Rehab Green cc
Registration No: 2002/094339/23

PI Steenekamp
PO Box 12636
Queenswood
0121
Pretoria

Cell: 082 560 0592
Fax: 086 678 1690
E-mail: rehabgreen@ee-sa.com

Rehab Green
Environmental and Rehabilitation Monitoring Consultant cc

Report No: RG/2011/02/28/1
Date: 7 July 2014

REPORT

Soil, land capability and land use assessment of the proposed Greenfields Rietvlei Opencast Coal Mine footprint, situated on portion 1 and the remaining extent of the farm Rietvlei 397 JS, near Middelburg, Mpumalanga Province

Requested By

WSP Environmental (Pty) Ltd

Compiled By

Rehab Green Monitoring Consultants CC
Environmental and Rehabilitation Monitoring Consultant cc
P.I. Steenekamp (Cert.Sci.Nat.)

Declaration of Independence

In terms of Section 32 of the EIA Regulations 2010 published in terms of Chapter 5 of the National Environmental Management Act (Act 107 of 1998) specialists involved in Impact Assessment processes must declare their independence and furnish details of experience.

I, Piet Steenekamp, hereby declare that I have no conflict of interest related to the work of this report. Specially, I declare that I have no personal financial interests in the property and/or development being assessed in this report, and that I have no personal or financial connections to the relevant property owners, developers, planners, financiers or consultants of the development. I declare that the opinions expressed in this report are my own and a true reflection of my professional expertise.

P.I. Steenekamp

Date: 7 July 2014

CONTENTS

TABLES:

Tables within appendices:

FIGURES:

Figures within appendices:

Appendices:

1. INTRODUCTION

1.1 Project background

Rietvlei Mining Company (Pty) Ltd has applied for a Mining Right in terms of Section 22 of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) on portion 1 and the remaining extent of the farm Rietvlei 397 JS, situated on the southern side of the R555 tar road, approximately 22 km northeast of Middelburg, Mpumalanga Province (Figure 1).

The proposed mine will be known as Rietvlei Opencast Coal Mine and will be mined by conventional truck and shovel methods. Mining will progress in both northerly and southerly directions.

Figure 1: Regional setting of the proposed Rietvlei Opencast Coal Mine

1.2 Scope of work

Rehab Green Monitoring Consultants cc was requested to conduct a detailed soil, land capability and land use assessment of the areas that might be utilized for mining and associated infrastructure.

The study provides input to the Environmental Impact Assessment (EIA) as required in terms of the Mineral and Petroleum Resources Development Act (MPRDA), Act 28 of 2002 and the National Environmental Management Act (NEMA), Act 107 of 1998. The Acts require that pollution and/or degradation of the environment is to be avoided, or where either aspect cannot be avoided, is to be minimized and remedied.

1.3 Assumptions

The proposed infrastructure shown on all figures in the report was extracted from an electronic Mine Layout Plan (in dwg format), dated 13/08/2013, received from WSP Environmental (Pty) Ltd (WSP). It was assumed that this plan is the most recent plan.

2. STUDY AIMS AND OBJECTIVES

The study objectives were to:

- Conduct a detailed soil assessment within the extent of proposed mining activities and infrastructure footprints;
- Classify and map soil forms according to the South African Taxonomic Soil Classification System, 1991;
- Derive and map land capability based on soil properties;
- Identify soil properties related to wetness to enable the delineation of wetland zones based on guidelines of the Department of Water Affairs;
- Map all pre-mining and current land uses;
- Determine all possible impacts by the proposed activities and provide associated mitigation measures; and
- Compile a soil stripping and stockpiling plan with rehabilitation guidelines and mitigation measures for proposed opencast mining areas.

3. LOCATION OF PROPOSED MINE INFRASTRUCTURE KEY FEATURES OF THE SOIL STUDY AREA

The boundaries of portion 1 and the remaining extent of the farm Rietvlei 397 JS are indicated with a thick solid red line in Figure 2. The area covered by the soil assessment is referred to as the Soil Study Area and is indicated with a dashed green line and covers 1419 ha. The proposed open pit footprint is shown with a solid yellow line and covers an area of 805 ha.

Three permanent pan wetlands and five temporary, weakly expressed pan wetlands, hatched in light blue, occur in the Soil Study Area. Three cultivated fields are indicated in green, comprising 75.12 ha, 39.49 ha and 59.54 ha which translated to a total of 174 ha.

The proposed infrastructure consisting of a current access road, diverted access road, haul roads, pollution control dam, catchment dam, hards stockpile, softs stockpile and plant footprint are shown in Figure 2.

The majority of the Soil Study Area (1058 ha) was used for forestry and consists currently mainly of re-grown *Eucalyptus* trees. Three cultivated fields comprising a total of 174 ha are used for soybeans and maize production. Some of the pan wetlands comprising a total of 101 ha are grazed from time to time.

Figure 2: Location of proposed mine infrastructure and key features of the Soil Study Area

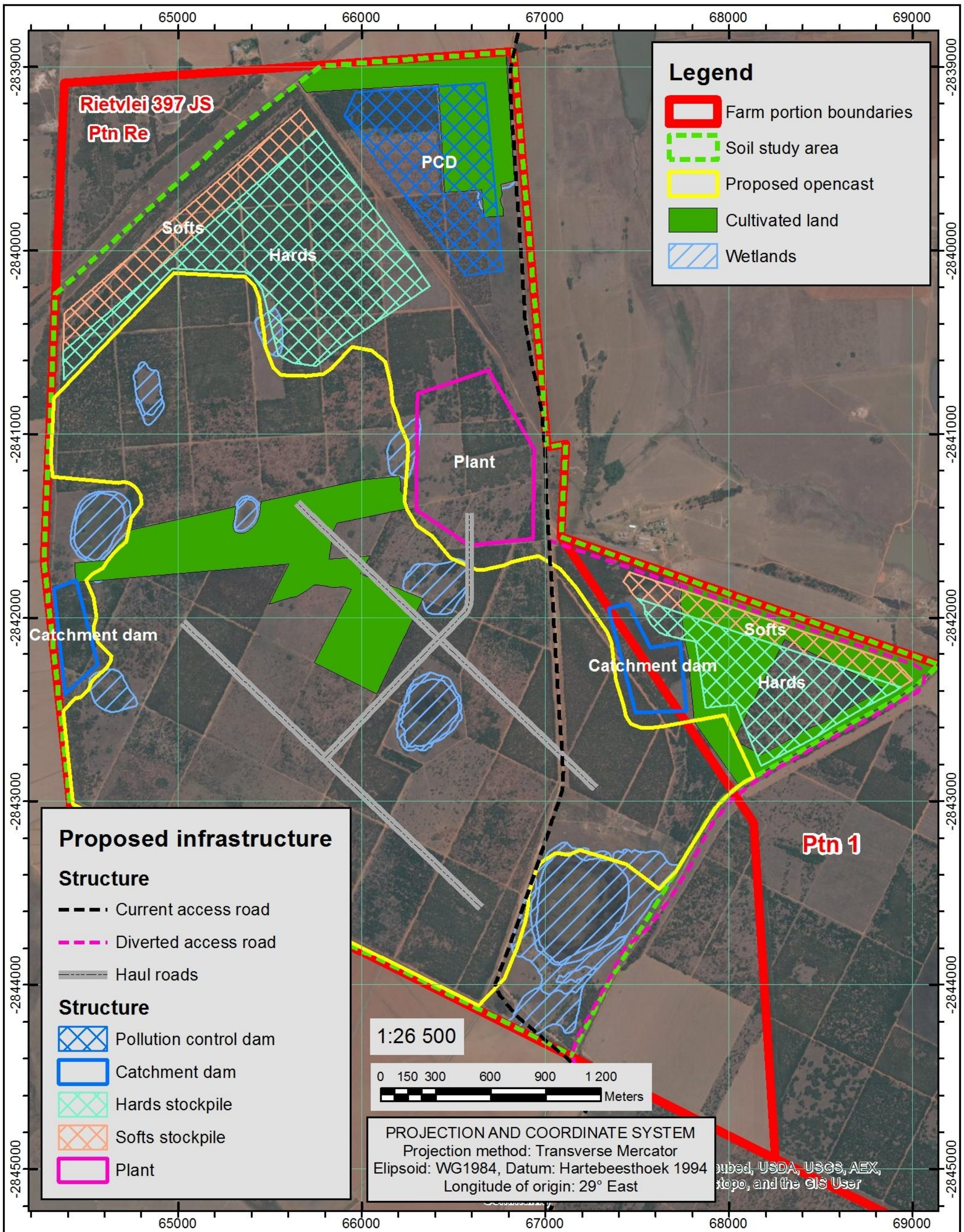


Figure 2: Location of proposed mine infrastructure and key features of the Soil Study Area

4. METHODOLOGY

4.1 Field preparation

Geographic Information System (GIS) software from Esri (ArcGIS-ArcMap) was used to process all available data for accurate surveying and map compilations. The farm portion boundaries was extracted from an electronic dgn file obtained from Ezendalo Environmental Solutions named “1104_ARN_RIETVLEI BHS _WG29”. The proposed infrastructure shown on all figures in the report was extracted from an electronic Mine Layout Plan (in dwg format), dated 13/08/2013, received from WSP. The extracted layers was converted to a shapefile format and superimposed on a Google Earth image.

A grid of field observation points were generated at 150 m intervals along all access routes crisscrossing the plantation. The coordinates of the observation points were calculated and loaded on a Geographic Positioning System (GPS) to accurately locate the position of the observation points in the field. Large scale field maps (1:5000 scale) showing the proposed mining area and observation points on aerial photo background were printed to use during the field assessment.

4.2 Soil classification

The soils of the proposed opencast and infrastructure areas were investigated by means of auger holes to a depth of 1500 mm or to refusal. The soils were described and classified according to the South African Taxonomic Soil Classification System (Soil Classification Working Group, 2nd edition 1991). The system of soil classification is explained in Appendix A.

The following procedure was followed to note soil properties and classify soils accordingly:

i) Identify applicable diagnostic horizons by noting the physical properties such as:

- Effective depth (depth of soil suitable for root development);
- Colour (in accordance with Munsell colour chart);
- Texture (refers to the particle size distribution);
- Structure (aggregation of soil particles into structural units);
- Mottling (alterations due to continued exposure to wetness);
- Concretions (cohesion of minerals into hard fragments);
- Leaching (removal of soluble constituents by percolating water);
- Gleying (reduction of ferric oxides under anaerobic conditions, resulting in grey, low chroma soil colours); and
- Illuviation of colloidal matter from one horizon to another, resulting in the development of grey sandy E-horizons and grey clay G-horizons.

ii) Determine the appropriate soil Form and soil Family according to the above properties.

The soil properties that were used to map fairly homogeneous soil types are discussed in Appendix B.

4.3 Soil sampling and analyses

The A-horizons (0-250 mm) and B-horizons (350-700 mm) of the dominant soil types were sampled and analysed at the Institute for Soil, Climate and Water. The analyses were conducted according to methods set out in the Handbook of Standard Testing for Advisory Purposes (Soil Science Society of South Africa, 1990). The following analyses were conducted:

- Soil acidity (pH) in a 1:2.5 water solution;
- Extractable cations (Na, K, Ca and Mg) according to the ammonium acetate method; and
- Phosphorus status according to the Bray 1 method.

4.4 Land capability assessment

Land capability was assessed according to the definitions outlined in the guidelines for the rehabilitation of mined land by the Chamber of Mines of South Africa and Coaltech Research Association (2007). Soil types were classified into the following categories for areas that exclude wetlands:

- Arable land;
- Grazing land; and
- Wilderness.

4.5 Dry land crop production potential

The classification of dry land crop production potential of soils was based on physical soil properties noted during auger observations, such as effective soil depth, texture, terrain unit, slope, soil wetness and disturbances. The effective soil depth and texture class are the main soil characteristics that determined the agricultural potential. The criteria applied for the classification of the agricultural potential of soils are as follows:

- **High** – well-drained and moderately well-drained loamy sand to sandy clay loam soils with an effective depth deeper than 900 mm.
- **Moderate** - well-drained and moderately well-drained loamy sand to sandy clay loam soils with an effective depth of 600- 900 mm.
- **Low** - well-drained and moderately well-drained sandy or clay soils.
- **Very low** – Imperfectly to poorly drained, grey, sandy soils showing evidence of periodic percolating water tables, or black and grey clay soils showing evidence of poor internal drainage.

4.6 Wetland and riparian delineation

Wetland and riparian zones were delineated according to the practical field procedure for the identification and delineation of wetlands and riparian areas (Department of Water Affair and Forestry, 2005). Four indicators were used in the study to delineate wetland and riparian zones, namely:

- Terrain unit;
- Soil form;
- Soil wetness; and
- Wetland and riparian vegetation.

