ENVIRONMENTAL MANAGEMENT ASSISTANCE (PTY) LTD

REPORT ON:

PORTIONS 8 AND 22 OF FARM KENNEDY'S VALE 361KT AND PORTIONS 24, 25 AND 28 OF FARM SPITSKOP 333KT SPECIALIST SOIL ASSESSMENT

REPORT: P324

Submitted to:

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EXECUTIVE SUMMARY

Environmental Management Assistance (Pty) Ltd requested during August 2015 a proposal for a baseline soil land use land capability wetland assessment at new proposed chromium mine at Steelpoort. The study area on Portions 8 and 22 of Farm Kennedy's Vale 361 and Portions 24, 25, 26 and 28 of Farm Spitskop 333KT is approximately 2,200ha.

The objectives of the investigation included a soil survey and mapping of study area, measurement of the effective depth of the soil(s), assessment of agriculture potential of soils, assessment of the erodibility and misuse of soils, mapping of land use & land capability, formulation of a soil stripping guide and plan, determination of chemical, mineralogical and physical properties of representative soil forms, assessment of suitability of soils for rehabilitation purposes and an impact assessment of topsoil stripping on soils with recommendations to mitigate negative impacts.

From the assessment it is conclusive that the dominant soil forms recorded and identified according to the Taxonomical Soil Classification System of South Africa are Hutton, Oakleaf, Bloemdal, Mispah and Glenrosa soil forms. The effective depth of the Hutton, Oakleaf and Bloemdal soils exceeds 300mm inclusive of the *Orthic A, Red Apedalic and Neocutanic B – Horizons*. The soils from the study area are weathering products from anorthosite and pyroxenite. Anorthosite rock is characterised by a predominance of plagioclase feldspar and minimal pyroxene, ilmenite and magnetite. Pyroxenite is an ultramafic rock consisting essentially of the minerals of the pyroxene group such as augite, diopside, hypersthene, bronzite or enstatite. Pyroxenites are classified into clinopyroxenites, orthopyroxenites and websterites. The soils are rocky shallow soils on the mountainous areas with an *Orthic A – Horizon* developed to maximum 300mm on hard rock and/or weathered rock material. In the low laying areas the soil catena is characterised by deep red horizons covered by an *Orthic A - Horizon* 300mm characterised by high organic material, micro-organisms and seed content representing a delicate micro-habitat overlaying *Red Apedalic* and *Neocutanic B - Horizons* >1,2m deep. The *Red Apedalic* and *Neocutanic B-Horizons* are characterised by well aerated and drained sandy soil profiles with an average clay content of 10-15% represented by predominantly 1:1 clay minerals, *i.e.* kaolinite and oxides of Fe and Mn. Signs of a ferricrete layer is present due to the presence of a shallow fluctuating water table causing the precipitation of Fe and Mn under fluctuating aerobic and anaerobic soil moisture conditions.

The agricultural potential (**Table 3, p20**) of the Hutton, Oakleaf and Bloemdal soils is considered medium to high under dryland (4*50mm/y rainfall*) and irrigation conditions *(>10-15mm/week 33-1,500kPa plant available water*).

Evidence of natural soil erosion was observed on the soils during the investigation. Careful consideration should be given during mining to minimise impacts on the soil

that could enhance soil erosion. It could be considered as contributing to the surrounding environment for the mine to implement artificial measures to minimise natural soil erosion – although the current erosion observed during the assessment is natural and was not caused by the mine.

The current land use includes 4,48% mining & industrial, 87,69% natural veld, 3,75% ploughed land, 3,46% settlement and 0,62% wetlands. Land capability includes 17,42% arable, 0,62% wetland, 76,14% wilderness with 2,36% occupied by mining & industrial and 3,46% settlement of the total study area investigated.

A minimum of topsoil stripping will occur during the mining process due to the fact the mining process will be confined to the steep slopes of the mountainous areas. A soil stripping and stockpiling strategy was compiled and is included in **Table 7, p41**. From the soil data considering all available topsoil on Portions 8 and 22 of Farm Kennedy's Vale 361KT and Portions 24, 25, 26 and 28 of the Farm Spitskop 333KT an estimated total 3,303ha could potentially be covered 300mm thick at a bulk density of 1,275kgm^3 during rehabilitation taking into consideration a 10% loss from the 11,010,000m^3 available topsoil due to handling, compaction *etc*.

The soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15mg/kg) and potassium (>50mg/kg) are readily available for plant uptake and sustainable plant growth. The *Orthic A-Horizon* is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10mm/h. The dominant clay mineral in the *Orthic A – Horizon, Yellow* & *Neocutanic B – Horizon* is kaolinite (*1:1 layer silicate*), with a low buffer capacity due to the low cation exchange capacity *(<10cmol+/kg*).

The soil horizons specified in **Section 5.1 p17** of the Hutton, Oakleaf and Bloemdal are suitable for rehabilitation purposes.

The potential impacts and reasons/activities with proposed mitigation measures on the soil due to mining infrastructure related activities include:

- ***Loss of topsoil***:

  Topsoil will be loss due to stripping, handling and placement of the soil associated with the pre-construction land clearing, operational clearing during mining, and during rehabilitation and it is recommended to strip all usable soil within mining rea, irrespective of soil depth. It is imperative that discretion is used during stripping and stockpiling to separate different soil layers for future use. This will be a function of the soil types comprised out of different soil layers, i.e. topsoil (0-300mm) should be stripped and stockpiled separately from all other horizons due to its chemical, mineralogical, mechanical, plant seed and *microbiological properties. Some sub-horizons could be stockpiled together and it is recommended that **guidelines set out in the soil stripping and stockpiling protocol comprised by a soil scientist with experience in rehabilitation of disturbed land** are used.*

- ***Change to soil's physical, chemical and biological properties***:

There is a high probability that topsoil will be lost due to wind and water erosion, which will alter the soils properties. Stockpiling and subsequent mixing of soil layers during handling will ultimately have a negative effect on altering the basic soil properties. It is suggested to implement live management and placement of topsoil where possible, improve the organic content of the soils, and maintain fertility levels through fertilisation and to curb topsoil loss as much as possible. Subsoil should be stockpiled separately from topsoil and managed properly to prevent loss, mixing with topsoil and wetland soils. Wetland soils of pans to be affected should be stripped and stockpiled separately for future use during rehabilitation. These soils can be used to construct wetlands during rehabilitation considering surface water flow and low lying areas to enhance wetland functions and biodiversity.

- ***Cumulative effect of the soil***:

Alteration of the natural surface topography due to reprofiling during construction after stripping will have an accumulation effect on the soils and careful consideration should be given to minimise compaction and ensure free drainage preferential surface water pathways. Stripping, transportation and stockpiling of topsoil and subsoil have an effect on chemical, physical and mechanic properties of the material. The texture (sand, silt, clay content) will be disturbed and ultimately the structure of the material will be changed. The clay content (particles <0,002mm) determines the cation exchange capacity of the material and depending on the type and quantity of the clay present (1:1 layer silicates) the retention capability of the soil material can be changed. This will affect nutrient retention and potentially chemical balances in the diffuse double layer around the clay particles. The major nutrients nitrogen, phosphorus and potassium might become deficient at the time of rehabilitation and will have to be supplemented. Ca:Mg, Mg:K and Ca+Mg/K ratio's need to be monitored and optimised before rehabilitation together with potential pH alterations (acidification and/or alkalinisation) and salinisation that would inhibit plant growth. Permeability, infiltration capacity and water retention will be affected upon disturbance of the texture and structure of top and subsoil and needs to be carefully assessed during rehabilitation. A water balance assessment should be conducted to determine if reconstructed profiles will have the capacity to store plant available water between 33 – 1,500kPa to sustain selected plant growth for rehabilitation purposes. The plasticity index, compaction, settlement, bearing capacity as function of texture and structure will be altered during stripping and stockpiling *and will have to be considered addressed and optimised for the purpose to establish free flowing grassed rehabilitated systems.*

DECLARATION OF INDEPENDENCE

Chris J Viljoen, CEO ***Viljoen Associates***, hereby declare:

- Viljoen Associates act as independent specialist in this investigation.

- The assessment is conducted in a scientific manner and findings will not be manipulated for a favourable outcome.

- Viljoen Associates have no financial, personal or any other interest in this application managed by ***Environmental Management Assistance (Pty) Ltd***.

- All particulars furnished in this declaration are true and correct.

***M.Sc., Pr. Sci. Nat*.**

PORTIONS 8 AND 22 OF FARM KENNEDY'S VALE 361KT AND PORTION 24, 25, 26 AND 28 OF FARM SPITSKOP 333KT SPECIALIST SOIL ASSESSMENT

1 TERMS OF REFERENCE

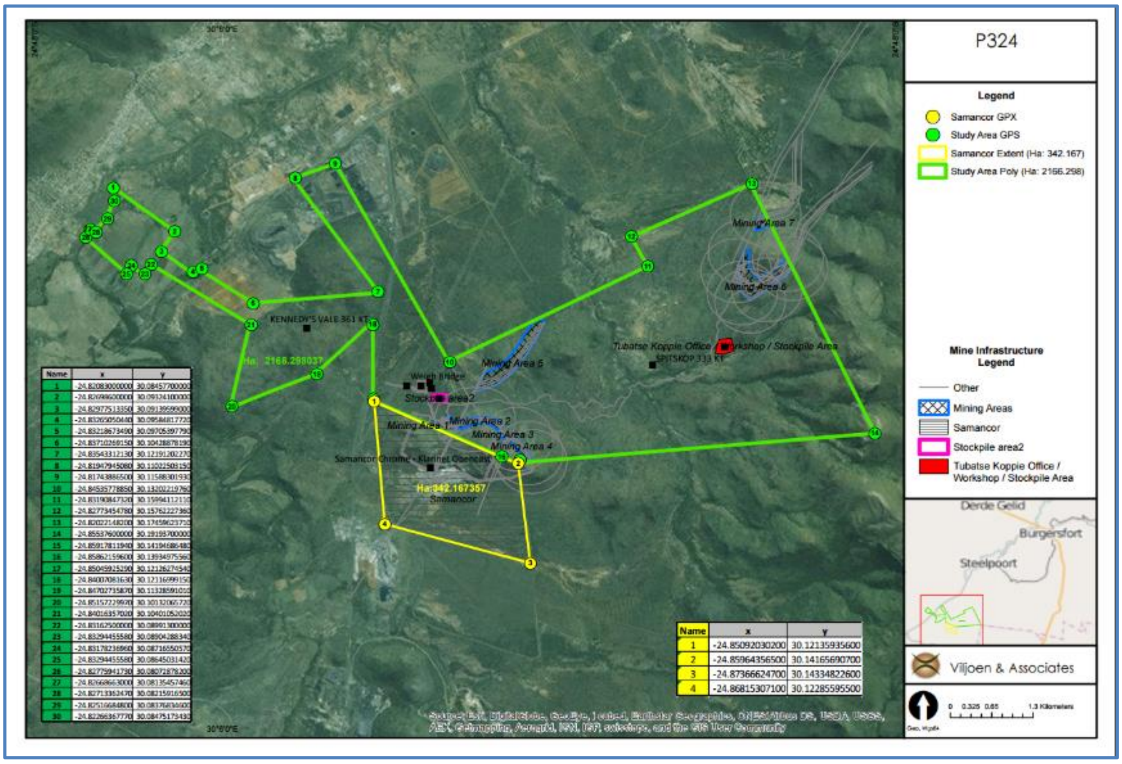


Figure 1. Investigation area on Portions 8 and 22 of Farm Kennedy's Vale 361KT and Portions 24, 25, 26 and 28 of Farm Spitskop 333KT.

During August 2015 Environmental Management Assistance (Pty) Ltd requested a proposal for a baseline soil land use land capability wetland assessment at new proposed BCR chromium mine near Steelpoort on Portions 8 and 22 of Farm Kennedy's Vale 361KT and Portions 24, 25, 26 and 28 of Farm Spitskop 333KT. The study area is approximately 2,200ha (**Figure 1**).

2 INVESTIGATION OBJECTIVES

The objectives of the investigation were interpreted as follows:

- **Objective 1:** *Soil survey and mapping of study area;*
- **Objective 2:** *Measurement of the effective depth of the soil(s);*
- **Objective 3:** *Assessment of agriculture potential of the soils;*
- **Objective 4:** Assessment and determination of the soils *erodibility and misuse of soils;*

- **Objective 5:** *Land use & land capability assessment;*
- **Objective 6:** *Soil stripping guide and plan*;
- **Objective 7:** *Determination of chemical, mineralogical and physical properties of representative soil forms;*
- **Objective 8:** *Assessment of suitability of soils for rehabilitation purposes*; and
- **Objective 9:** *Impact assessment of topsoil stripping, infrastructure development, stockpiling, etc. on soils with recommendations to mitigate negative impacts*.

3 METHOD OF INVESTIGATION

In order to meet the objectives of the investigation, the following scope of work was conducted:

- Collection of available information relevant to the study, *i.e.* GPS coordinates, map defining study area plotted on 1:50,000 tif image and aerial images;
- A soil survey according to standard soil survey techniques comprising of GPS referenced auger holes on a flexible grid 1,8m deep (or to auger refusal);
- Soil profile studies and classification according to the latest version of the *South African Taxonomical Soil Classification System of South Africa*;
- Representative sampling of soils;
- Analysis of the samples;
- Interpretation of analytical data and field observations;
- Compilation of draft report; and
- Internal review and submission of final report;

3.1 Sampling Procedures

Soil sampling was carried out according to the following procedures:

- Auger holes were drilled with a 75mm diameter 1,8m mechanical steel auger;

- The ground surface at the position of the auger hole was carefully cleared of loose material. When present, surface vegetation was carefully removed and the soil clinging to any roots left behind collected with the surface soil sample;

- The sampling interval in the auger holes was 150mm and consolidated to one sample per auger hole;

- The auger was advanced to the required depth and then carefully removed from the hole. The hole was covered to prevent foreign material from entering;

- Approximately 1.5kg soil sample was taken from the augered holes raisings and soil material removed from the auger. The samples were quartered to produce a representative sample of suitable weight, *i.e.* 500g;

- Prior to the taking of each sample, both the steel auger and stainless steel trowel used to collect the soil samples were wiped clean of soil, washed with tap water, rinsed in a phosphate free detergent and finally sprayed with de-ionised water to prevent cross contamination between sampling depths;

- The soil samples were placed directly in zip-lock freezer bags, clearly labelled in indelible ink with the name of the site, auger hole number and sampling date;

- The soil samples were stored in the shade prior to being transported to an air-conditioned environment awaiting transport to the analytical laboratory;

- Chain of custody forms accompanied the soil samples to the laboratory and the samples were verified and signed for by the laboratory chemist; and

- All auger hole logs were geo-referenced (GPS: datum WGS1984, decimal degrees).

3.2 Inorganic Analyses

Table 1 shows the analytical soil parameters that were collected and submitted to an accredited soil laboratory that conducted soil analyses on the soil analytical parameters.

