Earth Science Solutions

Project No: MBU5710

XIVONO MINING (PTY) LTD

WELTEVREDEN COAL MINE

Environmental Authorisation

BASELINE STUDIES

SPECIALIST SOILS, & LAND CAPABILITY STUDIES

Compiled For

DIGBY WELLS ENVIRONMENTAL

SPECIALIST SOILS REPORT

July 2019

Sustaining the Environment

XIVONO MINING (PTY) LTD
WELTEVREDEN COAL MINE

BASELINE SPECIALIST SOILS, & LAND CAPABILITY
STUDIES – EIA AND EMP

Compiled for
DIGBY WELLS ENVIRONMENTAL PTY LTD

Title	**Name**	**Capacity**	**Signature**	**Date**
Author	Ian Jones	Director ESS (Pty) Ltd		16th July 2019
Project Director	Sanusha Govender	Project Leader		
Technical Review				

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Our Ref:
Your Ref:

Stonecap Trading 14 (Pty) Ltd

16th July 2019

Digby Wells and Associates (South Africa) (Pty) Ltd
Private Bag X10046,
Randburg,
2125,
South Africa

Att: Sanusha Govender, Tel: (011) 789 9495, 084 219 8000

Dear Ms Govender,

WELTEVREDEN COAL MINING PROJECT
SCOPING STUDY – SPECIALIST SOILS AND LAND CAPABILITY STUDIES

Attached herewith please find our Baseline Report detailing the specialist inputs for the soils and land capability aspects in support of the Environmental Authorisations being undertaken by Digby Wells and Associates (Pty) Ltd on behalf of the Xivono Mining (Pty) Ltd on their Weltevreden Coal Mining venture in the Middelburg area of Mpumalanga Province, South Africa. This report details the outcomes of our field assessment for the area of concern, and the impact assessment based on the development plan proposed.

Should you have any queries in this regard, please do not hesitate to contact us.

Thanking you.

Yours faithfully,
Earth Science Solutions (ESS) (Pty) Ltd

Ian Jones B.Sc. (Geol) Pr.Sci.Nat, (400040/08), EAPASA Certified
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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 Soils and Land Capability Baseline Studies, where managed and signed off by Ian P.C. Jones (Pr. Sci Nat 400040/08) and Certified EAP, an Earth Scientist with 41 years of experience in the specialist fields.

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

The objectives of the study were to:

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

<u>Signed</u>: **July 2019**

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

EXECUTIVE SUMMARY

Xivono Mining are considering the possibility of mining coal by open pit truck and shovel roll over strip mining methods at their Weltevreden Coal Mining Project (WCMP) situated in the Highveld Region of the Mpumalanga Province – South Africa.

The specialist soils and land capability is part of the larger environmental assessment and assimilation of scientific input needed in the assessment of the potential impacts associated with mining and its associated activities.

The sites being considered are all greenfield sites in terms of their mining development. They are however all impacted by commercial farming and forestry development to some degree or other, and as such rank as brownfields sites in terms of their environmental status when considering soils and land capability. The degree of alteration of these areas from their original or natural condition varies across the area of study. The baseline studies have captured the pre mining/construction conditions, the point of departure for these impact assessments and rating.

The geomorphology (geology, soil, climate, topography, landform, ground roughness, aspect etc.) is significant to an understanding of how the activities of a development of this nature might impact on the overall biodiversity and the soils and land capability in particular.

The complex inter-relationships require that a full and scientifically defendable baseline of information is available before any impact assessment can be undertaken and any management or mitigation measures can be formulated.

The combination of open pit mining (roll over methods) and surface infrastructure (Figure 1.2) require a study and understanding of the surface resources prior to any development plan being formulated.

A scoping assessment was completed, and has been used as the basis for the detailed assessment going forward.

The soil characteristics considered in this evaluation comprise, soil depth, soil structure, texture and soil wetness, while the climate, topographic slope and relative steepness of the terrain combined with aspect and ground roughness are all considerations that have been taken into account as supporting information.

The assessment has been considered in terms of the existing/pre development soil utilisation potential or land capability, and places a significant weighting on the utilisation of the soil in terms of rehabilitation and workability, factors that are considered important to the overall sustainability of the project.

The characterisation (mapping) and classification of the soils have been undertaken using the Taxonomic Soil Classification System, a system developed for Southern African, and a system recognised nationally in terms of best practise guidelines.

As part of the impact assessment, a more comprehensive walk over investigation was carried out across the sites that will be impacted at surface (open pit mining areas).

Observations from the baseline study confirmed:

- A strong correlation between the underlying lithologies (geology) and the soil forms mapped;
- Our understanding of the topography and the role it plays in the spatial distribution of the soil forms noted and the change in land form units;

- Our understanding of the overall geomorphology and its importance in the delineation and rating of the land capability;
- Marked differences in soil depths across the study area; and
- Differences in the texture and structure of the soils across the study areas.

The soils are highly influenced by the parent materials from which they are derived (fine to medium grained sediments for the most part, with areas of quartzite and dolerite intrusives) and by the subtle but variable topography that results in a net positive erosive environment.

The attitude of the underlying lithologies (generally flat lying/horizontal) and the negative water balance (evaporation is higher than rainfall) has also had an influence on the weathering processes at work and the pedogenetic mechanisms (soil forming) that contribute to the soil forms mapped.

The soils vary in texture and structure, from apedal and single grained silty and sandy loams to sandy clay loams with slightly stronger structure (crumby to slight blocky) to strongly structure gley and gleycutanic soil forms associated predominantly with the topographic low lying areas and colluvial/alluvial derived soils.

Variation in the wet based hydromorphic soils was also noted, with lower mid-slope transitional form soils that comprise sandy clay to loamy and stratified sub soils and sandy topsoil on the alluvial outwash plains, to highly saturated gley and gleycutanic wetland soil forms that are characterised by topsoils with better than average organic carbon contents well developed hydromorphic characteristics. It should be noted that a separate wetland delineation was undertaken for the site.

It is important to note that the present land use also varies, from areas with little to no cultivation but with some commercial grazing, to areas with intensive commercial cropping, forestry and livestock grazing. There is little to no subsistence farming or grazing. These aspects have been taken into account when considering the merits of the proposed mining plan and developments on surface.

Based on these findings and with an understanding of the proposed mining and related activities at hand (no development plan other than the proposed mining areas was available at the time of study) the impacts have been rated in terms of the significance to the environment.

The following summary details the findings of the impacts that development would/could have on the study area in general:

- A greater proportion of the areas being considered for development returned soils that are of a moderate grazing land potential, with average soil depths, moderate to poor nutrient status and better than average water holding capabilities;
- The percentage of the overall study area associated with wet based soils is significant, with the associated wetland status being of concern to some of the proposed surface development (Wetland and Associated Report – Digby Wells, 2019);
- The wet based soils mapped on the midslope (midslope seeps) have for the most part been impacted by cultivation, forestry and/or livestock grazing;
- The soils are moderately easily worked and stored, albeit that erosion is an issue to be considered and managed;
- The land capability is considered to be of a moderate potential “grazing” to low potential “arable” status/rating, with significant areas of wet based soils and transition zone “wetland” status; and
- Commercial livestock grazing, forestry and agriculture are the dominant commercial activity.

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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.

Black turf: Soils included by this lay-term are the more structured and darker soils such as the Bonheim, Rensburg, Arcadia, Milkwood, Mayo, Sterkspruit, and Swartland soil forms.

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

Calcareous: Containing calcium carbonate (calcrete).

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 apedal 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.

Fertilizer: 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: A 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).

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, a 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 TERMS OF REFERENCE

Xivono Mining (Pty) Ltd (Xivono), are proposing to open pit mine two separate sections as part of their Weltevreden Project.

The site is situated approximately 8km south of Belfast in the Mpumalanga Province of South Africa (the project).

The project area proposed to be mined (open pit) has a combined footprint of approximately 400ha, the overall study area having covered approximately 1500ha.

Earth Science Solutions (Pty) Ltd were appointed by Digby Wells Environmental (Pty) Ltd. (Lead Consultants) for a soil assessment as part of the baseline investigation and impact assessment for the open pit mining.

Digby Wells is the appointed Lead Consultant for Xivono Mining, and have been commissioned to compile the project EIA/EMP.

The soil study was undertaken during July 2019, with input from the lead consultants and collaboration with the wetland and hydrological specialists.

This document deals with the soils assessments for the overall mining right area, with specific emphasis having been placed on the proposed open pit mining area as delineated by the lead consultants (Refer to Figure 1.2).

The study has been structured so as to satisfy the requirements of the overall Environmental Management Programme as required in terms of the MPRDA (Act 20 of 2002), as well as complying with the regulations as directed by the NEMA and the EIA requirements in terms of the listed activities.

To this end, a number of soil parameters were mapped and classified using the standard *Taxonomic Soil Classification, a System for South Africa (Mac Vicar et al, 2nd edition* 1991**)** and the Chamber of Mines Land Classification System of rating.

The objectives of the study were to:

- Provide a permanent record of the present soil resources in the areas that are potentially going to be affected by the proposed developments;
- Assess the nature of the sites in relation to the overall environment and its present and proposed utilisation, to determine the capability of the land in terms of agricultural utilization (arable, grazing, wilderness or wetland), and
- To provide a base plan from which long-term ecological and environmental decisions can be made, impacts of construction and operation can be determined and planned, and mitigation and rehabilitation management plans can be formulated.

Historically, the area has been utilised for commercial forestry production, commercial food production and organised grazing of livestock. Little to no previous mining or industrial development has taken place on the study area, albeit that coal mining is being undertaken in close proximity to the proposed development.

Mining and the development of support infrastructure is a feature of the landscape in the vicinity, and mining as an activity in the vicinity has been accepted as a way of life for generations.

However, with the ever-increasing competition for land, it has become imperative that the full scientific facts for any particular site are known, and the effects on the land to be used by any other proposed enterprise must be evaluated, prior to the new activity being implemented (NEMA).

The advent of coal mining in this particular area has been mooted for many years as part of the Highveld Coal Fields, and the possibility of mining for coal resources has been known to exist.

The proposed Open pit mining will require that limited but significant surface area is affected, with the conveyencing of raw materials, the stockpiling of RoM coal, and the beneficiation of the coal and the transportation of the beneficiated product to market all contributing to impacts on the natural environment. The loss and sterilisation of resource (soils), erosion and compaction of disturbed land, and the potential for dirty water contamination, dust impacts and hydrocarbon and product (coal) spillage are all negative impacts that can be expected for the duration of the project.

The land proposed for the open pit mining operations is existing farmland that has been zoned as such and is already disturbed by these activities (commercial forestry and cultivated land or livestock grazing).

This document describes the in-field methods used to classify and describe the soils, using a well-documented rating system to classify and rank the land capability based on the soils and geomorphological assessment (regional climate information, geology, ground roughness and topographic variables), and records the pre mining/construction land use as a baseline to the proposed planning. This information will be invaluable in managing the end land use and rehabilitation plans for the closure phase of the developments.