Further details on the delineation of wetland areas are included in Appendix C.

4.7 Land use mapping

The localities and extents of land use practices were surveyed during the time of the soil assessment.

4.8 Erodibility evaluation

Erodiblity was broadly assessed based on soil texture, slope and the inherent stability of the parent rock (geology) from which the soil originated.

Low: Soils with stable physical and chemical properties which occur on flat to gentle slopes to ensure low erosion susceptibility in the natural state. Few erosion protection measures are necessary.

Moderate: Soils with low to moderately unstable physical or chemical properties or soils occurring on moderate to steep slopes. Sheet and rill erosion often occur in the natural state but may become severe when these soils are disturbed or due to any misuse such as overgrazing. Erosion protection measures are necessary.

High: Soils with unstable physical and chemical properties or soils occurring on very steep slopes. Rill and donga erosion often occur in the natural state and will become severe during any disturbance or misuse. Specialised erosion protection measures are necessary.

4.9 Map compilations

The field data was captured in shapefile format (shp) and processed and stored in a Geographic Information System called ArcGIS. The maps are compiled in a map extendable document format (mxd) and exported to Jpeg format. The shapefiles can be exported to a dxf or dwg format for CAD users. The shapefiles, dxf and dwg formats are available on request.

The maps were generated in a projected coordinate system using the longitude of origin (LO) coordinate system based on the 29° East meridian, WG1984 Ellipsoid and Hartebeesthoek 1994 Datum.

4.10 Approach to impact assessment and management

The EIAMAP[1] is a comprehensive tool used to manage the negative environmental impacts associated with mining and related activities and consists of two key aspects.

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

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

4.10.1 Impact assessment methodology

Section 31(2)(k), Chapter 3 of the R. 543 (2010) in terms of the NEMA[2], 1998 requires an assessment of the extent, duration, probability and significance of the identified potential environmental impacts of the proposed mining operation. In order to comply

[1] EIAMAP: Environmental Impact Assessment and Management Action Plan.
[2] NEMA: National Environmental Management Act, 1998 (Act no: 107 of 1998).

with best practice principles, the evaluation of impacts was conducted in terms of the criteria presented in **Table 1.1**.

The significance of the current impacts, which exist even with mitigation measures in place, was determined using the methodology indicated below.

Table 1.1: Impact assessment criteria

Status		
Positive	+	Impact will be beneficial to the environment (a benefit).
Negative	-	Impact will not be beneficial to the environment (a cost).
Neutral	0	Where a negative impact is offset by a positive impact, or mitigation measures, to have no overall effect.
`Magnitude		
Minor	2	Negligible effects on biophysical or social functions / processes. Includes areas / environmental aspects which have already been altered significantly, and have little to no conservation importance (negligible sensitivity).
Low	4	Minimal effects on biophysical or social functions / processes. Includes areas / environmental aspects which have been largely modified, and / or have a low conservation importance (low sensitivity).
Moderate	6	Notable effects on biophysical or social functions / processes. Includes areas / environmental aspects which have already been moderately modified, and have a medium conservation importance (medium sensitivity).
High	8	Considerable effects on biophysical or social functions / processes. Includes areas / environmental aspects which have been slightly modified and have a high conservation importance (high sensitivity).
Very high	10	Severe effects on biophysical or social functions / processes. Includes areas / environmental aspects which have not previously been impacted upon and are pristine, thus of very high conservation importance (very high sensitivity).
Extent		
Site only	1	Effect limited to the site and its immediate surroundings.
Local	2	Effect limited to within 3-5 km of the site.
Regional	3	Activity will have an impact on a regional scale.
National	4	Activity will have an impact on a national scale.
International	5	Activity will have an impact on an international scale.
Duration		
Immediate	1	Effect occurs periodically throughout the life of the activity.
Short term	2	Effect lasts for a period 0 to 5 years.
Medium term	3	Effect continues for a period between 5 and 15 years.
Long term	4	Effect will cease after the operational life of the activity either because of natural process or by human intervention.
Permanent	5	Where mitigation either by natural process or by human intervention will not occur in such a way or in such a time span that the impact can be considered transient.
Probability of occurrence		
Improbable	1	Less than 30% chance of occurrence.
Low	2	Between 30 and 50% chance of occurrence.
Medium	3	Between 50 and 70% chance of occurrence.
High	4	Greater than 70% chance of occurrence.
Definite	5	Will occur, or where applicable has occurred, regardless or in spite of any mitigation measures.

Once the impact criteria were ranked for each impact, the significance of the impacts was calculated using the following formula:

Significance = (Magnitude + Duration + Extent) x Probability

As is evident from the above equation, the extent (spatial scale), magnitude, duration (time scale) and the probability of occurrence of each identified impact were assigned a value according to the impact assessment criteria (presented in Table 1.1, above) and used to calculate the significance of each impact.

A Significance Rating was then calculated by multiplying the Severity Rating with the Probability, and is therefore a product of the probability and the severity of the impact. The maximum value that can be reached through the described impact evaluation process is 100 SP[3]. The scenarios for each environmental impact are rated as High (SP≥60), Moderate (SP 31-60) and Low (SP<30) significance as shown in **Table 1.2**.

Table 1.2: Definition of significance rating

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

Once the significance rating of an impact before mitigation has been determined, the reversibility of the impact, 'replaceability' of the affected resources and the potential of the impact to be further mitigated also need to be determined. These factors are explained in the table below, and play an important role in the determination of the level and type of mitigation performed or to be implemented. **Table 1.3** sets out the criteria that were used to assess the reversibility, loss of resources and potential for further mitigation.

Table 1.3: Mitigation prediction criteria

Reversibility of impact		
Reversible	1	The impact on natural, cultural and / or social structures, functions and processes is totally reversible.
Partially	2	The impact on natural, cultural and / or social structures, functions and processes is partially reversible.
Irreversible	3	Where natural, cultural and / or social structures, functions or processes are altered to the extent that it will permanently cease, i.e. impact is irreversible.
Irreplaceable loss of resources		

[3] SP: Significant Points.

Replaceable	1	The impact will not result in the irreplaceable loss of resources.
Partially	2	The Impact will result in a partially irreplaceable loss of resources.
Irreplaceable	3	The impact will result in the irreplaceable loss of resources.
Potential of impacts to be mitigated		
High	1	High potential to mitigate negative impacts to the level of insignificant effects, or to improve management to enhance positive impacts.
Medium	2	Potential to mitigate negative impacts. However, the implementation of mitigation measures may still not prevent some negative effects.
Low	3	Little or no mechanism exists to mitigate negative impacts.

The EIAMAP also provides a column in the table that identifies a specific impact as an I&AP[4] concern and also indicates who raised the concern as well as cross referencing with the relevant public participation parts of this document for more detail

The impacts expected to occur as result of the activities that are anticipated to take place at the proposed Project site may combine with those resulting from surrounding activities and land uses to form cumulative impacts, or to contribute to cumulative impacts that already exist. These have been assessed in Section 8.

4.10.2. Environmental Management Plan (EMP)

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

- **The mitigation management objectives and principles**– these have been identified to enable goals to be set for the environmental management of the proposed mining operations. Carefully planned management objectives and principles are the foundations of an effective EMP[5].
- Design plays a large role in the mitigation process, thereby ensuring that the project takes a proactive stance to environmental management. Therefore, **mitigation by design** has also been discussed where applicable in the EIAMAP's.
- **Proposed mitigation measures**– some mitigation measures / recommendations have been proposed that, when implemented, would enable the project to achieve the identified environmental management goals / objectives. The mitigation measures identified will modify, remedy, control or stop any action, activity or process that is identified as possibly impacting adversely on the environment.
- **Time Frames**–an indication of the estimated timeframe for the implementation of the proposed mitigation measures has been identified, where possible.

[4]I&AP: Interested and Affected Party/ies
[5] EMP: Environmental Management Programme.

5. SURVEY RESULTS

5.1 Dominant soil types

Soil types were mapped based on soil information gathered by means of auger observations at 150 meter intervals along all roads crisscrossing the Soil Study Area. A total of 744 auger observations were made of which 406 were at pre-determined grid points and 338 randomly and in transects of 25 m intervals towards pans in order to locate and accurately map soil boundaries and to delineate wetland zones.

Only the 406 pre-determined auger observation points are shown on the soils map Figure 3. The 338 random and transects points towards the pan wetlands are not shown or labelled due the high density of the points which clutter the labelling of the soil type units on the current scale of the map. A separate A2 size map showing labelled observation points is available on request.

A total of 14 soil types, based on dominant soil form, effective soil depth, internal drainage, terrain unit and slope percentage were identified during field observations and were symbolised as: **Hu1**, **Hu2**, **Hu3**, **Gf**, **Cv1**, **Cv2**, **Cv3**, **Cv4**, **Gc, Ct/Lo**, **Lo1**, **Fw**, **Fw-Exc** and **Kd-w**. An excavated area or quarry with no remaining soil were identified and symbolised as Exc. The extent of the soil types are shown on the soil map, Figure 3.

A detailed soil legend is provided in Table 2 which describes the soils in terms of the following aspects:

- Dominant soil forms and families and subdominant soil forms;
- The estimated clay content of the A and B or E or G-horizons;
- A broad description of the dominant soil form and terrain in terms of the effective soil depth, internal drainage, soil colour, soil texture class, terrain unit, average slope percentage range and erodibility class;
- A description of the soil horizon sequences;
- The derived agricultural potential, land capability and wetland zone classification; and
- The area and percentage comprised by each soil type.

Figure 3: Detailed soil map of the proposed Rietvlei opencast mining area

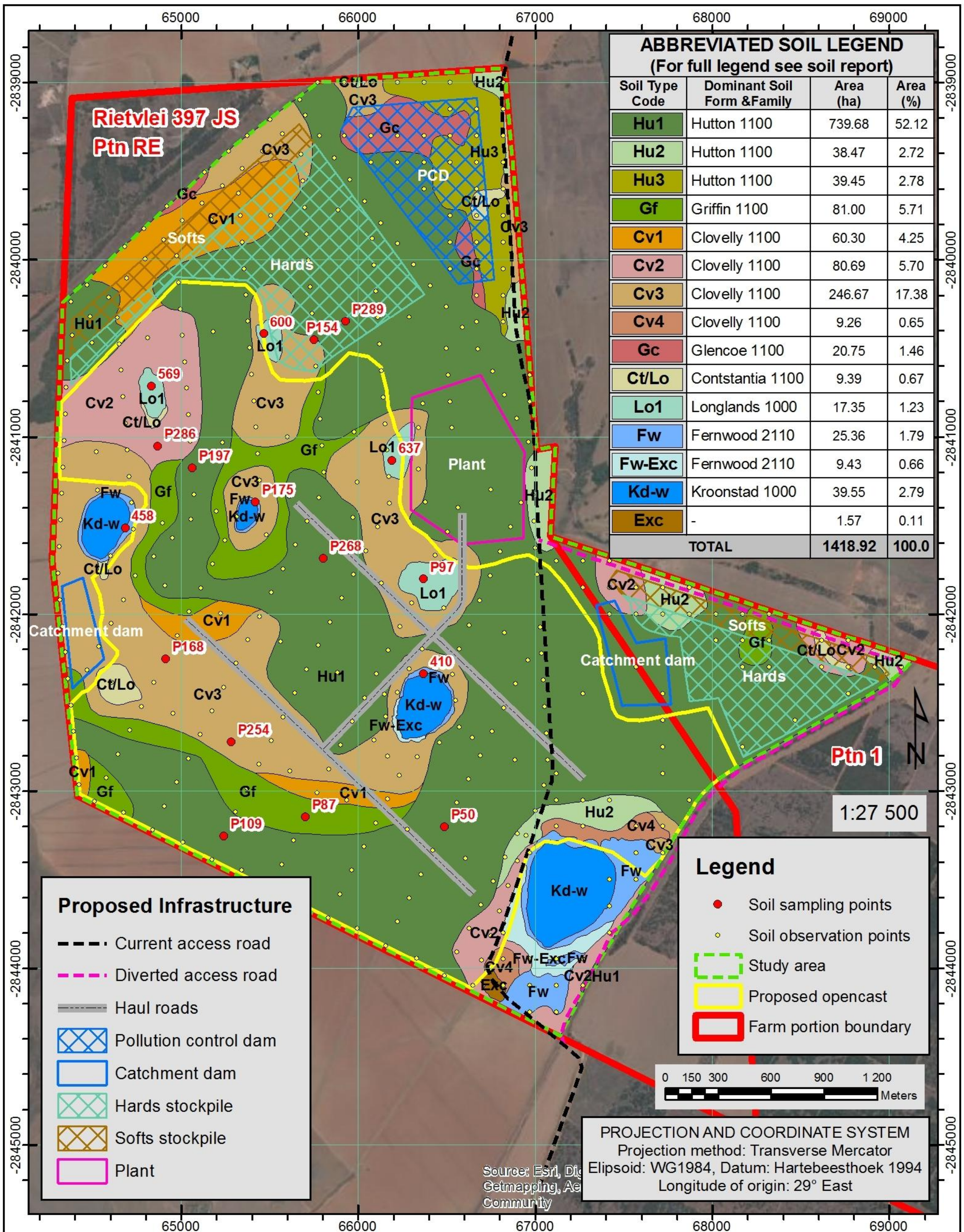


Figure 3: Detailed soil map of the proposed Rietvlei opencast mining area

Table 2: Soil legend based on soil types, effective soil depth, terrain unit and slope percentage

