START

Case15; 1885

PERTH EMP AND EIA APPENDICES

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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/2012/03/02/1
Date: 27 April 2012

REPORT

Soil, land capability and land use assessment of the mining right application area comprising a portion of the farm Perth 276 near Hotazel, Northern Cape province

Requested By

IRENE LEA ENVIRONMENTAL & HYDROGEOLOGY

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 33 of the EIA Regulations 2006 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: 27 April 2012

EXECUTIVE SUMMARY

Project background

Sebilo Resources (Pty) Ltd applied for a mining right, involving a portion of the farm Perth 276, situated approximately 10 km south of the town Hotazel, Northern Cape province (Figure 1). The mining application area comprises 159.63 ha.

The proposed mining project will involve underground mining as well as an open pit of 23.57 ha and will be mined using a roll-over mining method. This implies that rehabilitation will commence during the operational phase and soils will be stripped and stockpiled up to a point where after direct replacing will take place.

Scope of work

Rehab Green Monitoring Consultants cc was requested to conduct a detailed soil, land capability and land use assessment of the mining application area. The field assessment was done during March 2012.

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.

Study objectives

The study objectives were to:

- Conduct as detailed soil assessment within the extent of mining application area;
- Classify and map soil forms according to the South African Taxonomic Soil Classification System, 1991;
- Derive and map land capability based on soil properties;
- Map all pre-mining and current land uses;
- Compile a soil stripping and stockpiling plan with rehabilitation guidelines;
- Identify soil properties related to wetness to enable the delineation of zones with similar degrees of wetness categorized in permanent, seasonal or temporary wetland zones or riparian zones based on guidelines of the Department of Water Affairs;
- Locate a 100 m buffer line along the outer edge of wetland and riparian zones;
- Determine all possible impacts by the proposed operation and provide associated mitigation measures; and
- Compile a soil stripping and stockpiling plan with rehabilitation guidelines.

CONCLUSIONS

The following conclusions are made from the study:

Soils and land capability (Figures 3 and 4 and Table 6)

- ***No areas were classified as arable land.***
- ***Approximately 69.23% of the mining aplication area is classed as grazing***

land capability with low agricultural potential. The grazing potential soils consists of very deep, well-drained, red aeolian sand, dominated by the Hutton soil form, symbolized as soil types Hu and Hu-D comprising 62.23 and 7.0 % of the mining application area respectively.

- ***No areas were classed as wetland.***

- ***Approximately 7.92% of the study area is classed as riparian land with very low agricultural potential.*** The soils in the riparian zone consists of deep, pale yellow, calcareous, sandy soils underlain by soft or hardpan carbonate, dominated by the Addo soil form, symbolized as soil type Ad.

- ***Approximately 22.85% of the study area is classed as wilderness land with no agricultural potential.*** These sections consists of the existing open pit, symbolized as unit OP, comprising 5.73% of the mining application area and areas covered by overburden material, symbolized as unit OB-Cal, comprising 17.12% of the mining application area.

Pre-mining land use (Figure 5 and Table 7)

- ***Approximately 57.35% of the mining application area is utilized for grazing purposes (mainly cattle).***

- **The gravel road and fenced off edges occupy 6.22% of the mining application area.**

- **The fenced off old mining area comprises 36.45% of the study area consisting of an old open pit, overburden dump, old ore stockpile footprint and vacant areas.**

Impact assessment

Soil stripping and replacing, no matter whether it is stockpiled or immediately replaced, will always have a high potential degrading impact on soil, post-mining land capability and land use. Poor rehabilitation generally leads to an enormous deterioration from pre-mining to post-mining land capability or agricultural potential in South Africa. The degree of degradation will **always** depend on the **precise execution, management and monitoring** of the rehabilitation procedures.

The major impacts on soil, land capability and land use during the construction and operational phase are identified as:

Construction phase

Soil horizon sequences will be **disturbed due to the erection of structures such as a** pollution control dams, a crusher, processing plant, workshop, offices, explosives magazines and a load out and ancillary facility. The topsoil will be disturbed to some extent and the soil surface will be covered completely. The impacts at the footprint of the structure will be:

- Disturbance of natural soil horizon sequences.
- Loss of the natural functioning of the soil as a growth medium and habitat for fauna and flora
- Loss of original soil fertility.

- A complete cease of all land capability e.g. grazing.
- A complete cease of all current possible land uses.

The environmental significance of these impacts was rated as high during the lifespan of the structure but can be mitigated to acceptable levels at the end of the lifespan of the structure.