The findings of this investigation are based on a pedological survey involving a number of specialists in differing fields of expertise and the interpretation of the resulting data.

This study was aimed at describing the physical and chemical properties of the soils that are to be disturbed, to identify the soil forms and characterise the pedological status of the areas that are to be utilised for development, and to determine the effect that the proposed mining project will have on the land capability and sustainability of the area.

This includes an evaluation of the soil physical attributes, their effective rooting depths, nutrient status, the potential erodibility, and the soil utilisation potential. In addition, the investigation required that the impacts be assessed, and mitigation methods recommended where possible.

Figure 1.1 - Locality Plan

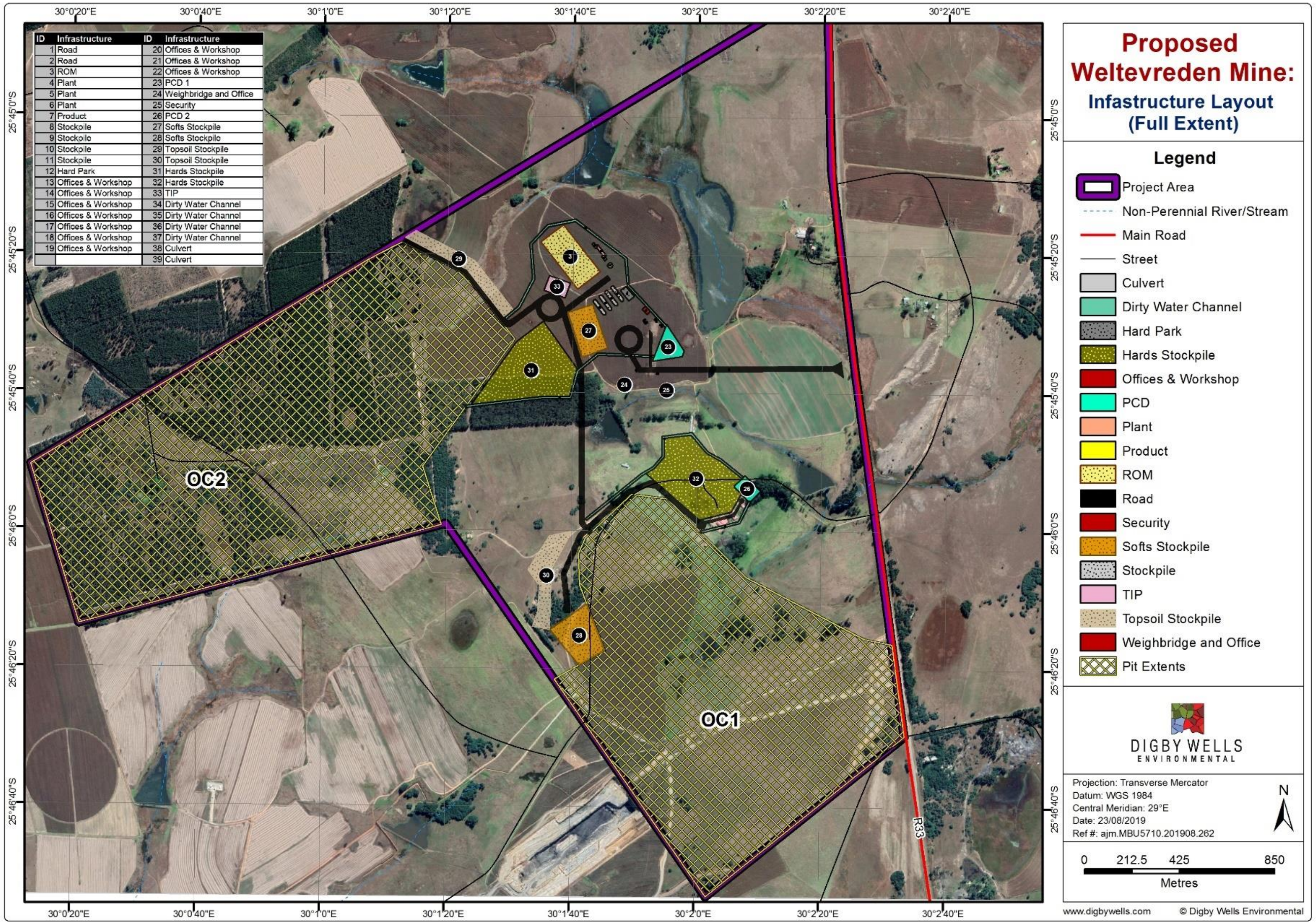

Figure 1.2 - Proposed Mine Plan

2. DESCRIPTION OF THE PRE-MINING/CONSTRUCTION ENVIRONMENT

2.1 Soils

2.1.1 Data Collection

Review of Published Reports and Maps

The area proposed for development is in close proximity to a number of existing mining operations, both to the north and the south west, and forms part of the greater coal mining regions of the eastern and central Highveld coal fields of South Africa. Extensive geological and geotechnical information is available for this area, and a substantial amount of existing information is available with regard to the geology and geochemistry of the sedimentary formations that make up the major portion of the materials that are to be affected by mining or infrastructure development. The proponent have undertaken a detailed economic and geological/geotechnical investigation over the area of prospect, and have a proven resource that underlies the area. With the economic viability of the resource understood, and with a mine plan on the table, it remains only for the socio economic and environmental aspects of the site to be assessed and the impacts understood.

The Land Type Mapping of S.A. (1:250000 scale), the Geological Map of S.A. and local knowledge of the soils and land capability where made available to the study and used in understanding the regional aspects. However, no existing detailed mapping was available.

The soils of the overall study area have been assessed on a reconnaissance grid base, with a more detailed specialist investigation being undertaken for the baseline information required as part of the study for the open pit mining areas being planned.

Additional information was also obtained from the wetland delineation study and hydrology were included as part of better understand the general geomorphology of the site.

The underlying geology is used as the basis for the soil study, the lithological units reflecting the general chemistry and physical components of the resultant soils produced. The moderately complex suite of rocks that make up the geological sequence (sandstones, shales and dolerite intrusives) is reflected in the variation in soil pedogenisis.

It is these complexes of lithologies combined with the topographic changes that produce the complex of differing soil polygons noted across the study site.

In its simplicity, the major portion of the area studied is underlain by the Ecca sediments and younger dolerite/diabase intrusives.

Field Work

The pedological study was performed based on a variable grid bases with the understanding that the differences in soil forms, site sensitivity, the impact of open pit mining will affect the surface environment to differing degrees.

The soil classification/characterisation and mapping has delineated the broad soil patters for the total mining right area, the dominant soils map produced reflecting the spatial distribution of the different soil groupings.

The survey was undertaken during July of 2019.

The fieldwork comprised a site visit during which profiles of the soil were examined and observations made of the differing soil extremes. Relevant information relating to the climate, geology, wetlands and terrain morphology were also considered at this stage. This information was obtained from the client or from other consultants involved in these areas of speciality.

The soil mapping was undertaken on a 1:10,000 scale (Refer to Figure 2.1.1).

The majority of observations used to classify the soils were made using a hand operated Bucket Auger and Dutch (clay) augers with any and all natural exposures (road cuttings etc.) being used to obtain a better understanding of the in-situ characteristics of the soils.

In all cases, the observation points were excavated to a depth of 1,500mm or until refusal. Immediately after completing the classification of the profiles, the excavations were backfilled for safety reasons.

Standard mapping procedures and field equipment were used throughout the survey. Initially, geological map of scale 1:250,000 and top cadastral maps at a scale of 1:50,000 were used to provide an overview of the area, while Ortho photographs at a scale of 1:10,000 being used as the base map for the soil survey.

The pedological study was aimed at investigating/logging and classifying the soil profiles. Topography and Land Form information and all geomorphological information was recorded and used to better understand and map the baseline conditions for the study site

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 Soil Classification 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 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:

i. Demarcate master horizons (Refer to Figure 2.1.1)

ii. Identify applicable diagnostic horizons by visually noting the physical properties such as:

- 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)

iii. Determine from i) and ii) the appropriate Soil Form

iv. Establishing provisionally the most likely Soil Family

Table 2.1.1 - Typical Arrangement of Master Horizons in Soil Profile

<table>
<tr><td rowspan="11">SOLUM</td><td rowspan="11">(Zone in which the soil forming processes are maximally expressed)</td><td colspan="5">Arrangement of master horizons</td><td>Comments on Layers</td></tr>
<tr><td rowspan="10">O - Organic</td><td rowspan="5">C - Regic Sands (C), Stratified Alluvium (C), Man - Made Soil Deposits (C).</td><td rowspan="2">A</td><td rowspan="2">Humic,Vertic, Melanic, Orthic</td><td rowspan="10">G</td><td>Loose leaves and organic debris, largely undecomposed</td></tr>
<tr><td>Organic debris, partially decomposed or matted</td></tr>
<tr><td rowspan="3">B</td><td rowspan="3">Red Apedel, Yellow-brown Apedel, Soft Plinthic, Hard Plinthic, Prismacutanic, Pedocutanic, Lithocutanic, Neocutanic, Neocarbonate, Podzol, Podzol with placic pan</td><td>Dark coloured due to admixture of humified organic matter with the mineral fraction</td></tr>
<tr><td>Light coloured mineral horizon</td></tr>
<tr><td>Transitional to B but more like A than B</td></tr>
<tr><td colspan="2" rowspan="4">C</td><td rowspan="4">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>Transitional to A but more like B than A</td></tr>
<tr><td>Maximum expression of B-horizon character</td></tr>
<tr><td>Transitional to C</td></tr>
<tr><td>Unconsolidated material</td></tr>
<tr><td colspan="3">R - Hard Rock</td><td>Hard rock</td></tr>
</table>

2.1.2 Description

Soil Forms Identified

The dominant soil forms encountered during the site investigation include those of the orthic phase Hutton, Clovelly, Griffin and the more shallow Mispah and Glenrosa, with sub dominant forms that include the Glencoe and Dresden forms. In addition, and of importance to the area in question, is the significantly large proportion of the area that comprises wet based soils.

These hydromorphic form soils are extremely prevalent and of significance to the overall site sensitivity analysis, the low angled topographic slopes and resulting wide expansive drainage lines coupled with the presence of restrictive sedimentary layers (sandstone predominantly), have resulted in proportionately much larger areas of transition zone moist grasslands and wet based soils that meet the wetland classification both pedologically as well as ecologically (refer to Wetland Study).

The horizontal to sub horizontal bedding of the sedimentary lithologies (Sandstone, siltstone and shales) that underlie the site, and the presence of significant hard sandstone partings have resulted areas of ouklip/hard plinthic horizons both in the lower lying drainage lines, as well as relic land forms at lower midslope and midslope positions in the landscape.