SOIL LEGEND													
Soil Type Code	**Dominant Soil Form and Family**	**Subdominant Soil Form and Family**	**Effective Soil Depth (mm)**	**% Clay per horizon A, E, G, B**	**Texture Class**	**Terrain**	**Summarized Description of Dominant Soil Form**	**Agricultural Potential**	**Land Capability**	**Ero-dibility**	**No of Units**	**Area (ha)**	**Area (%)**
Hu1	Hutton 1100	Bloemdal 1100	1500-1600	A: 12-15 B1: 16-20 B2: 20-30	Loamy sand-sandy clay loam	Flat to gently sloping crests and midslopes (0-3% slopes)	Soil: Very deep, red, well-drained soils. Profile: Brownish red, loamy sand Orthic A-horizons underlain by red, apedal, sandy loam to sandy clay loam B1 and B2 horizons.	High	Arable	Low	3	739.68	52.12
Hu2	Hutton 1100	Bloemdal 1100	400-800	A: 12-15 B1: 15-20	Loamy sand-sandy loam	Gentle sloping midslopes (3-6% slopes)	Soil: Shallow to moderately deep, red, well-drained soils with occasional gravely spots. Profile: Brownish red, loamy sand Orthic A-horizons underlain by red, apedal, sandy loam B1 horizons underlain by weathered rock.	Moderate	Arable	Low	6	38.47	2.72
Hu3	Hutton 1100	Dresden, Glencoe, Glenrosa, Mispah, Avalon	200-500	A: 15-20 B1: 15-25	Sandy loam	Gentle sloping midslopes (2-6% slopes)	Soil: Shallow, mainly reddish brown, gravely soils underlain by hardpan ferricrete. Profile: Brownish red, sandy loam, gravely Orthic A-horizons directly underlain by hard plinthite or via a thin gravely, sandy loam, red apedal B-horizon.	Low	Grazing	Moderate	1	39.45	2.78
Gf	Griffin 1100	Clovelly 1100, Hutton 1100	1400-1600	A: 10-13 B1: 12-15 B2: 18-25	Loamy sand-sandy clay loam	Flat to gently sloping crests and midslopes (0-3% slopes)	Soil: Very deep, yellow brown to yellowish red, well-drained soils. Profile: Yellowish brown, loamy sand Orthic A-horizons underlain by brownish yellow, apedal, sandy loam B1 horizons underlain by yellowish red, sandy clay loam B2-horizons.	High	Arable	Low	5	81.00	5.71
Cv1	Clovelly 1100	Griffin 1100	1400-1600	A: 10-12 B1: 12-18	Loamy sand-sandy loam	Gentle midslopes (0-3% slopes)	Soil: Very deep, yellow brown, well-drained soils. Profile: Yellowish brown, loamy sand Orthic A-horizons underlain by brownish yellow, apedal, sandy loam B1 horizons.	High	Arable	Low	4	60.30	4.25
Cv2	Clovelly 1100	Pinedene 1100, Avalon 1100	1200-1500	A: 10-12 B1: 12-18	Loamy sand-sandy loam	Flat to gently sloping crests and midslopes (0-3% slopes)	Soil: Deep, yellow brown, well-drained soils. Profile: Yellowish brown, loamy sand Orthic A-horizons underlain by brownish yellow, apedal, sandy loam B1 horizons underlain by saprolite (highly weathered sandstone).	Moderate-high	Arable	Low	5	80.69	5.70
Cv3	Clovelly 1100	Pinedene 1100, Avalon 1100, Glencoe 1100	600-1200	A: 10-12 B1: 12-18	Loamy sand-sandy loam	Flat to gently sloping crests and midslopes (0-3% slopes)	Soil: Moderately deep, yellow brown, well-drained soils. Profile: Yellowish brown, loamy sand Orthic A-horizons underlain by brownish yellow, apedal, sandy loam B1 horizons underlain by saprolite (occasional sesquioxide concretions in B-horizons).	Moderate	Arable	Low	8	246.67	17.38
Cv4	Clovelly 1100	Avalon 1100, Glencoe 1100	250-500	A: 10-12 B1: 10-14	Loamy sand	Flat to gently sloping mid and footslopes (0-4% slopes)	Soil: Shallow, yellow brown, well-drained soils underlain by weathered rock. Profile: Yellowish brown, loamy sand Orthic A-horizons underlain by brownish yellow, apedal, sandy loam B1-horizons underlain by weathered rock.	Low	Grazing	Low	2	9.26	0.65

Gc	Glencoe 1100	Dresden, Avalon, Clovelly	300-600	A: 10-12 B1: 10-14	Loamy sand	Gentle midslopes (1-3% slopes)	Soil: Shallow, yellow brown, well-drained soils underlain by hard plinthite. Profile: Yellowish brown, loamy sand Orthic A-horizons often directly underlain by hard plinthite or via a thin brownish yellow, sandy loam, apedal B-horizon.	Moderate to low	Grazing	Low-moderate	3	20.75	1.46
Ct/Lo	Contstantia 1100	Longlands 2000, Pinedene 1100	600-1000	A: 8-10 E: 6-10 B1: 15-20 B2: 20-30	Sandy-sandy loam	Gently sloped, temporary seepage zones, isolated or adjacent to closed depressions (<1% slope)	Soil: Greyish yellow to yellow brown, imperfectly drained soils. Profile: Grey, sandy Orthic A-horizons, underlain by grey to greyish yellow, sandy E-horizons, underlain by yellow brown, sandy loam B-horizons	Low	Temporary wetland	Low	6	9.39	0.67
Lo1	Longlands 1000	Fernwood 2110	400-1000	A: 8-10 E: 4-8 B: 20-30	Sandy-loam	Slightly concave, weakly expressed, closed depressions on crests (0-1% slopes)	Soil: Grey, imperfectly to poorly drained, sandy soils. Profile: Dark grey to black, sandy Orthic A-horizons, underlain by grey to greyish white, sandy E-horizons, underlain by grey, slightly mottled soft plinthite	Low	Temporary/ seasonal	Low	4	17.35	1.23
Fw	Fernwood 2110	Longlands 1000	400-1000	A: 4-8 E: 1-5	Sandy	Dryer edge of submerged, closed depressions on crests (0-1% slopes)	Soil: Grey, poorly drained, sandy soils. Profile: Grey to dark grey, sandy Orthic A-horizons, underlain by greyish white, sandy E-horizons, underlain by hard or weathered rock or soft plinthite	Low	Seasonal wetland	Low	6	25.36	1.79
Fw-Exc	Fernwood 2110	-	0-1000	A: 4-8 E: 1-5	Sandy	Dryer edge of submerged, closed depressions on crests (0-1% slopes)	Soil: Disturbed, grey, imperfectly drained, sandy soils. Profile: Grey, sandy Orthic A-horizons, underlain by greyish white, sandy E-horizons, underlain by hard or weathered rock.	Low-none	Seasonal wetland	Low-moderate	2	9.43	0.66
Kd-w	Kroonstad 1000	Fernwood 2110, Longlands 1000, Katspruit 1000	0-200	A: 10-15 E: 5-10 G: 30-50	Sandy-clay	Slightly concave, submerged, closed depressions on crests (</% slopes)	Soil: Grey, saturated, sandy soils underlain by gleyed clay. Profile: Grey, loamy sand Orthic A-horizons, underlain by greyish white, sandy E-horizons, underlain by grey, clay G-horizons	Low-none	Permanent wetland	Low	4	39.55	2.79
Exc	-	-	0	-	-	Excavated area - quarry	No remaining topsoil - Excavated area - quarry	None	Wilderness	High	1	1.57	0.11
										TOTAL	**60**	**1418.92**	**100.0**

5.2 Soil chemistry

The positions of the soil sampling points are shown on the soil map Figure 3 and coordinates are included in Appendix D, Table D1.

A sample of the A and B-horizon of the dominant **arable** soil types were taken at 10 localities and the analytical results is highlighted in green in Table 3. The average cation, potassium (K), calcium (Ca) magnesium (Mg) and sodium (Na) as well as phosphorus and ph values were calculated and highlighted in yellow.

A-horizon samples (0-250mm) were taken in the pan wetlands (**wetland soils**) and the analytical results are highlighted in blue in Table 4. The electrical conductivity (EC) and sulphate content (SO_4) were analyzed additionally (highlighted in orange) in order to determine salt content and any mine related pollution. The average cation K, Ca, Mg and Na as well as phosphorus, ph, EC and SO_4 values were calculated and highlighted in pink.

Table 3: Soil chemical analyses

Samp Point	Soil Form	Hor	Depth	K	Ca	Mg	Na	Titr.Acid	Acid saturat.	Resis-tance	P (Bray1) mg/kg	pH (H_2O)	Electr Cond. (EC) mS/m	Sulphate (SO_4) mg/kg
				mg/kg	mg/kg	mg/kg	mg/kg							
				Ammonium acetate				cmol(+)/kg	%	ohm				
Arable soils														
P50	Hu2200	A	0-250	10	19	4	12.6	0.98	86.4725	9060	1.9	4.59		
		B1	350-700	5	2	0.71	10.4			8530	1.7	4.34		
P87	Gf2100	A	0-250	12	1	0.22	12.9	1.48	97.5294	8280	1.8	4		
		B1	350-700	6	0.35	0.24	15.2			8940	1.3	4.39		
P109	Hu2200	A	0-250	20	45	5.9	10.1	0.95	74.5530	5180	3.3	4.6		
		B1	350-700	11	23	3.1	10.6			6900	1.7	4.41		
P154	Cv2100	A	0-250	22	0.33	5	3.9	1.4	93.3916	4270	5.9	4.16		
		B1	350-700	13	0.47	14.2	3.5			11730	1.4	4.67		
P168	Cv2100	A	0-250	8	2	0.35	3.6	1.3	97.5009	7100	1.4	4.27		
		B1	350-700	5	0.74	6.9	3.2			6720	1.3	4.29		
P197	Hu2200	A	0-250	29	40	8.8	3.8	0.92	72.6585	4040	2.5	4.65		
		B1	350-700	19	7	20.2	3.3			7880	1.6	4.75		
P254	Av2100	A	0-250	24	43	3	2.5	1.01	77.0614	5950	2.7	4.55		
		B1	350-700	13	47	24	3.7			11190	1.3	4.96		
P268	Hu2200	A	0-250	40	226	43	3.2	0.07	4.2323	2930	10.2	5.5		
		B1	350-700	17	91	21	4.6			3340	1.6	4.74		
P286	Cv2100	A	0-250	18	3	8	5.1	1.11	89.7441	4690	1.6	4.46		
		B1	350-700	37	1	17	5.5			6020	1.3	4.68		
P289	Hu2200	A	0-250	21	49	13	4.1	0.91	69.1902	4650	1.9	4.66		
		B1	350-700	17	8	3	4.7			7100	1.4	4.48		
Averages of arable soils				**17.4**	**30.4**	**10.1**	**6.3**				**2.39**	**4.6**		
Wetland soils														
P97	Lo1000	A	0-250	31	106	15	6.1	0.81	52.5400	4540	1.5	4.76	**15**	**16.75**
P175	Lo1000	A	0-250	44	136	32	16.5	0.49	31.7245	2310	1.2	5.05	**23**	**33.75**
410	Fw2110	A	0-250	52	159	35	3.2	0.67	35.5537	4220	5.1	4.89	**11**	**10.37**
458	Fw2110	A	0-250	22	106	19	7.7	0.33	30.7955	6290	1.3	5.24	**8**	**6.05**
569	Lo1000	A	0-250	122	76	18	3.4	0.79	48.4838	3430	12.2	4.76	**17**	**26.92**
600	Lo1000	A	0-250	47	42	11	0.9	1.06	71.6061	4610	5.7	4.5	**11**	**7.92**
637	Lo1000	A	0-250	88	198	79	12.9	0.76	28.9712	2560	2.3	4.8	**20**	**29.45**
Averages of Wetland soils				**58**	**117**	**30**	**7.2**				**4.2**	**4.8**	**13**	**22.4**

5.2.1 Soil fertility status

The averages of the cations, phosphorus and pH values of the **arable soils** (highlighted in yellow, Table 3) were compared to general fertility guidelines in Table 4. The averages of K, Ca and Mg values are very low (see comparison in Table 4) and reflect the general low fertility status of non cultivated loamy sand to sandy loam soil in the Highveld region. The low average ph value of 4.6 indicates very acid soil conditions.