TABLE 1: SOIL ANALYTICAL PARAMETERS

ELEMENT	METHOD
CHEMICAL	
Sample Preparation	Standard
pH (H_2O)	Standard
CEC+K+Na	NH_4Ac-extraction
EC+NO_3	Saturated distilled water extract
P	Bray 1-extract
Lime Requirement	Double Buffer Titration
MINERALOGY	
Clay fraction (<0.002mm) identification	XRD-scan (6 treatments)
PHYSICAL	
Particle size distribution (3 fractions-sand+silt+clay)	Hydrometer

3.3 Quality Assurance / Quality Control

The quality assurance/quality control procedure for the investigation entailed a combination of the following:

- Duplicate analyses on 5% of the samples submitted;
- Carry out additional checks using standard reference materials;
- Conduct multi linear regression techniques to ensure analytical equipment is properly calibrated; and
- Double check calibrated equipment with spiked standards above highest standard and confirm with 10x dilution.

4 PROBLEM ANALYSES

Section 4.1 is a brief description of basic soil forming principles to set a framework for evaluation of the baseline soil assessment:

4.1 Basic Soil Forming Principles

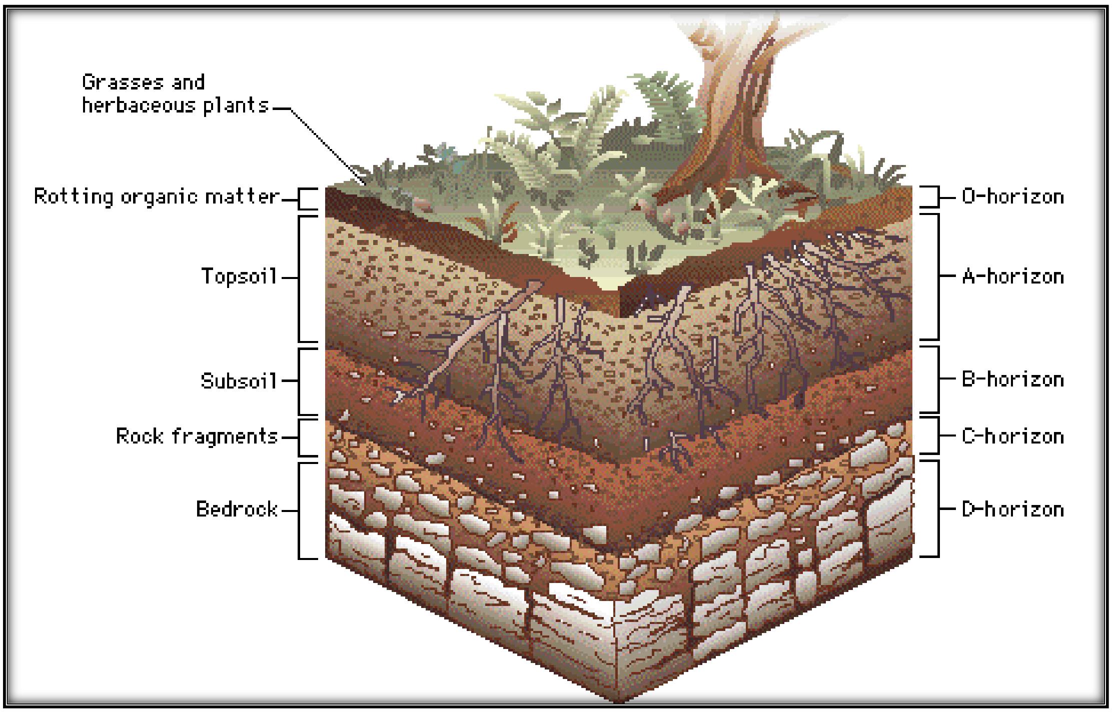


Figure 2. An example of a typical soil profile (*Van Der Watt & Van Rooyen; 1990*).

According to Van Der Watt & Van Rooyen (1990) soil **(Figure 2)** can be defined as:

"the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for growth of plants, or, the unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including precipitation and temperature effects), macro- and micro-organisms and topography all acting over the period of time and producing a product – soil – that differs from the material, which is derived in many physical, chemical, biological and morphological properties and characteristics".

Soil is the thin surface covering of the bedrock of most of the land area of the Earth. It is a resource that, along with water and air, provides the basis of human existence. Soil develops when rock is broken down by weathering and material is exchanged through interaction with the environment. Organic matter becomes incorporated into the soil as the result of the activity of living organisms. Soil also contains water, minerals, and gases. The soil system (**Figure 3**) is dynamic and it develops a distinct structure, often with recognizable layers or soil horizons arranged vertically through the soil profile.

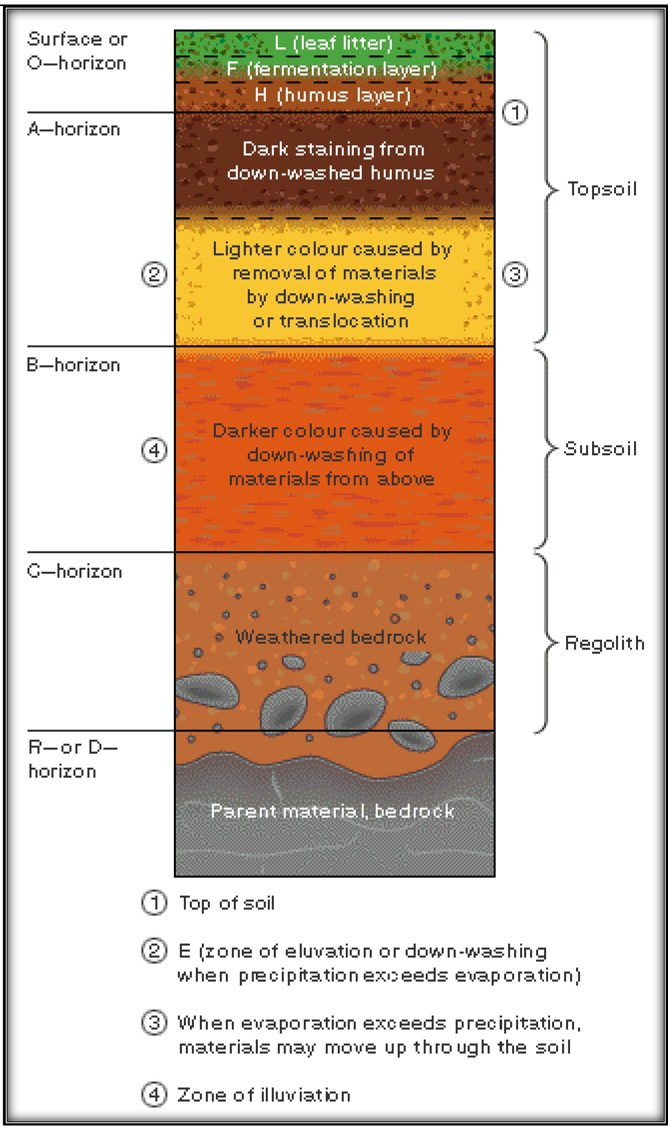


Figure 3. Soil system with different layers (*Wikipedia*).

Soil is essential for the development of most plants, providing physical support and nutrients. Plants are anchored in the soil by their roots. Nutrients, dissolved in soil water, are necessary for the plants' growth. Soil contains various types of organic matter, including dead material from plants and animals as well as animals that choose to live in the soil. The soil is therefore a store of major nutrients such as carbon and nitrogen and plays an important role in global nutrient cycles and in regulating hydrological cycles and atmospheric systems.

Soils vary from place to place due to varying conditions such as climate, rock type, topography, and the local soil-forming processes. Over time soils develop characteristics specific to their location, which relate closely to the climate and vegetation of the area. The major world biomes reflect a clear association between vegetation and soil that has developed in response to the prevailing climate. Each soil type has a distinct combination of soil horizons and associated soil properties.

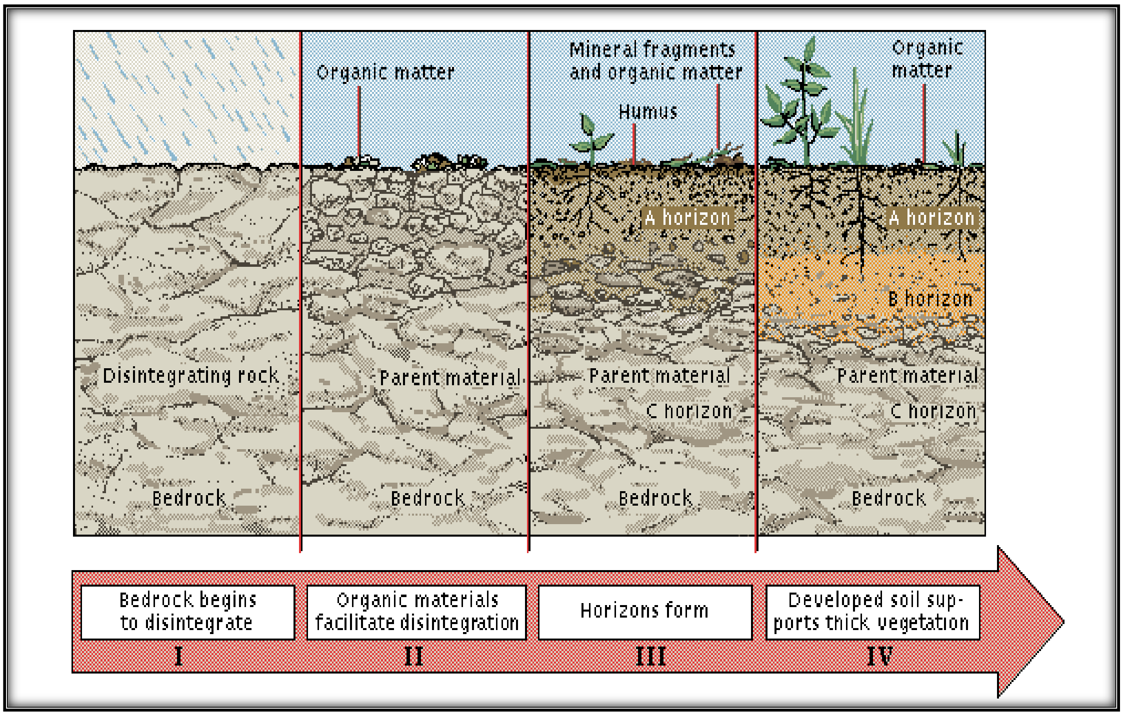


Figure 4. Different stages of soil formation (*Wikipedia*).

People depend on the soil for agriculture, and as such it is a valuable natural resource. Soils form continuously as the result of natural processes (**Figure 4**), and can therefore be regarded as a renewable resource. However, the soil-forming processes operate very slowly and the misuse or mismanagement of the soil may lead to damage or erosion, (**Figure 5**) or can disrupt the processes by which the soil forms.

Figure 5. Example of soil erosion (*not taken on site*).

If this happens the resource can be degraded or even lost and this is what should be prevented during topsoil stripping, stockpiling, replacement and rehabilitation. Many human activities cause damage to soils. These include bad farming techniques, overgrazing, deforestation, urbanization, construction, soil stripping, wars, contamination, pollution and fires. The most critical result of these is soil erosion as depicted above in (**Figure 5**). With growing populations, the need for productive soils is increasing. Soil loss in many developing countries is a major cause for concern and will become a major issue in the future. The process of soil loss can have a detrimental effect on other systems as it produces sediment that can cause siltation of river systems and reservoirs, set off flooding downstream, and contribute to pollution and damage to estuaries, wetlands, and coral reefs. Soils need to be managed carefully in order to remain in good condition.

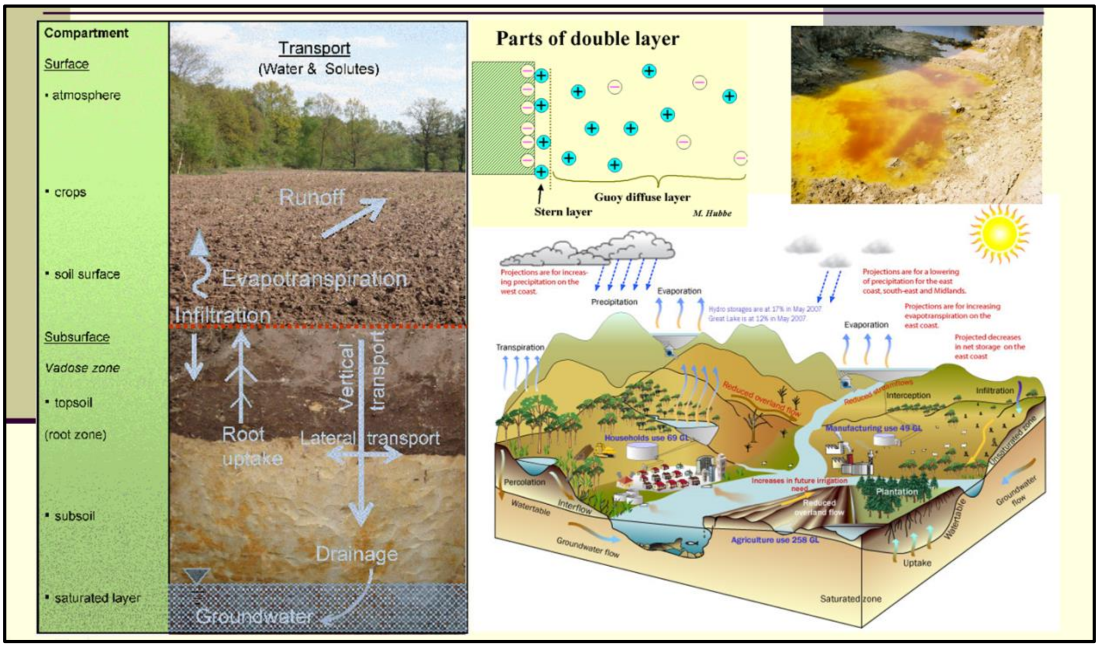


Figure 6. Soil water balance (Wikipedia).

Careful consideration should be given to saturated and unsaturated soil water conditions and the effect of disturbed soils, erosion and contamination. **Figure 6** illustrates a ***conceptual water solute transport model*** considering all possible water balance contributors, loss through seepage along preferential surfaces, subsurface seepage pathways and environmental receptors. Strategic planning should be conducted for managing topsoil as a finite resource during the mining project to be utilised optimally for rehabilitation purposes.