Operational phase

The impact will be the complete removal and stockpiling of topsoil at the footprint of the proposed open pit which will result in:

- Loss of the original spatial distribution of soil types and soil horizon sequences
- Loss of original effective soil depth and soil volume.
- Loss of original topography and drainage pattern
- Loss of original soil fertility.
- A complete cease of all land capability e.g. grazing or riparian.
- A complete cease of all current possible land uses.

The environmental significance of these impacts was rated as high until rehabilitation takes place during both the operational or decommissioning phase. The environmental significance after mitigation is hard to predict because it is solely dependent on the quality of rehabilitation. The environmental significance can however be mitigated to acceptable levels if the procedure in section 6 and the recommendations in section 9 are strictly followed.

Proposed mine plan

The proposed mine plan is shown on Figures 3, 4, 5 and 6 in order to evaluate possible impacts or conflicts by proposed infrastructure in terms of soils, land capability and land uses. The following conclusions were made:

- ***The existing mine plan does not indicate dedicated topsoil stockpiles for different soil types and soil horizons.*** This issue was addressed and dedicated stockpiles for different soil types and horizons is shown on Figure 6 and should be incorporated in the updated mine plan.

- ***The proposed open pit includes sections of the riparian zone.*** The riparian zone was accurately delineated based on soil properties, topography and vegetation indicators. Stake points were generated at 50 m intervals on the eastern riparian edge as well as a 100 m buffer line as shown in Figure 6. The coordinates of the stake points are provided in Appendix D. The extent of riparian zone within the proposed open pit is shown in Figures 4 and 6.

- ***The most northern proposed pollution control dam is situated on the edge of a dune with a slope of 14%.*** This locality might need to be re-evaluated.

- ***Various proposed infrastructure is located on the existing overburden dump shown as unit V-OBD on Figure 5.*** It was indicated by the mine that the footprints of these planned structures will be thoroughly cleaned before structures are erected.

RECOMMENDATIONS

- The soil, land capability and land use information on Figures 3, 4 and 5 should be used to refine the proposed mine plan.

- The stripping plan, Figure 6 includes the soils within the riparian zone but it is subject to authorization by the relevant government divisions.

Requirements for successful rehabilitation

In order to guarantee successful rehabilitation, the procedures in section 6 need to be executed precisely and the following is required:

- Soil boundaries of soil types that should be stripped and stockpiled separately should be staked at 50 m intervals before any soil stripping commences.
- Soil types should be stripped at stripping depths as specified on Figures 6 and Table 9.
- Topsoil should be stockpiled on 2 stockpiles as specified on Figure 6 to accommodate 2 soil groups namely red aeolian sand of undulating dunes and pale, yellowish brown, calcareous sand of the riparian zone. Each stockpile should consist of separate sections for the A and B-horizons.
- The spoils should be leveled to a free draining surface, similar to the pre-mining topography, before topsoil is replaced during rehabilitation.
- Topsoil should be replaced evenly over spoils during rehabilitation at depths as specified in Figure 6 and Table 9.
- The A and B-horizons should be reconstructed in the original sequence as specified by the procedures in section 6.
- The replaced topsoil should be ameliorated according to soil analysis before seeding and re-vegetation take place.
- Rehabilitated areas should be re-vegetated as soon as possible with a grass mixture dominated by local climax species in order to stabilize the soils.
- Soil erosion on the rehabilitated areas should be monitored and remediate if necessary until the area can be declared as stabilized and self sustaining.
- A post-mining soil depth and land capability evaluation should be done by a soil specialist registered at the Council for Natural Scientific Professions (SACNASP). A post-mining land capability map should be compiled and submitted for closure purposes.

CONTENTS

1. INTRODUCTION

1.1 Project background

Sebilo Resources (Pty) Ltd applied for a mining right, involving a portion of the farm Perth 276, situated approximately 10 km south of the town Hotazel, Northern Cape province (Figure 1). The mining application area comprises 159.63 ha.

The proposed mining project will involve underground mining as well as an open pit of 23.57 ha and will be mined using a roll-over mining method. This implies that rehabilitation will commence during the operational phase and soils will be stripped and stockpiled up to a point where after direct replacing will take place.

