31st May 2016

Clean Stream Environmental Consultants
P.O. Box 32201
Glenstantia
0010
Tel: 012 993 5988, Fax: 012 993 1361, Cell: 072 127 8220
Attention: Natalie Lubbe

Dear Natalie,

Draft Report - Baseline Study and Impact Assessment - Extension to the Impumelelo Coal Mine

Specialist Soils, Land Capability and Impact Assessment

Attached herewith is our draft of the specialist report detailing the findings of the reconnaissance soils and land capability studies for the extension to the Impumelelo Mining Project being considered by SASOL (Order No 93 dated 01st December 2015).

Earth Science Solutions were commissioned to undertake the specialist soils and land capability studies for a number of areas within the Block 2 mineral rights area.

Please do not hesitate to contact us should you require any additional information in this regard.

Thanking you.

Yours faithfully,

Earth Science Solutions (ESS) (Pty) Ltd

Ian Jones   B.Sc. (Geol) Pr.Sci.Nat   EAP Certified

Director
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION AND PHYSIOGRAPHY</td>
<td>6</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td>6</td>
</tr>
<tr>
<td>1.2 Project Description</td>
<td>8</td>
</tr>
<tr>
<td>1.3 Methodology and Approach</td>
<td>13</td>
</tr>
<tr>
<td>1.4 Legal Considerations</td>
<td>14</td>
</tr>
<tr>
<td>1.5 Assumptions, Limitations and Uncertainties</td>
<td>16</td>
</tr>
<tr>
<td>2. DESCRIPTION OF THE PRE-CONSTRUCTION ENVIRONMENT</td>
<td>17</td>
</tr>
<tr>
<td>2.1 Data Collection and Gap Analysis</td>
<td>17</td>
</tr>
<tr>
<td>2.1.1 Review of Available Information</td>
<td>17</td>
</tr>
<tr>
<td>2.1.2 Description</td>
<td>20</td>
</tr>
<tr>
<td>2.1.3 Soil Chemical and Physical Characteristics</td>
<td>26</td>
</tr>
<tr>
<td>2.1.4 Soil Erosion and Compaction</td>
<td>27</td>
</tr>
<tr>
<td>2.2 Pre-Construction Land Capability</td>
<td>29</td>
</tr>
<tr>
<td>2.2.1 Data Collection</td>
<td>29</td>
</tr>
<tr>
<td>2.2.2 Description</td>
<td>30</td>
</tr>
<tr>
<td>2.3 Pre-Construction Land Use</td>
<td>33</td>
</tr>
<tr>
<td>2.3.1 Data Collection</td>
<td>33</td>
</tr>
<tr>
<td>2.3.2 Description</td>
<td>33</td>
</tr>
<tr>
<td>3. ENVIRONMENTAL IMPACT ASSESSMENT</td>
<td>35</td>
</tr>
<tr>
<td>3.1 Approach to Impact Assessment and Management</td>
<td>35</td>
</tr>
<tr>
<td>3.2 Impact assessment methodology</td>
<td>35</td>
</tr>
<tr>
<td>3.3 Environmental Management Plan (EMP)</td>
<td>38</td>
</tr>
<tr>
<td>3.4 IMPACT ASSESSMENT</td>
<td>39</td>
</tr>
<tr>
<td>3.4.1 Construction Phase</td>
<td>39</td>
</tr>
<tr>
<td>3.4.2 Operational Phase</td>
<td>39</td>
</tr>
<tr>
<td>3.4.3 Decommissioning &amp; Closure Phase</td>
<td>41</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL MANAGEMENT PLAN</td>
<td>44</td>
</tr>
<tr>
<td>4.1 Construction Phase</td>
<td>46</td>
</tr>
<tr>
<td>4.2 Operational Phase</td>
<td>47</td>
</tr>
<tr>
<td>4.3 Decommissioning and Closure</td>
<td>48</td>
</tr>
<tr>
<td>5 ENVIRONMENTAL MONITORING PLAN</td>
<td>50</td>
</tr>
<tr>
<td>5.1 MONITORING PHILOSOPHY AND REQUIREMENTS</td>
<td>50</td>
</tr>
<tr>
<td>5.1.1 Monitoring Philosophy</td>
<td>50</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1a Regional Locality Plan 10
Figure 1b – Mine Layout and Plan C2 11
Figure 1c – Mine Layout and Plan C4L 12
Figure 2.1.2a - Schematic of the Wet Lands and their relation to Topography 20
Figure 2.1.2b Regional Geology 22
Figure 2.1.2c Dominant Soil Polygon Map 23
Figure 2.1.2d Soil Sensitivity Plan/Map 24
Figure 2.2 Land Capability Map 32
Figure 2.3 Pre development Land Use 34

LIST OF TABLES

Table 2.1.1 Explanation - Arrangement of Master Horizons in Soil Profile 19
Table 2.2.1 Criteria for Pre-Construction Land Capability (S.A. Chamber of Mines 1991) 29
Table 3.1 – Impact Assessment Criteria 35
Table 3.2: Definition of significance rating 37
Table 3.3: Mitigation prediction criteria 37
Table 3.2 – Impact Significance Rating 42
Table 4.2 – Operational Phase – Soil Utilisation Plan 47
Table 4.3 – Decommissioning and Closure Phase – Soil Conservation Plan 49
Foreword

These Specialist Studies have been compiled in accordance with the requirements for the submission of an “Application for a Mining Right” under section 22 of the Minerals and Petroleum Resources Development Act (28) 2002 (“MPRDA”) and the NEMA Regulations being carried out by Cleanstream Environmental Consulting (CSEC) on behalf of Sasol Mining.

The Impumelelo Mining Project (SASOL Mining) is part of an extension to an existing development being undertaken by the proponent to the south and west of Trichardt, and in close proximity to Secunda, part of the Witbank Coal Fields of the Mpumalanga Province in South Africa. The mining project requires that a number of specialist studies be undertaken as part of the larger application being made for the underground mining of coal in the mining right area. The specialist soils and land capability studies are undertaken as support information to the earth science and biodiversity aspects of the Impumelelo Mining Right application being undertaken by CSEC (Lead Consultants).

The Minerals and Petroleum Resources Development Act (28) 2002 (MPRDA) specifies various requirements for the environmental scoping of any project. These include both the physical as well as the social and economic aspects. This document covers three of these aspects, namely:

- The Pedological (Soils) Assessment;
- The Land Capability Study
- The Land Use

These studies are to be incorporated into the overall environmental review and baseline assessment of the expansion to the underground workings.
Declaration

This specialist report has been compiled in terms of Regulation 33.3 of the National Environmental Management Act 107/1998 (R. 385 of 2006), and forms part of the overall impact assessment, both as a standalone document and as supporting information to the overall impact assessment for the proposed development.

The specialist Pedological and Land Capability studies where managed and signed off by Ian Jones (Pr. Sci. Nat 400040/08), an Earth Scientist with 36 years of experience in the field of expertise.

I declare that both, Ian Jones, and Earth Science Solutions (Pty) Ltd, are totally independent in this process, and have no vested interest in the project.

The objectives of the study were to:

- Provide a record of the present resources in the area that are potentially going to be affected by the proposed development – Pre mining environment,
- Assess the nature of the site in relation to the overall environment and its present and proposed utilisation, and assess the capability of the land, and
- Provide a base plan from which long-term ecological and environmental decisions can be made, impacts of mining can be determined, and mitigation and rehabilitation management plans can be formulated.

The Taxonomic Soil Classification System and Chamber of Mines Land Capability Rating Systems were used as the basis for the soils and land capability investigations respectively. These systems are recognized nationally.

Signed: 31st May 2016

Ian Jones  B.Sc. (Geol) Pr.Sci.Nat 400040/08, EAPASA Certified
Director
EXECUTIVE SUMMARY

This report details the findings of the baseline investigations and the results of the assessment of the impacts expected for the proposed mining and beneficiation of the mineral resource, and in particular the proposed extension to the mining of the coal resource by underground bord and pillar mining.

It is noted that no new infrastructure (beneficiation of associated support activities) other than the construction of a Power Line (PL) is considered as part of the expansion at Impumelelo Colliery. The PL has been dealt with as a separate submission.

In line with the minimum requirements and best practice, a soil utilization plan has been considered and submitted as part of the management plan in mitigation for the proposed activities being considered by this project.

The proposed activities will all occur as underground bord and pillar operations, and as such the potential impact footprint at surface is relatively small, albeit that the potential for subsidence due to collapse of undermined areas cannot be discounted and is considered a potential impact. The “probability” of collapse being expressed at surface is considered “low”.

The total mining right area is presented in Figure 1a– Locality Plan, with the areas of study delineated in Figure 1b.

In terms of the National Environmental Management Act (NEMA), listed activities require licensing. Mining and the change of land use (present state to mining) are considered listed activities. To this end, a detailed environmental impact assessment (EIA) is needed. The baseline of information gathered for the soils and general geomorphology of the sites has been used to assess and rate the land capability, while the land use was noted as part of the pre development data set.

The obtaining of all relevant information pertinent to the baseline conditions is essential to an understanding of the sensitivity of the natural resource that is going to be affected, and is used in the assessment of potential impacts and the development of a management strategy.

The specialist information is tabled in terms of the S.A. Legislation and guidelines, with the principles for best practice being followed using the IFC Performance Principles (a set of internationally accepted guidelines and principles for sustainable development).

The sites of concern (study area) comprises significantly large areas of moderately sensitive to highly sensitive soil forms, while the land capability rating comprises low intensity grazing land capability for the most part. There are significantly large areas of shallow and wet based soils and moist grasslands (transition zone). These areas are rated as wilderness and wetlands respectively.

Soil are an important natural resource and form part of the Eco System Services quadrant, are considered important to the ecological and biodiversity life cycle, and form an intricate link between the surface activities (above ground) and underground morphology (sub surface), with soil water, soil depth and nutrient status but three of the aspects considered in evaluating the geomorphology, land capability and site sensitivity for the sites of concern.

The development planning for this project is confined to the areas delineated for the extension to the underground mining (Refer to Figures 1b).
The area is presently utilized for commercial livestock grazing, and commercial agriculture (cash crops). The land was historically used for summer grazing, with grasslands being the natural land/veld type (refer to biodiversity studies).

The mining activities proposed, could, if not well managed have a negative impact on a significantly large surface area. The resultant loss of the soil as a resource, contamination (dirty water ingress and ponding), erosion of disturbed soils by wind and water, compaction and the possibility of spillage and contamination by hydrocarbons from vehicles used to rehabilitate collapsed areas would detrimentally affect the capability of the land as well as changing its long term end land use.

The “probability” of the underground mining impacting at surface is however considered low. The depth to coal and the presence of competent lithologies within the stratigraphy reduces the probability of the effects of underground subsidence reflecting at surface.

A well-structured and implemented design (engineering, geotechnical and environmental) and implementable management plan, will help in minimising and mitigating the impacts to an acceptable levels of risk.
GLOSSARY OF TERMS

Alluvium: Refers to detrital deposits resulting from the operation of modern streams and rivers.

Base status: A qualitative expression of base saturation. See base saturation percentage

Beneficiation: Process of adding value to a raw product

Buffer capacity: The ability of soil to resist an induced change in pH.

Calcareous: Containing calcium carbonate (calcirete).

Catena: A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic conditions, but having different characteristics due to variation in relief and drainage.

Clast: An individual constituent, grain or fragment of a sediment or sedimentary rock produced by the physical disintegration of a larger rock mass.

Cohesion: The molecular force of attraction between similar substances. The capacity of sticking together. The cohesion of soil is that part of its shear strength which does not depend upon inter-particle friction. Attraction within a soil structural unit or through the whole soil in apedel soils.

Concretion: A nodule made up of concentric accretions.

Crumb: A soft, porous more or less rounded ped from one to five millimetres in diameter. See structure, soil.

Cutan: Cutans occur on the surfaces of peds or individual particles (sand grains, stones). They consist of material which is usually finer than, and that has an organisation different to the material that makes up the surface on which they occur. They originate through deposition, diffusion or stress. Synonymous with clayskin, clay film, argillan.

Desert Plain: The undulating topography outside of the major river valleys that is impacted by low rainfall (<25cm) and strong winds.