The hydromorphic soils range from extremes of deep Avalon, Bloomsdale, Glencoe and Pinedene forms on the transition zone terries slopes, and shallow Avalon, Westleigh, Longlands and Katspruit Forms associated with the lower slopes and lower midslopes, to structured and gleyed soil forms (Katspruit) associated with the alluvial floodplains.

The dominant soil forms classified in the area are discussed below (Refer to Figure 2.1.1 - Dominant Soils Map), the physical and chemical attributes of each being important to an understanding of how the materials might be impacted and effected by the development being proposed.

This information along with the geomorphology of the site was also used in rating the land capability (Chamber of Mines Land Capability Rating System and the Canadian Land Inventory System) and assessing the site sensitivity.

The soils have been categorised and mapped into a number of groups, each group comprising soils of similar characteristics that can be handled and managed in a similar way.

The soil structure, texture and depth along with the soil wetness characteristics are the main attributes used to characterise the different groups.

The dominant groups include, the deep sandy loams (generally >700mm) with no signs of wetness, moderately deep sandy loams and silty clay loams, shallow soils and very shallow materials, and a number of groups of hydromorphic soil forms that vary in depth and underlying plinthite character (Refer to Figure 2.1.1).

The **deep sandy loams and silty clay loams** are characterised by a variety of pale red, red and yellow brown topsoil colours on brown and orange to red subsoil, that exhibit an apedal to single grained structure and are for the most part well drained. The clay contents vary from as low as 12% in the sandy topsoil's, rising as high as 25% in some of the more basic (dolerite) derived soils. .

The subsoil clay percentages range from about 15% to 45% depending on the position that they occupy in the topographic sequence and the host geology from which they are derived.

In almost all cases mapped, the soils classify as having a mesotrophic leaching status (moderately leached) and are luvic in character.

These soil forms generally occupy the upper and upper midslopes, and returned effective rooting depths (ERD) that vary from as shallow as 400mm to greater than 1,000mm.

This group comprises deep (Generally >700mm) Hutton and Clovelly form soils, with sub dominant Clovelly, Griffin and deep Glenrosa forms for the most part.

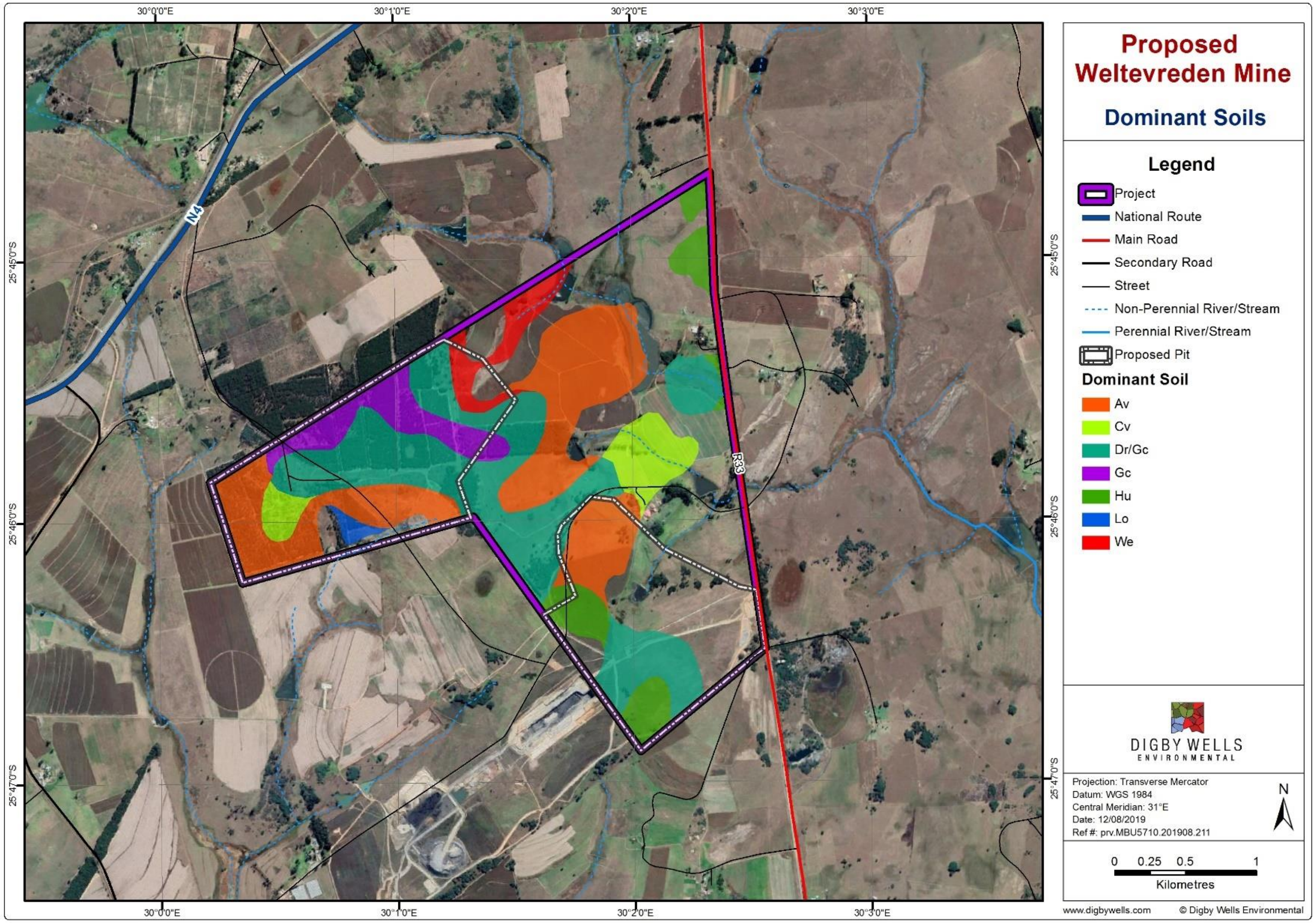

Figure 2.1.1 **Dominant Soil Map**

The **moderately deep sandy loams and silty clay loams** are separated from the deep materials based solely on their effective rooting depth. Their structure and texture are similar or the same as for the deep soils described above. Depths to hard rock and or saprolite will restrict the depth of soil stripping (where required), a factor that is important in maintaining the soil viability for future use.

The deeper soils comprise Hutton (Hu) and Clovelly (Cv) form soils for the most part with areas of deep Glencoe (Gc) in places.

Management of these soils will be moderately easy albeit that if saprolite or soft rock is included into the utilisable soil stockpiles, this will reduce the soils viability (dilutes the nutrient pool and water holding capability). Compaction and erosion are physical hazards to be aware of and catered for when working on and with these soil types.

The **shallow and very shallow** sandy loams and clay loams have again be separated out based on their depth to an inhibiting horizon, the ability of these soils to be managed posing a much more difficult issue in terms of the materials sensitivity and vulnerability to erosion.

The site sensitivity mapping has been used as a management tool in this regard, and although limited in extent, the soil depths of less than 400mm have been mapped were present and are regarded as sensitive sites (Refer to Figure 2.1.2).

The major soil forms included in this group include the Glenrosa (Gs), shallow Glencoe (Gc), Dresden (Dr) and Mispah (Ms) forms with sub dominant forms including the shallow Hutton, Clovelly and Dresden (Dr) forms. These soil returned effective rooting depths of between 150mm and 400mm. The major constraint envisaged with these soils will be tillage, sub surface hindrance and erosion. The restrictive layer associated with these soils is a hard lithocutanic layer in the form of weathered parent material (Gs), hard plinthite (Gc/Dr) or hard rock (Ms).

The effective soil depth is restricted, resulting in reduced soil volumes and as a result, depletion in the water holding capacity as well as nutrient availability.

Geophysical characteristics of these soils include moderate clay percentages (12% to 20%), moderate internal drainage and low water holding capabilities.

These materials are of the poorer land capability units mapped. It is imperative that good management of these soils is implemented, both from the erosion as well as the compaction perspective.

The **wet based soils** vary somewhat in depth and degree of wetness and are also considered sensitive sites, with a significant proportion of the area mapped comprising soils that classify as transitional moist grasslands and wetland soil forms in terms of the wetland delineation classification. The wetlands were mapped independently of this study.

The wet based materials are generally confined to the lower mid-slope, lower slope and bottom land positions, and are found associated with the transition zone and wetland areas that are regularly influenced by the soil water and surface accumulations of runoff within the vadose zone.

These soil forms are indicative of a resistant wetting of the subsoil and the effects of evaporation, and the formation of a hard plinthic horizon at the base of the profile (evaporites).

Physically these soils returned fine to medium grained, pale red to brown, apedal structure in the topsoil's ("A" horizon), with moderate to low clay contents (12% – 18%) and moderate to low water holding capabilities (40 – 60 mm/m).

The subsoil is generally pale yellow/red to pale red in colour, returning moderate clays (12% – 22%), fine to very fine-grained sand fractions, with a concretionary layer at the interface between the "B" horizon and the hard plinthic "C" horizon.

Chemically, the soils are similar to the Avalon, Pinedene and Westleigh soil Forms described herein.

Hazards to be managed on these soils include the impeded drainage caused by the hard plinthic layer, compaction in the wet state, and erosion.

The dominant soil forms associated with these soils include the shallow Glencoe (Gc), Avalon (Av), Longlands (Lo) and Westleigh (We) forms.

The **wet based soils** are of much more sensitive nature and are considered of greater risk in terms of both their contribution to biodiversity and the ecology of an area as well as their ability to be worked on.

By definition, these soils vary in the degrees of wetness at the base of their profile. i.e. the soils are influenced by a rising and falling water table, hence the mottling within the lower portion of the profile and the pale background colours.

In general, the wet based soils are high in transported clay in the lower "B" horizon with highly leached topsoil's and pale denuded horizons at shallow depths. The nutrient status is variable, but due to excessive leaching is generally low. These materials will be more difficult to work due to the wetness factor, both during the construction phase and operation, as well as on rehabilitation. Compaction is a problem to contend with if these soils are to be worked during the wet months of the year. Stockpiling of these soils should be done separately from the dry soils and greater care is needed with the management of erosion problems during storage. Any strong structure that develops during the stockpiling stage will need to be dealt with prior to the use of this material for rehabilitation.

Compaction is a problem to contend with if these soils are to be worked during the wet months of the year.

Stockpiling of these soils should be done separately from the dry soils and greater care is needed with the management of erosion problems during storage.

Any strong structure that develops during the stockpiling stage will need to be dealt with prior to the use of this material for rehabilitation.

2.1.3 Soil Chemical and Physical Characteristics

A suite of composite and representative samples from the differing soil forms/types were taken and sent for analyses for both chemical as well as physical parameters (Refer to Table 2.1.3.1 for the results). A select number of samples were submitted, each sample containing a number of sub samples, thus forming a composite sample, which is representative of the soil polygon rather than just the point sampled.

