meq [Magnesium (Amm-acet.)]	meq/100g	6.8	3.1	3.7
Na_meq [Sodium (Amm-acet.)]	meq/100g	0.65	0.35	0.42
Al_meq [Aluminium (KCl)]	meq/100g			
CEC [Cation Exch. Cap.]	meq/100g	12.5	6.31	7.22
Ca/Mg Ratio [Calcium/Magnesium Ratio]		0.69	0.87	0.81

Na% of Cations [Sodium % of Cations (ESP)]	%	5.2	5.5	5.8
Cu [Copper (DTPA)]	mg/kg	0.75	0.44	0.52
Fe [Iron (DTPA)]	mg/kg	17	9.7	11
Mn [Manganese (DTPA)]	mg/kg	7.6	4.4	3.4
Zn [Zinc (DTPA)]	mg/kg	0.24	0.06	0.046
B [Boron (Hot CaCl2)]	mg/kg	0.93	0.46	0.7
P [Phosphorus (Colwell)]	mg/kg	6.7	<5.0	5.6