Denitrification: The biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen.

Erosion: The group of processes whereby soil or rock material is loosened or dissolved and removed from any part of the earth’s surface.

Fertiliser: An organic or inorganic material, natural or synthetic, which can supply one or more of the nutrient elements essential for the growth and reproduction of plants.

Fine sand: (1) A soil separate consisting of particles 0.25-0.1mm in diameter.

(2) A soil texture class (see texture) with fine sand plus very fine sand (i.e. 0.25-0.05mm in diameter) more than 60% of the sand fraction.

Fine textured soils: Soils with a texture of sandy clay, silty clay or clay.

Hardpan: massive material enriched with and strongly cemented by sesquioxides, chiefly iron oxides (known as ferricrete, diagnostic hard plinthite, ironpan, ngubane, ouklip, laterite hardpan),
silica (silcrete, dorbank) or lime (diagnostic hardpan carbonate-horizon, calcrete). Ortstein hardpans are cemented by iron oxides and organic matter.

**Land capability:** The ability of land to meet the needs of one or more uses under defined conditions of management.

**Land type:** (1) A class of land with specified characteristics. (2) In South Africa it has been used as a map unit denoting land, mapable at 1:250,000 scale, over which there is a marked uniformity of climate, terrain form and soil pattern.

**Land use:** The use to which land is put.

**Mottling:** A mottled or variegated pattern of colours is common in many soil horizons. It may be the result of various processes *inter alia* hydromorphy, illuviation, biological activity, and rock weathering in freely drained conditions (i.e. saprolite). It is described by noting (i) the colour of the matrix and colour or colours of the principal mottles, and (ii) the pattern of the mottling.

The latter is given in terms of abundance (few, common 2 to 20% of the exposed surface, or many), size (fine, medium 5 to 15mm in diameter along the greatest dimension, or coarse), contrast (faint, distinct or prominent), form (circular, elongated-vesicular, or streaky) and the nature of the boundaries of the mottles (sharp, clear or diffuse); of these, abundance, size and contrast are the most important.

**Nodule:** Bodies of various shapes, sizes and colour that have been hardened to a greater or lesser extent by chemical compounds such as lime, sesquioxides, animal excreta and silica. These may be described in terms of kind (durinodes, gypsum, insect casts, ortstein, iron, manganese, lime, lime-silica, plinthite, salts), abundance (few, less than 20% by volume percentage; common, 20 – 50%; many, more than 50%), hardness (soft, hard meaning barely crushable between thumb and forefinger, indurated) and size (threadlike, fine, medium 2 – 5mm in diameter, coarse).

**Overburden:** A material which overlies another material difference in a specified respect, but mainly referred to in this document as materials overlying weathered rock.

**Ped:** Individual natural soil aggregate (e.g. block, prism) as contrasted with a clod produced by artificial disturbance.

**Pedocutanic,**

**Diagnostic B-horizon:** The concept embraces B-horizons that have become enriched in clay, presumably by illuviation (an important pedogenic process which involves downward movement of fine materials by, and deposition from, water to give rise to cutanic character) and that have developed moderate or strong blocky structure. In the case of a red pedocutanic B-horizon, the transition to the overlying A-horizon is clear or abrupt.

**Pedology:** The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.

**Slickensides:** In soils, these are polished or grooved surfaces within the soil resulting from part of the soil mass sliding against adjacent material along a plane which defines the extent of the slickensides. They occur in clayey materials with a high smectite content.
**Sodic soil:** Soil with a low soluble salt content and a high exchangeable sodium percentage (usually EST > 15).

**Stratigraphy**  
Geological Units

**Swelling clay:** Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried. The latter are also known as heaving soils.

**Texture, soil:** The relative proportions of the various size separates in the soil as described by the classes of soil texture shown in the soil texture chart (see diagram on next page).

The pure sand, sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided (see diagram) according to the relative percentages of the coarse, medium and fine sand subseparates.

**Vertic, diagnostic**

**A-horizon:** A-horizons that have both, high clay content and a predominance of smectitic clay minerals possess the capacity to shrink and swell markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet.
1. INTRODUCTION AND PHYSIOGRAPHY

1.1 Introduction

The Impumelelo Expansion Project (IEP) also referred to as the Block 2 Project, is a “Brownfields” mining project in terms of the existing underground mining, transportation and beneficiation of coal in the area, while the proposed expansion to the area of influence, albeit of an underground mining system, and will utilise the existing infrastructure, will undermine and impact areas that have been altered and impacted by commercial farming for many generations.

A significant amount of exploration has also been completed with the resultant impacts associated have been noted, while the effects of commercial cultivation and crop farming are widely evident, with effects of both erosion and compaction having impacts on the soil resource and the natural conditions have been altered. Limited, but significant areas of erosion on the exposed and more sensitive soils are adding to the degradation of the area.

Sasol Coal are in the process of applying for a mining license for the expansion to their existing operations. The process proposed involves the mining of coal by underground bord and pillar using mechanised methods of mining.

No additions to the beneficiation plant or any of the support infrastructure is envisaged as part of this application.

The mining will result in a number of specific impacts associated with the potential for collapse and resultant loss of resource utilisation.

The underground methods of mining being proposed (bord and pillar) and the depth at which the mining will occur (+-100m) will limit the effects at surface. The impact significance is considered low but real, and subsidence is a distinct possibility over time. These impacts will definitely effect the soils, which in turn will have an effect on the capability of the land to function optimally.

It is thus imperative that an understanding of the pre development aspects and baseline conditions are understood and documented if sustainable management and mitigation measures are to be designed and implemented as part of the planning and operational strategy.

The end land use (ELU) will require that the pre development topography is emulated as closely as possible at closure if a free draining state is to be achieved. Ponding and the effects of soil saturation, salinisation and the settlement of the reinstated materials will require planned and designed landscaping as a minimum. The impacts have been assessed and management and mitigation measures (soil utilisation plan) tabled.

Of importance to the earth sciences and an understanding of the socio economics of an area, are the possible impact that the mining activities could have on the future livelihoods of the land owners and the reduction in eco system services for the area.

An evaluation at a desktop level of the geomorphology of the area (topography, geology, geohydrology and hydrogeology) indicated that all of the specialist earth sciences would be necessary if a sustainable solution was to be found for the many aspects of change that could affect the area due to a project of this nature.

The relative coverage proposed for the soils baseline studies was tailored so as to obtain sufficient scientifically derived information and a statistically reliable information set. The information could be used for the assessment of impacts and the design of a meaningful management plan for
mitigation and minimisation of underground mining risk. The density of observations is not however sufficient to compile a soil polygon map. The dominant soils map does however reflect the spatial distribution based on site evaluation and an interpretation of the geomorphology (topography, geology etc.).

One of the added outcomes of the site study was the assessment of site sensitivity. These considerations have been used as part of the impact assessment study and assist in the pre-development planning and design of the mining project. The guidelines required that the sensitive sites be identified and the degree of sensitivity catalogued as part of the baseline investigation (Refer to Figure 2.1.2c). The authorities (MPB, DWA and DEDET) regard soil wetness as an area of concern, and an aspect that requires close assessment and investigation as part of any baseline study.

The baseline has highlighted wet based soils as an area of concern and delineated these as highly sensitive or No Go areas for surface impact. The “probability” of mining impacts at surface, although “low” are “possible” and could affect some of the hydromorphic environments identified if collapse does occur and reflect at surface.

The sensitive sites (predominantly streams, water ways and river crossings) will need to be discussed in more detail with the wetland scientist and hydrologist as part of the final design planning. Only with the inputs of the related earth sciences will a full understanding and more in-depth comprehension of these issues be obtained. This information (impact assessment) is invaluable to the development of a workable and sustainable management plan based on the spatial extent of the areas of concern.

All of these issues will ultimately have an effect on the biodiversity and ecological status of the area.

This report has been compiled in line with the Guideline Document for Impact Assessment philosophy and Significance Rating System (South African Integrated Environmental Management Information Series (DEAT 2002) and the “Hacking” System of Impact Assessment (Theo Hacking - 1998) and the IFC Performance Principles.

The impact assessment aims to identify and quantify the environmental and/or social aspects of the proposed activities, to assess how the activities will affect the existing state, and link the aspects to variables that have been defined in terms of the baseline study.

In addition, the impact assessment has defined a maximum acceptable level of impact for each of the activities, inclusive of any standards, limits and/or thresholds, and has assessed the impact in terms of the significance rating as defined by Theo Hacking 1998. This required that the cumulative effects are considered, and that the common sources of impact are detailed.
1.2 Project Description

The project is considered a Brownfields Project in terms of mining and the commercial farming that covers a significant portion of the mining right area. These activities will have had an impact on the area in terms of changes to the physical and Socio Economic Environment as a significant proportion of the site has been altered or changed from its original state.

The size of the mining venture is understood to be medium to large in extent/tonnage as well as in terms of its life of mine, but small in terms of the surface footprint that is to be disturbed.

Cumulative impacts are likely to be confined to the present land use and the effects of the dwellings that exist in close proximity to the project, while existing mine activities and industry within the greater area (Power Stations etc.) are considered contributors to the larger and more regional impacts on the environment.

It is evident from the regional government mapping and the geological sections provided (CSEC) that large portions of the area of concern are underlain by a dolerite sill. This is important in terms of the pedogenisis, soil/vadose water and the soil structure, while also having an influence on the geotechnical considerations of surface collapse and the potential for the underground mining to affect aspects at surface. The geotechnical information (Jones and Wagener July 2009) supplied added to the understanding of the soil and surface conditions.

The site is located close to Leandra, Secunda and Trichardt in the Mpumalanga Province of South Africa.

The additions to the present mining are being considered as part of the optimisation of the coal resource that underlie the study area.

The partial extraction of the deeper seated coal seam by bord and pillar methods of mechanical mining is a recognised method of mining, and involves the removal of the coal from underground with limited or no disturbance of the surface overburden (soils and soft decomposed rock). These actions, are, if well managed and engineered (geotechnical and rock mechanics) considered adequate for the extraction of the resource and will not disturb the surface features unless collapse occurs.

The sustainability of any project requires that, not only a profit is made in terms of the resource mined, but that there is sufficient return of the money made to rehabilitating the disturbed environment at closure. The proposed soil utilisation plan has been tailored to achieve this in terms of the soils and land capability aspects of this project.

The baseline mapping and characterisation of the soils is the basis from which the impact and effects on the soils has been measured. In line with these findings, the site specific management planning and mitigation measures for the soils have been defined and detailed. This has included the defining of what the mitigation will do to reduce the intensity and probability of the impact occurring, and what is necessary to ensure that the prescriptive mitigation proposed is clear, site specific and practical.

Apart from these issues being required in terms of the law, it is important that the potential loss of an important resource (soil and land use) needs to be understood in terms of the sustainability equation and the concept of “No Net Loss”.

In addition, and as part of the practical management plan, a monitoring system has been proposed and tabled.
The lead consultants (CSEC) contracted Earth Science Solutions (Pty) Ltd (ESS) to assist with the specialist soils sections of the baseline studies, impact assessment and the development of a management plan for the construction, operation and closure components of the proposed project.

Figure 1a shows the general location of the different portions of the project, while Figure 1b and Figure 1c show the extent of the underground mining that is planned within the mining right area.
Figure 1a Regional Locality Plan
Figure 1b – Mine Layout and Plan C2
Figure 1c – Mine Layout and Plan C4L
The results of the soils and land capability study have been discussed in terms of the geomorphology, the soils and site sensitivity, with the soils mapping having been simplified based on the dominant soil forms, their functionality and their associated land capability. In this way, the sustainability of the project can be measured in terms of the impacts and related mitigation, with sensitive areas being managed in a sound scientifically derived manner (Refer to Figures 2.1.2b and 2.1.2c).

The baseline findings have been used to assess and rank the impacts that can be expected, while the management plan for mitigation is based on the proposed activities tabled as part of the development plan, and the findings of the impact assessment.

A reconnaissance soil utilisation plan is tabled as part of the Environmental Management Planning and describes how the soils should be managed if the impacts are to be minimised.