2.1.3.1: Soil Chemical Characteristics

Sampling of the soils for nutrient status was confined where possible to areas of uncultivated land. However, some of the land being used for grazing may have been cultivated previously, and fertilized in the past, and thus these results may not be truly representative of the soils in their natural state.

These results represent the pre mining/construction conditions, and will give a baseline from which to compare the soils at closure. However, due to the possible loss of nutrients from the soils during stockpiling and storage, additional sampling and analysis of the soils will be needed prior to their use for rehabilitation.

The results of the analysis returned moderate to light textured soils with a pH (KCl)and base status typical of sedimentary lithologies within the highveld coal fields of South Africa, and nutrient levels reflecting generally acceptable concentrations of calcium and magnesium, but deficiencies in the levels of potassium, phosphorous and zinc, with predictably low organic carbon matter.

The structured and basic derived soils returned values that are indicative of the higher reserves of calcium and magnesium. They are inherently low in potassium reserves, and returned lower levels of zinc and phosphorous for economically acceptable agricultural growth.

The nutrient status indicates a need for fertiliser applications of “Zn” “P” and “K”.

It should be noted however, that the addition of “P”, “K” and “Zn” in the form of commercial fertilisers are potential pollutants to the riverine and groundwater environment if added in excess. This must be taken into account when applying these additives. Small amounts of fertilizer should be added on a regular/more frequent basis, rather than adding large quantities in one application.

Soil acidity/alkalinity

In general, it is accepted that the pH of a soil has a direct influence on plant growth. This may occur in a number of different ways, which include:

- The direct effect of the hydrogen ion concentration on nutrient uptake;
- Indirectly through the effect on major trace nutrient availability; and by
- Mobilising toxic ions such as aluminium and manganese, which restrict plant growth.

A pH range of between 6 and 7 most readily promotes the availability of plant nutrients to the plant. However, pH values below 3 or above 9, will seriously affect, and reduce the nutrient uptake by a plant.

The dominant soils mapped in this area are neutral to acid, generally within the accepted range for good nutrient mobility albeit that lime is often a requirement for some of the commercial crops grown. Where present however, soils derived from intrusive material (dolerite and/or diabase) will tend to be more alkaline than indicated by these results due to the potential buffering capacity of the moderately high levels of calcium carbonate. This may affect the pH of the soils to some extent. It is unlikely however, that they will be dramatically impaired.

Soil salinity/sodicity

In addition, to the acidity/alkalinity of a soil, the salinity and/or sodicity are of importance in a soils potential to sustain growth.

Highly saline soils will result in the reduction of plant growth caused by the diversion of plant energy from normal physiological processes, to those involved in the acquisition of water under highly stressed conditions. Salinity levels of <60mS/m will have no effect on plant growth. From 60 – 120mS/m salt sensitive plants are affected, and above 120mS/m growth of all plants is severely affected.

Soil salinity may directly influence the effects of particular ions on soil properties. The sodium adsorption ratio (SAR) is an indication of the effect of sodium on the soils. At high levels of exchangeable sodium, certain clay minerals, when saturated with sodium, swell markedly.

With the swelling and dispersion of a sodic soil, pore spaces become blocked and infiltration rates and permeability are greatly reduced. The critical SAR for poorly drained (grey coloured) soils is 6, for slowly draining (black swelling as found in this site) clays it is 10 and for well drained, (red and yellow) soils and recent sands, 15.

Generally, the soils mapped in this area are non-saline in character, but could become susceptible to an increase in salinity if their water regime is not well managed, particularly on the more clay rich materials (Rensburg and Arcadia).

Nutrient Storage and Cation Exchange Capacity (CEC)

The potential for a soil to retain and supply nutrients can be assessed by measuring the “cation exchange capacity” (CEC) of the soils.

The low organic carbon content is balanced to some extent by the relatively high clay content which naturally provide exchange sites that serve as nutrient stores. These conditions will result in a moderate 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 to low, due to the moderate clay contents but poor organic matter content.

2.1.3.2 Soil Physical Characteristics

The majority of the soils mapped exhibit apedal to weak structure, moderate clay contents and mesotrophic to dystrophic characteristics.

Due to the texture and structure inherent in these soils, compaction within the "A" horizon is likely to occur if heavy machinery is used during the wet summer months over unprotected ground, while the sensitivity of the soils to erosion is a factor to be considered during the rehabilitation process (refer to section on Soil Handling and Removal and Mitigation and Management Measures).

A large proportion of the overall area to be affected by the construction operations and its associated infrastructure is underlain by soils with a more sensitive nature to heavy traffic. This will affect both compaction and erosion of the materials if not well managed.

The area is flat to undulating, with wide open drainage lines and active water ways. The natural movement of eroded materials has resulted in the distribution of differing soils associated with the midslopes and lower midslope positions.

The end result is a complex of differing soil forms within a relatively small spatial area.

2.1.3.3 Characteristics of different Soil Groups

Light Textured -Yellow-brown and Red Apedal Soils

The majority of the soils associated with this area comprise lighter textured soils. These soils (Hutton, Clovelly and Glencoe) are characterised by an orthic A-horizon overlying a red or orange to brown apedal “B”, with possible indications of a ferricrete layer in the B/C-horizon.

The lithologies encountered are generally resistant, massive, intrusive geologies, resulting in shallow weathering within the saprolitic zone.

The working of these soils as well as the storage (stockpiling) will need to be well managed.

Shallow soils

The generally shallow rooting depths of the soils that dominate the area (<500mm) are associated with the hard and resistant lithologies that underlie the site.

2.1.4 Soil Erosion and Compaction

The erosion potential of a soil is expressed by an erodibility factor (“K”), which is determined from soil texture, permeability, organic matter content and soil structure.

The Soil Erodibility Nomograph of (*Wischmeier et al,* 1971) was used to calculate the “K” value. An index of erosion (IOE) for soils is then determined by multiplying the “K” value by the slope percentage. Erosion problems may be experienced when the IOE is greater than 2.

The “K” value is used to express the “erodibility” of a particular soil form. Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of that soil as well as the treatment of the soil.

The average “Erosion Indices” for the dominant soil forms on the study site can be classified as having a moderate erodibility index. This is largely ascribed to the generally low organic carbon content and the sensitivity of the soils to solution weathering. These factors are offset by the generally gentle to flat topography and the moderate clay contents. The vulnerability of the “B” horizon to erosion once/if the topsoil is removed must not be under estimated.

The wet and slightly more structured soils are susceptible to compaction due to the transported clays that are common in the majority of the materials classified. These soils will need to be managed extremely well, both during the stripping operation, as well as during the stockpiling/storage and rehabilitation stages.

The concerns around erosion and compaction are directly related to the fact that the protective vegetation cover and topsoil will be disturbed during any mining or construction operation. Once disturbed, the 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 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.

2.1.5 Dry Land Production Potential

The dry land production potential of the shallow soils and the more structured Forms, are poor.

The deeper, and apedal soil are easier to cultivate and have a better propensity to both drainage as well as the holding of moisture within the soil that is available to the plant. These soils are more productive dry land materials that are also easier to manage.

2.1.6 Irrigation Potential

The irrigation potential for the soils is “moderate to good” in terms of the soil structure and drainage capability. With good water management, and adequate drainage, the deeper (>700mm) soils could be economically cultivated to irrigated crops. The spatial distribution and occurrence of these soils is limited and it is unlikely that sufficiently large enough areas of soil are available to make the use of irrigation viable on anything other than highly intensive market gardening tunnel gardening.

Irrigation is practice to some extent in the area of study albeit there is no irrigation on the area of potential impact.

2.1.7 Soil Utilisation Potential

In general, the soils that will be disturbed and that will require rehabilitation, are moderately deep to shallow, (ERD = 400mm to 800mm), moderately well drained, with a susceptibility to erosion and compaction and in a significant proportion of the study area show signs of wetness at depth (shallow or perched water table).

The wet based and structured soils will be difficult to work, both from a trafficability, workability, storage and rehabilitation point of view.

Compaction must be considered carefully as the working of the wet based and structured soils when wet (rainy season), will be detrimental and compaction will occur.

The structure of the soil will affect their workability, and provision will need to be made for the timing of the stripping and rehabilitation works to be undertaken if the structural integrity of these soils are to be maintained.

The potential for the use of the hydromorphic soils for economic crop production and/or market gardening is at best poor, and should not be considered for anything other than as wilderness/conservation lands (preferred option). The less structured and non-hydromorphic soils are that cover a substantial portion of the site are considered arable class soils, and as such can be considered for use in low intensity livestock grazing and or arable crop production.

2.2 Pre-Construction Land Capability

2.2.1 Data Collection

The land capability of the study areas was classified into four classes (wetland, arable land, grazing land and wilderness/conservation) according to the *Chamber of Mines Guidelines*, 1991. The criteria for this classification are set out in Table 2.2.1.

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

Criteria for Wetland

- Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.

Criteria for Arable land

- Land, which does not qualify as a wetland.
- The soil is readily permeable to a depth of 750mm.
- The soil has a pH value of between 4.0 and 8.4.
- The soil has a low salinity and SAR
- The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm.
- Has a slope (in %) and erodibility factor ("K") such that their product is <2.0
- Occurs under a climate of crop yields that are at least equal to the current national average for these crops.

Criteria for Grazing land

- Land, which does not qualify as wetland or arable land.
- 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.
- 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.

Criteria for Wilderness/Conservation Land

- Land, which does not qualify as wetland, arable land or grazing land.

2.2.2 Description

The "land capability classification" as described above was used to classify the land units identified during the pedological survey. In conjunction with the soils classified, the climate, ground roughness and topography (Geomorphology) were assessed and used in the determination of the Land Capability Rating. Figure 2.2 illustrate the spatial distribution of land capability classes.

Arable

Significantly large portions of the study area have been cultivated and are being economically farmed to annual crops under dry land and irrigation. The percentage area of soil that classify as "arable" land is however somewhat smaller, with some of the farming being undertaken on soils that are either less than 700mm in depth, rocky and inhibited in rooting depth, are associated with the transition zone wetlands or in some cases cultivation is being undertaken in the wetland zone. The area of actual cultivated land use is therefore not the same as the "arable" land capability delineated on the map.

Grazing

A significant portion of the study area rates as grazing land potential , and is used as such. These areas are generally confined to the shallower (500mm to 700mm) and transitional hydromorphic soil Forms that are moderately 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 on a sustainable basis, especially since only the subsoil's (at a depth of 500mm) are periodically saturated. In addition, there should be no rocks or pedocrete fragments in the upper horizons of this soil group. If present it will limit the land capability to wilderness/conservation land.

Wilderness/Conservation

The areas that classify as either conservation or wilderness land are found associated with the more structured, and shallower rocky soils (Glenrosa and Mispah) that are associated with non-hydromorphic soils. These are for the most part evident as outcrop or shallow sub-outcrop on the lower mid-slopes, or occasionally on the crest slopes. This land capability unit is not prevalent in the area of concern.