4.2 Abbreviated Legal Register for Rehabilitation

The following ***Acts*** focused on human rights, protection of the environment, accountability and financial provision should be considered with projects in South Africa:

- *Mineral & Petroleum Resources Development Act (Act No. 28 of 2002) (MPRDA), the MPRD Regulations R527;*
- *Constitution of South Africa Act (Act No. 108 of 1996);*
- *National Environmental Management Act (Act No. 107 of 1998) (NEMA), and Amendments to it;*
- *National Water Act (Act No. 36 of 1998) (NWA) (Section 36), and Amendments, with specific reference to the NWA Regulations GN704 of 1999 and use of Water for Mining and Related Activities aimed at the Protection of Water Resources;*
- *The Water Services Act (Act No. 108 of 1997);*
- *The Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA) & Amendments (Govt. Gazette Vol. 429 No. 22166 of March 2001);*
- *National Forest Act (Act No. 84 of 1998) (CARA);*
- *Physical Planning Act (Act No. of 1991);*
- *National Environmental Management Biodiversity Act (Act No of 2003;*
- *National Environmental Management Protected Areas Act (Act No. of 2003;*
- *National Veld and Forest Fire Act (Act No. 101 of 1998);*
- *National Environmental Management: Air Quality Act (Act No. 39 of 2004);*
- *National Heritage Resources Act (Act No. 25 of 1999);*
- *Promotion of Access to Information Act (Act No. 2 of 2000);*
- *National Monuments Act (Act No. 28 of 1969);*
- *Nuclear Energy Act (Act No. 46 of 1999);*
- *National Nuclear Regulatory Act (Act No. 47 of 1999);*

- *Health Act (Act No. 63 of 1997);*
- *Plant Improvement Act (Act No. 53 of 1976);*
- *Occupational Health and Safety Act (Act No. 85 of 1993);*
- *Agricultural Pests Act (Act No. 36 of 1983);*
- *Fertilisers, Farm Feeds, Agricultural remedies and Stock Remedies Act (Act No. 36 of 1947);*
- *Mine Health and Safety Act (Act No. 29 of 1996);*
- *Hazardous Substances Act (Act No. 15 of 1973);*
- *Land Survey Act (Act No. 8 of 1997);*
- *SABS 0286: 1998 Code of Practice for Mine Residue;*
- *Chamber of Mines of SA Guidelines for Environmental Protection: Engineering Design, Operation & Closure of Metalliferous, Diamond & Coal residue deposits;*
- *Guideline on the Compilation of a Mandatory Code of Practice on Mine Residue Deposits;*
- *Department of Water Affairs & Forestry Guideline on water & salt balances for TSF's;*
- *Chamber of Mines Guidelines for Vegetation of Mine Residue Deposits;*
- *Department of Water Affairs Policy and Guidelines for dealing with pollution from TFS's, and the containment and rehabilitation of abandoned TFS's, and prosecutions;* and
- *Convention of Wetlands of International Importance especially as Waterfowl Habitat RAMSAR (in force in SA from 12 Dec 1975).*

4.3 South African Environmental Soil Legislation

The following section outlines a summary of *South African Environmental Legislation* that needs to be considered for the proposed project with reference to management of soil:

- *The law on Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal;*

- *The Bill of Rights states that environmental rights exist primarily to ensure good health and wellbeing, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources;*

- *The Environmental right is furthered in the National Environmental Management Act (Act No. 107 of 1998) (NEMA), which prescribes three principles, namely the precautionary principle, the "polluter pays" principle and the preventive principle;*

- *It is stated in NEMA that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source;*

- *Soils and land capability are protected under the National Environmental Management Act (Act No. 107 of 1998) (NEMA), the) and the Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA);*

- *The National Veld and Forest Fire Act 101 (10 July 1998) and the Fertiliser, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No. 36 of 1947) can also be applicable in some cases;*

- *The National Environmental Management Act (Act No. 107 of 1998) NEMA requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimized and remedied;*

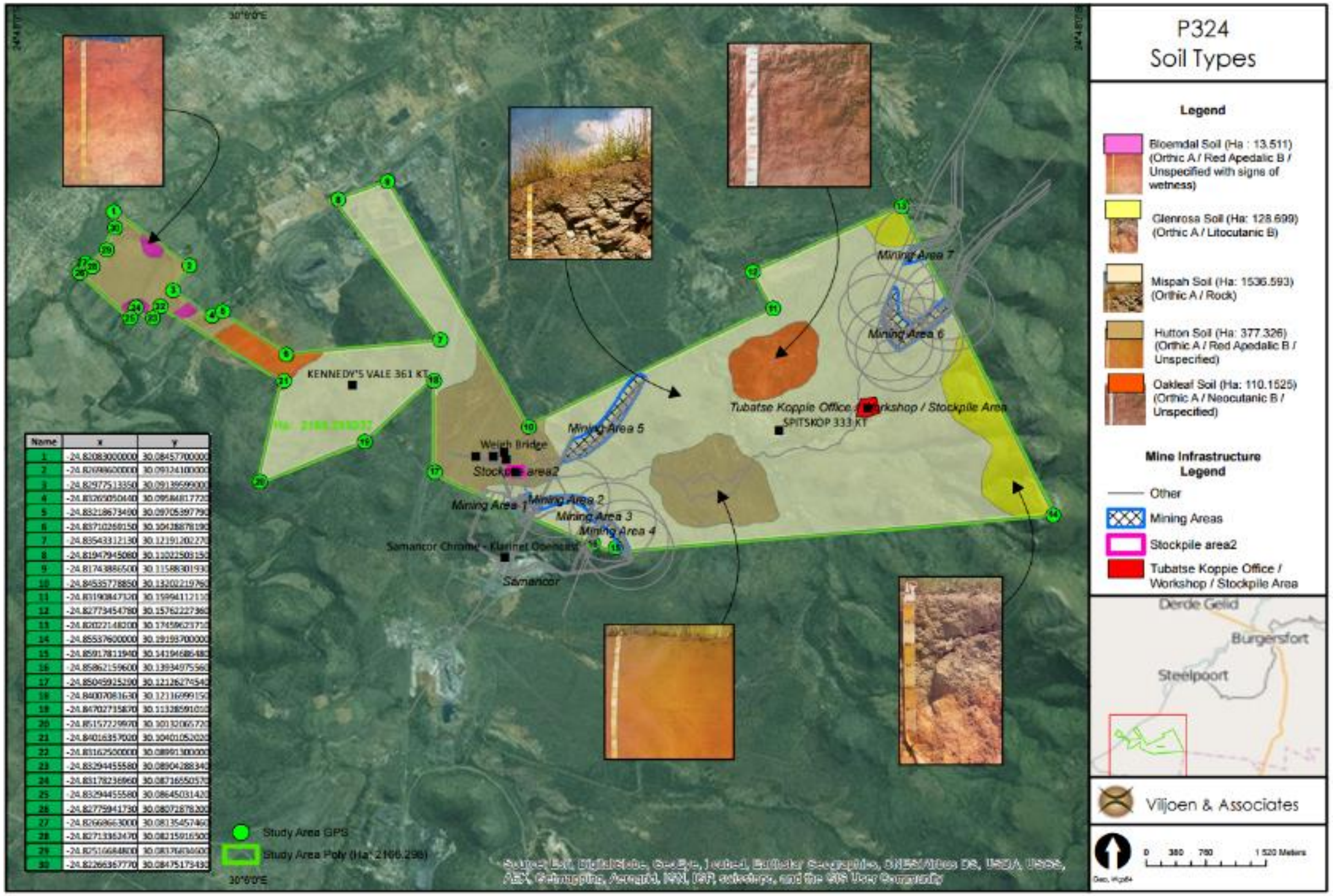
- *The MPRDA requires an EMPR, in which the soils and land capability be described;* and

- *The Conservation of Agriculture Resources Act (Act No. 43 of 1983) (CARA) requires the protection of land against soil erosion and the prevention of water logging and salinization of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and water courses is also addressed.*

- *National Environmental Management: Waste Act, 2008 (Act No 59 of 2008). National Norms and Standards For The Remediation Of Contaminated Land and Soil Quality.*

5 PROBLEM ANALYSES

5.1 Soil Classification and Effective Soil Depth



Name	x	y
1	-24.82083000000	30.08457700000
2	-24.82698600000	30.09124100000
3	-24.82977513350	30.09139599000
4	-24.83265050440	30.09584817720
5	-24.83218673490	30.09705397790
6	-24.83710260150	30.10428878190
7	-24.83543312130	30.12191202270
8	-24.81947945080	30.11022503150
9	-24.81743886500	30.11588301930
10	-24.84535778850	30.13202219760
11	-24.83190847320	30.15994112110
12	-24.82773454780	30.15762227360
13	-24.82022148200	30.17459623710
14	-24.85537600000	30.19193700000
15	-24.85917811940	30.14194686480
16	-24.85862159600	30.13934975560
17	-24.85049925290	30.12126274540
18	-24.84007081630	30.12116999150
19	-24.84702715870	30.11328591010
20	-24.85157729970	30.10132065720
21	-24.84016357020	30.10401052020
22	-24.83162500000	30.08991300000
23	-24.83294455580	30.08904288340
24	-24.83178236960	30.08716550570
25	-24.83294455580	30.08645031420
26	-24.82775941730	30.08072878200
27	-24.82668663000	30.08135457460
28	-24.82713352470	30.08215916500
29	-24.82516684800	30.08176404600
30	-24.82266367770	30.08475173430

Figure 7. Soil types.

Figure 7 shows the distribution of the different soils types identified and classified according to the latest version of the *South African Taxonomical Soil Classification System* into different soil types within Portions 8 and 12 of Farm Kennedy's Vale 361KT and Portions 24, 25, 26 and 28 of Farm Spitskop 333KT surface area.

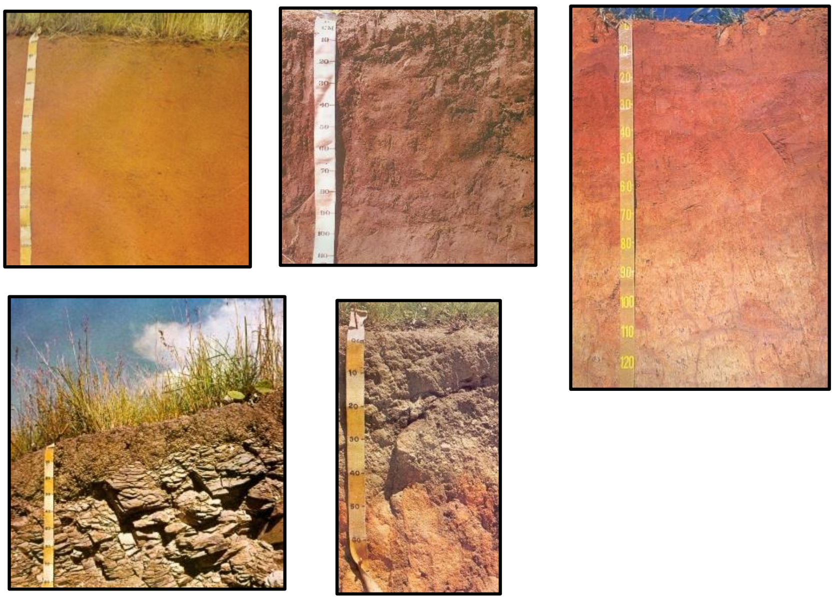


Figure 8. Hutton, Oakleaf, Bloemdal (*top left to right*), Glenrosa and Mispah soils (*bottom left to right*).

- Orthic A – Horizon: Is a surface horizon containing abundance of organic material darkened by organic matter, occurring over virtually the full range of soil forming conditions encountered in South Africa. The horizon excludes the properties of organic, humic, vertic or melanic topsoil horizons;

- Rock: This horizon will be represented by the underlying geology, *i.e.* andesite, shale, sandstone, *etc.* It offers extreme resistance to root and water penetration;

- Litocutanic B – Horizon: The horizon is represented by the undelaying geology in a weathered state with a cutanic character expressed as tongues of prominent colour variations caused by illuviation resulting from localisation of clay, iron and manganese oxides, *etc*.

- Neocutanic B – Horizon: The horizon diagnostically is characterised to have very little structure due to the low clay content and the presence of predominantly 1:1 layer silicates.

- Red Apedalic B – Horizon: Characterised by 1:1 clay minerals, *i.e.* kaolinite and oxides of iron and manganese. The clay percentage ranges between 10 and 20% (*hydrometer method*) and due to the low clay content there is a lack of structure.

The soil types are summarised in **Table 2**:

TABLE 2: SOIL TYPES

SOIL TYPE	DIAGNOSTIC HORIZONS	EFFECTIVE DEPTH (MM)
Hutton	Orthic A – Horizon/Red Apedalic B – Horizon/Unspecified	>300
Oakleaf	Orthic A – Horizon/Neocutanic B – Horizon/Unspecified	>300
Bloemdal	Orthic A – Horizon/Red Apedalic B – Horizon/ Unspecified with signs of wetness	>300
Mispah	Orthic A – Horizon/Rock	<300
Glenrosa	Orthic A – Horizon/Litocutanic B – Horizon	<300

5.2 Agricultural potential

The agricultural potential was assessed using the following formula as a function of various variables:

$$YIELD\ (kg\ ha^{-1}) = R/B \times ED/A \times C \times X$$

R – Rainfall (mm);

B - Species growth characteristics factor;

ED - Effective depth of the soil;

A - Soil wetness factor for textural classes of soil above effective depth;

C - Correction factor for aeration of soil; and

X - Fixed coefficient for species.

The main variables determining the soil's agricultural potential for maize (**Table 3**) include the **average rainfall** (mm), **soil depth** (mm) and **water management & holding capacity**. The yield estimates in **Table 3** exclude any other management practices, *i.e.* fertilisation, cultivar, plant density, *etc.* that can make a significant difference in yield.

The Hutton, Oakleaf and Bloemdal soils have high agricultural potential under dryland and irrigation conditions. However, the main constraint for optimum production is the availability of water for irrigation purposes. Production under dryland conditions of 30,000 plants/ha with average rainfall of 450mm/year will not be sustainable, especially during the summer period with extreme heat units. Production under irrigation conditions would require 6,100m^3/ha/year of water for 100,000 plants/ha, which is the equivalent of 30,000l/ha 24hours, 7 days per week. There is also the possibility that water quality could not be sufficient for irrigation purposes. The Dresden and Mispah soils are not suitable for agricultural purposes.

TABLE 3: AGRICULTURAL POTENTIAL OF SOIL

SOIL TYPE	AGRICULTURAL POTENTIAL	
	DRY LAND	IRRIGATION
Hutton	High	High
Oakleaf	High	High
Bloemdal	High	High
Mispah	Low	Low
Glenrosa	Low	Low

5.3 Erodibility of soils and evidence of misuse

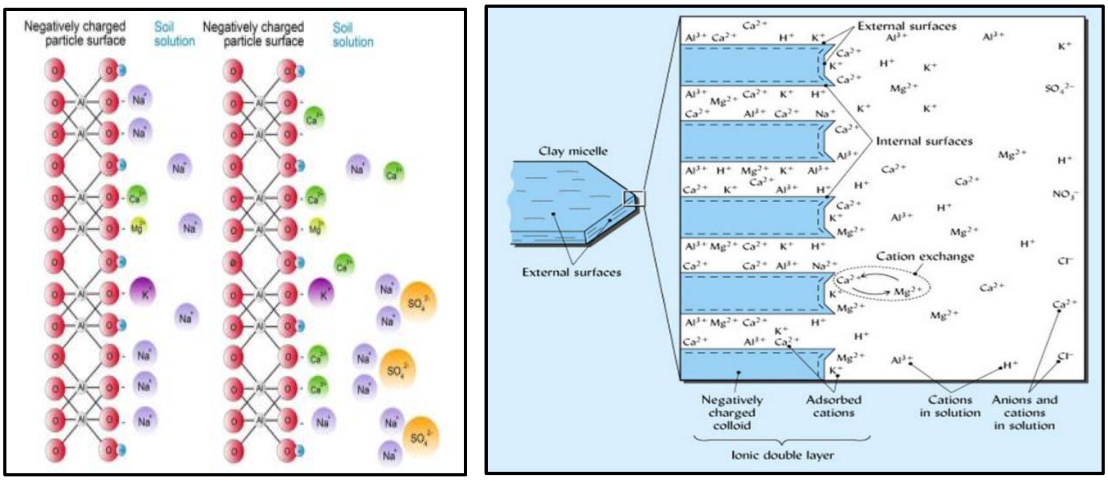


Figure 9. Exchangeable sodium molecules on exchange sites of clay surfaces as percentage of cation exchange capacity.