The principle of “No Net Loss” (NNL) has been tabled as the ultimate aim in developing a project that is sustainable. Any development that disturbs the soil will challenge the concept of No Net Loss, albeit that underground mining of the system being proposed will definitely minimise both the “Probability” as well as the “Possibility” of medium or high rated negative impact.

### 1.3 Methodology and Approach

The soil, land use and land capability studies have been designed and tailored around the mining method and proposed mine plan, while taking cognisance of the potential impacts that the proposed activities might impose on the natural resources of the areas.

The soil study also took notice of the relative geomorphological attributes for the site and designed the site mapping accordingly.

The norms (soil and land capability) are based on a specific set of principles as set down in the “Taxonomic System of soil classification, and the Chamber of Mines land Capability Rating System, systems that have been designed for “South Africa” (described in detail later). These norms are consistent with the NEMA Regulations, World Bank Standards and national nomenclature.

The physical and chemical characteristics of the materials are used to characterise and highlight the site specific sensitivities which are then combined into dominant soils “groupings”. These groups have similar characteristics and will react to the impacts and activities being considered in the development plan in a similar manner, and for which a set of management actions can be design in mitigation (Soil Utilisation Plan – SUP).

The SUP can be used by the developer as part of long term decision making and as part of the design toolbox (Not for Engineering Design purposes). The SUP is also useful in answering questions and issues raised by interested or affected parties (Public and Authorities), and is useful in making informed and scientifically based decisions on the relative sustainability of the project (soils and land capability).

The Soil Classification System and Land Capability Rating Systems supply the scientific basis and knowledge needed to determine the sensitivity or vulnerability of the different actions being proposed.
The soils physical, chemical properties and the way in which these react to the elements (wind, water erosion, heat, chemical reaction etc.), the sensitivity of having the vegetative cover removed, or their vulnerability to having the topsoil disturbed, and the reaction of the materials to chemical impacts (ease of being taken into solution), are all aspects that have been assessed in measuring sensitivity and ultimately the vulnerability of the site to development.

These measures are important when considering the impact assessment, and will dictate the mitigation and management measures (degree of input etc.) that will be required.

It is essential to ensure that the soils are adequately described and characterised so as to allow for an accurate assessment of the impact of the actions that are being proposed by the developer and to obtain sufficient site specific information so as to allow for the development of a conceptual soil utilisation guide and plan that is sustainable and practical.

It is also important that the findings of this study are able to deal with, and wherever possible answer the issues and concerns regarding land use and land capability that might be raised by the stakeholders (IAP’s).

Using this philosophy the study area was investigated on a reconnaissance grid base and an assessment and understanding of the baseline conditions for the soils and land capability obtained.

The level of study and intensity (spatial variance) of the observations made was guided by a number of practical variables. These included the geomorphology of the site, a knowledge of the proposed development (mine plan) and an understanding of the actions/activities that are intended.

Very little detailed soils information was available from any of the regional assessments, and although previous studies contiguous to the study areas were made available, there was no baseline maps available for anything other than the areas of surface disturbance (Shaft areas and Conveyencing Line). The Land Type Maps (Government) and Geological Maps helped with the high level understanding of the geomorphology for the area and, while the LiDAR Imagery assisted with the land uses in the area of study. However, the agricultural potential, land capability and associated earth sciences variables, the sensitivities and site specific variations and aspects that are important to the ecological balance of the area of study were lacking and required additional inputs.

1.4 Legal Considerations

As part of understanding the consequences of the proposed development a knowledge of the national legislation that pertains to soils is important, and is a guide in understanding the permissible standards and limits that can be considered, albeit that there are no prescribed quantitative limits quoted.

The most recent South African Environmental Legislation that needs to be considered for any new development with reference to management of soil includes:

- The Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal.
- The Bill of Rights (chapter 2) states that environmental rights exist primarily to ensure good health and wellbeing, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources.
• The Environmental right is furthered in the National Environmental Management Act (No. 107 of 1998), which prescribes three principles, namely the precautionary principle, the “polluter pays” principle and the preventive principle.
• It is stated in the above-mentioned Act that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source.
• Soils are protected under the National Environmental Management Act 107 of 1998, the Minerals Act 28 of 2002 and the Conservation of Agricultural Resources Act 43 of 1983.
• The National Environmental Management Act 107 of 1998 requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimised and remedied.
• The Minerals Act 28 of 2002 requires an EMPR, in which the soils must be described.
• The Conservation of Agriculture Resources Act 43 of 1983 requires the protection of land against soil erosion and the prevention of water logging and salinisation of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and water courses are also addressed.
• In addition to the South African legal compliance this proposed development has also been assessed in terms of the International Performance Standards as detailed by the International Finance Corporation (IFC).

The IFC has developed a series of Performance Standards to assist developers and potential clients in assessing the environmental and social risks associated with a project and assisting the client in identifying and defining roles and responsibilities regarding the management of risk.

Performance Standard 1 establishes the importance of:
• Integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects;
• Effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and
• The client’s management of social and environmental performance throughout the life of the project.

Performance Standards 2 through 8 establish requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate. While all relevant social and environmental risks and potential impacts should be considered as part of the assessment, Performance Standards 2 through 8 describe potential social and environmental impacts that require particular attention in emerging markets. Where social or environmental impacts are anticipated, the client is required to manage them through its SEIA and Environmental Management System consistent with Performance Standard 1.

Of importance to this report are:
• The requirements to collect adequate baseline data;
• The requirements of an impact/risk assessment;
• The requirements of a management program;
• The requirements of a monitoring program; and most importantly;
• To apply relevant standards (either host country or other).
With regard to the application of relevant standards there are no specific quantitative guidelines relating to soils and land use/capability, either locally or within the World Bank’s or IFC’s suite of Environmental Health and Safety Guidelines. However, the World Bank’s Mining and Milling, guideline does state that project sponsors are required to prepare and implement an erosion and sediment control plan.

The plan should include measures appropriate to the situation to intercept, divert, or otherwise reduce the storm water runoff from exposed soil surfaces, tailings dams, and waste rock dumps.

Project sponsors are encouraged to integrate vegetative and non-vegetative soil stabilisation measures in the erosion control plan.

Sediment control structures (e.g., detention/retention basins) should be installed to treat surface runoff prior to discharge to surface water bodies. All erosion control and sediment containment facilities must receive proper maintenance during their design life.

This will be included in the appropriate management plans where appropriate.

1.5 Assumptions, Limitations and Uncertainties

It has been assumed that:

- The total area of possible disturbance was included in the area of study.
- The mining plan as tabled has documented/catered for all actions, activities that could potentially have an impact on the soils, land use and land capability, and
- The recommendations made and impact ratings tabled will need to be re-assessed if the development plan changes.

Limitations to the accuracy of the pedological mapping (as recognised within the pedological industry) are accepted at between 50% (reconnaissance mapping) and 80% (detailed mapping), while the degree of certainty for the soils physical and chemical (analytical data) results has been based on the detailed sampling undertaken as part of the original EIA.
2. DESCRIPTION OF THE PRE-CONSTRUCTION ENVIRONMENT

2.1 Data Collection and Gap Analysis

2.1.1 Review of Available Information

The specialist study was undertaken in a series of phases, with the baseline assessment being undertaken during February and March of 2016. The mapping was based on the Mine Plan made available through the lead consultants (Figures 1b and 1c).

The site specific nature of the proposed mining, and the spatial distribution of the resource renders the impact from the mining as site specific or local and no alternatives can/could be considered other than the no-mining option. The Powerline is planned to follow the existing conveyer route, an area that has already been disturbed and for which both an EIA and EMP has been completed.

Site sensitivities and possible “No Go” considerations have been highlighted wherever pertinent, with specific regard being given to areas of shallow soil depths, soil wetness, soil erosion and the potential for compaction.

The site specific sensitivities have been highlighted and used in the delineation of environmentally sensitive “No Go” or “High Sensitivity” areas. These considerations are recognised as essential in the process of sustainable development and the obtaining of scientific information that is acceptable to answering the stakeholders and IAP’s concerns.

The government survey maps (geological and topocadastral) along with the existing site assessment of land type undertaken by Terrasoil Science (2008 and 2009), were used in obtaining an understanding of the general lithological setting and baseline conditions for the soils along the conveyer line and main arterials, while discussions with the farming community helped in understanding the possible pedogenic processes that are unique to the specific environment. However, the scale of the regional information is insufficient for the level of data needed for a project of this magnitude.

Field Work

A reconnaissance pedological study of the site was carried out using the LiDAR Imagery supplied as the base map onto which the overall geomorphological and pedological data was mapped. The scale of mapping is insufficient for soil polygon delineation, but has been used to distinguish the broader soil groupings as part of understanding the site sensitivities and vulnerabilities, aspects needed in the assessment of the impact significance of the proposed expansion to the underground mining activities.

Mining is planned to expand out of the existing underground workings and no additional infrastructure is planned for on surface other than the proposed Power Line to be constructed along the existing conveyer servitude. Areas of subsidence due to the collapse of mined out areas are considered as possible surface impacts.

The excavation for pylon footings will require the removal of all soils and all overburden (softs and weathered rock) but is planned to be confined to the existing disturbed area occupied by the conveyancing system.
These actions/activities (Sink holes and/or areas of subsidence) will result in the alteration/modification of the surface topography, resulting in the change in hydrological flow patterns and the potential for “ponding” of surface water at surface. Impeding the flow will result in saturation and sterilisation of the soil resource, and the overall loss of eco system services.

Ponding of surface water and the un-managed increased in infiltration of surface water into the vadose zone will have significant implications for the land capability and utilisation potential.

Field Methodology

The surveys were undertaken during February and March 2016.

The site mapping was undertaken on a 1:10,000 scale (Refer to Figure 2.1.2b – Dominant Soils) orthophotographic base using a variable grid base coverage.

Standard and recognised mapping procedures and field equipment were used throughout the survey. The majority of observations used to classify the soils were made using a hand operated bucket auger or Dutch (clay) auger.

In addition to the soil classification and characterisation, relevant information relating to the climate, geology, wetlands and terrain morphology were also considered and used in the classification of the sites delineated, while the variation in the natural vegetation was also noted.

The pedological study was aimed at classifying the area in terms of:

- The soil types to be disturbed/rehabilitated;
- The soil physical and chemical properties;
- The soil depth;
- The erodibility of the soils;
- Pre-construction soil utilisation potential, and

Soil Profile Identification and Description Procedure

The identification and classification of soil profiles were carried out using the Taxonomic Soil Classification System (Mac Vicar et al, 2nd edition 1991)

The Taxonomic System is in essence a very simple system that employs two main categories or levels of classes, an upper level or general level containing Soil Forms, and a lower, more specific level containing Soil Families.

Each of the soil Forms in the classification is a class at the upper level, defined by a unique vertical sequence of diagnostic horizons and materials.

All soil forms are subdivided into two or more families, which have in common the properties of the Form, but are differentiated within the Form on the basis of their defined properties.

In this way, standardised soil identification and communication is allowed by use of the names and numbers given to both Form and Family.

The procedure adopted in field when classifying the soil profiles is as follows:
- Demarcate master horizons;
- Identify applicable diagnostic horizons by visually noting the physical properties:
  - Depth (below surface)
  - Texture (Grain size, roundness etc.)
  - Structure (Controlling clay types)
  - Mottling (Alterations due to continued exposure to wetness)
  - Visible pores (Spacing and packing of peds)
  - Concretions (cohesion of minerals and/or peds)
  - Compaction (from surface)
- Determine from i) and ii) the appropriate Soil Form
- Establishing provisionally the most likely Soil Family

### Table 2.1.1
**Explanation - Arrangement of Master Horizons in Soil Profile**

<table>
<thead>
<tr>
<th>SOLUM (Zone in which the soil forming processes are maximally expressed)</th>
<th>Arrangement of master horizons</th>
<th>Comments on Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>O - Organic</td>
<td>A</td>
<td>Humic, Vertic, Melanic, Orthic</td>
</tr>
<tr>
<td>C - Regic Sands (C), Stratified Alluvium (C), Man - Made Soil Deposits (C)</td>
<td>B</td>
<td>Red Apedel, Yellow-brown A pedel, Soft Plinthic, Hard Plinthic, Prismatic, Lithic, Neocutanic, Neocarbonate, Podzol, Podzol with plasic pan</td>
</tr>
<tr>
<td>C</td>
<td>Dorbank, Soft Carbonate horizon, Hard Carbonate Horizon, Saprolite, Unconsolidated materials without signs of wetness, Unconsolidated materials with signs of wetness, Unspecified materials with signs of wetness</td>
<td></td>
</tr>
<tr>
<td>R - Hard Rock</td>
<td>G</td>
<td>Light coloured mineral horizon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transitional to B but more like A than B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transitional to A but more like B than A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum expression of B-horizon character</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transitional to C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unconsolidated material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard rock</td>
</tr>
</tbody>
</table>

Loose leaves and organic debris, largely undecomposed
Organic debris, partially decomposed or matted
Dark coloured due to admixture of humified organic matter with the mineral fraction
Light coloured mineral horizon
2.1.2 Description

Soil Characterisation

The soils encountered can be broadly categorised into four major groupings, with six dominant soil forms and eight sub dominant forms noted that characterise the area of concern (Refer to Figure 2.1.2c).