The average cation, phosphorus and pH values of the **wetland soils** (highlighted in pink, Table 3) are fairly higher than the arable soils but still low compared to guidelines in Table 4. The average SO_4 value of 22.4 mg/kg is low and indicate no current mine related pollution. The average EC value of 13 mS/m is low and indicates no accumulation of salts in the soil horizons and subsequent absence of sodic or saline soil conditions.

Table 4: Soil fertility compared to broad fertility guidelines

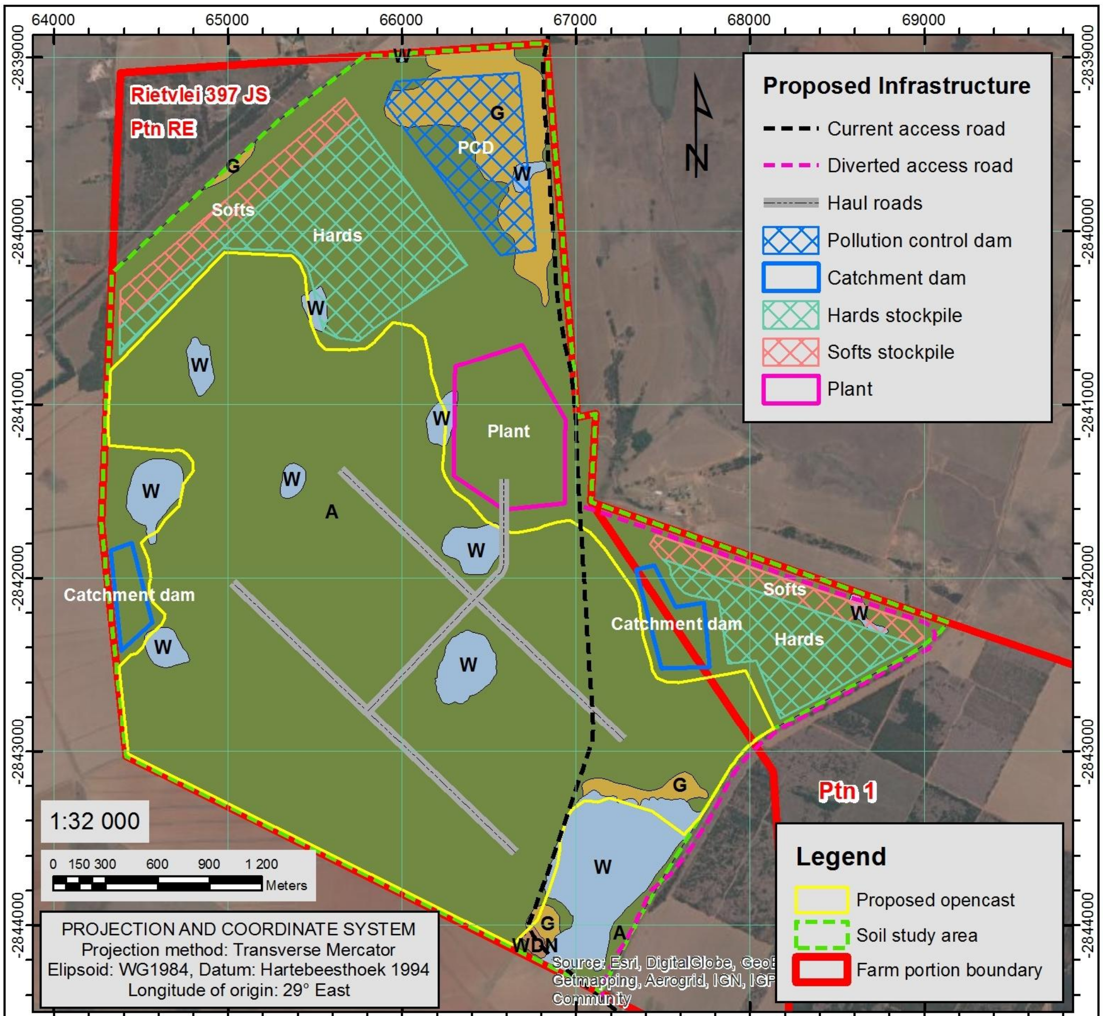
Guidelines (mg/kg)			Actual analysis
	Low	**High**	Average calculated in Table 4 (mg/kg)
Potassium (K)	<40	>250	17.4 (Very low)
Calcium (Ca)	<200	>3000	30.4 - (Extremely low)
Magnesium (Mg)	<50	>300	10.1 - (Very low)
Sodium (Na)	<50	>200	6.3 - (Low)
Phosphorus (P)	<5	>35	2.39 - (Low)

pH(H_2O)						
Very acid	Acid	Slightly acid	neutral	Slightly alkaline	Alkaline	
<4	5-5.9	6-6.7	6.8-7.2	7.3-8	>8	4.6 (Very acid)

5.3 Land Capability

The location and extent of land capability classes within the Soil Study Area are shown in Figure 4.

Figure 4: Land capability map of the proposed Rietvlei opencast mining area



LEGEND: LAND CAPABILITY

Land Capability Code	Land Capability Class	*Soil Types	Broad Soil Description	Unit Count	Area (ha)	Area (%)
A	Arable	Hu1, Hu2, Gf, Cv1, Cv2, Cv3	Terrain: Flat to gently sloping crests and midslopes (0-6% slopes). Soil: Very deep (>1500 mm), red, well-drained, loamy sand to sandy clay loam soils; Moderately deep to deep (600-1500 mm), yellow brown, well-drained, loamy sand to sandy loam soils.	2	1246.81	87.88
G	Grazing	Hu3, Cv4, Gc	Terrain: Gently sloping midslopes and footslopes (0-6% slopes); Soil: Shallow, red, gravely, sandy loam soils and shallow, brownish yellow, loamy sand soils.	4	69.46	4.89
W	Wetland	Ct/Lo, Lo1, Fw, Fw-Exc, Kd-w	Terrain: Gently sloped, temporary seepage zones, weakly expressed closed depressions and prominent closed depressions on crests. Soil: Grey, imperfectly to poorly drained sandy soils underlain by weathered or hard rock, soft plinthite or gleyed clay.	12	101.08	7.14
WDN	Wilderness	Exc	Terrain: Excavated area - Quarry; Soil: No remaining soil.	1	1.57	0.11
*See soil map, Figure 3			**Total**	**19**	**1418.92**	**100.0**

Figure 4: Pre-mining land capability map of the proposed Rietvlei opencast mining area

The land capability of the Soil Study Area is summarized in Table 5 which shows the soil types grouped into each land capability class, a broad description of the soil group, the number of units per land capability class, and the area and percentage comprised by each land capability class.

Table 5: Land capability classes

LEGEND: LAND CAPABILITY						
Land Capability Code	**Land Capability Class**	***Soil Types**	**Broad Soil Description**	**Unit Count**	**Area (ha)**	**Area (%)**
A	**Arable**	Hu1, Hu2, Gf, Cv1, Cv2, Cv3	Terrain: Flat to gently sloping crests and midslopes (0-6% slopes). Soil: Very deep (>1500 mm), red, well-drained, loamy sand to sandy clay loam soils; Moderately deep to deep (600-1500 mm), yellow brown, well-drained, loamy sand to sandy loam soils.	2	1246.81	87.88
G	**Grazing**	Hu3, Cv4, Gc	Terrain: Gently sloping midslopes and footslopes (0-6% slopes); Soil: Shallow, red, gravely, sandy loam soils and shallow, brownish yellow, loamy sand soils.	4	69.46	4.89
W	**Wetland**	Ct/Lo, Lo1, Fw, Fw-Exc, Kd-w	Terrain: Gently sloped, temporary seepage zones, weakly expressed closed depressions and prominent closed depressions on crests. Soil: Grey, imperfectly to poorly drained sandy soils underlain by weathered or hard rock, soft plinthite or gleyed clay.	12	101.08	7.14
WDN	**Wilderness**	Exc	Terrain: Excavated area - Quarry; Soil: No remaining soil.	1	1.57	0.11
*See soil map, Figure 3			**Total**	**19**	**1418.92**	**100.0**

5.3.1 Wetland and riparian delineation

Land capability was assessed in categories of arable land, grazing land, **wetlands** and wilderness land. Wetlands were therefore delineated as part of the land capability assessment based on soil properties by means of systematic auger observations towards wetland zones in order to locate the point where soil properties reflect signs of wetness within 500 mm from the surface or where soil, topography and vegetation combined, indicate the boundary of the riparian zone.

The soil types associated with wetlands are summarized in Table 5 and the locality and extents are shown on the land capability map Figure 4. (See Appendix C for details on soil properties related to wetland zones).

5.3.2 Derived dry land crop production potential and long term potential yields

The derived dry land crop production potential and potential crop yields (based on soil properties) of soil types within the Soil Study Area are summarised in Table 6. These soil qualities were rated as high, moderate and low with classifications in-between these.

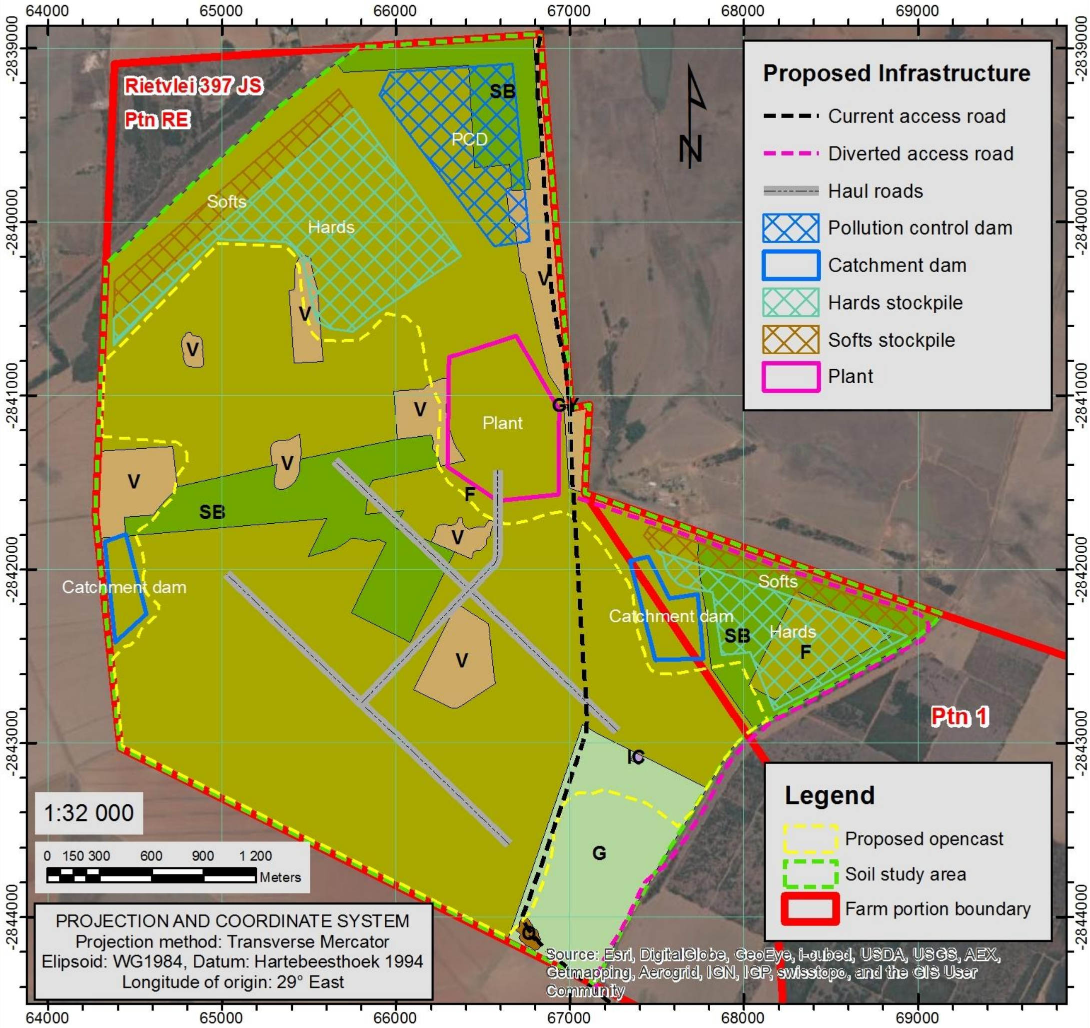
Table 6: Derived dry land crop potential and long term potential yields

Soil Type (Code)	Dry land crop production potential class	Potential long term yields for maize (t/ha/a)	Potential long term yields for soybeans (t/ha/a)	Grazing capacity for cattle (ha/lsu)
Hu1, Gf, Cv1	High	5-8	1.8-2	5-8
Cv2	Moderate-high	4-6	1-1.8	
Hu2, Cv3	Moderate	3-5	1-1.5	
Hu3, Gc, Cv4	Moderate-low	2-3	0.8-1.2	
Ct/Lo, Lo1, Fw,	Low	1-3	0.5-1	
Fw-Exc, Kd-w	Very low to none	0	0	
Miscellaneous land classes				
Exc	None	0	0	Not suitable

5.4 Pre-mining land use

The localities and extents of pre-mining and current land uses within the Soil Study Area are shown in Figure 5 and are summarized in Table 7.