The soils have a cation exchange capacity to adsorb cations to neutralise electrical charges on the exchange sites of the clay minerals. The clay minerals are the fraction smaller than 0,002mm and would be presented mainly by 1:1 layer silicate, *i.e.* kaolinite. The exchange sites are usually occupied by Ca, Ma, K, Na and/or heavy metals in solution around the clays and if Na occupies more than 15% of the cation exchange capacity it would result in dispersion of the clays due to hydration of the Na on the exchange sites causing the double layer around the clays to swell.

The exchangeable sodium percentage (**Figure 9**) of the soils is below 15% of the cation exchange capacity, rendering the soils free of dispersion anomalies caused by the hydration of sodium and consequent soil erosion.

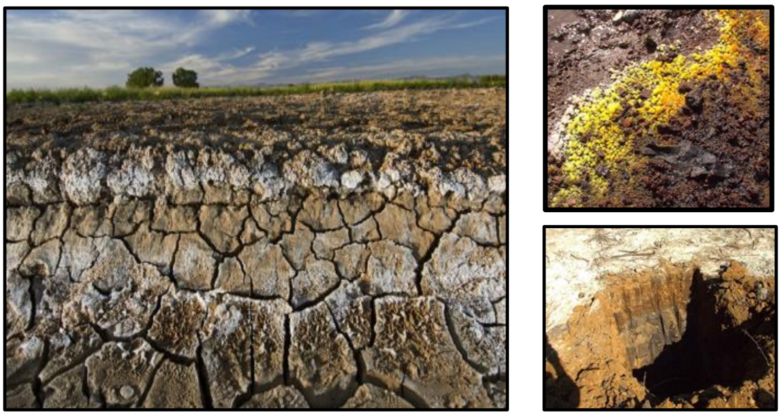


Figure 10. Examples of soil misuse *i.e.* salinization, heavy metal precipitation (*not taken on site*).

No evidence of soil contamination or misuse (**Figure 10**) was observed during the investigation).

5.4 Land Use & Land Capability

Land use can be defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain, *i.e.* the human use of land. Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as dams, infrastructure, natural veld, pans, ploughed land, settlements, wetlands, pastures, and managed woods.

Land capability classification shows the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management.

TABLE 4: CRITERIA FOR DETERMINATION OF LAND CAPABILITY

Summarised Description Of Land Capability Criteria	
Wetlands, Pans, Drainage Lines	Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.
Arable (>600mm)	Land that does not qualify as wetland. Soil is readily permeable to depth of 750mm. Soil has pH value between 4 and 8.4. Soil has low salinity and SAR. Soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm. Has a slope (%) 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.
Grazing (250 – 600mm)	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 used by domesticated livestock or game animals on a commercial basis.
Wilderness (<250mm)	Land which does not qualify as wetland, arable or grazing land.

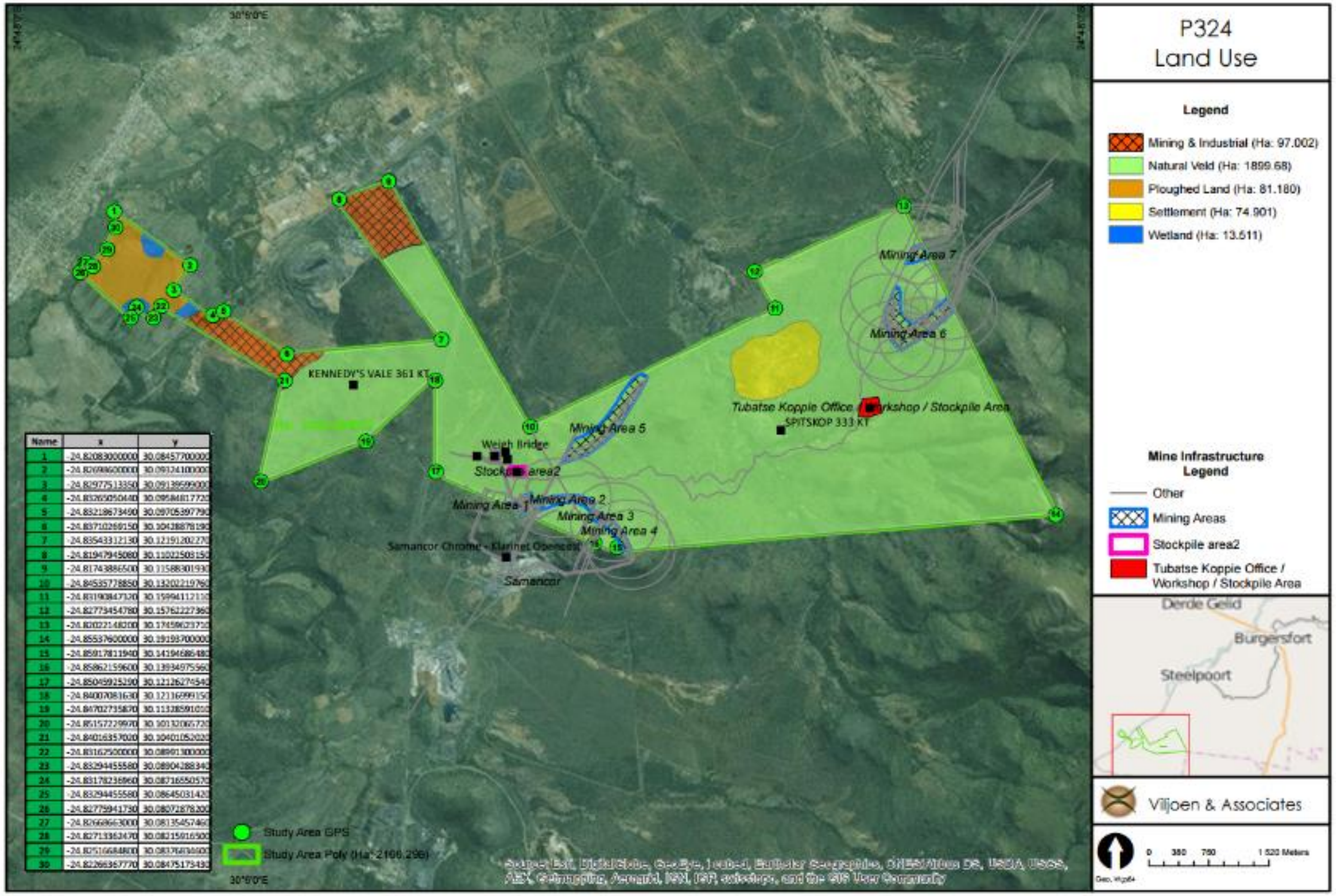


Figure 11. Land Use.

Table 5 summarises the *land use* (**Figure 11**) of the area investigated:

TABLE 5: LAND USE

Area	**Land Use**	**Surface Area (ha)**	**% of Total**
Portions 8, 22 Farm Kennedy's Vale 361KT & Portions 24, 25, 26 and 28 Farm Spitskop 333KT	Mining & Industrial	97	4,48
	Natural Veld	1,899	87,69
	Ploughed Land	81	3,75
	Settlement	75	3,46
	Wetlands	14	0,62
	Total	**2,166**	**100**

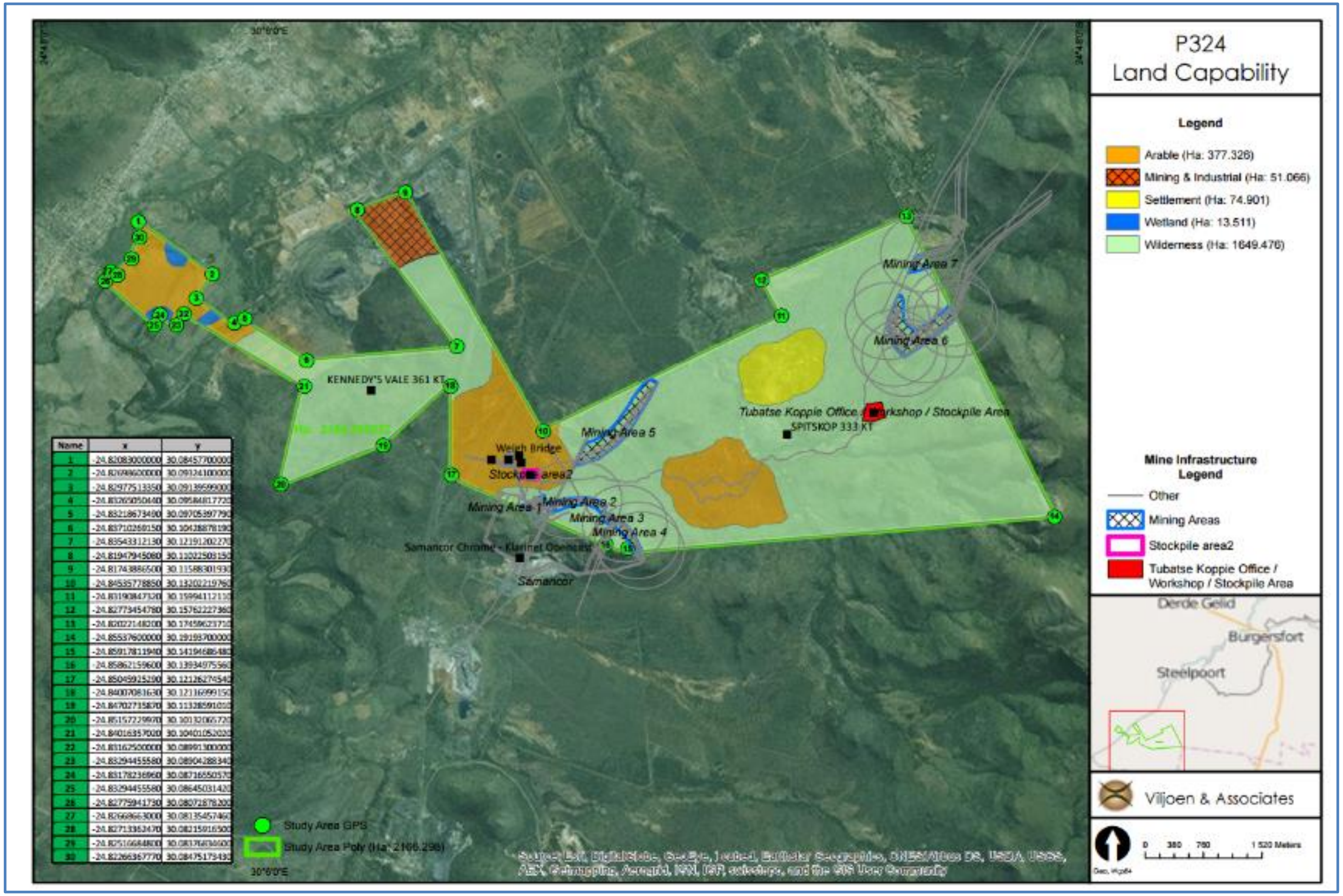


Figure 12. Land Capability.

Table 6 summarises the *land capability* (**Figure 12**) of the area investigated:

TABLE 6: LAND CAPABILITY

Area	**Land Capability**	**Surface Area (ha)**	**% of Total**
Portions 8, 22 Farm Kennedy's Vale 361KT & Portions 24, 25, 26 and 28 Farm Spitskop 333KT	Arable	377	17,42
	Wilderness	1,649	76,14
	Wetland	14	0,62
	Settlement	75	3,46
	Mining & Industrial	51	2,36
	Total	**2,166**	**100**

5.5 Soil stripping utilisation guide and plan

5.5.1 Soil Management

The objectives of soil management are:

- Provide sufficient stable topsoil material for rehabilitation;
- Optimise the recovery of topsoil for rehabilitation;
- Identify soil resources and stripping guidelines;
- Identify surface areas requiring stripping;
- Manage topsoil reserves so as not to degrade the resource;
- Identify stockpile locations and dimensions; and
- Identify soil movements for rehabilitation use.

In order to provide sufficient topsoil material for rehabilitation purposes and to optimise soil recovery, the following aspects are recommended:

1. Stockpiles to be located outside proposed mine disturbance area(s);
2. Construction of stockpiles by dozers rather than scrapers to minimise structural degradation;
3. Construction with a "rough" surface condition to reduce erosion, improve drainage and promote re-vegetation;
4. Re-vegetation of stockpiles with appropriate fertiliser (based on soil analyses) and seed in order to minimise weed infestation, maintain soil organic content, soil structure and microbial activity and maximise vegetative cover of the stockpile; and
5. Disturbance areas to be stripped progressively as required to reduce erosion and sediment generation, to reduce the extent of topsoil and utilise stripped topsoil as soon as possible for rehabilitation.

5.5.2 Basic Volume Calculations

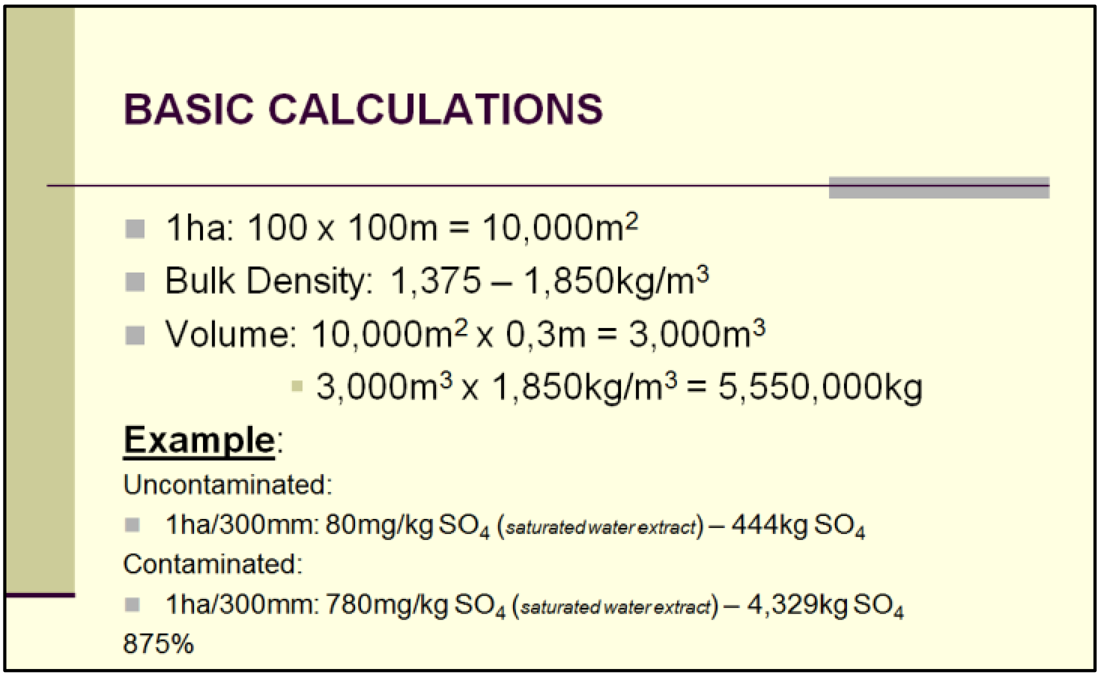


Figure 13. Basic Volume Calculations.