The major soil forms are closely associated with the changes in the geology/lithologies, topography and climate, the in-situ derived materials reflecting differences in both the soil physical characteristics as well as chemical attributes (Refer to Figure 2.1.2b – Regional Geology), while the colluvial and alluvial derived materials are reflective of a much more diverse origin.

The generally flat to slightly undulating topography has had less of an impact on the pedogenisis of the soils, albeit that the retention of soil water within the vadose zone (lack of preferred horizontal flow) has resulted in the creation of a prominent ferricrete layer within some of the soil profiles with associated wetness features, while the accumulation of colluvium in the lower lying areas (streams and valley bottoms) has resulted in clay rich soil with wetland characteristics. These characteristics have been enhanced by the dolerite sill that underlies a significant portion of the study area.

The barrier to water movement enhances the inhibiting character (barrier) to vertical flow within the profile, a factor that is considered important to the ecology and biodiversity of the area.

The occurrence of extensive hard pan ferricrete/hard plinthite horizons within the soil profile classify as “relic” land forms for the most part, albeit that significant area of more recent laterite development were also mapped.

Figure 2.1.2a - Schematic of the Wet Lands and their relation to Topography

The relic land forms commonly result in hillside seeps and “sponge zones” (Refer to Figure 2.1.2a), both of which are associated with possible wetland development. These layers occasionally outcrop at surface as ouklip or hardpan ferricrete and are the basis for many of the pan structures found within the sedimentary profile and landscape. These features are important to the ecological and biodiversity cycle, and are regarded as sensitive to highly sensitive features.
The transition zone and contributing features (soils within the pan catchment) need to be seen as part of the site of sensitivity.

The dominant soils classified are described in terms of their physical and chemical similarities along with their topographic position and overall geomorphology, their spatial distribution being of importance to the management recommendations (Refer to Figure 2.1.2c – Dominant Soils and Figure 2.1.2d – Site Sensitivity).

The major soil groupings are described in more detail later in this section.

The soils mapped range from shallow sub-outcrop and outcrop of hard plinthite and parent materials (Sediments and intrusive dolerite) to moderately deep sandy loams and sandy clay loams that vary in texture, colour and structure.

The shallowness of a soil and its ability to sustain a vegetative cover is important to the conservation of resource and the limiting of soil erosion, while the inhibiting of water movement within the vadose zone will affect the soil hydrology and ecological aspects for an area. The hard pan ferricretes and their position in the topography and soil profile are important to the sensitivity analysis, the inhibiting nature of these horizons resulting in perched soil water and the development of wet based soils, while deep well drained conditions with sufficient water holding capability and nutrient status are considered less problematic and less vulnerable to being disturbed.

The wetland aspects are of significance as soil water contributes to the overall biodiversity and balance of the ecological system, keeping the surface water bodies functioning through the drier spells in the climatic cycle while contributing to the overall soil moisture balance. Many of these features are associated with the dolerite silt, lithologies that are inherently rich in iron and magnesium, and the development of ferricrete/laterites where the climatic conditions (evaporation > rainfall) and availability of vadose water are present.

The shallow, to very shallow soil profiles are often associated with these inhibiting layers at or close to surface, and as already alluded to, are the defining features that control the ability (or not) of water to flow vertically through the profile (restrictive layer).

The degree to which the plinthite layer has been cemented (friability of the ferricrete) will determine the effectiveness of the layer as a barrier to infiltration, while the depth of overlying soil will dictate how easily or difficult it is for the soil water to be accessed by the fauna and flora, and in the extreme case will dictate how water is held at surface as a pan. The friability of the ferricrete will also have an effect on the amount of clay mineralisation that the soil contains within this horizon, and will in turn influence the water holding characteristics of the soil.

In addition to the soil system of classification, a similar system has been developed for the describing and classification of ferricretes (Refer to Appendix 2). This has been used in better understanding the land forms that result from their presence and the possible outcome and sensitivities of any development on these sites.

In contrast, the deeper and more sandy profiles, although of a similar or the same pedogenetic processes are characterised by lower clay contents, better than average drainage and in most cases a more variable texture.
Figure 2.1.2b  Regional Geology
Figure 2.1.2c Dominant Soil Polygon Map
Figure 2.1.2d  Soil Sensitivity Plan/Map
As with any natural system, the transition from one system to another is often complex with multiple facets and variations over relatively small distances. In simplifying the trends mapped, the following major soil groupings are considered (Refer to Table 2.1.2):

- The *deeper and more sandy loam* soils are considered *High Potential* materials and are distinguished by the better than average depth of relatively free draining soil to a greater depth (> 700mm). This group is recognisable by the absence of the mottling (water within the profile), the lack of any rock or hard pan setting and a land capability rating of moderate intensity grazing and/or arable depending on the production potential. These soils are generally lower in clay than the associated wet based soils and more structured colluvial and dolerite derived materials, have a distinctly weaker structure and are deeper and better drained (better permeability). The ability for water to move through these profiles is described as well drained. The more sandy texture of this soil group renders them more easily worked and as a result they are considered to have a lower sensitivity.

- In contrast, the *shallower and more structured* materials are considered to be more *sensitive* and will require greater management if disturbed. This group of *shallower and more sensitive soils* (<500mm) are associated almost exclusively with the sub outcropping of the parent materials (Karoo Sediments and dolerite intrusives) at surface, and constitute a relatively large percentage of the overall area of study.

- The third group of soils comprise those that are associated with the hard pan ferricrete/calcrete and perched soil water. This group of soils have a set of distinctive characteristics and nature that are separated out due to their inherently much more difficult management characteristics. These soils are characterised by relatively much higher clay contents (often of a swelling nature), poor intake rates, poor drainage, generally poor liberation of soil water and a restricted depth – often due to the inhibiting barrier within the top 500mm of the soil profile – and are generally associated with a *wet base*. These soils will be more difficult to work in the wet state, store and re-instate at closure. This group of soils contain the pan structures and are associated with the hill slope seep zones and springs associated with contact between the dolerite sill and more competent sandstone lithologies.

  The development of *wet based* soils and moist grassland environments are mapped in association with these soil forms.

  Again, it is noted as important to the baseline study, that these soil groupings are extensive in spatial area with a number of sensitive sites associated with the underground mining areas and the potential for subsidence and/or ponding that could possibly effect the areas at surface. The results would include both saturation and soil salinisation.

- In addition, but not separated from the wet based structured soils are the group of soils that reflect *wetness* within the top 500mm. These soils are easily recognised by the mottled red and yellow colours on low chroma background colours. These soils are regarded as *highly sensitive* zones that will require authorisation/permission if they are to be impacted. The legal implications (licensing) will need to be considered if these soils are to be considered within the development.
Table 2.2.2 – Major Soil Forms

<table>
<thead>
<tr>
<th>Soil Description</th>
<th>Major Soil Forms Associated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Based soils</td>
<td>Avalon, Westleigh, Longlands, Rensburg, Katspruit, Kroonstad, Sepane, Pinedene and Glencoe</td>
</tr>
<tr>
<td>Structured Clay Loam</td>
<td>Arcadia, Rensburg, Valsrivier, Swartland and Sterkspruit</td>
</tr>
<tr>
<td>Deep Sandy Loam</td>
<td>Hutton, Clovelly, Avalon and Glencoe</td>
</tr>
<tr>
<td>Deep Sandy Clay Loam</td>
<td>Valsrivier, Clovelly</td>
</tr>
<tr>
<td>Moderate to deep Sandy Clay Loam</td>
<td>Glencoe, Clovelly, Hutton, Glenrosa and Valsrivier</td>
</tr>
<tr>
<td>Shallow Sandy Loam</td>
<td>Mispah, Glenrosa, Mayo</td>
</tr>
</tbody>
</table>

2.1.3 Soil Chemical and Physical Characteristics

A large number of soils were collected and analysed as part of the studies undertaken by Terrasoi Science during their 2008 and 2009 studies in the area. Samples were taken from points along the main arterials and country roadways and analysed for their chemical and physical attributes.

The soil analysis results for the samples collected on the site are recorded in Tables 5 and 6 of the Terrasoi Science Report entitled “SOIL, LAND USE AND LAND CAPABILITY SURVEY - SASOL BLOCK 2 AND IMPUMELELO CONVEYOR - July 23rd, 2008, Compiled by: J.H. van der Waals”.

The findings concluded that, “the pH values of the soils on the site are below or near to neutral. This is the result of the high Ca and Mg levels in the soils. This in turn is the result of parent materials rich in these elements as well as often poorly drained soils leading to the accumulation of the basic cations. In many of the samples the Ca to Mg ratios approach 1 (Table 6). This ratio provides an indication of the erodibility of the soils as Mg is dispersive and leads to the de-floculation of clay particles. The implication is that the soils found on the sites are naturally sensitive to erosion and that poor land management practises will lead to erosion. It is thus important to maintain plant and grass cover on the soils of the survey site to minimize erosive pressures. Please refer to these documents for further input in this regard.

The more structured (moderate blocky) and associated clay loams returned values that are indicative of the more iron rich materials and more basic lithologies present. The growth potential on these soils is at best moderate to poor.

The potential for a soil to retain and supply nutrients can be assessed by measuring the cation exchange capacity (CEC) of the soils. The inherently low organic carbon content is detrimental to the exchange mechanisms, as it is these elements which naturally provide exchange sites that serve as nutrient stores. The moderate clay contents will temper this situation somewhat with at best a moderate to low retention and supply of nutrients for plant growth. Low CEC values are an indication of soils lacking organic matter and clay minerals. Typically a soil rich in humus will have a CEC of 300 me/100g (>30 me/%), while a soil low in organic matter and clay may have a CEC of 1-5 me/100g (<5 me%).

Generally, the CEC values for the soils mapped in the area are moderate.

The soils mapped are generally low in organic carbon. This factor coupled with the moderate to high clay contents for the majority of the soils mapped will adversely affect the erosion indices for the soils.

There are no indications of any toxic elements that are likely to limit natural plant growth in the soils mapped within the study area.
The physical characteristics of the soils are important to both the biodiversity and ecological aspects of the natural environment as well as to the management aspects of any development.

Of significance to this study, and a feature that is moderately common across the site where the soils are associated with the dolerite intrusives is the presence of a hard pan ferricrete (plinthite) layer within the soil profile.

The semi-arid climate (negative water balance) combined with the geochemistry of the host rock geology are conducive to the formation of evaporites, with the formation of ferruginous layers or zones within the vadose zone.

The accumulation of concentrations of iron and manganese rich fluids in solution will result in the precipitation of the salts and metals due to high evaporation. This process results in the development of an evaporite and restrictive or inhibiting layer/zone within the profile over time.

The negative water balance is evidenced by the generally low rainfall of 800mm/year or less, and the high evaporation that averages 1,300mm/year. These are the driving mechanisms behind the formation of ouklip/hard pan ferricrete.

The degree of hardness of the evaporite is gradational, with soft plinthic horizons (very friable and easily dug with a spade or shovel), through hard plinthite soil (varying in particle size from sand to gravel – but no cementation) to nodular and hard pan ferricrete or hard plinthic (cementation of iron and manganese into nodules) that are not possible to free dig or brake with a shovel.