Wetland

The wetland areas are defined in terms of the wetland delineation guidelines, which use both soil, topography as well as vegetation criteria to define the domain limits.

These zones are dominated by hydromorphic soils that are often structured, and have plant life that is associated with aquatic processes.

The soils are generally dark grey to black in the topsoil horizons, high in transported clays, and show pronounced mottling on gleyed backgrounds (pale grey colours) in the subsoil's. These soils occur within the zone of groundwater influence.

This land capability unit is very prevalent in the study area and makes up a significant proportion of the area that could potentially be impacted by the proposed development.

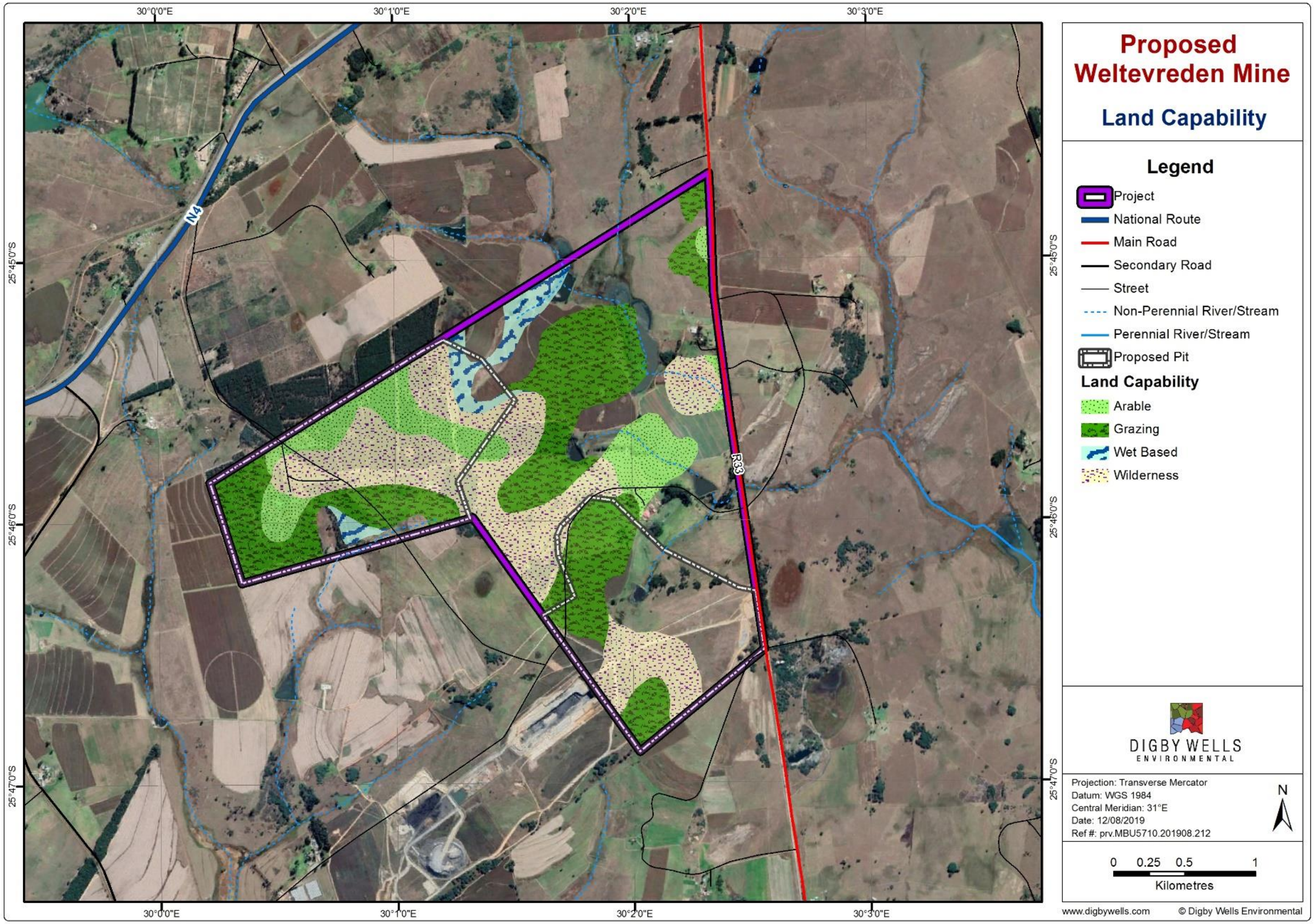

Figure 2.2 Land Capability Plan

3. ACTIVITIES BEING ASSESSED AND DESCRIPTION OF THE PROPOSED PROJECT

A list of project activities to be assessed for the project has been discussed in Table 3-1

Table 3-1: Description of Activities to be assessed

Project Phase	Project Activity	Project Structures
Construction	Site Clearance	Topsoil Stockpiles
	Blasting and Excavation	Hard Rock below soils and soft overburden
	Construction of Surface Infrastructure	Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads Overland Conveyor Pollution Control Dam
	Water Abstraction and Use	Reticulation (Water and Electricity)
	Waste Generation and Disposal	Waste Skips
	Power Generation	Diesel Generator
Operations	Open pit Blasting and Mining	Heavy Machinery and Equipment
	Stockpiling	Waste Rock Berms Product Stockpile
	Hauling/Conveying of Coal	Haul and Access Roads
	Plant and Equipment Operations	Localised Workshop and Diesel Storage Tanks
	Water Use and Storage	Pollution Control Dam and Jo Jo Tanks
	Waste Generation and Storage	Waste Skips
	Power Generation	Diesel Generator
Mine Decommissioning and Closure	Removal of infrastructure and surface rehabilitation	Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads Pollution Control Dam Diesel Storage Tanks
	Waste Generation and Disposal	Waste Skips

4. ENVIRONMENTAL IMPACT ASSESSMENT

Impact Assessment Methodology

The system used for the rating and ranking of impact is based on the Hacking Methodology, a system recognised and accepted by the authorities and the industry in general.

The system considers the significance of an impact in terms of its probability, duration, extent or scale and magnitude or sensitivity.

The impacts are assessed based on the impact's magnitude as well as the receiver's sensitivity, culminating in an impact significance which identifies the most important impacts that require management.

Based on international guidelines and South African legislation, the following criteria are taken into account when examining potentially significant impacts:

- Nature of impacts (direct/indirect, positive/ negative);
- Duration (short/medium/long-term, permanent(irreversible)/temporary (reversible), frequent/seldom);
- Extent (geographical area, size of affected population/habitat/species);
- Intensity (minimal, severe, replaceable/irreplaceable);
- Probability (high/medium/low probability); and
- Possibility to mitigate, avoid or offset significant adverse impacts.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 4-1a. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measures proposed.

The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 4-1b, which is extracted from Table 4-1a. The description of the significance ratings is discussed in 4.1c.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 4-1a – Impact Assessment Parameter Ratings

RATING	INTENSITY/REPLICABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
7	Irreplaceable damage to highly valued items of great natural or social significance or complete breakdown of natural and / or social order.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable damage to highly valued items of natural or social significance or breakdown of natural and / or social order.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.
5	Very serious widespread natural and / or social baseline changes. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	On-going serious natural and / or social issues. Significant changes to structures / items of natural or social significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

RATING	INTENSITY/REPLICABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
3	On-going natural and / or social issues. Discernible changes to natural or social baseline.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor natural and / or social impacts which are mostly replaceable. Very little change to the baseline.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.
1	Minimal natural and / or social impacts, low-level replaceable damage with no change to the baseline.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 4-1b: Probability/Consequence Matrix

Probability	Significance																																					
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Consequence	**-21**	**-20**	**-19**	**-18**	**-17**	**-16**	**-15**	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**

Table 4-1c – Significance Rating Description[1]

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive)
36 to 72	An positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative)

[1] It is generally sufficient to only monitor impacts that are rated as negligible or minor

4.1 Impact Assessment Rating

4.1.1 Construction Phase

Issue: **Loss of Utilisable Soil Resource due to – Erosion, Compaction and possible Contamination during construction**

The relative differences between the soils classified (structure, texture and hydromorphy), their position in the landscape and their pedogenisis (soil forming systems and characteristics – in-situ versus transported materials etc.) will have an influence on the impact significance, which in turn will have an influence on the mitigation measures that will need to be manage the impacts to a reasonable and acceptable level. The extent of impact will be confined to a relatively small spatial area (adit decline, beneficiation and support infrastructure).

Construction for Project
Stripping of utilisable soil, preparation (levelling and compaction) of lay-down areas and pad footprint for stockpiling and stormwater berms, opening up of foundations, mining voids, stockpiling of soft overburden, and slope stability where required. Haulage and access road construction and stockpiling of utilisable soils. Control of dust and loss of materials to wind and water erosion, and protection of materials from contamination (chemical and hydrocarbons)

The construction phase will impact on all of the infrastructural activities and areas of disturbance on surface, inclusive of:

- The construction/preparation of the footprint for the overall lay down of the materials stockpiles (Removal of vegetation and utilisable soil (A Horizon and portion of B2/1 horizon);
- Stockpiling of the utilisable soils needed to secure a viable cover for the areas to be rehabilitated at decommissioning and closure;
- The opening up of the open pit workings;
- The construction of the starter walls for the storm water control dams;
- Construction of pipelines for water reticulation;
- Construction of access and haulage roads;
- Conveyer routes where necessary;
- Stockpiling of the soils and overburden (softs and cover material) from construction footprints;
- Design and construction of dirty water control dams, channels and berms (storm water control facilities) to cater for all dirty water and diversion of clean water around the facility;
- Design and construction of site offices and related infrastructure (workshops, change house etc.), and
- Clearing and removal of vegetation and the stockpiling of the utilisable soil prior to the lay down of soft overburden materials from the shafts and deep excavations.

Soils will need to be stockpiled in different locations throughout the construction and operational phases, with the materials stripped from the areas of infrastructure, roads and pad footprint construction being best stockpiled as close as possible to these features in the form of berms upslope of the facilities, and the shaft complex soils being stored as low level dumps and/or berms close to the voids to which they are planned to be used.

Description of Impacts

The loss of the soil resource to the overall environment due to stripping of footprint areas to mining infrastructure, construction of the water management facilities, the conveyencing system and support infrastructure (Workshops, Offices etc) will be of a negative significance in the medium term (life of mine) and restricted to the immediate mining area. The overall loss of the soil resource to the environment if un-mitigated will result in a Moderate Significant Rating.

Disturbance of the surface restrictive layers associated with the relatively more sensitive soils (Ferricrete and soft plinthic layers) will occur for all founding areas, and particularly those associated with the relict land forms that occupy the upper portions of the transition zone/moist grasslands that are going to be affected in some cases by the surface infrastructure, while the deeper foundations required for the heavier structures (PCD etc.) requiring that the underlying restrictive layers (inhibiting barrier layer) is broken through.