Figure 5: Pre-mining land use map of the proposed Rietvlei opencast mining area



LEGEND – PRE-MINING LAND USE				
Land Use Code	**Pre-mining Land Use**	**Unit Count**	**Area (ha)**	**Area (%)**
F	Forestry - Eucalyptus trees	2	1058.40	74.59
SB	Cultivation - Soybeans	3	174.15	12.27
G	Grazing by local people - mainly cattle	1	84.55	5.96
V	Vacant - no specific land use - mainly wet zones	8	99.94	7.05
GY	Graveyard	1	0.02	0.00
Q	Quarry	1	1.57	0.11
IC	Informal community	1	0.28	0.02
	TOTAL	**17**	**1418.91**	**100.0**

Figure 5: Pre-mining land use map of the proposed Rietvlei opencast mining area

Table 7: Pre-mining land uses

LEGEND – PRE-MINING LAND USE				
Land Use Code	**Pre-mining Land Use**	**Unit Count**	**Area (ha)**	**Area (%)**
F	Forestry - Eucalyptus trees	2	1058.40	74.59
SB	Cultivation - Soybeans	3	174.15	12.27
G	Grazing by local people - mainly cattle	1	84.55	5.96
V	Vacant - no specific land use - mainly wet zones	8	99.94	7.05
GY	Graveyard	1	0.02	0.00
Q	Quarry	1	1.57	0.11
IC	Informal community	1	0.28	0.02
	TOTAL	**17**	**1418.91**	**100.0**

Table 7 shows that the majority of the soil study area (74.59%) was utilized for forestry (currently mainly re-grow of *Eucalyptus* trees), 12.27% is used for cultivation (soybeans), 5.96% for grazing (mainly cattle) and 7.05% are vacant spots where forestry or cultivation could not take place due to wetness. Small land uses such as graveyards, a quarry and housing footprint of the local community occupies 0.03% of the soil study area

5.5 Historical agricultural production

The majority of the Soil Study Area (1058.4 ha) is used for forestry. Cultivated fields covers 174 ha which is used for soybeans or maize production. Some of the pan wetlands (101 ha) are grazed from time to time by local farmers.

5.6 Evidence of misuse

The plantation appeared to be poorly managed. Many blocks of trees were cut previously and not replanted which subsequently adversely affect the current productivity of the area.

5.7 Existing structures

Existing structures are graveyards and the housing structures of the informal community.

5.8 Sensitive landscapes

The pan wetlands are sensitive landscapes (see Figure 4)

6. ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impact assessment in terms of soils, land capability and land use for the construction, operational and decommissioning phases including mitigation measures is compiled in a separate MS Excel spreadsheet.

7. REHABILITATION / MITIGATION

7.1 Principles for stripping and stockpiling of topsoil

Stripping and stockpiling has an impact on soil, land capability and land use, but it is important to realize that the way this action is performed is also the first and one of the most important mitigation measures. The impact on soil, land capability and land use are mitigated by means of the rehabilitation process which commences with **stripping and stockpiling of topsoil before mining takes place** and is **not** a process that **starts with replacing of topsoil** after or during the mining operation. Rehabilitation and subsequent mitigation of soil, land capability and land use consists therefore of the following phases:

- Stripping and stockpiling of topsoil
- Backfill of open pits and leveling of spoil material to a free draining surface
- Replacing and leveling of topsoil and preparation of the surface
- Soil amelioration and re-vegetation

If the first phase of rehabilitation namely stripping and stockpiling of topsoil, is not done with the aim of reinstating post-mining land capability similar to pre-mining land capability, then successful rehabilitation will not be achieved and it will probably result in a serious deterioration from pre-mining to post-mining land capability.

In practice, even with optimal rehabilitation procedures applied, some deterioration from pre-mining to post-mining land capability is unavoidable. It is therefore crucial to follow the proposed rehabilitation procedures precisely in order to minimise degradation of soil characteristics and to re-establish the highest possible post-mining land capability.

The term topsoil refers to the A and B-horizons of the soil profile as defined in the Taxonomic Soil Classification system for South Africa. The A-horizon comprises the upper part (0-300 mm) of the soil profile and the B-horizon from 300 mm up to the stripping depth specified per soil type indicated in Figure 6. The characteristics of soil horizons (A- and B-horizons) are further described in Appendix E in terms of soil stripping, stockpiling and replacing.

Stripping, stockpiling and replacing of topsoil has a very high impact on soil, land capability and land use and the procedures followed during execution of these actions directly influence the post-mining land capability and consequently determine the degree of deterioration from pre-mining to post-mining land capability. They also directly determine the possible post-mining land uses.

During stripping and stockpiling the following principles should be aimed for:

- ***Prevent mixing of high quality topsoil (A and B-horizons) with low quality underlying material to ensure sufficient volumes of high quality soil for rehabilitation*.** The quality of soil earmarked for rehabilitation purposes significantly deteriorates when the high quality topsoil is mixed with the underlying poorer quality material (clay layers, calcrete, plinthite, weathered rock etc). This results in significant deterioration in the quality of the soil's physical and chemical properties and a decline in the soil fertility necessary for re-vegetation. The deterioration in soil quality also significantly increases the susceptibility of rehabilitated soils for erosion and seal and crust formation.

- ***Separate stockpiling of different soil type groups to obtain the highest post-mining land capability*.** Topsoil quality or potential is not just limited to the grade of soil generally referred to as topsoil but can vary from very high to low due to various properties. Soil properties of different soil types can vary substantially e.g. high quality red and yellow well-drained soils and low quality grey poorly drained wetland soils can occur over very short distances in the same field. Mixing of different soil types results in rapid changes in soil properties and characteristics such as texture, infiltration rates and water holding capacity over short distances after replacement, which will definitely adversely affect the post-mining land capability.

- ***Separate stripping, stockpiling and replacing of soil horizons (A and B-horizon) in the original natural sequence to combat hardsetting and compaction, maintain soil fertility and conserve the natural seed source.*** The higher soil fertility of the A-horizon, especially phosphorus and carbon contents, declines significantly when it is mixed with the B-horizon, resulting in poorer re-vegetation success. It also increases the susceptibility to compaction and hard setting. The A-horizon also serves as a seed source which will enhance the re-establishing of natural species. The A and B-horizons should be stripped and stockpiled separately and replaced with the A-horizon overlying the B-horizon. Contrary to the general perception, separate stockpiling of different soil types and horizons does not have significant cost implications for the mine and only requires planning and continuing management.

The soil horizons and properties influencing stripping and stockpiling procedures are discussed in Appendix E.

7.2 Handling of topsoil from construction to decommissioning phase

Handling of topsoil from construction to decommissioning phase should be based on the following principles. However, some deviation of the principles may take place in order to accommodate the engineering design and requirements for each specific structure.

7.2.1 Structures to be demolished during the decommissioning phase

Procedures to follow for structures with a flat basis involving coalliferous material such as coal stockpiles, haul roads, sidings and plants:

- The A-horizon should be removed to a depth of 200-300 mm and stored as a berm along linear structures or around block structures. This can be achieved by using graders or dozers. The aim (on the long term) is to leave the B-horizon undisturbed and later replace the A-horizon in its original position, which implies a reconstruction of the original soil horizon sequences and subsequent less deterioration of land capability. The natural seed source which occurs mainly within the A-horizon is then replaced on the surface which will enhance succession to the natural state to some extent.
- The structure footprint should then be covered with a base material layer suitable for

the specific structure which will probably be specified by the engineering design (roads, foundations, sidings, stockpiles etc.)

- During the decommissioning phase the footprint should be thoroughly cleaned and all base material should be removed to a suitable disposal facility.
- The cleaned footprint (or exposed upper part of the B-horizon) should be ripped thoroughly to alleviate all compaction caused by the structure and related activities before replacement of the stored A-horizon.
- The stored A-horizon should be graded evenly over the total structure footprint.
- The soil should then be ameliorated according to soil chemical analysis of samples taken after replacement.
- The footprint should be re-vegetated with a grass seed mixture dominated by local species or a suitable mixture such as the so-called "Anglo Standard Pasture Mixture" as provided in Appendix F.

Procedures to follow for structures with a deeper concave basis involving coalliferous material such as pollution control dams:

- The A-horizon should be removed to a depth of 200-300 mm and stored as a berm around the structure or any other suitable position. This can be achieved by using graders or dozers. The aim (on the long term) is to replace the A-horizon in its original position, which implies some reconstruction of the original soil horizon sequences and subsequent less deterioration of land capability.
- The B-horizon (300 mm up to subsoil material) can be used for the construction or elevation of wall embankments but may not be mixed with subsoil material.
- The entire footprint should be lined with a polyethylene membrane or similar to prevent soil and groundwater pollution during the operational phase of the structure.
- During the decommissioning phase the footprint should be thoroughly cleaned and all coaliferous material should be removed to a suitable disposal facility.
- Material used for wall embankments should be replaced at the bottom
- The stored A-horizon should be graded evenly over the entire footprint.
- The soil should be ameliorated according to soil chemical analysis of samples taken after replacement.
- The footprint should be re-vegetated with a grass seed mixture dominated by local species or a suitable mixture such as the so-called "Anglo Standard Pasture Mixture" as provided in Appendix F.

Procedures for structures not involving coalliferous material such as roads, explosives magazines, pipelines, buildings, parking areas:

- The engineering design of some of these structure may require removal of a thin soil layer and others not. All topsoil which might be removed for the foundations of these structures should be stored for later rehabilitation.
- During the decommissioning phase the footprint should be thoroughly cleaned.
- The footprint should be ripped to alleviate compaction
- Stored topsoil should be replaced (if any) and the footprint graded to a smooth surface.
- The topsoil should be ameliorated according to soil chemical analysis.
- The footprint should be re-vegetated with a grass seed mixture dominated by local species or a suitable mixture such as the so-called "Anglo Standard Pasture Mixture" as provided in Appendix F.

7.2.2 Structures that will remain after the decommissioning phase

Procedures for structures involving coalliferous material such as discard dumps:

- Structures such as discard dumps mostly remain after the decommissioning phase and are usually responsible for serious salt pollution to soil and water resources on a continuing bases. It is therefore critical to ensure that sufficient soil material is removed and stored during the construction phase in order to properly rehabilitate (cap) the structure to prevent pollution as far as possible.
- Shortages of topsoil are a common problem when large discard dumps needs to be capped and often leads to the creation of borrow pits which is an additional impact on soil, land capability and land use. It is recommended that at least 1000 mm of topsoil are removed within the planned footprint area. If less than 1000 mm of soil are available, the stripping depth as indicted on the stripping plan should be applied (Figure 6). In will be important to incorporate the stripping depths in the engineering design.
- The entire footprint should be compacted and lined as specified by the engineering design to prevent soil pollution due to leachates.
- Leachates should be channeled to a pollution control dam via lined or concrete drains.
- The gradients of the dump edges should be designed to facilitate effective capping of the dump with topsoil.
- During the operational and decommissioning phase the edges of the dump should be shaped to suitable gradients and can be covered with a lime layer before the topsoil are replaced.
- The soil should be ameliorated according to soil analysis and re-vegetated with a grass seed mixture dominated by a strong grower and stabilizing specie such as *Cynodon dactylon*.