This classification is taken from - Petrological and Geochemical Classification of Laterites - Yves Tardy, Jean-Lou, Novikoff and Claude Roquid, and forms the basis for classifying the hard pan ferricrete or lateritic portion of the soil horizon in terms of its workability (engineering properties) and storage sensitivities.

The soil classification system takes cognisance of ferricrete and has specific nomenclature for these occurrences (Refer to The South African Taxonomic Soil Classification – See list of references).

The variation in the consistency of the evaporite layer, its thickness and extent of influence across/under the site are all important to the concept of a restrictive horizon or barrier layer that is formed at the base of the soil profile and/or close to the soil surface. Where this horizon develops to a nodular form or harder (Nodular, Honeycomb and Hard Pan) the movement of water within the soil profile is restrict from vertical movement and is forced to move laterally or perch within the profile. It is this accumulation of soil water and the precipitation of the metals from the metal and salt rich water that adds progressively to the ferricrete layer over time.

Important to an understanding of the development of the ferricrete is the geological time and presence of the specific soil and water chemistry and the climatic conditions under which the horizon forms. This situation will be very difficult to emulate or recreate if impacted or destroyed.

2.1.4 Soil Erosion and Compaction

Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of a particular soil as well as the treatment of the soil.

The resistance to, or ease of erosion of a soil is expressed by an erodibility factor ("K"), which is determined from soil texture/clay content, permeability, organic matter content and soil structure. The Soil Erodibility Nomograph (Wischmeier et al, 1971) was used to calculate the “K” value.
With the “K” value in hand, the index of erosion (I.O.E.) for a soil can then be determined by multiplying the “K” value by the “slope” measured as a percentage. Erosion problems may be experienced when the Index of Erosion (I.O.E) is greater than 2.

In addition, the Ca to Mg ratios are recorded as approaching 1 in many instances (Terrasoil Science 2008), a ratio that provides an indication of the erodibility of the soils as Mg is dispersive and leads to the de-flocculation of clay particles. The implication is that many of the soils associated with the dolerite host rock and associated the soils found on the sites are naturally sensitive to erosion and that poor land management practises will lead to increased erosion. It is important to maintain plant and grass cover on the soils of the survey site to minimize erosive pressures.

The majority of the soils mapped can be classified as having a moderate to low erodibility index in terms of their organic carbon content, Manganese content and clay content. This rating is off-set and tempered by the undulating to flat terrain to an index of low or resistant.

**However, the vulnerability of the “B” horizon to erosion once the topsoil and/or vegetation is removed must not be under estimated when working with or on these soils. These horizons (B2/1) are vulnerable and rate as medium to high when exposed.**

The concerns around erosion and inter alia compaction, are directly related to the disturbance of the protective vegetation cover and topsoil that might be disturbed during the construction and operational phases of the mining venture. Once disturbed, the effects and actions of wind and water are increased.

Loss of soil (topsoil and subsoil) is extremely costly to any operation, and is generally only evident at closure or when rehabilitation operations are compromised.

Well planned management actions during the planning, construction and operational phases will save time and money in the long run, and will have an impact on the ability to successfully “close” an operation once completed.
2.2 Pre-Construction Land Capability

2.2.1 Data Collection

Based on a scientifically founded baseline of information, and using the South African Chamber of Mines (1991) Land Capability Rating System in conjunction with the Canadian Land Inventory System as the basis for the land capability classification the spatial distribution has been mapped (Refer to Figure 2.2).

Using these systems, the land capability of the study area was classified into four distinctly different and recognisable classes, namely, wet land or lands with wet based soils, arable land, grazing land and wilderness or conservation land. The criteria for this classification are set out in Table 2.2.1.

Table 2.2.1 Criteria for Pre-Construction Land Capability (S.A. Chamber of Mines 1991)

<table>
<thead>
<tr>
<th>Criteria for Wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria for Arable Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land, which does not qualify as having wetland soils.</td>
</tr>
<tr>
<td>• The soil is readily permeable to a depth of 750mm.</td>
</tr>
<tr>
<td>• The soil has a pH value of between 4.0 and 8.4.</td>
</tr>
<tr>
<td>• The soil has a low salinity and SAR</td>
</tr>
<tr>
<td>• The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm.</td>
</tr>
<tr>
<td>• Has a slope (in %) and erodibility factor (“K”) such that their product is &lt;2.0</td>
</tr>
<tr>
<td>• Occurs under a climate of crop yields that are at least equal to the current national average for these crops.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria for Grazing Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land, which does not qualify as having wetland soils or arable land.</td>
</tr>
<tr>
<td>• Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100mm.</td>
</tr>
<tr>
<td>• Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria for Conservation of Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land, which does not qualify as having wetland soils, arable land or grazing land, and as a result is regarded as requiring conservation practise/actions.</td>
</tr>
</tbody>
</table>
2.2.2 Description

The area to be disturbed by the proposed expansion to the underground mining comprises a range of land capability classes. These include significant areas of moderate grazing potential land on the more friable and less sensitive sites, low potential grazing land associated with the more sensitive and highly structured (erosion and compaction) materials and wilderness land rating and wetland status on the highly sensitive areas of shallow and/or wet based soils.

The “land capability classification” as described above was used to classify and rate the land units identified during the site survey, the geomorphological aspects (soil, ground roughness, topography, climate etc.) of the site forming the primary input to the rating.

Figure 2.2 illustrates the distribution of land capability classes across the study area.

Arable Land

There are relatively small but significant sites with soil depth that meet the arable land potential rating. However, in many cases the growth potential (nutrient status) and ability of these soils to return a cropping yield equal to or better than the national average is lacking, a factor that is enhanced on a commercial basis by the additions of fertilisers and additives. These lands in their natural state often classify as grazing lands.

Grazing Land

The classification of grazing land is generally confined to the shallower and transitional zones that are well drained. These soils are generally darker in colour, and are not always free draining to a depth of 750mm but are capable of sustaining palatable plant species, especially since only the subsoil’s (at a depth of >500mm) are periodically wetted. In addition, the classification requires that there are no rocks or pedocrete fragments in the upper horizons of this soil group. If present it will limit the land capability to wilderness land.

The majority of the study area classifies as moderate to low intensity grazing land or wilderness status.

Wilderness / Conservation Land

The shallow rocky areas and soils with a structure stronger than strong blocky (pedocutanic, prismacutanic and/or vertic etc.) are characteristically poorly rooted and support at best very low intensity grazing, or more realistically are of a Wilderness character and rating.

Wetland (Areas with wetland status soils)

Wetland areas in this document (soils and land capability) are defined in terms of the wetland delineation guidelines, which use both soil characteristics, the topography as well as floral and faunal criteria to define the domain limits (Separate Wetland Delineation has been undertaken). Only the soils are described here.
These zones (wetlands) are dominated by hydromorphic soils (wet based) that often show signs of structure, and have plant life (vegetation) that is associated with seasonal wetting or permanent wetting of the soil profile (separate study).

The wetland soils are generally characterised by dark grey to black (organic carbon) in the topsoil horizons and are often high in transported clays and show variegated signs of mottling on gleyed backgrounds (pale grey colours) in the subsoil’s. Wetland soils occur within the zone of soil water influence.
Figure 2.2 Land Capability Map

Legend
1 = Arable
2 = Grazing
3 = Wilderness
4 = Wet based soil
5 = Waterway
6 = Pans
7 = Dams
8 = Man made

Impumelelo Extension Project
Baseline Soil, Land Capability
and Land Use Studies

Figure: Land Capability Map

Earth Science Solutions (Pty) Ltd
2.3  Pre-Construction Land Use

2.3.1  Data Collection

The land use was visually assessed using the orthophotographs and during the walk over field study as part of the ground truthing undertaken for the soils assessment. No attempt has been made to spatially identify the actual types of crops being cultivated as these change from year to year, with a distinction having been made between cultivated lands, actively grazed lands and natural veld grasslands. Where evident homesteads have been delineated and major infrastructure noted (Refer to Figure 2.3).

Note was made of the major commercial crops that are grown in the study area. These include maize, soya beans, small areas of market gardening and vegetable production along with cultivated pastures, some commercial forestry and small areas of woodlot.

2.3.2  Description

A significant proportion of the site has been disturbed by either intensive agricultural cultivation or livestock grazing. Little to no residence are still lived in on the site with the majority of the people having left to live in the closest towns.
Figure 2.3 Pre development Land Use
3. **Environmental Impact Assessment**

3.1 **Approach to Impact Assessment and Management**

The EIAMAP1 is a comprehensive tool used to manage the negative environmental impacts associated with mining and related activities and consists of two key aspects:

- The EIAMAP includes a full impact assessment according to activity (mining or mining-related), mining phase (construction, operational and decommissioning), and environmental component, and

- An Environmental Management Programme (EMP) proposed for the expected impacts as part of the EIAMAP. This section of the EIAMAP includes proposed mitigation measures, time frames for implementation of the proposed mitigation measures and relative financial provisioning for the implementation of the proposed mitigation measure. These aspects comply with applicable legislation, as described in detail below.

3.2 **Impact assessment methodology**

Section 31(2)(k), Chapter 3 of the R. 543 (2010) in terms of the NEMA2, 1998, requires an assessment of the extent, duration, probability and significance of the identified potential environmental impacts for the proposed mining operation. In order to comply with best practice principles, the evaluation of impacts is conducted in terms of the criteria presented in *Table 3.1*.

**Table 3.1 – Impact Assessment Criteria**

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Impact will be beneficial to the environment (a benefit).</td>
</tr>
<tr>
<td>Negative</td>
<td>Impact will not be beneficial to the environment (a cost).</td>
</tr>
<tr>
<td>Neutral</td>
<td>Where a negative impact is offset by a positive impact, or mitigation measures, to have no overall effect.</td>
</tr>
</tbody>
</table>
Once the impact criteria have been ranked for each impact, the significance of the impacts is calculated using the following formula:

**Magnitude**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td>2</td>
</tr>
<tr>
<td>Low</td>
<td>4</td>
</tr>
<tr>
<td>Moderate</td>
<td>6</td>
</tr>
<tr>
<td>High</td>
<td>8</td>
</tr>
<tr>
<td>Very high</td>
<td>10</td>
</tr>
</tbody>
</table>

Negligible effects on biophysical or social functions / processes. Includes areas / environmental aspects which have already been altered significantly, and have little to no conservation importance (negligible sensitivity*).

Minimal effects on biophysical or social functions / processes. Includes areas / environmental aspects which have been largely modified, and / or have a low conservation importance (low sensitivity*).

Notable effects on biophysical or social functions / processes. Includes areas / environmental aspects which have already been moderately modified, and have a medium conservation importance (medium sensitivity*).

Considerable effects on biophysical or social functions / processes. Includes areas / environmental aspects which have been slightly modified and have a high conservation importance (high sensitivity*).

Severe effects on biophysical or social functions / processes. Includes areas / environmental aspects which have not previously been impacted upon and are pristine, thus of very high conservation importance (very high sensitivity*).

**Extent**

<table>
<thead>
<tr>
<th>Scope</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site only</td>
<td>1</td>
</tr>
<tr>
<td>Local</td>
<td>2</td>
</tr>
<tr>
<td>Regional</td>
<td>3</td>
</tr>
<tr>
<td>National</td>
<td>4</td>
</tr>
<tr>
<td>International</td>
<td>5</td>
</tr>
</tbody>
</table>

Effect limited to the site and its immediate surroundings.

Effect limited to within 3-5 km of the site.

Activity will have an impact on a regional scale.

Activity will have an impact on a national scale.

Activity will have an impact on an international scale.

**Duration**

<table>
<thead>
<tr>
<th>Duration</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
<td>1</td>
</tr>
<tr>
<td>Short term</td>
<td>2</td>
</tr>
<tr>
<td>Medium term</td>
<td>3</td>
</tr>
<tr>
<td>Long term</td>
<td>4</td>
</tr>
<tr>
<td>Permanent</td>
<td>5</td>
</tr>
</tbody>
</table>

Effect occurs periodically throughout the life of the activity.

Effect lasts for a period 0 to 5 years.

Effect continues for a period between 5 and 15 years.