The majority of the infrastructure, and all of the proposed structures associated with the mining development are outside of the alluvial/riverine environment and are for the most part associated with the moderately shallow to deep soils of the sedimentary host rock, with only small areas of transitional zone soil forms affected.

The variation in soil sensitivity is marked, with the dry friable sandy loams and silty loams being far easier to manage than the hydromorphic soils that comprise the transition zone upslope of the wetlands.

The impact of removing the topsoil's and upper portion of the subsoil horizon (Utilisable soil) will destroy any surface capping that might be in place, will remove all vegetative cover, and will expose the subsoil's to wind and water affects and induce possible erosion and compaction if not well managed and protected.

The sensitive and highly sensitive soils (friable soils) will be susceptible to erosion and compaction once disturbed, and will be difficult to manage, or lost if left unprotected.

It must be emphasised, that the failure to manage the soils will result in the total loss of this resource, with a resultant moderate to major significance.

Mitigation/Management Actions

With management, the loss of this primary resource can be reduced and mitigated to a level that is more acceptable.

The impacts on the soils may be mitigated with a number of management procedures, including:

- Effective soil stripping during the dryer and less windy months when the soils are less susceptible to erosion and compaction. This will assist the stockpiling and vegetative cover to propagate before the following wet season;
- Effective cladding of any stockpiles, dumps and berms, and the minimising of the height of all stockpiles wherever possible will help to reduce wind erosion and the loss of materials;
- Soil replacement to all areas (temporary) that are not required for the operational phase, and the preparation of a seed bed to facilitate the re-vegetation program for these areas will limit potential erodibility during the operational phase and into the rehabilitation and closure phases.
- Soil amelioration (cultivation) to enhance the growing capability of the stockpiled soils so that they can be used for rehabilitation at closure and to maintain the soils viability during storage.
- Backfilling of any voids and deep excavations with rock, soft overburden, and the creation through compaction of a barrier layer at the soil backfill interface using the relatively more impermeable clay rich subsoil and soft overburden. This is recommended as the ferricrete layer and any hard impermeable sedimentary layers will have been destroyed and will not be available to re-create this barrier;
- Replacement of the growing medium (Utilisable soil) in the correct order and as close as possible to its original position in the topography will help to maintain the soil pedogenisis and utilisation potential relative to the ecology and biological constraints;
- Soil replacement and the preparation of a seed bed to facilitate the re-vegetation program and to limit potential erodibility during the rehabilitation process.

Care will need to be taken to keep any wet based soils separated from the dry soils, and to keep all stockpiled soils that are in storage vegetated and protected from contamination and erosion.

These soils will be stripped as “Utilisable Soil” stored in a position that will be convenient for the final rehabilitation of the facilities during the decommissioning and closure phases – reduce distances to be hauled and negate the need for double handling.

Only if these materials are available can rehabilitation possibly be executed successfully and cost effectively. It is suggested that an average “Utilizable Soil Depth” (USD) of 500mm be stockpiled where present/available.

Residual Impact

The above management procedures will probably reduce the significance of the impacts to negligible in the long term.

Table 4.1.1 – Construction Phase – Impact Significance

Dimension	Rating	Motivation	Significance
Description of Risk: Loss of utilisable soil as a resource through sterilisation, compaction, erosion, and salinisation/contamination.			
Prior to mitigation/ management			
Duration	Project Life (5)	Utilisable soil will be stripped and stockpiled. If this is done without following the mitigation measures the impact will have a long term affect.	Major (negative) – 84
Extent	Local (3)	Loss of soil will only occur within and immediately around the Project site.	
Intensity	Medium (4)	Loss of soil may result in loss of land capability and land use. Soil regeneration takes a very long time.	
Probability	Certain (7)	By excavating the soil it will certainly impact on the soil.	
Mitigation/ Management actions			
Soils are to be stripped as per the stripping guidelines (contained within the soil utilisation and management section of this report) and erosion of stockpiles should be minimized by establishing vegetation on the stockpiles. Compaction should be avoided.			
Post- mitigation			
Duration	Project Life (5)	Loss of utilisable soil makes land less productive. Effects will occur long after the project life.	Negligible (negative) – 27
Extent	Very Limited (1)	Loss of topsoil will only occur within and immediately around the Project infrastructure area.	
Intensity	Moderate (3)	Loss of topsoil may result in loss of land capability and land use.	
Probability	Unlikely (3)	If the mitigation is followed then it is unlikely that the impacts will occur.	

4.1.2 Operational Phase

Issue: **Loss of Soil Usability/Utilisation Potential**

Operation of Project – Cumulative

Loss of soil utilisation – Ponding of water due to Open pit subsidence, raw materials conveyencing and the possible contamination by spillage and dirty water interaction, dust and/or hydrocarbon spillage, loss of resource/sterilisation due to covering of the soils by infrastructure, by-product stockpiles, storage facilities and dumps, compaction by vehicle movement, and erosion and loss of materials due to wind and water interaction with unprotected soils.

Description of Impacts

During the operational phase, all of the construction activities for the infrastructure and major by-product storage structures will have been completed, any on-site beneficiation of materials and the deposition of by-product will have begun along with the continuous opening up of additional mining areas.

The loss of the soil utilisation due to surface collapse, ponding and/or the covering of materials for extended periods of time will lead to both the loss of the utilisable resource as well as salinisation, compaction and sterilisation. If this occurs it will result in a major negative impact that will last for the duration of the mining venture.

The consequence is major with an overall significance of minor.

The movement of haulage vehicles, the conveyencing of the raw product, the use of access roads and the on-going additions of by-product to the stockpiles and storage facilities will all impact on the size of area being affected, and ultimately on the area of soil affected.

Spillage from moving vehicles or from conveyer lines of product and possibly leakage or spillage of hydrocarbons will negatively impact the in-situ materials, while unmanaged dirty water flow will erode and contaminate the soils that it comes into contact with (*in-situ* and stored).

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

All of these soils will be impacted upon to differing degrees, while the stockpiled materials will be available for future use during the rehabilitation phase and at closure.

The significance of the impact during the operational phase will differ both in intensity and duration, with the soils associated with the infrastructure and stormwater management remaining in a stockpile/stored state for the full life of the mining and processing operations.

It is inevitable 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 disturbed areas;
- Timorous replacement of the soils so as to minimise the area of disturbance (concurrent rehabilitation where possible);
- Adequate protection from erosion (wind and water);
- Effective vegetative and soil cover and protection from wind (dust) and dirty water contamination;
- Servicing of all vehicles on a regular basis and in well-constructed and bunded areas, well-constructed and maintained oil traps and dirty water collection systems;
- Cleaning of all roadways and haulage/conveyencing ways, 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 operation and its related support structures and activities, 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. The action of wind on dust generated and the loss of materials downwind will need to be considered, while contamination of the soils used on the roads and workshop areas will need to be managed.

If the soils are stripped to a "utilisable" depth, and replaced in the correct sequence and as close as possible to their original position in the topography, the chances of nature being able to restore the systems present prior to disturbance will be more easily achieved.

Residual Impact

In the long term, the above mitigation measures will probably reduce the impact on the utilisable soil reserves from a minor significance rating to one of negligible significance.

Table 4.1.2 – Operational Phase – Impact Significance

Activity and Interaction: ▪ **Operation and maintenance of the in-situ soil and stockpiles**			
Dimension	**Rating**	**Motivation**	**Significance**
Description of Risk: The operation and maintenance of the utilisable soil and stockpiles will require the minimisation of compaction and erosion and the on-going management of contamination.			
Prior to mitigation/ management			
Duration	Project Life (6)	When the soil has eroded the impact will be permanent and is potentially irreversible even with management.	Minor (negative) – 39
Extent	limited (2)	Compaction and erosion will occur on a limited scale and in the unmitigated situation the erosion will extend beyond the direct infrastructure.	
Intensity	Very Serious (5)	Loss of soil may result in loss of land capability and land use. Soil regeneration takes a very long time.	
Probability	Unlikely (3)	The maintenance of all vehicles will be confined to the workshop area.	
Nature	Negative		
Mitigation/ Management actions			
Maintenance on the soil stockpiles must be done regularly to check for compaction and erosion. Where prevalent corrective measures must be taken so as to minimise the loss of utilisable soil as a resource and minimise the effects of sedimentation on the receiving water bodies. These would include keeping a soil balance, inspection for erosion and loss of soil, fertility of stockpiles and vegetation establishment on these stockpiles.			
Post- mitigation			
Duration	Short term (2)	If the mitigation measures are implemented the impact will be for less than a year.	Negligible (negative) – 12
Extent	Very limited (1)	Compaction and erosion will occur on a very limited scale.	
Intensity	Moderate (3)	The intensity of the impact will be reduced if mitigation is implemented.	
Probability	Rare (2)	If mitigation is followed the impact will rarely occur	
Nature	Negative		

4.1.3 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 construction vehicles. Positive impacts of reduction in areas of disturbance and return of soil utilisation potential, uncovering of areas of storage and rehabilitation of compacted materials.

Description of Impact

The impact will remain the net loss of the soil resource if no intervention or mitigating strategy is implemented. The impact will be of a negative intensity, local extent, permanent over the area of disturbance, with a moderate consequence and resultant minor significance rating. 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 soils.

The initial impact will be negative due to the necessity for vehicle movement while rehabilitating the open voids, moving of softs and soils, the demolishing of storm water controls, dams etc and the demolishing of buildings and infrastructure. Dust will be generated and soil will be contaminated and eroded.

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

Residual Impacts

On mine closure the long-term negative impact on the soils will probably be of a minor to negligible significance if the management plan set out in Environmental Plan is effectively implemented to reinstate current soil conditions

Chemical amelioration of the soils will possibly have a low but positive impact on the nutrient status (only) of the soils in the medium term.

Table 4.1.3 – Decommissioning Phase – Impact Significance

Activity and Interaction: ▪ **Decommissioning and rehabilitation phase of Dry Port area**			
Dimension	**Rating**	**Motivation**	**Significance**
Description: Decommissioning and rehabilitation phase of the project could cause compaction and erosion if rehabilitation is not done correctly. This could be as a result of poor vegetation establishment which would result in exposed surfaces and increase the risk of erosion. Heavy machinery driving continuously over rehabilitated areas may result in compaction, which would impact on plant rooting depth which then would have a further impact to vegetation establishment.			
Prior to mitigation/ management			
Duration	Project Life (6)	When the soil has eroded the impact will be permanent and is potentially irreversible even with management.	Minor (negative) – 39
Extent	Limited (2)	Compaction and erosion will occur on a limited scale and in the unmitigated situation the erosion will extend beyond the direct infrastructure.	
Intensity	Very Serious (5)	Loss of topsoil may result in loss of land capability and land use. Soil regeneration takes a very long time.	
Probability	Unlikely (3)	Vehicles will remain on existing access routes	
Nature	Negative		
Mitigation/ Management actions			
Rehabilitate according to the rehabilitation plan.			
Post- mitigation			
Duration	Short term (2)	If the mitigation measures are implemented the impact will be for less than a year.	Negligible (negative) – 12
Extent	Very limited (1)	Compaction and erosion will occur on a very limited scale.	
Intensity	Moderate (3)	The intensity of the impact will be reduced if mitigation is implemented.	
Probability	Rare (2)	If mitigation is followed the impact will rarely occur	

4.2 Cumulative Impacts

One of the negative impacts associated with long term development is the disturbance of the soil environment, the naturally occurring layers of decomposed rock and accumulations of eroded materials as soil horizons.