7.2.3 Stripping and stockpiling of topsoil for opencast areas

The following procedures are mainly aimed for stripping and stockpiling of topsoil at the proposed open pit areas. The procedures are also applicable only to the phase before stripping and direct replacing (roll-over mining) takes place and does not imply that direct replacing may not take place. The amount of topsoil that will need to be stockpiled will therefore depend on at what stage and how effective the rehabilitation process are implemented and executed. The soil types that should be stripped and stockpiled together based on soil type and soil quality is shown in Figure 6. The Figure should be read together with Table 8 which shows the stripping depths, the areas and percentages as well as the total soil volume per soil type, based on the stripping depth. The stripping depths indicted in Figure 6 reveals the real average of available high quality soil. In order to make the stripping depth more achievable in practise it can be adapted to the closest interval of 300 mm (eg. 300, 600, 900, 1200 mm)

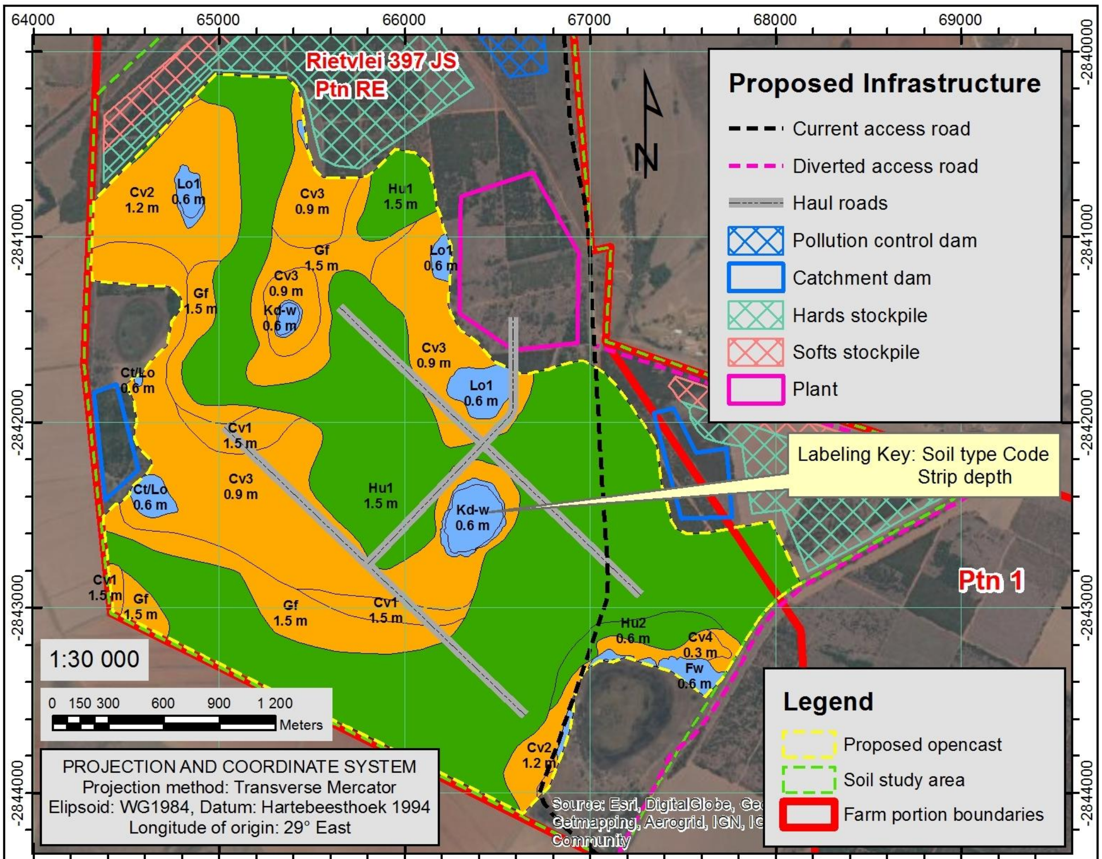
Table 8 also shows the replacing depth (topsoil thickness) and post-mining land capability class. The replacing depths is applicable to stockpiled topsoil only and not to areas where stripping and direct replacing takes place. The replacing depth was determined by calculating the total soil volume per soil group (Figure 6), divided by the original area which was stripped. This implies that topsoil which were stripped at different depths, and then stockpiled together, will be replaced at a single average depth.

At areas where stripping and direct replacing takes place, the replacing depths should be similar to the stripping depth as indicated in Figure 6.

The following guidelines for stripping and stockpiling procedures need to be aimed for:

- Figure 6 and Table 8 show the soil types to be stripped in the proposed open pit area. This Figure and Table show the combination (groups) of soil types that need to be stripped and stockpiled on 3 separate stockpiles. The size of the stockpiles should be based on the soil volume per stockpile as indicated in Figure 6 and Table 8. The volume will be determined by the timeframe before a roll-over mining method (direct replacing) is initiated. No stockpile height restriction is proposed as long as the soil type groups are stockpiled together as specified in Figure 6.
- The boundaries of the soil types that should be stripped at different depths and/or stockpiled separately should be surveyed and staked by the mine surveyor before any soil stripping commences. The soil boundaries can be adapted to follow the nearest mining blocks as usually created for a mine plan.
- Soils to be stripped and stockpiled on stockpile 1 are shown in green and consist of well-drained red soils.
- Soils to be stripped and stockpiled on stockpile 2 are shown in orange and consist of well to moderately well-drained brownish yellow soils.
- Soils to be stripped and stockpiled on stockpile 3 are shown in blue and consist of grey, imperfectly drained, sandy soils in temporary, seasonal and permanent wetland zones.
- The stripping plan, Figure 6, includes soil types in wetlands, shown in blue, but mining of these wetland areas is subject to authorization by the relevant government departments.
- The most suitable stockpile positions should be determined by the mine planner based on the mining sequence plan and need to be surveyed and staked by the mine surveyor.

Figure 6: Soil tripping and stockpiling guideline map



Legend: Pre-mining stripping depths, soil volumes, post-mining replacing depths and land capability

Soil stripping group and stockpile no.	Pre-mining					Post-mining			
						Replacing			
	Soil Types	Strip depth (m)	Area (ha)	Area (%)	Soil volume (m^3)	Depth (m)	Area (ha)	Area (%)	Land capability
Stockpile 1 (Red well-drained soils)	Hu1	1.5	421.94	52.44	6329100	1.5	433.96	53.93	Arable
	Hu2	0.6	12.02	1.49	72120				
		TOTAL	**433.96**	**53.93**	**6401220**				
Stockpile 2 (Brownish yellow well and moderately well-drained soils)	Gf	1.5	73.48	9.14	1102200	1.0	333.32	41.43	Arable
	Cv1	1.5	19.71	2.45	295650				
	Cv2	1.2	55.89	6.95	670680				
	Cv3	0.9	177.36	22.04	1596240				
	Cv4	0.3	6.88	0.85	20640				
		TOTAL	**333.32**	**41.43**	**3685410**				
***Stockpile 3** (Grey, imperfectly drained, sandy wetland soils)	Ct/Lo	0.6	5.02	0.62	30120	0.6	37.45	4.64	Grazing
	Lo1	0.6	13.37	1.66	80220				
	Fw	0.6	7.06	0.87	42360				
	Fw-Exc	0.6	1.91	0.24	11460				
	Kd-w	0.6	10.09	1.25	60540				
		TOTAL	**37.45**	**4.64**	**224700**				
		Grand Total	**804.73**	**100.00**	**10311330**		**804.73**	**100.0**	

*Stripping of the wetland soil units is subject to authorization of the relevant Government authorities

Figure 6: Soil stripping and replacing map of the proposed Rietvlei opencast mining area

The following procedures might also take place during the operational phase if a rollover mining method is applied.

7.2.4 Backfilling of open pits and leveling of spoil material

- Before topsoil can be replaced, the open pit should be backfilled to an elevation similar to the pre-mining topography in order to ensure a continuation of the pre-mining surface drainage pattern. The backfilled surface should be surveyed by a surveyor in order to ensure that it has the correct elevation and slopes to be free draining. A non free draining surface results in local depressions of periodically saturated zones and increased percolation which usually leads to localised subsidence of underlying spoil material. Slopes of the spoil surface should therefore be similar to the pre-mining surface and should change gradually since abrupt changes in slope gradient increase the susceptibility for erosion initiation.

7.2.5 Replacing and leveling of stored topsoil and preparation of the surface

- The backfilled and levelled spoil surface should be covered with stockpiled topsoil. Care should be taken to tip enough soil per square unit to reinstate the total required post mining soil depth at once. Spreading of soil over far distances and repeated traversing of heavy mechanical equipment should be minimised in order to prevent compaction in the lower profile which is difficult to alleviate afterwards. The dumped soil heaps should thus only be levelled on top to reach the required soil thickness. Caterpillar-type tracked equipment is preferred for levelling of topsoil because these tracks cause less compaction. Bowl scrapers cause enormous compaction and should not be used.
- The replaced topsoil thickness should be progressively monitored during replacement to verify if it is similar to the replacing depth provided in Table 8 and to prevent encountering shortages of topsoil.

Table 8 forms part of Figure 6 shows the stripping depths per soil type, the areas and percentages as well as the total soil volume per soil type. It also shows the post-mining land capability class and replacing depth (topsoil thickness) which was determined by calculating the total soil volume per soil group (stockpile), divided by the original areas which were stripped.

Table 8: Soil stripping, stockpiling and replacing guideline

Legend: Pre-mining stripping depths, soil volumes, post-mining replacing depths and land capability									
	Pre-mining					Post-mining			
						Replacing			
Soil stripping group and stockpile no.	Soil Types	Strip depth (m)	Area (ha)	Area (%)	Soil volume (m^3)	Depth (m)	Area (ha)	Area (%)	Land capability
Stockpile 1 (Red well-drained soils)	Hu1	1.5	421.94	52.44	6329100	1.5	433.96	53.93	Arable
	Hu2	0.6	12.02	1.49	72120				
		TOTAL	**433.96**	**53.93**	**6401220**				
Stockpile 2 (Brownish yellow well and moderately well-drained soils)	Gf	1.5	73.48	9.14	1102200	1.0	333.32	41.43	Arable
	Cv1	1.5	19.71	2.45	295650				
	Cv2	1.2	55.89	6.95	670680				
	Cv3	0.9	177.36	22.04	1596240				
	Cv4	0.3	6.88	0.85	20640				
		TOTAL	**333.32**	**41.43**	**3685410**				
***Stockpile 3** (Grey, imperfectly drained, sandy wetland soils)	Ct/Lo	0.6	5.02	0.62	30120	0.6	37.45	4.64	Grazing
	Lo1	0.6	13.37	1.66	80220				
	Fw	0.6	7.06	0.87	42360				
	Fw-Exc	0.6	1.91	0.24	11460				
	Kd-w	0.6	10.09	1.25	60540				
		TOTAL	**37.45**	**4.64**	**224700**				
		Grand Total	**804.73**	**100.00**	**10311330**		**804.73**	**100.0**	
*Stripping of the wetland soil units is subject to authorization of the relevant Government authorities									

7.2.6 Soil amelioration and re-vegetation

- The soil fertility status should be determined by soil chemical analysis after levelling (before seeding/re-vegetation), and soil amelioration should be done accordingly as recommended by a soil specialist, in order to correct the pH and nutrition status before re-vegetation.
- The footprint should be re-vegetated with a grass seed mixture dominated by local species or a suitable mixture such as the so-called “Anglo Standard Pasture Mixture” as provided in Appendix F. Crop farming can be re-introduced after a post-mining soil and land capability assessment was done by a soil specialist on areas declared suitable for crop farming.
- Re-vegetation should preferably take place in early summer to stabilize the soil and prevent soil loss during the rainy season.
- A short term fertilizer program should be based on the soil chemical status after the first year in order to maintain the fertility status for 2 to 3 years after rehabilitation until the area can be declared as self sustaining.

7.3 Post-mining land capability requirements

The post-mining land capability class will be determined mainly by the soil type and the thickness of the soil layer placed back on the spoil surface. Other factors and characteristics that might influence the post-mining land capability are slope, compaction and reduction of soil quality due to contamination of soils by subsoil, soft overburden or spoil material.

The post-mining land capability based on post-mining topsoil thickness should be as follows as provided in Table 8:

- Arable - 54 % of the mined area with a soil thickness of at least 1.5 m.
- Arable – 41% of the mined area with a soil thickness of at least 1.0 m.
- Grazing – 5% of the mined area with a soil thickness of at least 0.6 m consisting of the low potential, grey sandy soils of current wetland areas. (If the wetlands are mined, the wetland drivers will be destroyed and the pre-mining wetland land capability will change from wetland to grazing potential.

A post-mining land capability assessment needs to be done progressively (annually) during the operational phase by a soil specialist by means of auger observations at a grid spacing of 100 x 100 m. This is required to evaluate the rehabilitation procedures and to verify that the topsoil thickness is similar to the replacing depths provided in Table 8. A final post-mining land capability map needs to be compiled and should be submitted for closure purposes.

The post-mining land uses should remain a grass mixture until a post-mining soil and land capability assessment was done by a soil specialist. Crop farming can be re-introduces on areas declared suitable by the soil specialist.