Effect will cease after the operational life of the activity either because of natural process or by human intervention.

Where mitigation either by natural process or by human intervention will not occur in such a way or in such a time span that the impact can be considered transient.

**Probability of occurrence**

<table>
<thead>
<tr>
<th>Probability</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improbable</td>
<td>1</td>
</tr>
<tr>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td>Medium</td>
<td>3</td>
</tr>
<tr>
<td>High</td>
<td>4</td>
</tr>
<tr>
<td>Definite</td>
<td>5</td>
</tr>
</tbody>
</table>

Less than 30% chance of occurrence.

Between 30 and 50% chance of occurrence.

Between 50 and 70% chance of occurrence.

Greater than 70% chance of occurrence.

Will occur, or where applicable has occurred, regardless or in spite of any mitigation measures.

*Note for specialists – please use the sensitivity information / rankings you determine in your studies here.*
The extent (spatial scale), magnitude, duration (time scale) and the probability of occurrence of each identified impact is assigned a value according to the impact assessment criteria (Table 3.1, above) and is used to calculate the significance of each impact.

A Significance Rating is then calculated by multiplying the Severity Rating with the Probability. The maximum value that can be reached through the described impact evaluation process is 100. The scenarios for each environmental impact are rated as High (SP≥60), Moderate (SP 31-60) and Low (SP<30) significance as shown in Table 3.2.

Table 3.2: Definition of significance rating

<table>
<thead>
<tr>
<th>Significance of predicted NEGATIVE impacts</th>
<th>Significance of predicted POSITIVE impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low 0-30 Where the impact will have a relatively small effect on the environment and will require minimum or no mitigation.</td>
<td>Low 0-30 Where the impact will have a relatively small positive effect on the environment.</td>
</tr>
<tr>
<td>Medium 31-60 Where the impact can have an influence on the environment and should be mitigated.</td>
<td>Medium 31-60 Where the positive impact will counteract an existing negative impact and result in an overall neutral effect on the environment.</td>
</tr>
<tr>
<td>High 61-100 Where the impact will definitely influence the environment and must be mitigated, where possible.</td>
<td>High 61-100 Where the positive impact will improve the environment relative to baseline conditions.</td>
</tr>
</tbody>
</table>

Once the significance rating of an impact before mitigation has been determined, the reversibility of the impact, ‘replacability’ of the affected resources and the potential of the impact to be further mitigated is determined Refer to Table 3.3

Table 3.3: Mitigation prediction criteria

<table>
<thead>
<tr>
<th>Reversibility of impact</th>
<th>Irreplaceable loss of resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reversible 1 The impact on natural, cultural and / or social structures, functions and processes is totally reversible.</td>
<td>Replaceable 1 The impact will not result in the irreplaceable loss of resources.</td>
</tr>
<tr>
<td>Partially 2 The impact on natural, cultural and / or social structures, functions and processes is partially reversible.</td>
<td>Partially 2 The impact will result in a partially irreplaceable loss of resources.</td>
</tr>
<tr>
<td>Irreversible 3 Where natural, cultural and / or social structures, functions or processes are altered to the extent that it will permanently cease, i.e. impact is irreversible.</td>
<td>Irreplaceable 3 The impact will result in the irreplaceable loss of resources.</td>
</tr>
</tbody>
</table>
The impacts expected to occur as result of the activities that are anticipated to take place at the proposed project site may combine with those resulting from surrounding activities and land uses to form cumulative impacts. The EIAMAPs for cumulative impacts exclude any potential mitigation measures as they will have been addressed in the other activity-specific EIAMAPs.

### 3.3 Environmental Management Plan (EMP)

Regulation 33 of the EIA Regulations GN R.543 (2010) under the NEMA (1998) sets out the requirements for an EMP. To address these requirements, the EIAMAPs includes the following aspects:

**The mitigation management objectives and principles**— these are identified to enable the proponent to set goals for the environmental management of the proposed mining operations.

Design plays a large role in the mitigation process, thereby ensuring that the project takes a proactive stance to environmental management. **Mitigation by design** is central to the implementation of any EMP.

**Proposed mitigation measures**— These measures need to make recommendations that, when implemented, will enable the project to achieve the environmental management goals / objectives identified. The proposed mitigation measures identified should modify, remedy, control or stop any action, activity or process that is identified as possibly impacting adversely on the environment.

**Time Frames**— An indication of the acceptable timeframe for the implementation of the proposed mitigation measures is required.

**Person responsible**— The client and/or lead consultants will decide who is responsible for the implementation and management of the EMP.
3.4. Impact Assessment

Using the impact assessment methodology tabled by the lead consultants (CSEC), the base line information and the development plan tabled for the underground mining expansion, the impact significance has been rated (Refer to Appendix 1 and Table 3.4) and a set of management and mitigation measures presented.

3.4.1 Construction Phase

There will be no impacts associated with this phase. All development will be continued from existing mining ends and development portals with no impact at surface.

3.4.2 Operational Phase

Issue: Loss of Soil Usability/Utilisation

<table>
<thead>
<tr>
<th>Operation of Project – Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of soil utilisation - U/G Mining collapse, ponding, erosion, contamination and compaction of disturbed soils, on-going management of soil stockpiles and the potential for contamination of soils by dirty water ingress, dust and/or hydrocarbon spillage from construction vehicles on repairing sinkholes, and compaction.</td>
</tr>
</tbody>
</table>

Description of Impacts

During the operational phase the project will require the maintenance and management of the materials stockpiles, mitigation of dirty water and possible contamination of the resource and the containment of the resource from erosion. Inundation and ponding due to subsurface subsidence and the management of impeded surface flow is also considered.

The impact on the soil utilisation and eco system services as a result of change in land use and sterilisation of materials for extended periods of time and the inundation by ponding of surface water in hollows due to subsidence of the underground workings will lead to potential salinisation, sterilisation, and the loss of the materials for future use. This will definitely result in a High (H) negative impact that will last for the duration of the project within the development area. The consequence is moderate (M) with an overall significance of High (H).

The use of access roads and the on-going additions of by-product to the stockpiles and storage facilities will all add to the cumulative impact, while any spillage from moving vehicles and the conveyancing of coal, possibly leakage or spillage of hydrocarbons and leakage from any waste areas such as dirty water containment facilities, sewage works etc. will negatively impact the in-situ materials, while unmanaged dirty water will erode and contaminate the soils that it comes into contact with.

Un-managed, the soil stockpiles and soil that is left uncovered/not vegetated will be lost to water and wind erosion, and surfaces will be prone to compaction.

The different soil forms will react differently to the activities and associated impacts, the sensitivity analysis having been tabled as a management tool in impact significance rating.

The significance of an impact on the soils during the operational phase will differ both in intensity and duration, with the soils associated with long term infrastructure remaining in a stockpile for the
full life of the project, while the construction access ways and temporary laydown areas will be available for rehabilitation.

It is inevitable however, that the soils utilisation potential will be lost during the operational phase, and possibly for ever if they are not well managed and a mitigation plan is not implemented.

**Mitigation/Management Action**

The impacts on the stockpiled and stored soils may be mitigated with management procedures including:

- Minimisation of overall/total area of impacted;
- Timorous replacement of the soils so as to minimise the area of disturbance;
- Effective vegetative and soil cover and protection from wind (dust) and dirty water contamination;
- Monitoring for subsidence and collapse at surface due to underground collapse and sinks, and the management of areas of ponding and restricted surface flow;
- Adequate protection from erosion (wind and water) of all soils;
- Servicing of all vehicles and equipment on a regular basis and in well-constructed and bunded areas, the management of well-constructed and maintained oil traps and dirty water collection systems;
- Cleaning of all access roadways and service routes, drains and storm water control facilities;
- Containment and management of spillage;
- Soil replacement and the preparation of a seed bed to facilitate and accelerate the re-vegetation program and to limit potential erosion, and
- Soil amelioration to enhance the growth capability of the soils and sustain the soils ability to retain oxygen and nutrients, thus sustaining vegetative material during the storage stage;

Of consequence during the operational phase will be the minimising of the area that is being impacted by the underground mining operation and its related support structures and operations, and maintenance of the integrity of the stored soils. This will require that the soils are kept free of contamination (dust and dirty water), and stabilised and protected from erosion and compaction.

However, if the utilisable soils are stripped and replaced as close as possible to their original position in the topography as soon as the areas become available for rehabilitation, the chances of natural attenuation being able to restore the systems will be better.

**Residual Impact**

In the long term, the above mitigation measures will probably reduce the impact on the utilisable soil reserves to a Medium or Low impact.
3.4.3 Decommissioning & Closure Phase

Issue: Net loss of soil potential due to change in materials (Physical and Chemical) and loss of nutrient base.

Decommissioning and Closure – Cumulative

Loss of the soils original nutrient store by leaching, erosion and de-oxygenation while stockpiled. Impact of vehicle movement, dust contamination and erosion during soil replacement and demolishing of infrastructure, slope stabilisation and re-vegetation of disturbed areas. Possible contamination by dirty water interaction (use of mine water for irrigation of re-vegetation), dust and/or hydrocarbon spillage from rehabilitation/construction vehicles. Positive impacts of reduction in areas of disturbance and return of soil utilisation potential, uncovering of areas of mining infrastructure, reconstruction of landscape and rehabilitation of compacted materials.

Description of Impact

During the decommissioning and closure phase all infrastructure will need to be removed, any and all voids (dams etc.) will need to be filled, the on-going control of dirty stormwater runoff maintained, and any depressions caused by underground collapse will need to be landscaped to be free draining.

Service roads and access ways will need to be rehabilitated if they are not required by the land owner, and any stockpiles of waste or by-product stockpiles/dumps will need to be managed to a stable land form (sloped and covered).

The impact will remain the net loss of the soil resource if no intervention or mitigating strategy is implemented. The impact will be High (H), negative and permanent over the area of disturbance, with a relatively high consequence and resultant high significance. Un-managed closure will result in a long term depletion of soil utilisation potential.

Management/Mitigation Actions

Ongoing rehabilitation during the decommissioning phase of the project will bring about a net long-term positive impact on the site.

The initial impact will be high and negative due to the necessity for vehicle movement while moving materials (soft overburden and soils), the demolishing of storm water controls etc. Dust will be generated and soil will be contaminated and eroded.

The positive impacts of rehabilitating an area are the reduction in the disturbed areas, the amelioration of the affected soils and oxygenation of the growing medium, the stabilising of slopes and the revegetation of areas decommissioned with a reduction in areas previously subjected to wind or water erosion.

Residual Impacts

On decommissioning and closure the long-term negative impact on the soils will be of medium to low significance if the management plan set out in Environmental Plan is effectively implemented to reinstate current soil conditions.
Table 3.2 – Impact Significance Rating
| Potential Impact                                                                 | Score | Magnitude | Extent | Probability | Significance | Magnitude Rating | Extent Rating | Responsibility | Responsible Person | Financial Plan |
|---------------------------------------------------------------------------------|-------|-----------|--------|-------------|--------------|-----------------|---------------|----------------|-------------------|----------------|-----------------|
| Loss of soil utilisation potential and once services provided.                  | 6     | 1         | 5      | 4           | 2            | 1              | 0             | N/A            | N/A               | N/A            |
| Management of stored materials, monitoring for contaminants and system          | -     | 10        | 5      | 2           | 2            | 3              | 0             | N/A            | N/A               | N/A            |
| 2. Activity: Underground Mining                                                |       |           |        |             |              |                 |               |                |                   |                |
| Loss of soil utilisation potential and once services provided.                  | -     | 5         | 5      | 4           | 2            | 2              | 0             | 4             | 4                 | 48 SHEQ manager |
| Management of stored materials, monitoring for contaminants and system          | -     | 6         | 2       | 5           | 4            | 2              | 2             | 4             | 4                 | 48 SHEQ manager |
| 3. Decommissioning Phase (after operational phase until closure goals are reached) |       |           |        |             |              |                 |               |                |                   |                |
| 3.1 Activity (Rehabilitation of any remaining impacts)                          |       |           |        |             |              |                 |               |                |                   |                |
| Replacement of soils and vegetation of land suitable area                       | -     | 6         | 1       | 3           | 5            | 2              | 2             | 4             | 4                 | 10,000/ha      |
| Irrigation of vegetation                                                      | -     | 8         | 1       | 2           | 4            | 2              | 2             | 4             | 4                 | 700/ha         |
| Rehabilitation of impacted impacted areas (ground, surface, and notes)          | +     | 6         | 1         | 2           | 5            | 6              | 2              | 4             | 4                 | 12,000/ha |
| 4. Post-Closure Phase                                                          |       |           |        |             |              |                 |               |                |                   |                |
| 4.1 Activity Rehabilitation of any remaining impacts                            |       |           |        |             |              |                 |               |                |                   |                |
| Maintenance of vegetation                                                      | -     | 6         | 1         | 2           | 4            | 3              | 2              | 4             | 4                 | 20 Closure     |
4. ENVIRONMENTAL MANAGEMENT PLAN

It is imperative that a full and detailed EMP is implemented if the economics of mine closure are to be understood, and the relative positioning and timings of materials handling are to be aligned with the development plan.