The amount of available topsoil to be stripped prior to mining operations could be under estimated and should be treated conservatively as a finite resource. A basic unit of 10,000m^2 300mm deep can potentially yield 3,000m^3 of topsoil at a bulk density ranging between 1,375 – 1,850kg/m^3. An increment of 100mm depth could yield an additional 1,000m^3 or could be lost due to inappropriate stripping practices.

Considering the above basic volume calculations (**Figure 13**) it is obvious that due care must be exercised when stripping topsoil.

5.5.3 Soil Types

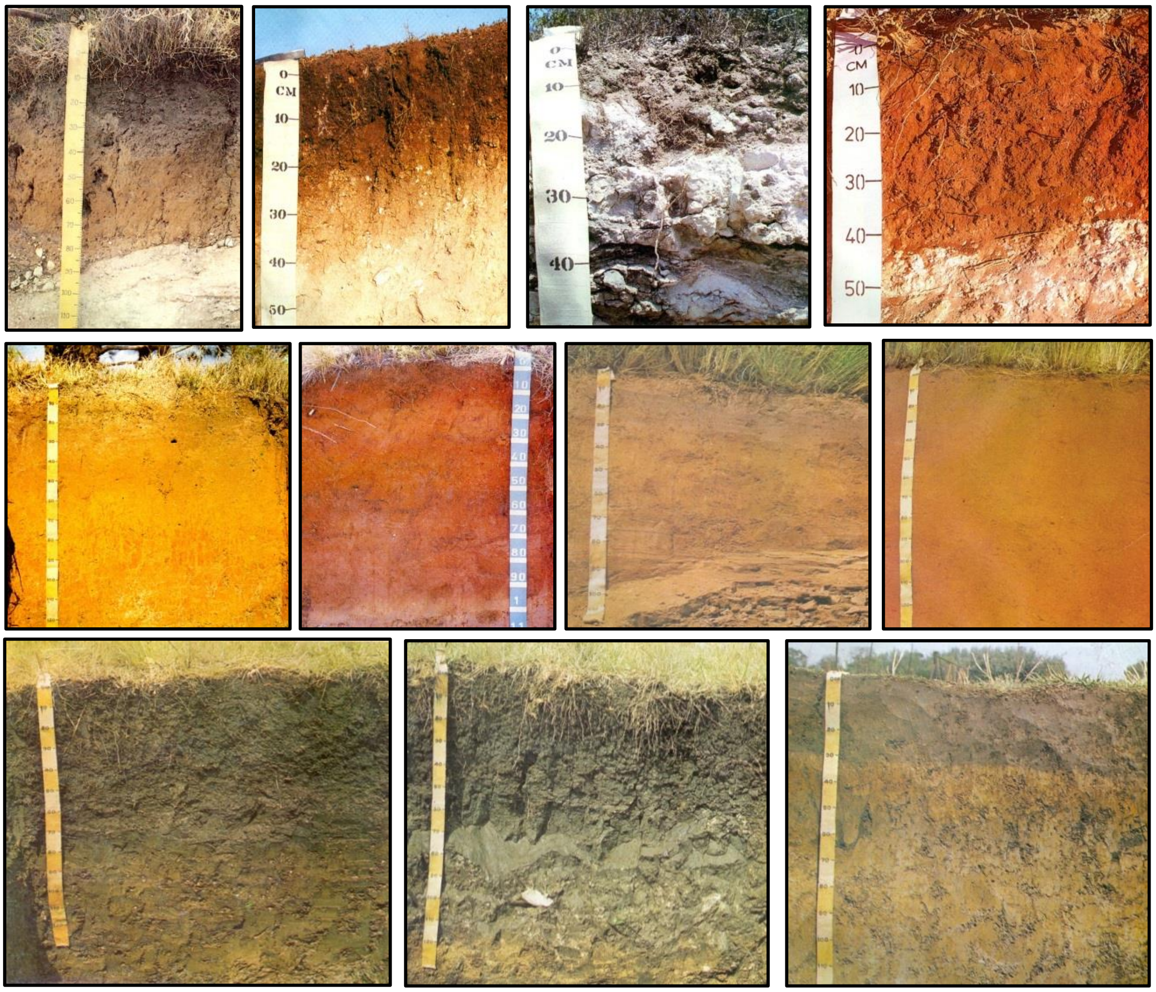


Figure 14. Soil Types (*Examples from South African Taxonomical Soil Classification System*).

The ***South African Taxonomical Soil Classification System*** is comprised of 53 different soil types (**Figure 14**) each soil type is characterised by a sequence of diagnostic horizons.

Soils can be formed *in situ* from underlying geology through natural weathering and/or could be transported and deposited through wet and dry geological periods. The soil will be a function of the mineralogy from which it was derived and which will determine its prevailing chemical, physical and mechanical properties.

Consideration should be given to different diagnostic soil horizons when stripping topsoil, *i.e.* certain layers can be stripped and mixed together and certain layers should be stockpiled separately. Careful consideration and planning should be given to different soil layers and thickness during topsoil stripping for rehabilitation purposes, which should not be dictated solely by civil engineering geotechnical criteria.

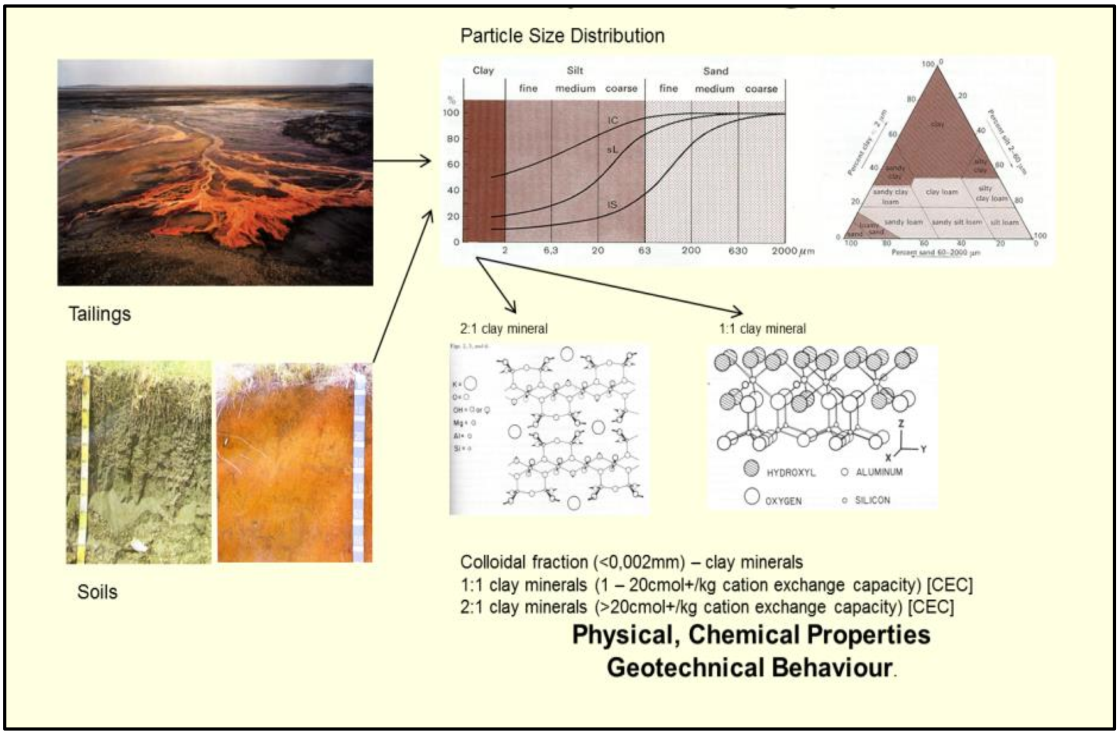


Figure 15. Influence of colloidal fraction in topsoil stripping.

Clay mineralogy (**Figure 15**) is the primary diagnostic criteria for soil layer identification and selection during topsoil stripping and stockpiling. The colloidal fraction (*particles <0,002mm*) can be divided in 1:1 layer and 2:1 layer silicates and should not be mixed and stockpiled together. Organic material, bulk density and seeds are secondary diagnostic criteria for horizon selection to be stripped and stockpiled.

5.5.4 Topsoil Stripping – general recommendations

Soil Layers

A review of available soil mapping information should be conducted to determine the distribution of soil types and diagnostic layers prior to any soil stripping project. Clear distinction should be made of available soil layers to be stripped and stockpiled separately or together. It is recommended to use an experienced soil surveyor with rehabilitation experience and track record (*inclusive of failures and successes*).

On completion of identifying soil layers to be stripped and stockpiled a guidance digital terrain map for earthmoving machinery should be compiled. The guidance stripping waypoints should be plotted and placed by a qualified surveyor in accordance with standard survey practices and techniques.

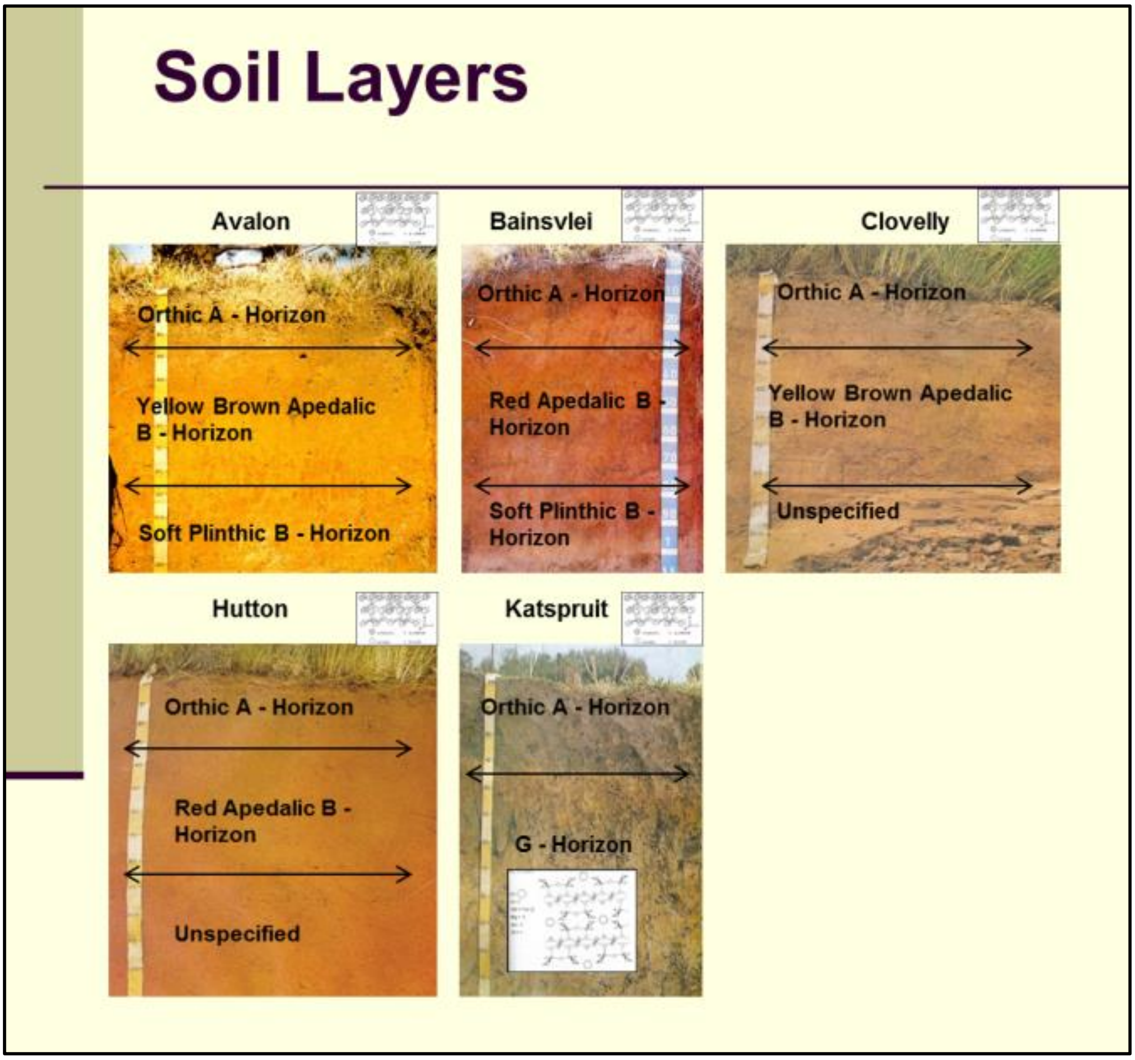


Figure 16. Different soil layers to be stripped.

The Orthic A – Horizon (**Figure 16**) will in most soils represent the topsoil layer 0-300mm. The topsoil layer should be stripped and stockpiled separately and stripping should not exceed 300mm.

The remainder of the soil layers should be carefully identified and selectively grouped together for stripping and stockpiling. For example, the Red, Yellow Apedalic, Stratified Alluvium, Neocutanic B - Horizons and Regional Sand can be stripped and stockpiled together, whereas the Pedocutanic B, Soft Carbonate B, E - Horizon , Red Structured B, Podzol B, G - Horizon, Prismacutanic B, Pedocutanic B, Neocutanic B, Neocarbonate B – horizons should be stripped and stockpiled separately. Wetland soils should be stripped and stockpiled separately for future rehabilitation purposes.

Covering vegetation can make the removal of specific topsoil depths difficult and excessive quantities of vegetative matter in long term stockpiles may promote chemical and biological degradation of the seed reserves that are a future source of regeneration during rehabilitation. Prior to stripping, vegetation should be removed or reduced by grazing and/or clearing in accordance with the Health and Safety Management Plan of the mine.

<u>Field Practice</u>

Prior to soil stripping activities the site engineer/supervisor must ensure the appropriate clearance approvals have been obtained. Through all stages of topsoil stripping and stockpiling, operations should be closely supervised to determine recovery depths and to identify suitable soils. The designated supervisor will direct and control the recovery, handling and management of the site soils through the following activities:

1. Delineation of areas to be stripped for daily stripping operations;

2. Ground truthing in the field of mapped soil types;

3. Delineation of suitable stockpile areas;

4. Ensuring dust generation during topsoil stripping is at acceptable levels; and

5. Recording of volumes stored.

Topsoil stockpile locations, volumes and date of soil stripping should be recorded in an electronic database correlating with a digital terrain map of the area.