8. CUMULATIVE IMPACTS

Activities such as opencast mining have severe and long term to permanent impacts on the environment and especially on the soil resource. Any impacts on soils directly impact on land capability and land use. These impacts accumulate over regional scale as larger and larger areas become mined and more and more mines are opened every year. Thousands of hectares of high potential and highly productive soils on the Eastern Highveld have already been mined and rehabilitated and are currently to a large extent vacant. The impact assessments of almost every mine currently indicate that the post-mining land capability will be similar to pre-mining. Unfortunately there are a huge difference between what almost every EMPR report declare the post-mining land capability will be and the **reality**. In reality almost none of the thousands of hectares of rehabilitated land are and can be used for crop farming such as maize or soybeans as prior to mining. Unfortunately the real statistics of post-mining land capability of soils in South Africa is unknown and it is difficult to obtain such information. Such information can only be obtained by means of detailed post-mining soil assessments. Rehab Green cc has assessed over the last 20 years numerous patches of rehabilitated land and the degradation from pre-mining to post-mining soil potential was found to be devastating. If the question is ask: Why does almost every single ha of rehabilitated land on the Eastern Highveld lies abandoned and unproductive, the answer is simply that the post-mining land capability in **reality** is far from similar to pre-mining and the EMPR commitments were not reached and the impact assessment was therefore incorrect. When the cumulative impacts on soils, land capability and land use are predicted the question rises whether it should it be based on the significance rating of the impact assessment for the specific project or should it be based on the **reality**.

8.1 Cumulative impact on soil in reality

Approximately 805 ha will be mined by opencast method and a further approximately

150 ha will be occupied by mining related structures for the lifespan of the mine. The irreversible impacts and loss of resource will mainly take place at the opencast footprint. Soils on a portion of this 805 ha opencast will be subject to stripping and stockpiling and the remaining portion on stripping and direct replacing. No matter what method is used the natural soil horizon sequence in terms of an A-horizon with specific properties underlain by a B-horizon with specific properties (developed over thousands of years) will be mixed and the very important functions of this sequence will be destroyed. Many other soil characteristics such as the incremental clay content lower down in the B-horizon which gradually increases water holding capacity and almost exponentially increase crop production potential will be destroyed to a large extent.

The open pit area consists of 434 ha red, arable soils of which the majority has an effective depth of at least 1.5 meter. A further 333 ha consists of yellow brown, arable soils of which the majority has an effective soil depth of at least 1.2 meter. The remaining 37 ha consists of grey, leached sandy soils with grazing or wetland potential. Even if the mitigation measures in the impact assessment are applied precisely a notable decrease in post-mining soil potential will occur in at least the 767 ha arable land.

Furthermore the soils will probably not be stockpiled on 3 separate or adjacent stockpiles according to soil types (red soils, yellow brown soil and grey soils) as required according to the proposed mitigation measures. Normally the mine planners provide only for 1 topsoil stockpile no matter what the mitigation measures for soils require. The contractor or operators who do the soil stripping will probably not have any idée of what the required soil stripping depths per soil type are and the soil stripping plan provided in the soil report will probably never be used. The post-mining effective soil depth will probably be significant shallower than pre-mining. The topography will probably differ significantly from pre-mining to post-mining causing blind drainage and severe erosion sensitive spots.

In reality, not much effort are done to follow simple but effective rehabilitation procedures in order to prevent loss of soil potential and quality as far as possible. Prescribed rehabilitation procedures are always claimed to be impractical and too costly. Therefore the entire opencast footprint of 805 ha will probably suffer a significant loss of soil potential and quality to such and extent that is will be not be suitable and utilized for productive crop farming ever.

The cumulative impact on soil can therefore probably be described as another at least 805 ha of unproductive or very low productive land that can be added to thousands of hectares of abandoned unproductive poorly rehabilitated mine property on the Eastern Highveld.

8.2 Cumulative impact on land capability in reality

The impact on soils causing deteriorating of soil potential and soil quality equally reflects the deterioration in land capability. Therefore the cumulative impact on land capability in **reality** can probably be described as another at least 805 ha of high potential arable land that will deteriorate to such an extent that it will not be possible to be phased back to viable crop farming as prior to mining. Another 805 ha can to add to the existing thousands of hectare of unproductive or very low productive mined land.

8.3 Cumulative impact on land use in reality

How much of rehabilitated mined land are sold back to commercial farmers and what is the difference in land uses from pre-mining to post-mining and what is the viability and profit from post-mining land uses compared to pre-mining land uses? If these questions are asked the answer is probably that hardly any rehabilitated land is sold back to commercial farmers which imply that land are permanently withdrawn from private ownership in the agricultural sector as prior to mining. Rehabilitated land are occasionally leased to farmers which are then mainly used for cattle grazing and are hardly ever used for crop farming as prior to mining which implies that there is a significant change from pre-mining to post-mining land uses due to the reduction of land capability and restriction on possible post-mining land uses. Pre-mining crop farming such as maize with yields of 4-7 tons per ha are replace with occasional cattle grazing which implies a huge loss of income and profit per hectare.

The cumulative impact on land use can therefore probably be describe as at least another 805 ha with loss of private ownership and effective land management by an experienced farmer, another at least 805 ha with significant loss of land use potential and another at least 805 ha with a significant loss of income and profit per hectare for the agricultural sector.

9. CONCLUSION

9.1 Soils and land capability (Soil study area)

The majority of the Soil Study Area, 87.88% (1246.81 ha), consist of well-drained, red and yellow brown, loamy sand to sandy clay loam soils with **arable land capability** and moderate to high agricultural potential. The arable soils are dominated by Hutton, Griffin and Clovelly soil forms, symbolized as soil types Hu1, Hu2, Gf, Cv1, Cv2 and Cv3.

Approximately 4.89% (69.46 ha) of the Soil Study Area is classed as **grazing potential** land with low agricultural potential. The grazing potential soils consist of shallow, red and yellowish brown, well-drained, loamy sand to sandy loam soils, dominated by Hutton, Clovelly and Glencoe soil forms, symbolized as soil types Hu3, Cv4 and Gc.

Approximately 7.14% (101.08 ha) of the study area is classed as **wetlands**, consisting of grey, imperfectly to poorly drained sandy soils dominated by Constantia, Longlands, Kroonstad and Fernwood soil forms, symbolized as Ct/Lo, Lo1, Fw, Fw-Exc and Kd-w.

A quarry situated in the southern part of the Soil Study Area covering 0.11% (1.57 ha) were classified as **wilderness land**, symbolized as Exc on the soil map Figure 3.

9.2 Pre-mining land use (Soil study area)

The majority of the soil study area (74.59%) was utilized for forestry (currently mainly re-grow of *Eucalyptus* trees), 12.27% is used for cultivation (soybeans), 5.96% for grazing (mainly cattle) and 7.05% are vacant spots where forestry or cultivation could not take place due to wetness. Small land uses such as graveyards, a quarry and housing footprints of the local community occupies 0.03% of the soil study area

9.3 Agricultural potential

Poor rehabilitation can, and generally in South Africa, leads to an enormous deterioration from pre-mining to post-mining land capability or agricultural potential.

Soil stripping and replacing, no matter whether it is stockpiled or immediately replaced will always have a high potential deteriorating impact on post mining land capability and land use. The degree of deterioration will **always** depend on the **precise execution, management and monitoring** of the rehabilitation procedures. The fact is that good proposed rehabilitation procedures do not automatically manifests in good rehabilitation and subsequent land capability. Rehabilitation procedures have to be implemented and properly executed on site by the responsible people and to be guaranteed it has to be monitored progressively by competent specialists.

Soils in the proposed opencast footprint, excluding the pan wetlands, have very high agricultural potential and although some deterioration from pre-mining to post-mining land capability is unavoidable, all possible precaution should be taken to ensure that deterioration of land capability is as little as possible. The only way to ensure as little deterioration as possible is to execute the proposed stripping and replacing procedures given in section 7.

10. RECOMMENDATIONS

In order to guarantee successful rehabilitation, the procedures in section 7 need to be executed as far as possible and the following needs to be monitored.

- Stripping of soil types at stripping depths as specified on Figure 6 and Table 8.
- Progressive evaluation of a free draining spoil surface, similar to the pre-mining topography, before topsoil is replaced during rehabilitation. Slopes should not exceed 4% anywhere on the post-mining foot print.
- Replacing of topsoil evenly over spoils during rehabilitation at depths as specified in Table 8.
- A fertilizer program based on soil analysis in order to ameliorate soils before seeding and re-vegetation take place.
- Re-vegetation of rehabilitated areas as soon as possible with a grass mixture until soils are stabilized before crop farming can be introduced.
- Monitoring of soil erosion on the rehabilitated areas and remediation if necessary until the area can be declared as stabilized and self sustaining.
- A post-mining soil depth and land capability evaluation by a soil specialist registered at the Council for Natural Scientific Professions (SACNASP) in order to map the final post-mining land capability which will be used for final post-mining land uses and closure purposes.

REFERENCES

Chamber of Mines of South Africa, Coaltech Research Association, 2007. Guidelines for the rehabilitation of mined land. Johannesburg.

Department of Environmental Affairs and Tourism, 1998. Environmental impact management. Implementation of sections 21, 22 and 26 of the Environmental Conservation Act, 1989, Pretoria: Government Printer (1998).

Department of Mineral and Energy Affairs, 1992**.** Aide-Memoire for the preparation of Environmental Management Programme Reports for prospecting and Mining. Pretoria.

Department of Water Affairs and Forestry, 2003. A practical field procedure for the identification and delineation of wetlands and riparian areas, DWAF, Pretoria.

Die Misstof vereniging van Suid Afrika, 1986. Bemestings handleiding, tweede hersiende uitgawe 1986, Pretoria.

Non-Affiliated Soil Analysis Working Committee, 1991. Methods of soil analysis. SSSSA, Pretoria.

Soil Classification Working Group, 1991. Soil classification. A taxonomic system for South Africa. Institute for Soil, Climate and Water, Pretoria.

Van der Watt, H.v.H and Van Rooyen T. H, 1990. A glossary of soil science, Pretoria: Soil Science Society of South Africa (1990).

APPENDIX A
SOIL CLASSIFICATION SYSTEM

The classification system categorizes soil types in an upper soil Form level which is subdivided into a number of lower Family levels. Each soil Form (higher level) is defined by a unique vertical sequence of soil horizons with specific defined properties. The soil Families (lower level) are a subdivision of the soil Form (higher level), differentiated on the basis of specific characteristics such as leaching status, calcareousness, structure types and sizes etc.

In this way, standardised soil identification and communication is allowed by use of soil Form names and family numbers or names e.g. Hutton 2100 or Hutton Hayfield. The soil Form and soil Family together are referred to as soil types.

The soil Forms are indicated by the name and the Family by its appropriate number e.g. Hutton 2100. The soil Form and Family are then symbolized e.g. Hu and referred to as soil type Hu. The soil Form and Family are often further categorized based on effective soil depth, terrain unit and slope and a numerical number is added to the symbol e.g. Hu1. For example, where the Hutton 2100 soil Form and Family occurs at an effective depth of 900-1200 mm, it is symbolized and referred to as soil type Hu1, and where this soil Form and Family occurs at an effective depth of 600-900 mm it is symbolized and referred to as soil type Hu2.

APPENDIX B
SOIL PROPERTIES AND CHARACTERISTICS

Various terms in the soil legend are used to describe a series of soil properties and characteristics such as the dominant soil Form and Family, effective soil depth, internal drainage, and clay content per soil horizon and texture class.

1. Effective soil depth

Effective soil depth can be considered as the depth freely permeable to plant roots and water. Effective soil depth categories used in the soil legend are as follows:

Very shallow	< 300mm
Shallow	300-600 mm
Moderately deep	600-900 mm
Deep	900-1500 mm
Very deep	> 1500 mm

2. Internal drainage

Internal drainage is the flow of water (annual precipitation) through the soil profile. Soils with the ability to drain annual precipitation though the profile without waterlogged periods within certain parts of the profile are called **well-drained** soils. Soils which lack this ability will display properties indicating temporary to permanent water logged conditions in parts of the soil profile in the form of mottling, leaching or gleying.

Moderately well-drained soils mostly display impeded internal drainage in the lower profile e.g. soft plinthic horizons, which is the result of periodically fluctuating water tables which are characterized by mottling and accumulation of iron and manganese oxides.

Imperfectly drained soils mostly display impeded internal drainage in the upper and lower parts of the profile e.g. E and plinthic horizons, which is the result of periodic lateral flow of water in the profile and fluctuating water tables. Such soils are characterized by grey, leached, sandy horizons and mottled plinthic horizons.