Based on the studies undertaken and the mine plan proposed, it has been possible to assess the impacts that development could potentially have on the soils and their resultant utilisation potential (land capability), and has aided in a better understanding of the possible management and mitigation measures that can help in minimising the impacts during the life of the project. (Construction, operation through decommissioning and at closure).

The management and mitigation measures proposed have been tabled for the different stages of the project based on an understanding of the project activities and the site sensitivities (soil, topography etc.) that will potentially be affected.

These affects and the resultant utilisation change in land capability and land use are considered as part of this environmental management plan (EMP) for the expansion to the underground mining.

The plan has assumed that the overall project will be decommissioned and closed once the coal resource is exhausted, and thus caters for the operation and decommissioning stages of the project, gives recommendations on the handling of the soils during the operational phases, with recommendations given for the rehabilitation and ultimate closure of the facility as part of the “End Land Use” planning.

It is noted at the outset that, the underground methods of mining being planned (bord and pillar), the depth at which the mining is to take place (+100m) and the presence of a significant dolerite sill between the coal and the surface are considerations and conditions that lower the risk of surface disturbance by the mining activities. There is however, still a risk that the collapse of the underground workings over time (geological) could result in open voids at surface and the ponding of water in depressions on surface. These factors have been considered as part of the impact assessment and the management plan.

Management for the underground expansion project will be confined in the operational phase to monitoring and repair of sinkholes and ponding of water at surface and the on-going management of materials (additions to the waste stockpiles) and the soil resource where affected.

The concept of stripping and storage of “utilisable” soil is tabled as a minimum requirement and as part of the overall Soil Utilization Guidelines.

It is understood that no removal of soil will be required for the expansion project. However, the concept of soil storage and the need for sufficient soil resources to be available for surface rehabilitation (sinkholes etc.) requires that materials are identified and where impacted should be removed and stored for future use.

In terms of the “Minimum Requirements”, usable soil is defined here as “ALL soil above an agreed subterranean cut-off depth” defined by the project soil scientist. These depths will vary for different types of soil encountered. It does not differentiate between topsoil (orthic horizon) and other subsoil horizons.

Soil stripping requirements are set to enable the developer to achieve post mining land capabilities equal or better than the original status, a stipulation often included as part of best practice
guidelines and international best practice for site management. These requirements are generally based on pre-mining land capability assessment for the area in question.

Pre-mining grazing land capability is the norm that is aimed for in most situations post mining in this region, the original ecological status being grasslands with a low intensity grazing capability.

The following requirements (all be they generic) should be aimed for wherever possible:

- Over areas of OPEN CAST PITS, DEEP EXCAVATIONS (>1.2m) or openings to a boxcut or adit to UNDERGROUND workings strip all usable soil as defined (+700mm). Stockpile alluvial and wet based soils separately from the in-situ derived (dry) materials, which in turn should be stored separately from the overburden (Soft weathered rock).

  At rehabilitation replace soil to appropriate soil depths, and cover areas to achieve an appropriate topographic aspect and attitude to achieve a free draining landscape and as close as possible the pre-mining land capability rating.

- Over areas of STRUCTURES (Offices, Workshops, Conveyencing Routes and Power Line Pylon Plinth Footings and Excavations) AND SOIL or SOFT OVERBURDEN STOCKPILE footings – strip and stockpile the top 300 mm of usable soil over all affected areas and strip remaining usable soil where founding conditions require further soil removal (>300mm). Store the soil in stockpiles of not more than 1.5 m around infrastructure area for closure rehabilitation purposes. Stockpile hydromorphic soils separately from the dry materials. For rehabilitation strip all gravel and other rocky material, places in terraces and recycle as construction material or place in open voids. Remove foundations to a maximum depth of 1m. Replace soil to appropriate soil depths, and over areas and in appropriate topographic position to achieve pre-mining land capability and land form.

- Over area of CONSTRUCTION OF BY-PRODUCT/TAILINGS/SLURRY STORAGE FACILITIES AND HARD OVERBURDEN STOCKPILES strip usable soil to a depth of 750 mm in areas of arable soils and between 300mm and 500mm in areas of soils with grazing land capability. Stockpile hydromorphic soils separately from the dry and friable materials. For rehabilitation strip all gravel and other material places to form terraces and recycle as construction material or place in open pit. Remove foundations to a maximum depth of 1m. Replace soil to appropriate soil depths, and over areas and in appropriate topographic position to achieve pre-mining land capability.

In general, the depth of the topsoil’s material is between 300mm and 650mm. However, due to the shallow soil depths on the more rocky slopes and the structured nature of many of the soils, it is a concern that insufficient material will be available across all sites.

The need to rehabilitate areas with sufficient materials to induce growth at closure will require that a minimum of 500mm is stripped from the areas where it is present and required to be removed.

The positioning of any/all storage facilities will need to be assessed on the basis of the cost of double handling, distances to the point of rehabilitation need, and the potential for use of the materials as storm water management facilities (berms). Suggestions include the use of materials in the form of berms along linear infrastructure or stockpiles of low height at regular intervals for foundation materials removed from plinth footings to pylons.
Where necessary and present any/all vegetated soils should be stripped and stockpiled without the vegetation being cleared/removed, while any grassland/natural veld to be disturbed should be fertilized with super phosphate prior to being stripped. These actions will ensure that the fertilizer is well mixed into the soil during the stripping operation and will aid in the quick cover to the stockpiles and reduce the amount of fertilizer required during the rehabilitation program. All utilization of the land for any other purpose will need to stop before development begins.

The lower portions of the subsoil’s (>500mm) and the soft overburden material (where removed) can be stored as separate stockpiles close to the areas where they will be required for backfilling and final rehabilitation.

The base to all of the proposed structures (pylon plinths etc.) to be constructed should be founded on stabilized materials, the soils having been stripped to below the depth of utilizable soil (>500mm).

It is proposed that prior to soil stripping, an appropriate (to be determined by local soil experts) fertilizer (super phosphate) should be added to the soils at a rate of about 200 kg/ha if they have not previously been fertilized. This will help to enhance the seed pool and encourage growth within the stored materials. Correct handling of the soil resource will have a significant effect on the costs and the final success or failure of the rehabilitation plan at closure.

In addition, and as part of the success and long term sustainability of rehabilitating disturbed areas will be the replacement of the materials in their correct topographic position, and the ability of the rehabilitation team to re-create a viable soil profile. This will be no mean feat, as the materials that contribute to the retention of soil water, and the success of viable rooting conditions are will have been disturbed or destroyed (inhibiting layers, ferricrete and evaporite layers).

Long term and forward planning for the utilization of the materials to their best advantage and the understanding of the final “End Land Use” will need to be well understood if the optimum utilization of the materials is to be achieved. Please refer to the recommendations of materials replacement under the decommissioning and closure plan section.

The consequences of not achieving these goals will need to be assessed and quantified in terms of the long term ecological impacts, and will require the input of the specialist ecologists, hydrogeologists and engineers in formulating the management plan.

4.1 Construction Phase

There will be no construction associated with the underground expansion
4.2 Operational Phase

Soil Stockpiling and Storage

Based on the findings of the baseline studies the sensitivity of the soil materials has been evaluated and site specific conditions noted. The following summary of soil utilisation recommendations are made for the operational phase of the project.

Table 4.2– Operational Phase – Soil Utilisation Plan

<table>
<thead>
<tr>
<th>Phase</th>
<th>Step</th>
<th>Factors to Consider</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>Vegetation establishment</td>
<td>Rapid growth of vegetation on the Soil Stockpiles will be promoted (e.g. by means of</td>
<td>Stockpiles will be established with storm water diversion berms to prevent run off erosion.</td>
</tr>
<tr>
<td></td>
<td>and erosion control</td>
<td>of watering or fertilisation), The purpose of this exercise will be to protect the soils and combat erosion by water and wind.</td>
<td></td>
</tr>
<tr>
<td>Stockpile</td>
<td>Stockpile Height</td>
<td>Soil stockpile heights will be restricted where possible to &lt;1.5m so as to avoid</td>
<td>Stockpiles will be established with storm water diversion berms to prevent run off erosion.</td>
</tr>
<tr>
<td>management</td>
<td>and Slope Stability</td>
<td>compaction and damage to the soil seed pool. Where stockpiles higher than 1.5m</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>cannot be avoided, these will be benched to a maximum height of 15m. Each bench</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>should ideally be 1.5m high and 2m wide. For storage periods greater than 3 years,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>vegetative cover is essential, and should be encouraged using fertilization and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>induced seeding with water. The stockpile side slopes should be stabilized at a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>slope of 1 in 6. This will promote vegetation growth and reduce run-off related</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waste</td>
<td>No waste material will be placed on the soil stockpiles.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicles</td>
<td>Equipment movement on to of the soil stockpiles will be limited to avoid topsoil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>compaction and subsequent damage to the soils and seedbank.</td>
<td></td>
</tr>
</tbody>
</table>

The utilisable soil stockpiled will be maintained throughout the life of the project.

It is imperative, where possible, that the slopes of the stockpile and berm facilities are maintained at 1:6 or shallower. This will minimize the chances of erosion of the soils and will enhance the growth of vegetation. However, prior to the establishment of vegetation, it is recommended that erosion control measures, such as the planting of Vetiver Grass hedges, or the construction of benches and cut-off drains be included in the stockpile/berm design.

These actions will limit the potential for uncontrolled run-off and the subsequent erosion of the unconsolidated soils, while the vegetation is establishing itself, and throughout the life of the mining operation.

Vetiver is a recognised and certified natural grass specie in South Africa, and after many years of trials and testing has been given a positive record of decision as a non-invasive material that can be used as a hedging grass in the development of erosion control. The advantages to the use of Vetiver Grass, is documented in the attached brochure (Refer Appendix 2 - The Vetiver Network International - [www.vetiver.org](http://www.vetiver.org)).

Erosion and compaction of the disturbed soils and the management of the stored or stockpiled materials are the main issues that will need to be managed on these sensitive soil forms. This is due to the sensitivity of the soils to mechanical disturbances during/after the removal of surface vegetation and the difficulties in replacing the disturbed materials.
The potential for sinkhole development will need to be monitored on areas that have been undermined or disturbed at depth. This is particularly pertinent to areas where mining has occurred at shallow depths and around decline adits and ventilation installations.

Any subsidence will need to be surveyed and mapped to the mine plan as areas requiring remediation and rehabilitation before closure, with backfilling and landscaping of the topography to be free draining.

Working with or on the differing soil materials (all of which occur within the areas that are to be disturbed) will require better than average management and careful planning if rehabilitation is to be successful. Care in removal and stockpiling or storage of the “Utilisable” soils, and protection of materials which are derived from the “hardpan ferricrete” layer is imperative to the success of sustainable rehabilitation in these areas. The sensitivity of the soils is a factor to be considered during the rehabilitation process (Refer to section on Soil Handling and Removal – Construction Phase (4.1) and Mitigation and Management Measures – Decommissioning and Closure Section (4.2) and (4.3) respectively)

4.3 Decommissioning and Closure

Soil Replacement and Land Preparation

During the decommissioning and closure phase of any project there will a number of actions being undertaken or completed. The removal of all infrastructure and the demolishing of concrete slabs, the backfilling of any sinkholes, open voids and foundations, the compaction of the underlying barrier layer, and the topdressing of the disturbed and backfilled areas with utilizable soil ready for re-vegetation. These actions are all considered part of a successful closure operation.