Rehabilitation of disturbed areas aims to restore land capability to as close as possible its original state. Experience has however shown that the post development land capability is often of a lesser utilisable rating and compromises the end land us potential. The primary reason for this is poor management.

Soil formation is determined by a combination of naturally occurring geomorphological processes and actions. These include factors such as time, climate, slope, presence or lack of organisms and the type of parent material.

Soil formation is generally quite slow (geological time) rendering soil a non-renewable resource.

Soil quality deteriorates during storage and stockpiling, with nutrient and carbon loss due to leaching and the sterilisation of the resource by de-nitrification. Replacement of these soil materials into soil profiles during rehabilitation cannot replicate pre-construction conditions with the effective loss being of a financial consequence to the project if not well managed.

Depth however can be replicated if sufficient soil is tripped at the construction phase and it is retained and managed against erosion.

The resultant net loss of land capability due to these changes will forces a change in land use.

The loss of this natural resource is considered high and negative, with the loss of Eco System Services being detrimental to the long term sustainability of both the physical and socio economic environments.

The utilisable soil is considered the upper portion of the vadose zone, and comprises the materials which naturally holds water, are able to liberate nutrients and contain the major rooting system for plants. These layers comprise the conventional topsoil or "A" horizon and a significant portion of the upper portion of the subsoil "B2/1" horizon. This is the layer that needs to be stripped, stored and well managed throughout the project if any meaningful rehabilitation is to be considered at closure.

4.3 Unplanned Events and Low Risks

Low risks activities and outcomes are those that are considered to either be unlikely to occur, those that will have a minor or negligible effect on the receiving environment and to a lesser degree those that can easily be reversed such as the footprint to the offices and change house, internal roadways etc.

Low risks can be monitored to gauge if the baseline changes and mitigation is required rather than managing these as part of the management plan.

5. ENVIRONMENTAL MANAGEMENT PLAN

Based on the studies undertaken, and with the development plan (MWP) made available, it has been possible to assess the impacts that the proposed mining development could potentially have on the soils and their resultant utilisation potential, and has aided in the development of a meaningful soil utilisation and management plan for the development.

The management and mitigation measures proposed have been tabled (Refer to Tables 5.1, 5.2 and 5.3 respectively) for the different stages of the project in line with the system used to assess and rate the impacts, and gives recommendations on the soil utilisation (stripping and handling of the soils) during the construction and operational phases, and details the systems and actions for the rehabilitation and ultimate closure of the facility as part of the "End Use" planning.

It is important that a management plan (EMP) is implemented if the economics of mine closure are to be met, and the relative positioning and timings of materials handling are to be aligned with the mining plan. Tables 5.4 to 5.7 summaries the proposed management objectives and activities and lists the designated department and personnel responsible for their implementation.

The management planning is considered from the stand-point of "No Net Loss" (NNL), a concept that is admittedly difficult to achieve when dealing with the soils and vadose zone and mining, but a premise none the less that sets the goals at a level of sustainability that meets with best practice guidelines and international standards.

This concept, NNL, will be tested by both the development on surface as well as by the activities associated with the Open pit mining (surface subsidence due to collapse of Open pit workings).

For the management plan to succeed it will be essential that sufficient "utilisable" soil material is removed and saved/stored from the footprint of development prior to any construction taking place.

All materials/soils that are going to be impacted by the mining and/or its associated activities will require that the utilisable soil (top 500mm to 700mm) are stripped and stored ready for re-emplacement and rehabilitation at closure

5.1 Construction Phase

Soil Stripping and Handling

In considering any management plan for soils it is important that both the physical and chemical composition are known as these will be important in obtaining a utilisable material at decommissioning and/or during rehabilitation. The method of stockpiling and general handling of the soil will vary depending on its composition.

The relatively more sandy topsoil's (low clay contents) along with the upper portion of the subsoil's (B2/1 Horizon) within which the majority of the nutrient store occurs **(Utilisable Soil)** will need be stripped and stockpiled ready for use at closure.

The concept of stripping and storage of all UTILISABLE soil is tabled as a minimum requirement and as part of the overall Soil Utilisation Guidelines.

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, depths that will vary for different types of soil encountered as well as for the different activities that being planned in a project area. It does not differentiate between topsoil (orthic horizon) and other subsoil horizons.

Soil stripping requirements are set to enable the mining company to achieve post mining land capabilities wherever possible, and are based on the pre-mining land capability assessment as detailed in the baseline study. Pre-mining grazing land capability is the norm that is aimed for in most situations post mining in this area. However, in this sensitive environment, although a low intensity grazing land status is tabled as the minimum requirement, it is likely that moderate grazing could be achieved with the possibility of economic crop production if the rehabilitation plan is well managed and implemented.

The following requirements (***all be they generic***) should be considered wherever possible:

- Over areas of DEEP EXCAVATION *strip all usable soil* as defined (700mm). Stockpile alluvial/colluvial (transported wet based) soils separately from the *in-situ* materials, which in turn should be stored separately from the underlying overburden. Store the soils in berms or stockpile dumps of no more than 1,5m high if space allows.

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

- Over area of STRUCTURES (Offices, Workshops, Haul Roads) AND SOFT OVERBURDEN STOCKPILES *strip the top 300 mm* of usable soil over all affected areas including terraces and *strip remaining usable soil* where founding conditions require further soil removal. 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. At *rehabilitation* strip all gravel and other large material and place to form terraces or recycle as construction material or place in open voids below the soft overburden of soil horizon. Remove foundations to a maximum depth of 1m. Replace soil to appropriate soil depths, and cover areas in appropriate topographic position to achieve pre-mining land capability and a free draining land form.
- Over area of CONSTRUCTION OF STORAGE FACILITIES AND HARD OVERBURDEN STOCKPILES *strip usable soil* to a *depth of 700 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 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.
- Over area of ACCESS ROADS, LAY-DOWN PADS AND CONVEYOR SERVITUDES *strip the top 150mm* of usable soil over all affected areas and stockpile in longitudinal stockpile within the mining lease area.

In general, the depth of the topsoil's material for the site is between 450mm and 800mm. However, due to the shallow soil depths on the more rocky slopes, and the need to rehabilitate these areas with sufficient materials to induce growth at closure, it is recommended that a minimum of 500mm is stripped and stockpiled from all areas where it is available.

The positioning of these 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 positions upslope of the mining infrastructure and any/all areas as clean water diversion berms, and/or as stockpiles close to, but outside of the final voids that are to be created by the mining operations.

Soils removed from areas that require deep foundations, dam footprints, lay-down pads for by-product facilities and the processing facility, all access and haulage roads and their associated support infrastructure must be stockpiled as close as possible to the facilities as is possible without the topsoil's becoming contaminated or impacted by the operations.

The vegetated soils should be stripped and stockpiled without the vegetation having been cleared/stripped off wherever practical, while any grassland/natural veld that has not been cultivated or disturbed should be fertilized with super phosphate prior to being stripped (wherever practical). This will ensure that the fertilizer is well mixed into the soil during the stripping operation and will aid in a more rapid cover to the stockpiles, while reducing the amount of fertilizer required during the rehabilitation program. All utilisation of the land for any other purpose will need to stop before mining 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 to be constructed should be founded on stabilised materials, the soils having been stripped to below the topsoil contact (200mm to 300mm) and or to 500mm as the depth of utilisable soil might dictate.

It is proposed that prior to soil stripping, fertilizer in the form of super phosphate should be added to the sandy loams and silty clay loams 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.

The stripping and handling of materials during the construction phase is highlighted, because the correct removal, storage and reinstatement of the materials will have a significant effect on the overall costs and the final success or failure of the rehabilitation plan at closure.

Of importance to the success and long term sustainability of rehabilitating these sensitive environments will be the replacement of the materials in their correct order and topographic position, and the ability of the rehabilitation team to re-create the soil profile and landscape so that soil water is retained and surface water does not pond. This will be no mean feat, as the natural materials that are achieving this function at present (pre-mining and development) will have been disturbed or destroyed.

Long term and forward planning for the utilisation 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 utilisation 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 biodiversity loss, and will require the input of the specialist ecologists, wetland scientist, hydrogeologists and engineers in the final formulation of the overall management plan.

Table 5.1 is a summary of the soil handling and management plan for the construction phase.

Table 5.1 – Construction Phase – Soil Conservation Plan

Phase	Step	Factors to Consider	Comments
Construction	Delineation of areas to be stripped		Stripping will only occur where soils are to be disturbed by activities that are described in the design report, and where a clearly defined end rehabilitation use for the stripped soil has been identified.
	Reference to biodiversity action plan		It is recommened that all vegetation is stripped and stored as part of the utilizable soil. However, the requirements for moving and preserving fauna and flora according to the biodiversity action plan should be consulted.
	Stripping and Handling of soils	Handling	Soils will be handled in dry weather conditions so as to cause as little compaction as possible. Utilizable soil (Topsoil and upper portion of subsoil B2/1) must be handled and stockpiled separately from the lower "B" horizon and all softs (decomposed rock).
		Stripping	mThe "Utilizable" soil will be stripped to a depth of 500cm to 700mm or until hard rock is encountered. These soils will be stockpiled together with any vegetation cover present (only large bushes to be removed prior to stripping). The total stripped depth should be at least 500mm, wherever possible.
	Delineation of Stockpiling areas	Location	Stockpiling areas will be identified in close proximity to the source of the soil to limit handling and to promote reuse of soils in the correct areas.
		Designation of Areas	Soils stockpiles will be demarcated, and clearly marked to identify both the soil type and the intended area of rehabilitation.

5.2 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 recommendations are made that are relevant to the unique conditions that pertain to this Highveld environment.

It is proposed that the construction of any berms needed and soil storage stockpiles are undertaken in a series of 1,5m lifts if the storage facilities are to be greater than 1,5m high. For soils that are to be stored for any length of time (greater than three years) it is recommended that all utilisable soil should be stockpiled, while the heavier subsoil's and any ferricrete materials should be stored as separate stockpiles.

Storing the soil in this manner will maximize the beneficial properties of each material, and render them available for use at closure in the best position. Separation of these layers at the time of utilising these soils is a matter for management, as the mixing and dilution of the soil properties is not recommended.

The utilisable soil stockpiled must be adequately vegetated as soon after emplacement on the storage pads as possible and maintained throughout the life of mining.