Poorly drained soils mostly display impeded internal drainage in the upper and lower parts of the soil profile e.g. E, plinthic and G-horizons and are the result of long term to permanent wetness in the soil profile, which is characterized by grey, leached, sandy horizons, mottled plinthic horizons and gleyed clay horizons.

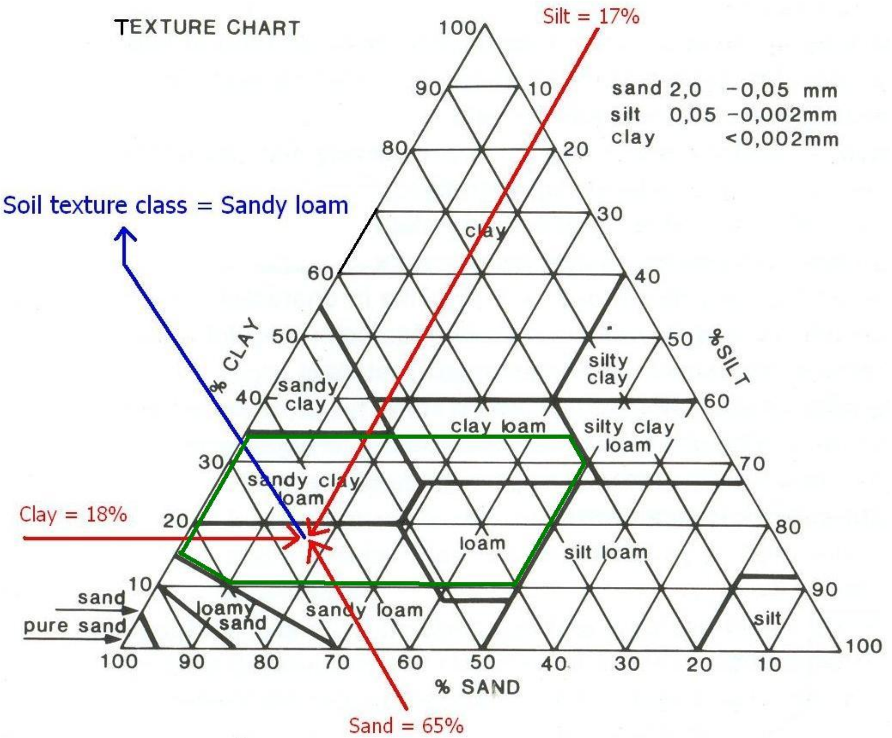
3. Texture class

Soil texture refers to the relative proportions of the various particle size separates in the soil. Particle sizes are defined in the following **fractions**.

Sand – (2.0 – 0.05 mm)
Silt – (0.05 – 0.002 mm)
Clay – (< 0.002 mm)

The relative proportions of these 3 fractions (as illustrated by the red arrows in Figure B1) determines 1 of 12 soil texture classes e.g. sandy loam, loam, sandy clay loam etc. The different texture class zones are demarcated by the thick black lines in the diagram. The green zone can be used as a guideline for moderate to high agricultural potential, but needs to be evaluated together with other soil properties.

Figure B1: Soil texture chart



APPENDIX C
WETLAND DELINEATION

1. Legal framework

In order to determine the existence and extent of a wetland in the proposed mining area the legal framework on what classifies as a wetland should be applied. The National Water Act, 1998 (Act 36 of 1998), (NWA), includes a wetland in the definition of a watercourse. A watercourse is:

- *"a river or spring;*
- *a natural channel in which water flows regularly or intermittently;*
- *a wetland, lake or dam into which, or from which, water flows, and*
- *any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse."*

A wetland is then further defined by the NWA as *"land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil".*

Based on the above definition, the Department of Water Affairs and Forestry (DWAF), now the Department of Water Affairs (DWA), published a set of guidelines describing field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries (DWAF, 2005). These guidelines state that wetlands must have one or more of the following attributes:

- *Wetland (Hydromorphic) soils* that display characteristics resulting from prolonged saturation;
- The presence, at least occasionally, of *water loving plants (hydrophytes)*; and
- A *high water table* that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.

Based on the NWA definition of a wetland, four indicators were identified within the DWAF (2005) guidelines to assist in identifying wetland areas:

- *Terrain Unit Indicator*. The topography of the area is usually used to determine where in the landscape the wetland is likely to occur.
- *Soil Form Indicator*. Certain soil forms, as defined by the Soil Classification Working Group (1991), are associated with prolonged and frequent saturation.
- *Soil Wetness Indicator*. The soil wetness indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- *Vegetation Indicator*. The vegetation indicator identifies hydrophilic vegetation associated with frequently saturated soils.

2. Processes in wetland soils and associated properties

The following processes normally take place under anaerobic/saturated or so-called wetland conditions:

- Mottling (localized colouring and alterations due to continued exposure to wetness);
- Concretions (accumulation and cohesion of minerals into hard fragments).
- Leaching (removal of soluble constituents by percolating water);
- Gleying (reduction of ferric oxides under anaerobic conditions resulting in grey, low chroma soil colours); and
- Illuviation of colloidal mater from one horizon to another, resulting in the development of grey sandy E-horizons and grey clay G-horizons.

These processes usually result in soil properties which provide undisputable evidence of temporary to permanent wetness such as:

Dark grey coloured A-horizons

The A-horizon is the upper 200-300 mm of the soil profile and is usually defined by a slightly darker colour due to a greater or lesser amount of humified organic matter. The dark grey A-horizon is common to almost all the soils found in permanent and seasonal zones. The dark grey colour usually appears only in the moist state and rapidly fades in to a plain grey colour when it dries out. The dark appearance is due to higher organic carbon content which builds up under the long term moist conditions in a wetland system. The carbon and also fine organic matter loses its dark colour in the dry state and the grey colour of the soil particles becomes prominent. The grey soil colour is the result of the removal of soluble constituents (iron oxides, silicate clay) by percolating water. The dark grey A-horizon is common in permanent, seasonal and temporary wetland zones.

Grey to pale grey E-horizons

The E-horizon underlies the A-horizon, having a lower content of colloidal matter (clay, sesquioxides, organic matter) usually reflected by a pale colour and a relative accumulation of quartz and/or other resistant minerals of sand or silt sizes. The E-horizon develops under high lateral flow (permanent or periodic) of water in the soil profile, which removes some colloidal matter to the lower soil profile and some further down the wetland system. The E-horizon is thus the flow path for shallow groundwater in the wetland zone. The grey and pale grey E-horizon is common in permanent and seasonal wetland zones and less common in temporary zones.

Yellowish grey E-horizons

The colour of the E-horizon reflects the intensity of removal of colloidal matter from the horizon. This results in the phenomenon that some E-horizons have a yellowish colour in the moist state but become grey in the dry state. The yellowish colour in the moist state is due to an incomplete covering of the mineral soil particle by ferric oxides and indicates a less leached state and less anaerobic (saturated conditions) conditions. The yellowish E-horizons are therefore strongly related to temporary wetland zones and occur less in seasonal or permanent wetland zones.

Plinthic horizons

Plinthic horizons are characterised by localization and accumulation of iron and manganese oxides under conditions of a fluctuating water table, resulting in distinct reddish brown, yellowish brown and/or black mottles, with or without hardening to form sesquioxide concretions. Plinthic horizons are the result of fluctuating water tables which implies wetter and dryer phases and are therefore found commonly in seasonal and temporary wetland zones and less in permanent wetland zones.

G-horizons

Gleying is the process of reduction of ferric oxides and hydrated oxides under anaerobic conditions, resulting in grey, low chroma matrix colours. This usually goes along with clay illuviation from the upper horizon which results in a grey clay horizon and is called a G-horizon. G-horizons are commonly found in permanent wetland zones, occasionally in seasonal zones and rarely in temporary wetland zones.

APPENDIX D
COORDINATES OF SOIL SAMPLING POINTS

Table D1: Coordinates of soil sampling points

Coordinates of Soil Sampling Points				
Soil sampling point	**Projected Coordinate System** **Elipsoid:** WGS 1984 **Coordinate system:** LO29 **Datum:** Hartebeesthoek 1994		**Geographic Coordinate System** **Elipsoid:** WGS 1984 **Coordinate system:** Decimal degrees **Datum:** Hartebeesthoek 1994	
	X (m)	**Y (m)**	**X/Lat (dd)**	**Y/Long (dd)**
P50	-2843201.216	66488.700	-25.694906	29.662394
P87	-2843144.807	65700.076	-25.694433	29.654535
P109	-2843253.261	65239.718	-25.695432	29.649955
P154	-2840451.228	65751.089	-25.670118	29.654911
P168	-2842255.017	64910.285	-25.686436	29.646624
P197	-2841174.859	65060.511	-25.676680	29.648068
P254	-2842724.101	65282.182	-25.690654	29.650352
P268	-2841685.965	65800.540	-25.681261	29.655464
P286	-2841053.952	64866.504	-25.675598	29.646129
P289	-2840347.665	65926.596	-25.669175	29.656653
P97	-2841802.280	66369.122	-25.682285	29.661133
P175	-2841366.617	65416.656	-25.678395	29.651625
410	-2842338.558	66368.895	-25.687125	29.661158
458	-2841513.691	64682.248	-25.679755	29.644317
569	-2840715.151	64830.649	-25.672541	29.645756
600	-2840418.531	65465.500	-25.669836	29.652064
637	-2841131.818	66191.167	-25.676241	29.659327

APPENDIX E

SOIL HORIZON PROPERTIES INFLUENCING STRIPPING AND STOCKPILING PROCEDURES

The stripping procedures aim, with consideration of practical limitations, to reconstruct the original horizon sequences. This is the only way to re-establish 70% or more of the pre-mining land capability. It is important to bear in mind that the natural soil horizons developed over thousands of years in a specific sequence and is the result of soil genesis (weathering) of the parent rock driven by climatic conditions (temperature and moisture) within a specific topography. Stripping and replacing of soil will always result in a moderate to severe disturbance of the natural balances in the soil's physical and chemical properties. This implies that, even with precise execution of well defined rehabilitation procedures, a degradation from pre-mining to post-mining land capability is unavoidable. This implies that, without precise stripping and replacing of topsoil, substantial degradation from pre-mining to post-mining land capability will probably take place.

The term topsoil in these guidelines refers to the A, B, E and G-horizons of the soil profile as defined in the Taxonomic Soil Classification system for South Africa. The A-horizon comprises the upper part (0-300 mm) of the soil profile and the B1 and B2-horizon from 300 mm up to the stripping depth specified per soil type as shown on Figure 6 and Table 10.

The A-horizon is characterised by a darker colour due to a higher organic carbon content, caused by decomposition of organic matter and roots of crops or natural vegetation. The organic carbon provides higher fertility and water holding capacity. It also improves infiltration and provides a natural buffer against compaction and hard setting. It also serves as a seed source of natural species which can re-establish after rehabilitation. It is therefore crucial to strip the A-horizon separately and replace it in the same position.

Well-drained, red and yellow brown B-horizons usually contain significantly lower organic carbon and have a higher clay content which gradually increases lower in the soil profile. The increasing clay content plays a significant role in soil potential and the soil's ability to sustain crops and plants, because it provides higher water storage capacity and prevents groundwater from rapidly leaching out of the rooting zones of plants. Red and yellow brown B-horizon materials which are placed on the surface (in the natural A-horizon position) tend to seal and compact severely, which leads to lower germination rates of seeds, restricted root development and higher runoff which triggers soil erosion.

Imperfectly to poorly drained plinthic B-horizons commonly have significantly higher clay contents than the well-drained horizons above them. They are characterised by prominent mottling and sesquioxide concretions which indicate impeded internal drainage. These materials are prone to severe compaction and sealing which result in low infiltration, higher runoff and consequent erosion when placed on the surface (in the natural A-horizon position).

Poorly drained G-horizons are clayey, very slowly permeable horizons. Placing this horizon on the surface will result in high runoff, very low infiltration and poor plant growth.

APPENDIX F
THE ANGLO STANDARD PASTURE SEED MIXTURE

Summer	Winter	Wetland
Digitaria eriantha 7kg/ha	*Digitaria eriantha* 5kg/ha	*Paspalum urveilei* 7kg/ha
Chloris gayana 6kg/ha	*Chloris gayana* 5kg/ha	*Paspalum dilatum* 7kg/ha
Anthephora pubescens 4kg/ha	*Anthephora pubescens* 4kg/ha	*Lolium multiflorum* 7kg/ha
Eragrostis tef 4kg/ha	*Eragrostis tef* 4kg/ha	*Eragrostis tef* 4kg/ha
Cyndodon dactylon 2kg/ha	*Cyndodon dactylon 2kg/ha*	
	Lolium multiflorum 8kg/ha	
	Festuca urundinaceae 8kg/ha	
	Avena sativa 8kg/ha	