The means of topsoil placement within storage locations will consider the economic implications of dozer pushing relative to load and truck haul with consideration also given to access constraints, machine availability and ground conditions.

Soil Stripping With Excavators and Dump Trucks

The purpose of this section is to provide a model for best practice where excavators and dump trucks are to be used to strip soil. The specific type, size or model of equipment is not specified, however it is recommended that it be contractually agreed on as part of the planning conditions of the project. The machines should be of a kind which will cause minimum compaction whilst being operated efficiently and they must be well maintained.

This soil handling method uses back-acting excavators in combination with dump trucks (*articulated or rigid*). An excavator is used to strip soil and load it into dump trucks for transportation to storage areas. Soil handling can affect the quality of the rehabilitation through soil compaction and smearing, primarily caused through trafficking, the effects of which increases with increase in soil wetness. The advantage of this guideline, if used properly, will avoid severe deformation of the soil as trafficking is minimised and there should be no need for decompaction during the operation.

The key operational aspects to avoid soil deformation include:

- Minimise compaction;
- Dump trucks must only operate on the basal/non-soil layer and their wheels must not run on the soil layers;
- The excavator should only operate on the topsoil layer;
- Implementation of a bed/strip system avoids the need for trucks to travel on the soil layers;
- Machines are to only work when ground conditions enable their maximum operating efficiency; and
- If compaction is caused then measures are required to treat (consult an experienced specialist).

To minimise soil wetness and re-wetting the following aspects are applicable:

- The soil layers should have moisture content below their lower plastic limit. Moisture content should be addressed by for example weight loss determined by weighing wet samples, oven drying them and calculation of moisture loss taken from respective locations and mid/lower points of each horizon;
- The bed/strip provides a basis to regulate exposure of lower soil layers to periods of rain and maintaining soil moisture. The soil profile within the active

strip should be stripped to the basal layer before rainfall occurs and before stripping is suspended. This is not always possible from a production perspective, however it should be implemented where possible.

- Measures are required to protect the face of the soil layer from ponding of water, maintain the basal layer in a condition capable of supporting dump trucks; and

- Surface water control measures must be in place to protect in-flow of water, ponding, *etc*. Wet sites should be drained in advance.

The stripping operation entails the following;

- The area to be stripped must be protected from in-flow of water, ponding, *etc*.

- Soil stripping operations should not start until the required soil moisture levels are reached, and should be suspended as soon as water content returns to these levels. In practice the chances of this taking place are very slim due to production targets to be met, however where possible it should be implemented. Prior to work commencing a weather forecast should be considered for potential rainfall interruptions. If significant rainfall occurs during operations, the stripping must be suspended, and where the soil profile has been disturbed it should be removed to base level. Stripping should not restart unless weather forecast is expected to be dry for a sufficient period of time.

- All machines must be in safe and efficient working condition at all times and only to work when ground conditions enable their maximum operating efficiency with skilled operators. Operations should be suspended before traction becomes a problem or the integrity of the basal layer and haul routes fails.

- Operations must follow a detailed stripping plan showing soil units to be stripped, haul routes and the phasing of vehicle movements. Soil units should be defined on site, with information to distinguish types, layers, ranges and thickness. Detailed daily records should be kept of operations undertaken with site and soil conditions.

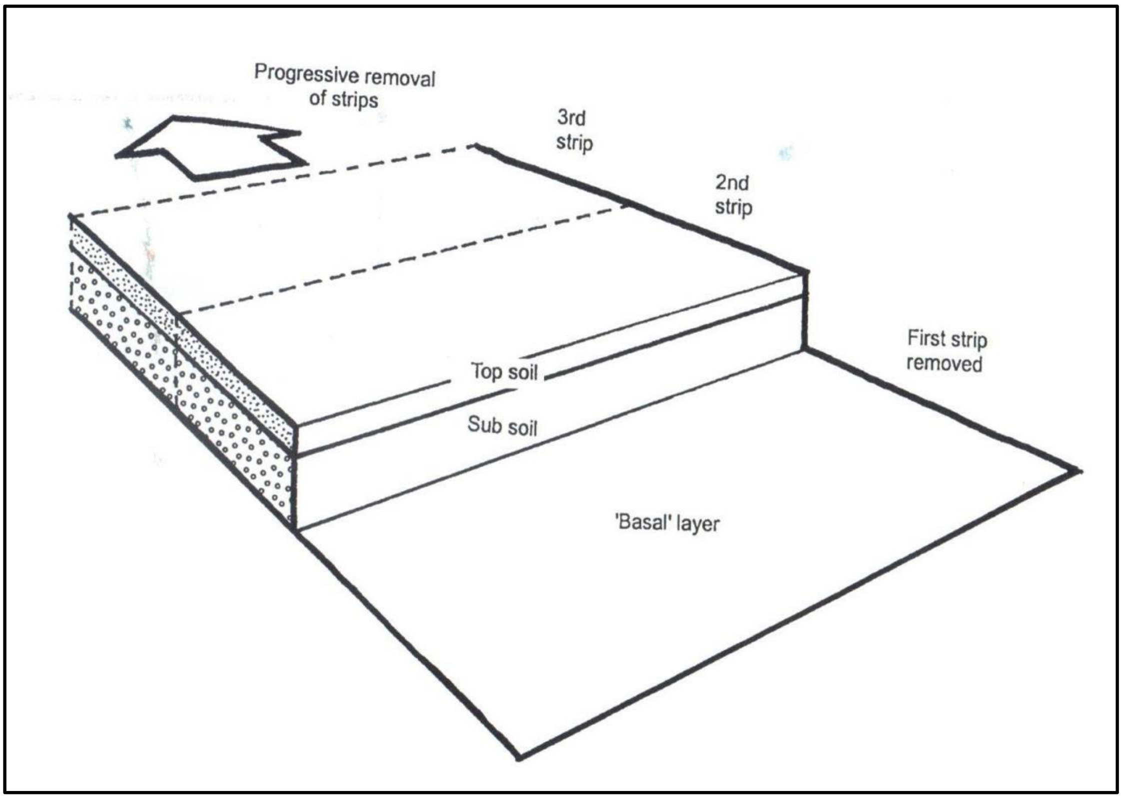


Figure 17. The bed strip system.

- Within each soil unit the layers above the base/formation layer must be stripped in sequential strips with the topsoil layer stripped first, followed by the subsoil layers, each layer stripped to its natural thickness without incorporating material from the lower layers. The next strip is not started until the current strip is completely stripped to the basal layer. This is referred to as the bed strip system (**Figure 17**). If a gradient is present on site, the main axis of the soil strips should be along the axis of the slope;

- Haul roads and stockpile areas must be defined, and stripped first in a similar manner; and

- The excavator is only to work on the topsoil layer and dump trucks are only to travel on the basal/formation layer.

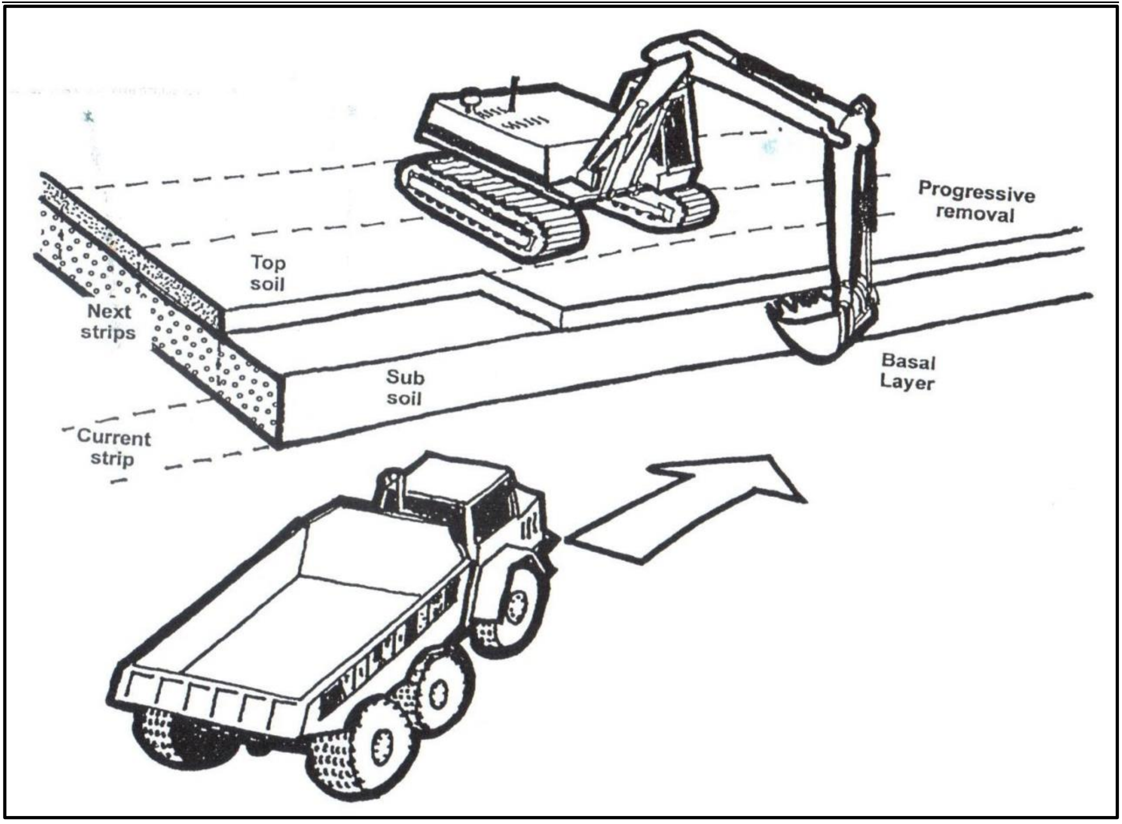


Figure 18. Removal of topsoil from a strip.

- Stripping to be undertaken by the excavator on the surface of the topsoil and digging the topsoil to its maximum depth and loading into dump trucks (**Figure 18**). In general a bucket with teeth is preferable. The dump trucks draw alongside the exposed soil profile, standing and travelling only on the basal layer;

- The initial strip width and axis should be demarcated. Strip width is determined by the length of the excavator boom less the stand-off to operate, typically 3 – 4m. Effective boom length can also reduce with profile depths greater than 1m, at 1.5m effective reach of standard boom may result in 2m wide strips; and

- Topsoil should be recovered to the full width of the strip without contamination with subsoil (not more than 20% of the lower horizon should be exposed at the layer junction within the strip). The thickness and identification of the horizon junction must be verified before and during stripping. The full thickness of topsoil should be stripped progressively along the strip before subsoil horizons are started.

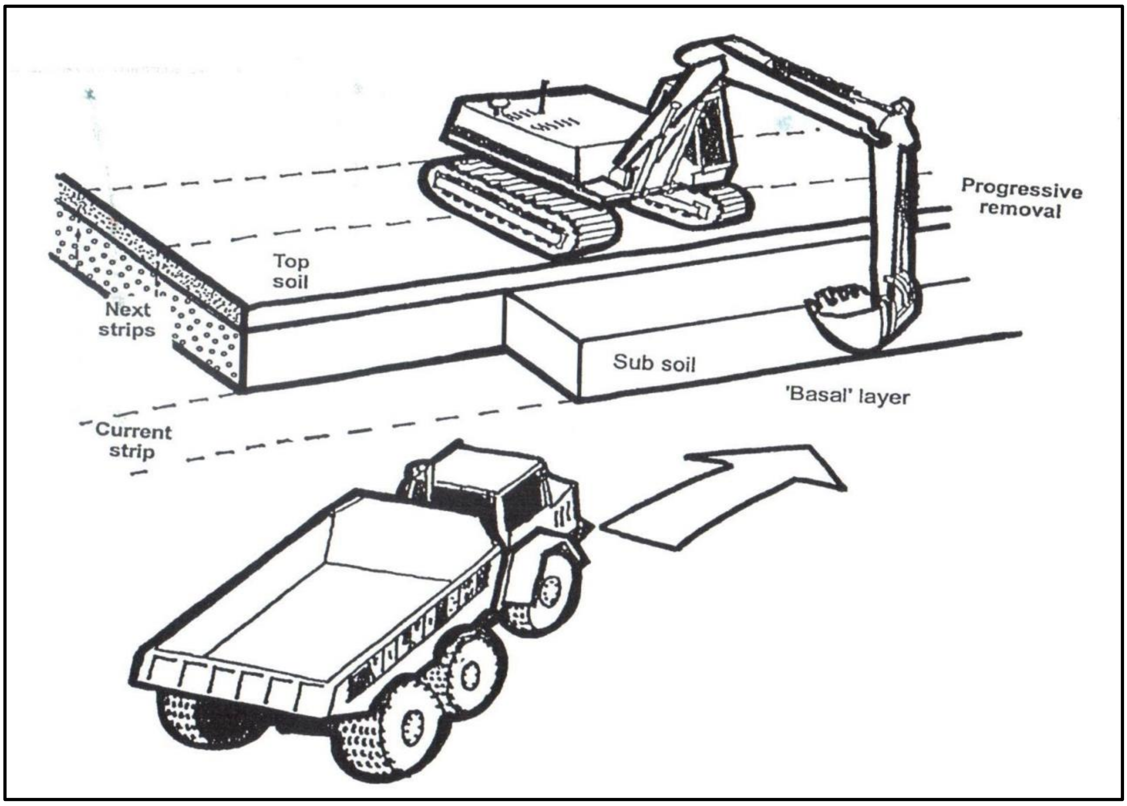


Figure 19. Removal of subsoil from a strip.

- The upper subsoil in the current strip must be stripped and monitored in the same manner (**Figure 19**). The final 25cm of the subsoil layer should be left as a step to protect the adjacent topsoil layer from local collapses. The process must be repeated for the lower subsoil and any other lower layer to be recovered as soil material;

- On completion of the strip the procedures are repeated sequentially for each subsequent strip until the area is completely stripped;

- Where soils are to be directly replaced without storage in mounds, the initial strip of the upper horizons will have to be stored temporarily to release the lowest layer and enable the sequential movement of materials. The stored soil would normally be placed on the lower layer removed from the final strip and the end of the programme or on partially completed profiles if rain interrupted the operation; and

- Where the stripping operation is likely to be interrupted by rain or there is likely to be over-night rain, remove any exposed subsoil down to the basal layer before suspending operations. Make provision to protect base of current or next strip from ponding/runoff by sumps and grips and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas and the basal layer is level with no ruts.

Stockpiles

Figure 20. Stockpiling of topsoil.

Stripped soil should be stockpiled upslope of areas of disturbance or development to prevent contamination of stockpiled soils by dirty runoff or seepage (**Figure 20**). All stockpiles should also be protected by a bund wall or berm to deflect surface water runoff and prevent erosion of stockpiled material.