It is important, where possible, that the slopes of the stockpile berm facility are constructed to 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 and Couch Grass, are documented in the attached brochure (Refer Appendix 2 - The Vetiver Network International - 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.

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 (5.1) and Mitigation and Management Measures – Decommissioning and Closure Section (5.3)).

Table 5.2 summaries the management and handling of the soils during the operational phase.

Table 5.2– Operational Phase – Soil Conservation Plan

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

5.3 Decommissioning and Closure

Soil Replacement and Land Preparation

During the decommissioning and closure phase of any mining 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 open voids and the compaction of the barrier layer, and the topdressing of the disturbed and backfilled areas with utilizable soil ready for re-vegetation are all considered part of a successful closure operation.

The order of replacement, fertilisation and stabilisation 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 up nutrient levels. These applications will be undertaken only if required, and only after additional sample analysis has been undertaken.

Fertilizer requirements reported herein are based on the sampling of the soils at the time of the baseline survey and will definitely alter during the storage stage.

The quantities of additives required at any given time during the storage phase or after rehabilitation has been established will potentially change due to physical and chemical processes. The fertilizer requirements should thus be re-evaluated at the time of rehabilitation.

It is recommended that a qualified person (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 will be necessary to re-evaluate the nutrient status of the soils at regular intervals to determine the possibility of needing additional fertilizer applications. In addition, it is important that only small amounts of fertilizer are added on a more frequent basis, rather than adding large quantities in one application.

Table 5.3 summaries the management and handling of the soil resource during the decommissioning and closure phase.

Table 5.3 – Decommissioning and Closure Phase – Soil Conservation Plan

Phase	Step	Factors to Consider	Comments
Decommissioning & Closure	Rehabilitation of Disturbed land & Restoration of Soil Utilization	Placement of Soils	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 open cast workings, 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.
		Fertilization	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.
		Erosion Control	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.
	Pollution of Soils	In-situ Remediation	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 DWA, on a case by case basis, before it is implemented.
		Off site disposal of soils.	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.

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 4-6 weeks after germination, and
- Repair any damage caused by erosion.

Table 5-4: Impacts

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Site clearance and topsoil removal prior to the commencement of physical construction activities.	Construction	Access routes, Servitude and associated Support Infrastructure Footprint	▪ Ensure proper storm water management designs are in place; ▪ If any erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; ▪ If erosion has occurred, soil should be sourced and replaced and the area shaped and protected to reduce the recurrence of erosion; ▪ Only the designated access routes are to be used so as to reduce any unnecessary compaction; ▪ Compacted areas are to be ripped to loosen the soil structure; ▪ The utilisable soil should be stripped by means of an excavator bucket, and loaded onto dump trucks; ▪ Soil stockpiles are to be kept to a maximum height of 1,5m where possible, or terraced and kept below 15m if not; ▪ Soil is to be stripped when the soil is dry, so as to reduce compaction; ▪ Bush clearing contractors will only clear bushes and trees larger than 1m the remaining vegetation will be stripped with the utilisable soil to conserve as much of the nutrient cycle, organic matter and seed bank as possible; ▪ The handling of the stripped soil will be minimized to ensure the soil's structure does not deteriorate significantly; ▪ Compaction of the removed soil must be avoided by restricting traffic on stockpiles; ▪ Stockpiles should only be used for their designated final purposes; and ▪ The stockpiles will be vegetated (details contained in rehabilitation plan) in order to reduce the risk of erosion, prevent weed growth and to reinstitute the ecological processes within the soil.	Chamber of Mines Guidelines	Construction

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Operation and maintenance of the Soil and Overburden Stockpiles.	Operational	Infrastructural Footprint(s), Conveyer Servitude and associated Support activities	▪ Ensure proper storm water management designs are in place and managed (kept clean); ▪ If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; ▪ Only the designated access routes are to be used to reduce any unnecessary impacts (contamination and sterilisation); and ▪ Compacted areas are to be ripped to loosen the soil structure and vegetation cover re-instated.	Chamber of Mines Guidelines	Operational
Demolition of infrastructure will take place and Rehabilitation of the Project area will be undertaken. Rehabilitation activities will cover the extent of the infrastructure footprint areas and will include the ripping of the compacted soil surfaces, spreading of soil and re-establishment of vegetation.	Decommissioning & Rehabilitation Phase	Infrastructural Footprint(s), Conveyer/Haulage Route Servitude and associated Support Infrastructure Footprint	▪ Ensure proper storm water management designs are in place and that it is functional at all times; ▪ If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; ▪ Only the designated access routes are to be used to reduce any unnecessary compaction and/or contamination; ▪ Compacted areas are to be ripped to loosen the soil structure and vegetation cover re-instated; ▪ Follow rehabilitation guidelines and implement land rehabilitation measures as defined in rehabilitation report. ▪ The utilisable soil should be moved by means of an excavator and loaded onto trucks; ▪ Soil should be worked on and with when dry wherever possible; ▪ On completion of the project disturbed areas need to be cleared of all infrastructure and foundations need to be removed; ▪ Utilisable soil needs to be replaced for rehabilitation purposes; ▪ The handling of the stripped soil will be minimized to ensure the soil's structure does not deteriorate; and ▪ Stockpiles should only be used for their designated final purposes.	Chamber of Mines Guidelines	Decommissioning and Rehabilitation Phase

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Post-closure monitoring and rehabilitation will determine the level of success of the rehabilitation, as well as identify any additional measures that have to be undertaken to ensure that the disturbed areas are restored to an adequate state. Monitoring will include soil fertility and erosion control.	Post-Closure Phase	Rehabilitated area	▪ The rehabilitated area must be assessed once a year for compaction, fertility, and erosion; ▪ The soils fertility must be assessed by a soil specialist yearly (during the dry season so that recommendations can be implemented before the start of the wet season) so as to correct any nutrient deficiencies; ▪ Compacted areas are to be ripped to loosen the soil structure, and vegetation cover re-instated; ▪ If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; ▪ If erosion has occurred, soil should be sourced and replaced and landscaped to reduce the recurrence of erosion; and ▪ Only the designated access routes are to be used to reduce any unnecessary compaction.	Chamber of Mines Guidelines	Post-Closure Phase

Table5-5: Objectives and Outcomes of the EMP

Activities	Potential impacts	Aspects affected	Phase	Mitigation Type	Standard to be achieved/objective
Site clearance and soil removal prior to the commencement of physical construction activities.	Loss of utilisable soil as a resource – Disturbance, Erosion, Sterilisation, Salinisation, Contamination and Compaction as well as loss of Land capability, and Land Use	Soils	Construction	▪ Stormwater Management Plan; ▪ Site Clearing Procedures; ▪ Rehabilitation Plan.	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Construction of surface infrastructure.	Loss of soil as a resource – Disturbance, Erosion, Sterilisation, Salinisation, Contamination and Compaction as Well as Loss of Land capability, and Land Use	Soils	Construction	▪ Stormwater Management Plan; and ▪ IWWMP.	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
The construction of stockpiles.	Loss of utilisable soil as a resource – Disturbance, Erosion, Compaction and Contamination.	Soils	Construction	▪ Rehabilitation Plan.	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Operation and maintenance of the stockpiles.	Loss of utilisable soil as a resource – Sterilisation, Salinisation, Contamination, Erosion and Compaction	Soils	Operational	▪ Stormwater Management Plan; ▪ IWWMP; and ▪ Rehabilitation Plan.	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Demolition of infrastructure and Rehabilitation of the Project area. Rehabilitation activities will cover the extent of the infrastructure footprint areas.	Loss of utilisable soil as a resource – Disturbance, Sterilisation, Salinisation, Contamination, Erosion, and Compaction as well as loss of Land capability, and Land Use	Soils	Decommissioning & Rehabilitation Phase	▪ Rehabilitation Plan; and ▪ Closure Plan.	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Post-closure monitoring of rehabilitated areas. Monitoring will include soil fertility and erosion.	Re-instatement of soil as a resource.	Soils	Post-Closure Phase	▪ Rehabilitation Plan; and ▪ Closure Plan.	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation

Table 5-6: Mitigation

Activities	Potential Impacts	Aspects Affected	Mitigation Type	Time Period for Implementation	Compliance with Standards
Site clearance and removal of utilisable soil prior to the commencement of physical construction activities.	Loss of utilisable soil as a resource – Disturbance, Contamination, Salinisation, Sterilisation, Erosion, Compaction and loss of Land capability, and Land Use	Soils	▪ Stormwater Management Plan; ▪ Site Clearing Procedures; ▪ Rehabilitation Plan.	Construction	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Construction of surface infrastructure.	Loss of utilisable soil as a resource – Disturbance, Sterilisation, Salinisation, Contamination, Erosion, Compaction and loss of Land capability, and Land Use	Soils	▪ Stormwater Management Plan; and ▪ IWWMP.	Construction	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
The construction of stockpiles.	Loss of utilisable soil as a resource – Disturbance, Erosion, contamination and Compaction.	Soils	▪ Rehabilitation Plan.	Construction	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Operation and maintenance of the topsoil and overburden stockpiles.	Loss of utilisable soil as a resource – Erosion, Compaction, sterilisation and salinisation	Soils	▪ Stormwater Management Plan; ▪ IWWMP; and ▪ Rehabilitation Plan.	Operational	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Demolition of infrastructure and Rehabilitation of the Project area.	Loss of utilisable soil as a resource – Disturbance, Sterilisation, Contamination, Erosion, Compaction and loss of Land capability, and Land Use	Soils	▪ Rehabilitation Plan; and ▪ Closure Plan.	Decommissioning and Rehabilitation Phase	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation
Post-closure monitoring of rehabilitated areas. Monitoring will include soil fertility and erosion.	Re-instatement of utilisable soil as a resource.	Soils	▪ Rehabilitation Plan; and ▪ Closure Plan.	Post-Closure Phase	Soil Management in terms of the Chamber of Mines Guidelines for Rehabilitation

Table5-7: Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law

Specialist field	Applicable standard, practice, guideline, policy or law
Soils	Chamber of Mines – Guidelines for the rehabilitation of mined land

6 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 are at the required level. 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 (H_2O);
- 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 %)

7 CONSULTATION UNDERTAKEN

Consultation by the soil scientist was limited and left to the Digby Wells Stakeholder Engagement Department to deal with. Spontaneous interaction with the land owners was undertaken and introductions made at the time of entering the areas of concern.

8 COMMENTS AND RESPONSES

Comments received as part of the baseline study where confined to a small number of the land owners communicating through the lead consultants.

9 CONCLUSION AND RECOMMENDATION

Based on the baseline of information and the impact assessment ratings of significance, it is the opinion of the specialist earth sciences that this project is feasible and could be considered if the management measures tabled are rigorously adhered to for the mining area and its associated activities.

10. LIST OF REFERENCES

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APPENDIX 1

A3 DRAWINGS

APPENDIX 2

Ferricrete Classification

APPENDIX 2

Vetiver Grass - Publication