The order of replacement, fertilization and stabilization of the backfilled materials and final cover materials (soil and vegetation) are all important to the success of the decommissioning plan and final closure.

There will be a positive impact on the environment in general and on the soils in particular as the area of disturbance is reduced, and the soils are returned to a state that can support low to moderate intensity grazing or sustainable agriculture.

Fertilizers and Soil Amendments

For any successful soil amelioration and resultant successful vegetative cover, it is necessary to distinguish between the initial application of fertilizers or soil amendments and maintenance dressings. Basal or initial applications are required to correct disorders that might be present in the in-situ material and raise the fertility status of the soil to a suitable level prior to seeding. The initial application of fertilizer and lime to the disturbed soils is necessary to establish a healthy plant cover as soon as possible. This will prevent erosion. Maintenance dressings are applied for the purpose of keeping nutrient levels optimal. These applications will be undertaken only if required, and only after additional sample analysis has been undertaken.
### Table 4.3 – Decommissioning and Closure Phase – Soil Conservation Plan

<table>
<thead>
<tr>
<th>Phase</th>
<th>Step</th>
<th>Factors to Consider</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning &amp; Closure</td>
<td>Placement of Soils</td>
<td>Stockpiled soil will be used to rehabilitate disturbed sites either ongoing as disturbed areas become available for rehabilitation and/or at closure. The utilizable soil (500mm) removed during the construction phase or while opening up of decline adit entrance, shall be redistributed in a manner that achieves an approximate uniform stable thickness consistent with the approved postmining land use (Low intensity grazing), and will attain a free draining surface profile. A minimum layer of 300mm of soil will be replaced.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fertilization</td>
<td>A representative sampling of the stripped soils will be analysed to determine the nutrient status of the utilizable materials. As a minimum the following elements will be tested for: EC, CEC, pH, Ca, Mg, K, Na, P, Zn, Clay% and Organic Carbon. These elements provide the basis for determining the fertility of soil. based on the analysis, fertilisers will be applied if necessary.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Erosion Control</td>
<td>Erosion control measures will be implemented to ensure that the soil is not washed away and that erosion gulleys do not develop prior to vegetation establishment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pollution of Soils</td>
<td>If soil (whether stockpiled or in its undisturbed natural state) is polluted, the first management priority is to treat the pollution by means of in situ bioremediation. The acceptability of this option must be verified by an appropriate soils expert and by DWAF, on a case by case basis, before it is implemented.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In-situ Remediation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Off site disposal of soils.</td>
<td>If in situ treatment is not possible or acceptable then the polluted soil must be classified according to the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste (DWAF 1998) and disposed at an appropriate, permitted, off-site waste facility.</td>
<td></td>
</tr>
</tbody>
</table>

No fertilizer requirements are considered here as the levels will definitely alter during the storage stage and will need to be re-assessed before the soils are reinstated.

It is recommended that a qualified agronomist or plant ecologist be employed to establish the possible need or not for lime, organic matter and fertilizer requirements that will be applied, prior to the starting of the rehabilitation process. It is important that only small amounts of fertilizer are added at a more frequent interval, rather than adding large quantities in one application. The following maintenance is recommended:

- The area must be fenced, and all animals kept off the area until the vegetation is self-sustaining;
- Newly seeded/planted areas must be protected against compaction and erosion;
- Traffic should be limited were possible while the vegetation is establishing itself;
- Plants should be watered and weeded as required on a regular and managed basis;
- Check for pests and diseases at least once every two weeks and treat if necessary;
- Replace unhealthy or dead plant material;
- Fertilise, hydro seeded and grassed areas with 200 kg/ha ammonium sulphate 4-6 weeks after germination, and
- Repair any damage caused by erosion;
Soil Sampling

During the rehabilitation exercise preliminary soil sampling should be carried out to determine the fertilizer requirements more accurately. Additional soil sampling should also be carried out annually until the levels of nutrients, specifically magnesium, phosphorus and potassium, are at the required level (approximately 20 and 120 mg/kg respectively). Once the desired nutritional status has been achieved, it is recommended that the interval between sampling be increased. An annual environmental audit should be undertaken. If growth problems develop, ad hoc, sampling should be carried out to determine the problem.

Sampling should always be carried out at the same time of the year and at least six weeks after the last application of fertilizer.

All of the soil samples should be analysed for the following parameters:

- pH (H₂O);
- Electrical conductivity;
- Calcium mg/kg;
- Magnesium mg/kg;
- Potassium mg/kg;
- Sodium mg/kg;
- Cation exchange capacity;
- Phosphorus (Bray I);
- Zinc mg/kg;
- Clay% and;
- Organic matter content (C %)

5 ENVIRONMENTAL MONITORING PLAN

5.1 MONITORING PHILOSOPHY AND REQUIREMENTS

5.1.1 Monitoring Philosophy

The observation and recording of environmental data are costly exercises and therefore the philosophy and reasoning behind an environmental monitoring system should always be sound and well-motivated.

The benefits of sound environmental monitoring are not only legal compliance, but also certain business benefits such as the improvement of operational efficiency, the improvement of risk management, the reduction of liabilities, the avoidance of adverse publicity and ultimately the improvement of business performance.

Current Environmental Legislation in South Africa requires mining and industry to comply with the philosophy of Integrated Environmental Management. The applicable legislation includes inter alia the Constitution, the National Environmental Management Act, the Environment Conservation Act, the Minerals and Petroleum Resources Development Act, and the National Water Act, to name but a few of the more prominent acts.

Some of the general principles of Integrated Environmental Management include meaningful participation with Interested and Affected Parties, due consideration of alternatives that includes the “no go option”, and understanding that activities will not be approved if there is scientific uncertainty.
The abovementioned legislation is furthermore applied subject to a number of emerging Environmental Law Norms, including norms such as sustainable development, a human right to a decent environment, legal standing, inter-generational equity, the public trust doctrine, the precautionary principle, the preventive principle, the polluter pays principle, local level governance and the norm of common but differentiated responsibility.

Some of these norms have a profound influence on the way in which mining and industry need to perform their environmental management. In this regard, the precautionary principle, which states that “where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.” This norm introduces and elevates scientific quantification of impacts, and the associated risks to human health and the environment, to a status of representing a fundamental requirement in Environmental Management.

This implies that from a technical perspective, all environmental systems must be understood to their full consequence, to allow for accurate, quantitative impact and risk assessment, on which to base decisions related to the management of these systems. In simple laymen terms, this means that the different biophysical components of the environment must be measured and monitored, to supply quantitative decision making information of high certainty, on which to base the management of the environment.

However, effective integrated environmental management does not only require a fundamental understanding of the environmental components and the activities and processes which could impact on the environment, but more important, the transient development of the impacts associated with these processes, need to be understood to such a degree that their future development and response to management, remedial and/or rehabilitation measures, can be predicted.

**Environmental Monitoring therefore forms the cornerstone of Integrated Environmental Management.**

Environmental Management policies in South Africa advocate the Risk Based (Averse) Approach, subject to the implementation of the Best Practical Environmental Option (BPEO), using the management hierarchy of Source-Pathway-Receptor. The Source-Pathway-Receptor hierarchy requires an in-depth understanding of the origin of all pollutants, the pathway these pollutants could follow into the environment and the ultimate fate of these pollutants. The overarching Risk Profile relates to the protection of Human Health and the Environment. BPEO is a minimum requirement in terms of South African Environmental Management Policy and forms the basis of all source control measures to be implemented.

On a practical level, compliance with all the above legislation, environmental law norms, guidelines and policies, requires environmental monitoring systems which must ensure the generation, interpretation and reporting of information of high scientific integrity.

The monitoring of the soil environment has not been legislated in terms of South African Law, but as an integral part of the “pathway” that any pollutant or contaminant is likely to follow, it is often an area where the contaminant is detected in the early stages of a problem, and often, due to its variability and ability to inhibit flow rates is part of the protection mechanism that can be used in mitigating impacts. The soils can also of course be part of the source of contamination.
Monitoring of the water in the environment are legislated and, although the nature of the material being sampled and analysed is different, the principles and methodology are similar. Formal technical guidelines for Environmental Monitoring are currently being developed locally.

Internationally there are norms that have been tabled for certain metal content and hydrocarbon limits to soils, and SA have adopted a similar approach to the understanding of soil quality, with research being undertaken on a need to know basis. This is often not satisfactory, and a retrospective philosophy that is often costly.

In addition, it is not only important to understand the presence of contamination in the vadose zone and soil profile, but it is necessary to understand the quality of a soil if it is to be used as a growing medium. The nutrient content of a soil is important to the success of failure of many a rehabilitation project.

The results of soil analysis should be assessed to determine areas of success and identify any activities that require corrective or preventative action and improvement.

In this particular case (Soil and Land Capability), it is the intention of this monitoring plan to raise awareness regarding the possibility of problems within the soil profile (be it due to inputs of material from the mining activities that are a potential source of contamination, or the observation of nutrient levels), that can be mitigated.

By monitoring and observing the development (trends) of change within a soil profile, the corrective action to remedy the situation is highlighted early.

Data should be collected systematically, from appropriate sources at a frequency consistent with the environmental objectives and targets, taking cognizance of the significance of the environmental aspects.

The environmental management plan specifies the baseline conditions that are to be achieved as part of the rehabilitation planning, and gives input into the procedures for the dealing of contaminated soils.

At the outset, and as part of the baseline information gathered, soil chemistry was measured for the pre-mining environment (Terrasoil Science). This should be used as the basis for any change that becomes apparent during the activity.

The demarcating of specific points for monitoring are not recommended as composite samples were originally taken at the time of baseline investigation. Sampling of specific points during the life cycle of the mining venture will need to be decided on a need to understand basis, with the rehabilitated areas being sampled for nutrient levels when required, and any areas of concern regarding contamination will need to be determined and a specific grid decided for each individual situation.

As with any monitoring and data capture, protocols need to be developed for the specifics of the area and the material being sampled. In the case of soils, it is important that aspects such as sampling technique, sampling equipment, sampling frequency, sample preservation, analysing technique, and variables to be analysed for, should be formalized and documented.
The frequency of monitoring/sampling should at all times be a combined function of the sampling objectives and the expected variability in the parameter(s) to be monitored. In the case of soils the changes and variation in quality are generally a function of input or removal due to a known action or process and the measuring of change will be determined on a need to know basis. This is specifically true for the rehabilitation of an area, or when a spill has occurred. Thus, the frequency of sampling will be determined by the circumstance.

The success of any monitoring program depends inter alia on the selection of appropriate sampling techniques and equipment to satisfy all monitoring objectives. Broadly speaking these objectives should support regulatory requirements, certain operational decision making requirements and corrective action evaluation. Incorrect or poorly selected sampling techniques will render all of the preceding effort (such as evaluation of site conditions, optimisation of sampling frequency and selection of variables to be analysed for) futile.

Great care should at all times be taken in the field to prevent mishaps or contamination. In the case of soil monitoring, the equipment used will depend on the depth at which the sample is to be taken and the quantity of material that is needed. If only the nutrient content of a soil is needed as part of the rehabilitation planning, then relatively small (250g) quantities of soil are needed, while the understanding of a soils physical attributes and its engineering properties or possible containment of a contaminant will often require that a much bigger (50kg) sample is taken a varying depths through the profile.

Aspects such as timing, techniques, and the capture of the information will vary with the different reasons for undertaking the sampling. Please refer to Section 4 above – Management Planning for details on sampling periods and determinants that are recommended.
LIST OF REFERENCES

Taxonomic Soil Classification System (Mac Vicar et al, 2nd edition 1991)

The Soil Erodibility Nomograph (Wischmeier et al, 1971)


The South Africa Vetiver Network – Institute of Natural Resources – Scottsville – Mr. D. Hay and J. McCosh1987 to present.


APPENDIX 1

VETIVER GRASS
APPENDIX 2

FERRICRETE & CALCRETE CLASSIFICATION
APPENDIX 3

IMPACT RATING TABLES