Stockpiles can be used as a barrier to screen operational activities. If stockpiles are used as screens, the same preventative measures described above should be implemented to prevent loss or contamination of soil. The stockpiles should not exceed a maximum height of 3 to 6m and it is recommended that the side slopes and surface areas be vegetated in order to prevent water and wind erosion. The higher the stockpile, the longer the slopes exposed to erosion, *i.e*. 3 meter height (*if there is enough space*) is a reasonable practical optimum height. A scientific assessment should be conducted to assess what grass species occur at baseline conditions in close proximity to the stockpile area. Based on this assessment, careful selection should be conducted to establish the correct species mixture in order to generate the required basal coverage and allow natural sustainable succession. The use of an annual species can be considered to function as a mother crop to stabilise the side slopes and create a micro-habitat for seed germination. If used to screen construction operations, the surface of the stockpile should not be used as a roadway as this will result in excessive soil compaction.

A general protocol for soil handling including handling measures to optimise the retention of soil characteristics (nutrients and micro-organisms) favourable to plant growth includes:

- The surface of the completed stockpile must be left in a rough condition to promote water infiltration and minimise erosion prior to vegetation establishment;
- Stockpiles to have a maximum height of 5m in order to limit the potential for anaerobic conditions to develop within the soil pile;
- Topsoil stockpiles to have an embankment grade of approximately ***1m vertical:4m horizontal*** (to limit the potential for erosion of the outer pile face);
- Stockpiles to be seeded and fertilised; and
- Soil rejuvenation practices to be undertaken (if required) prior to respreading as part of the rehabilitation works.

Strategic and planned stockpiling is a necessary part of civil engineering and mining operations. The storage period for stockpiled soil ranges from a few months to several years. The depth of the stockpile and the length of time it is stored affect the quality of the soil at replacement. Soil takes centuries to develop from parent material and organic matter. Stockpiling and the subsequent reapplication of the topsoil, allows for planting conditions that are closer to the pre-disturbance condition than planting on the subsoil layers that remain. Keep in mind the latter is possible, however requires remedial input from a specialist. If stockpiled soil is reapplied quickly, with care to reduce the compaction inherent in the use of mechanical means for stockpiling, most of the production potential will remain.

Earth Moving Equipment

Contractors are focussed on moving cubic meters of material as cost effectively as possible to maximise profits and they are used to engineering properties and guidelines dictating material differentiation. They need to be guided and supervised to strip topsoil and subsequent layers and to stockpile according to a rehabilitation protocol. Care must be taken not to mix different soil layers and stockpile them separately as prescribed.

Figure 21. Dozer, excavator, tipper, grader and front end loader earth moving equipment.

During topsoil stripping typical earth moving equipment (**Figure 21**), *i.e.* dozer, excavator, tipper, grader and front end loader will be used. Consideration should be given to the skills and experience of operators to make sure they get calibrated to the required level of operation. *For example*, if it is required for the dozer operator to strip a soil layer 300mm deep he must make sure to maintain the blade at a constant depth considering the fact the machine weighs in excess of 30t, areas of subsidence might cause uneven scraping, sensitivity of controls to maintain blade stability, health, skill, experience and state of mind of the operator, *etc*.

Figure 22. Grader ripping compacted soil.

During rainstorms enough time should be allowed to wait until the site has dried off sufficiently (*no compromise*) before starting the next shift due to considerations of safety and compaction. Considerable losses can occur due to compaction of heavy earthmoving machines over wet areas. Usually contractors blame a tight time schedule and budget constraints and push the agreed project time limits, however it is recommended to proactively plan and buffer for rainfall events. As an emergency measure graders and/or dozers are often used to rip soil (**Figure 22**) to uplift compaction prior to stripping.

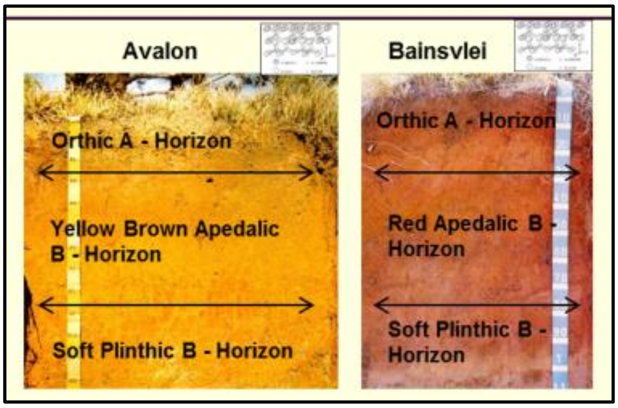


Figure 23. Avalon and Bainsvlei soils with Soft Plinthic B – Horizons.

When topsoil stripping has advanced to a stage where the Orthic A – Horizon and most of the Yellow Brown and Red Apedalic B – Horizons have been removed in case of Avalon and Bainsvlei soils (**Figure 23**), and ripping (**Figure 22**) extends into the Soft Plinthic B – Horizon, loss of removable soil will occur due to intermixing of the apedalic and plinthic layers, which should be prevented.

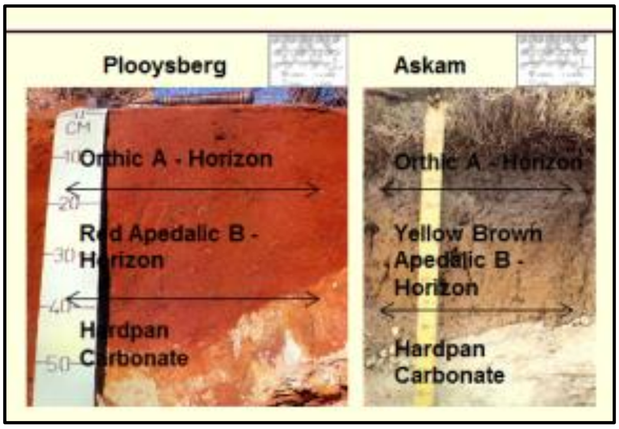


Figure 24. Plooysberg and Askam soils with Hardpan Carbonate Horizons.

If the topsoil stripping operation has advanced to a stage where the Orthic A – Horizon and most of the Yellow Brown and Red Apedalic B – Horizons have been removed in case of the Plooysberg and Askam soils (**Figure 24**) and ripping (**Figure 22**) extends into the Hardpan Carbonate – Horizon, loss of removable soil will occur due to intermixing of the apedalic and carbonate layers. This should be prevented at all cost.

Contamination

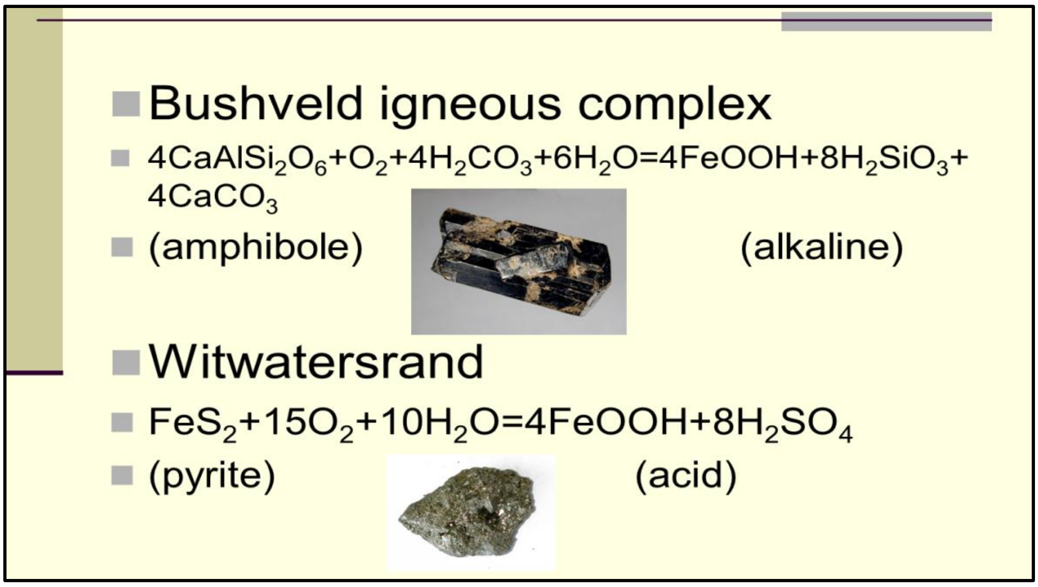


Figure 25. Influence of geology on soil contamination.

Alkaline and/or acidic anomalies could occur from processed and stockpiled waste rock exposed to surface conditions ideal for oxidation and reduction chemical reactions. **Figure 25** illustrates the effect of amphibole mineralogy (*Bushveld Igneous Complex*) resulting in alkaline conditions and pyrite (*Witwatersrand Complex, Coal*) resulting in acidic conditions.

From a ***pollution source seepage pathway receptor*** continuum in unsaturated and saturated soil water conditions, precautions should be taken not to contaminate stripped and stockpiled topsoil.

Soil contamination in the form of *acidification, alkalinisation, erosion, salinisation and heavy metal contamination,* and *loss of topsoil* due to dispersion of clay particles, should be prevented. General maintenance and safety precautions should be followed in accordance with a daily *Hazard Identification Risk Assessment* to prevent diesel and hydraulic fluids from contaminating the soil. If an incident occurs it should be reported and addressed.

Topsoil stripping and stockpiling for rehabilitation purposes requires a specific operational procedure that differs from conventional engineering ground moving protocols. Consideration should be given to available machinery, past experience and track record of potential contractors to be appointed for topsoil stripping and stockpiling projects. Quality assurance and quality control executed by a qualified and dedicated individual is necessary for successful monitoring of operational activities during topsoil stripping. A daily quantified audit and database kept on a digital terrain map of the area to be stripped will keep a calibrated line available to track progress and success. Furthermore, it will enable proactive management to prevent failures.

General maintenance and safety precautions should be followed in accordance with a daily *Hazard Identification Risk Assessment* to prevent soil contamination by diesel and hydraulic fluids. If an incident occurs it should be reported and addressed. In most cases the contaminated area can be treated *in situ* or diluted with clean soil, but in the event of a very significant spillage the contaminated soil should be removed and treated.

Surface water control measures should be in place during topsoil stripping operations to prevent topsoil losses due to water erosion. Construction sites are always earmarked by preferential seepage and drainage pathways eroding large quantities of sediment away, mainly due to poor housekeeping and lack of supervision.

Strategic and planned stockpiling is a necessary part of civil engineering and mining operations. The storage period for stockpiled soil ranges from a few months to several years. The depth of the stockpile and the length of time it is stored affect the quality of the soil at replacement. Soil takes centuries to develop from parent material and organic matter. Stockpiling and the subsequent re-application of the topsoil allows for planting conditions that are closer to the pre-disturbance conditions than planting on the subsoil layers that remain. If stockpiled topsoil is reapplied quickly, with care to reduce the compaction inherent in the use of mechanical means for stockpiling, most of the production potential will remain.

A conservative estimate of anticipated available topsoil to be stripped is summarised in **Table 7**.

TABLE 7: AVAILABLE TOPSOIL FOR REHABILITATION PURPOSES

Soil Type & Average Effective Depth (mm)	Size (ha)	Available Volume (m^3)
Hutton (1,200)	377	4,524,000
Oakleaf (1,200)	110	1,320,000
Bloemdal (1,200)	14	168,000
Glenrosa (300)	129	387,000
Mispah (300)	1,537	4,611,000
TOTAL		**11,010,000m^3 @ BD: 1,275kg/m^3**

An estimated total 3,303ha could potentially be covered 300mm thick at a bulk density of 1,275kgm^3 during rehabilitation taking into consideration a 10% loss of topsoil due to handling, compaction *etc*.

5.6 Overview of basic soil chemical, physical and mineralogical properties of soils

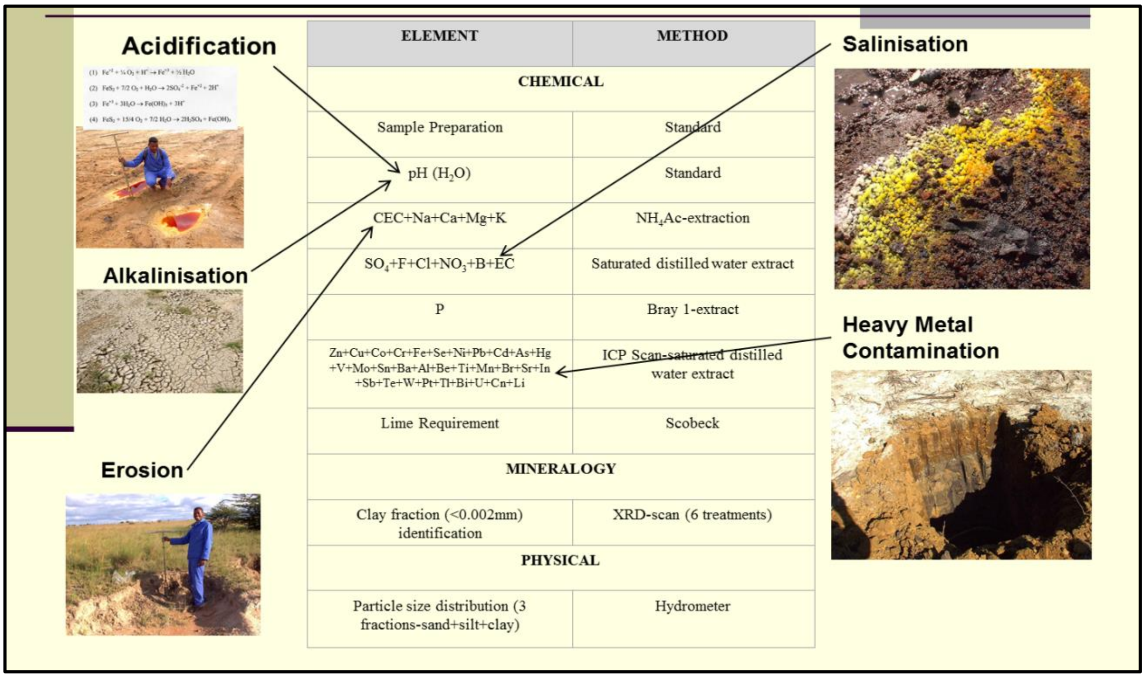


Figure 26. Potential soil chemical, physical and mineralogical anomalies.

The soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15mg/kg) and potassium (>50mg/kg) are readily available for plant uptake and sustainable plant growth. No irregular anomalies (**Figure 26**) occur in any one of the different soil types.

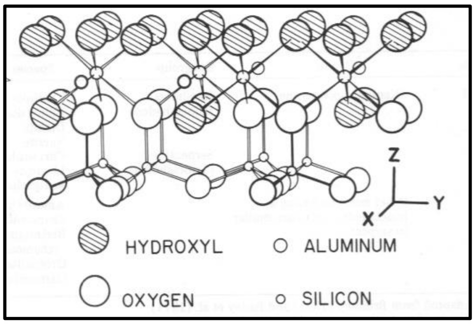


Figure 27. 1:1 Clay mineral.

The Orthic A-Horizon is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in the order of 10mm/h. The dominant clay mineral in the *Orthic A – Horizon, Yellow* & *Red Apedalic B – Horizon* is kaolinite (*1:1 layer silicate*), with a low buffer capacity due to the low cation exchange capacity *(<10cmol+/kg*) (**Figure 27**).

5.7 Assessment of suitability of soils for rehabilitation purposes

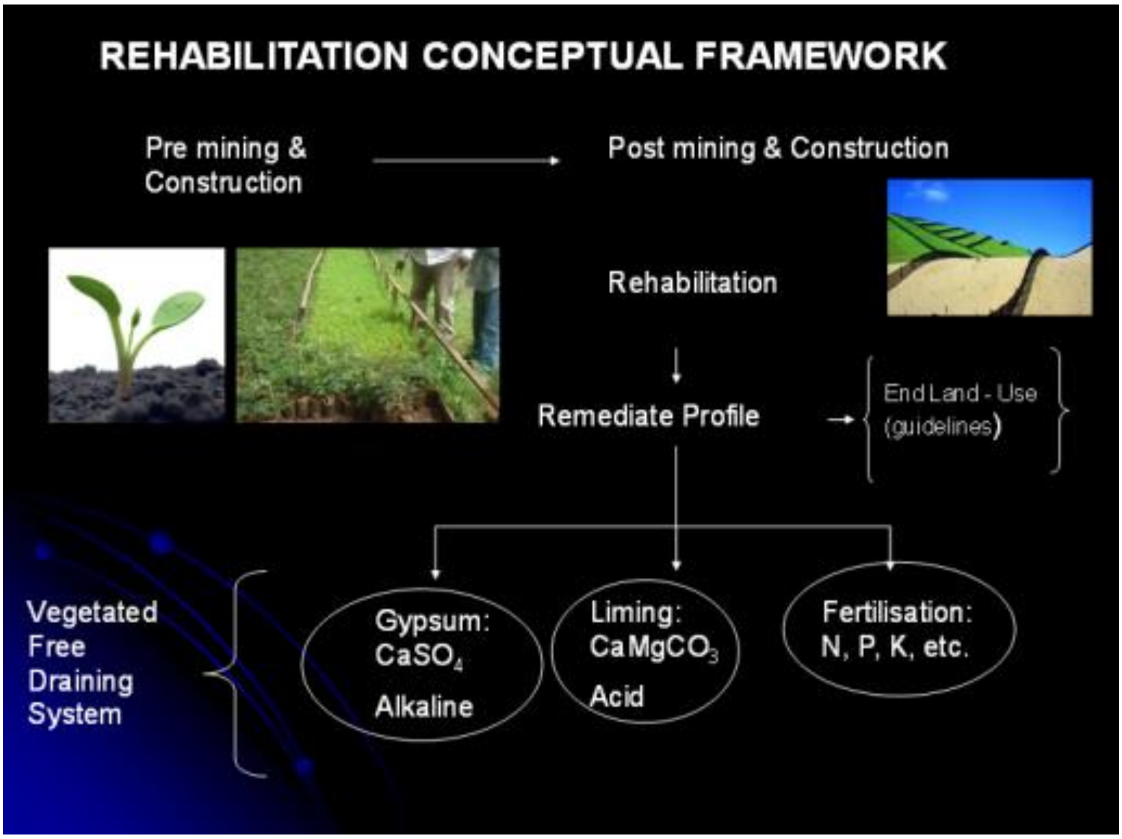


Figure 28. Conceptual Rehabilitation Framework.

The soil horizons specified in **Section 5.1 p19** of the Hutton, Oakleaf and Bloemdal soils are suitable for rehabilitation purposes to establish a vegetated free flow drainage system.

When stockpiled soils have been replaced during rehabilitation, the soil fertility should be assessed to determine the level of fertilisation required to sustain normal plant growth. The fertility remediation requirements need to be verified at the time of rehabilitation. The topsoil should be uniformly spread onto the rehabilitated areas and care should be taken to minimise compaction that would result in soil loss and poor root penetration. When returning the soil to the rehabilitation site care should be taken to place soil in a manner that will allow for levelling of soil to take place in a single pass. The soil profile should not be built up by using a repeated tipping and levelling action to increase the soil depth. Proper water control measures should be implemented to ensure a free draining rehabilitated landscape. When surveying the area to be rehabilitated and generating a digital terrain map, preferential seepage pathways should be identified and contoured to prevent surface runoff creating erosion during a 1:100 year rainstorm event with 20mm/h rainfall intensity. A soil scientist with remediation and rehabilitation experience should be consulted to assess water retention and storage abilities of soil types to utilise the net cascading effect of water storage under saturated and unsaturated flow conditions.

5.8 Objective 9: Impact assessment

The potential significance of environmental impacts identified during topsoil stripping was determined by using a ranking scale, based on the following (the terminology is from the DEAT guideline document on EIA Regulations, April 1998):

Occurrence

Probability of occurrence (how likely is it that the impact may occur?), and duration of occurrence (how long may it last?)

Severity

Magnitude (severity) of impact (will the impact be of high, moderate or low severity?), and scale/extent of impact (will the impact affect the national, regional or local environment, or only that of the site?).

In order to assess each of these factors for each impact, the following ranking scales **(Table 8**) were used:

TABLE 8. RANKING SCALES FOR IMPACT ASSESSMENT.

Probability:	**Duration**:
5 – Definite/don’t know	5 – Permanent
4 – Highly probable	4 - Long-term (ceases with the operational life)
3 – Medium probability	3 - Medium-term (5-15 years)
2 – Low probability	2 - Short-term (0-5 years)
1 – Improbable	1 – Immediate
0 – None	
Scale:	**Magnitude**:
5 – International	10 - Very high/don’t know
4 – National	8 – High
3 – Regional	6 – Moderate

2 – Local	4 – Low
1 – Site only	2 – Minor
0 – None	

Once the above factors had been ranked for each impact, the environmental significance of each was assessed using the following formula:

SP = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). Environmental effects were rated as either of high, moderate or low significance on the following basis:

- More than 60 significance points indicated high environmental significance.
- Between 30 and 60 significance points indicated moderate environmental significance.
- Less than 30 significance points indicated low environmental significance.

TABLE 9. IMPACTS ON SOIL

Nature: Loss of topsoil due to stripping, handling and placement of soil associated with pre-construction land clearing and rehabilitation.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Long Term (4)	Short Term (1)
Magnitude	Moderate (6)	Low (4)
Probability	Very Probable (4)	Very Probable (4)
Significance	**Moderate (44)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Irreversible	Reversible
Irreplaceable loss of resources?	Irreplaceable	Replaceable
Can impacts be mitigated?	Yes	
Mitigation measures: • Strip all usable soil, irrespective of soil depth.		
Cumulative impact: • Cumulative impact of loss of topsoil due to stripping and placement associated with pre construction land clearing and rehabilitation is rated as low because effective mitigation measures are available.		
Residual impact: • Minor localised loss of topsoil		

TABLE 9. IMPACTS ON SOIL/CONTINUED

Nature: Change of soil's physical, chemical and biological properties due to loss of topsoil due to erosion, stockpiling, mixing of deep and surface soils during handling, stockpiling and subsequent placement.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Long Term (4)	Short Term (1)
Magnitude	Moderate (8)	Low (4)
Probability	Very Probable (5)	Very Probable (4)
Significance	**Moderate (65)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Irreplaceable	Irreplaceable
Can impacts be mitigated?	Yes	
Mitigation measures: • Implement live placement of soil where possible, improve organic status of soils, maintain fertility levels and curb topsoil loss.		
Cumulative impact: • Cumulative impact of soil's physical, chemical and biological properties due to loss of topsoil, due to erosion, stockpiling, mixing of deep surface soils during handling, stockpiling and subsequent placement is considered to be low because effective mitigation measures can be implemented.		
Residual impact: • Minor localised degradation of topsoil's chemical, physical and biological properties.		

TABLE 9. IMPACTS ON SOIL/CONTINUED

Nature: Change of natural surface topography due to reprofiling of surface after stripping.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Long Term (4)	Short Term (1)
Magnitude	Moderate (8)	Low (4)
Probability	Very Probable (5)	Very Probable (4)
Significance	**Moderate (65)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Irreversible	Reversible
Irreplaceable loss of resources?	Irreplaceable	Replaceable
Can impacts be mitigated?	Yes	

Mitigation measures:

- Implement surface digital terrain mapping to ensure surface water control measures are implemented to ensure free draining system with minimal soil erosion.

Cumulative impact:

- Cumulative impact of the change of surface topography due to reprofiling of surface after stripping is considered to be low because effective mitigation measures can be implemented.

Residual impact:

- Minor changes in topography and localised degradation of topsoil's chemical, physical and biological properties.

TABLE 9. IMPACTS ON SOIL/CONTINUED

Nature: Loss of land with high agricultural potential and land capability.		
	Without Mitigation	**With Mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (4)	Low (4)
Probability	High Probable (4)	High Probable (4)
Significance	**Moderate (40)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Direct impacts cannot be mitigated but direct impacts can be minimised and avoided through adequate planning of layout and rehabilitation.	
Mitigation measures: • Loss of agricultural land due to establishment of infrastructure is a long term loss and no mitigation measures exist. Mitigation is restricted to limitation of extent of impact to the immediate area of impact and minimisation of off-site impacts. • Loss of agricultural land due to opencast mining is a temporary loss which can be mitigated by appropriate backfilling and re-placement of stockpiled topsoil. If done correctly, most of the original agricultural potential will be restored.		
Cumulative impact: • Soil erosion may arise due to altered surface water runoff. Management and erosion control measures should be implemented.		
Residual impact: • Loss of agricultural land is a long term loss, limited to the footprint of the		

infrastructure, which is a minimal percentage of the surface area of the land. Agriculture can still continue on the rest of the unoccupied areas.

5.8.1 Impact Assessment & recommendations

The results of the Impact Assessment for the proposed mine on Portions 8, 22 Farm Kennedy's Vale 361KT & Portions 24, 25, 26 and 28 Farm Spitskop 333KT find the proposed activity will have a medium to low impact on the immediate and surrounding soil systems. Implementation and management of proposed mitigation measures will minimize loss of topsoil, prevent contamination of topsoil and stockpiled soil and prevent overall soil erosion.

It is recommended that the proposed project be approved subjected to the mitigation measures stipulated in the Impact Assessment and Environmental Management Programme

5.8.2 Environmental Management Programme

The environmental management programme (**Table 10**) summarises the key findings of the mitigation measures and suggest potential management actions in order to mitigate the potential visual impacts.

TABLE 10. ENVIRONMENTAL MANAGEMENT PROGRAMME

OBJECTIVE: Mitigate the possible visual impact associated with construction phase.		
Project Component(s)	Construction site	
Potential Impact	Visual impact of general construction	
Activity/risk source	Potential impact on surrounding environmental receptors.	
Mitigation: Target/Objective	Minimal aesthetic disturbance by construction activities.	
Mitigation: Action/control	**Responsibility**	**Timeframe**
An Environmental Coordinator must manage environmental impacts in coordination with	Client	Pre-Construction

construction schedule.		
Contractors to sign and undertake environmental compliance.	Client	Pre-Construction
Keep disturbed areas and stockpiles to minimum to prevent soil loss.	Client/contractor	Construction
Identify suitable areas to stockpile stripped soil.	Client/contractor	Construction
Prevent surface runoff and seepage on site from contaminating stockpiled soils and stripped areas.	Client/contractor	Construction
Minimise soil erosion through wind and water	Client/contractor	Construction
Remediate and rehabilitate disturbed areas in accordance with development plan	Client/contractor	Construction
Performance Indicator	Construction site is confined to demarcated boundaries and buffer zones. No transgression is allowed outside the set boundaries and protocol of the set specifications.	
Monitoring	Monitoring to be undertaken by a certified appointed Environmental Officer.	

5.8.3 Cumulative Impacts

The major impacts associated with mining operations are the disturbance of natural occurring soil profiles consisting of layers or soil horizons. Rehabilitation of disturbed areas aims to restore land capability but the South African experience is that post mining land capability usually decreases compared to pre-mining land capability. Soil formation is determined by a combination of five interacting main soil formation factors. These factors are time, climate, slope, organisms and parent material. Soil formation is an extremely slow process and soil can therefore be considered as a non-renewable resource.

The study area is predominantly natural veld and wilderness. With mining taking place primarily on the steep slopes of the existing topography the cumulative project impact in the area is a minimal loss of loss off natural veld due to mining activities.

6 CONCLUSIONS

- The dominant soil forms recorded and identified according to the Taxonomical Soil Classification System of South Africa are Hutton, Oakleaf, Bloemdal, Mispah and Glenrosa soil forms.

- The effective depth of the Hutton, Oakleaf and Bloemdal soils exceeds 300mm inclusive of the *Orthic A, Red Apedalic and Neocutanic B – Horizons*.

- The agricultural potential (**Table 3, p20**) of the Hutton, Oakleaf and Bloemdal soils is considered medium to high under dryland (*650mm/y rainfall*) and irrigation conditions *(>10-15mm/week 33-1,500kPa plant available water*).

- Evidence of natural soil erosion was observed on the soils during the investigation. Careful consideration should be given during mining to minimise impacts on the soil that could enhance soil erosion. It could be considered as contributing to the surrounding environment for the mine to implement artificial measures to minimise natural soil erosion.

- The current land use includes 4,48% mining & industrial, 87,69% natural veld, 3,75% ploughed land, 3,46% settlement and 0,62% wetlands. Land capability includes 17,42% arable, 0,62% wetland, 76,14% wilderness with 2,36% occupied by mining & industrial and 3,46% settlement of the total study area investigated.

- A minimum of topsoil stripping will occur during the mining process due to the fact the mining process will be confined to the steep slopes of the mountainous areas. A soil stripping and stockpiling strategy was compiled and is included in **Table 7, p41**. From the soil data considering all available topsoil on Portions 8 and 22 of Farm Kennedy's Vale 361KT and Portions 24, 25, 26 and 28 of the Farm Spitskop 333KT an estimated total 3,303ha could potentially be covered 300mm thick at a bulk density of 1,275kgm^3 during rehabilitation taking into consideration a 10% loss from the 11,010,000m^3 available topsoil due to handling, compaction *etc*.

- The soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15mg/kg) and potassium (>50mg/kg) are readily available for plant uptake and sustainable plant growth. The *Orthic A-Horizon* is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and

15% clay with drainage properties in order of 10mm/h. The dominant clay mineral in the *Orthic A – Horizon, Yellow* & *Neocutanic B – Horizon* is kaolinite (*1:1 layer silicate*), with a low buffer capacity due to the low cation exchange capacity *(<10cmol+/kg*).

- The soil horizons specified in **Section 5.1 p17** of the Hutton, Oakleaf and Bloemdal are suitable for rehabilitation purposes.

7 REFERENCES

VAN DER WATT H. AND VAN ROOYEN, T.H. 1990. A Glossary for Soil Science. V&R Printing Works (Pty) Ltd, Pretoria.

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This investigation was done on available information and subsequent interpretation of data to reveal the properties on site with the techniques described.

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