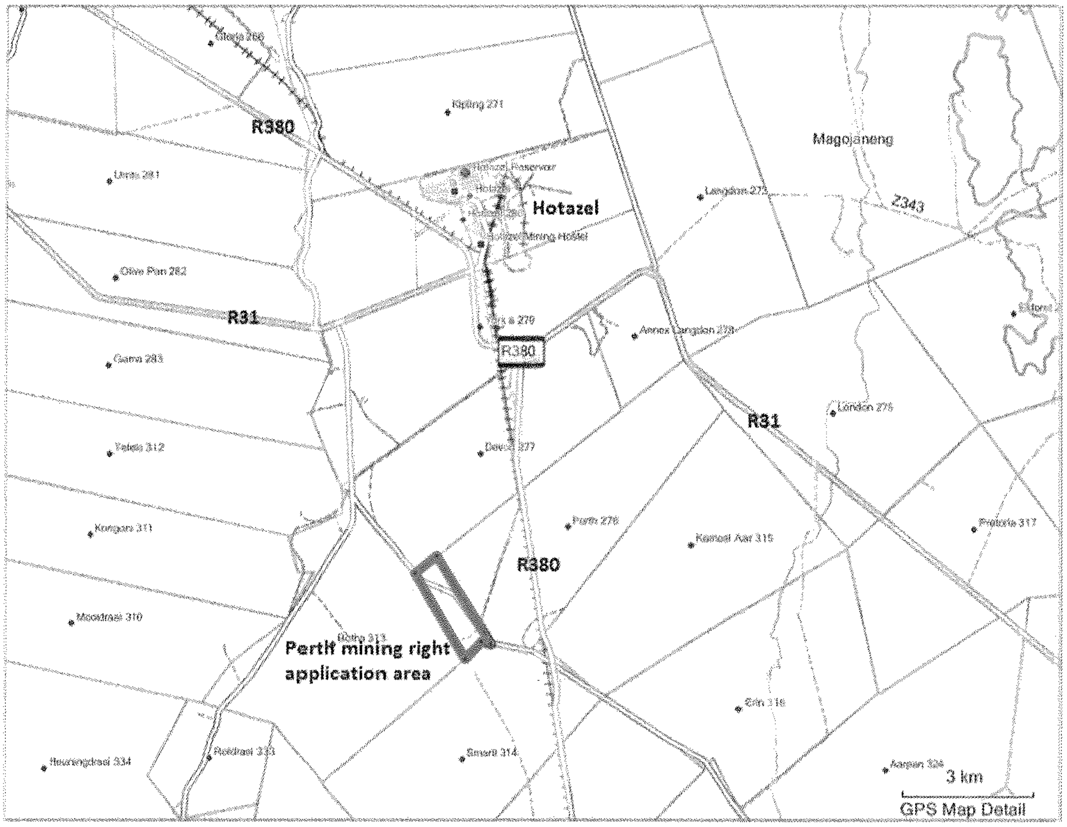


Figure 1: Regional setting of Perth Mining Application Area

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 mining application area. The field assessment was done during March 2012.

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.

2. STUDY OBJECTIVES

The study objectives were to:

- Conduct as detailed soil assessment within the extent of mining application area;
- Classify and map soil forms according to the South African Taxonomic Soil Classification System, 1991;
- Derive and map land capability based on soil properties;
- Map all pre-mining and current land uses;
- Compile a soil stripping and stockpiling plan with rehabilitation guidelines;
- Identify soil properties related to wetness to enable the delineation of zones with similar degrees of wetness categorized in permanent, seasonal or temporary wetland zones or riparian zones based on guidelines of the Department of Water Affairs;
- Locate a 100 m buffer line along the outer edge of wetland and riparian zones;
- Determine all possible impacts by the proposed operation and provide associated mitigation measures; and
- Compile a soil stripping and stockpiling plan with rehabilitation guidelines.

3. STUDY AREA AND KEY COMPONENTS OF THE OPERATION

The study area encompass the total mining application area, outlined in yellow in Figure 2 and covers 159.63 ha along the western boundary of the farm Perth 276.

The existing old open pit is highlighted in turquoise comprising 9.14 ha. The proposed open pit, hatched in red, covers 23.57 ha and includes sections of the riparian zone (light blue color) of a natural drainage line, known as Witleegte. A 100 m riparian buffer line is indicated as a dotted blue line. The footprint of dumped overburden material, consisting mainly of calcrete, is outlined with a red dotted line.

Proposed infrastructure involves a waste dump, tailings dam, 2 pollution control dams, crusher, processing plant, topsoil stockpile, workshop, offices, 2 explosives magazines and a load out and ancillary facility as shown in Figure 2. A number of these structures or facilities are situated on the current overburden dump footprint.

The Witleegte drainage line consists of a dry, concave channel, 75-150m wide with a 0.5% slope in the flow direction and 1-10% slopes on the edges. Apart from the disturbed old mining area and the drainage line, the remainder or the mining application area is dominated by gentle undulating dunes consisting of very deep (> 2400 mm), red aeolian sand.

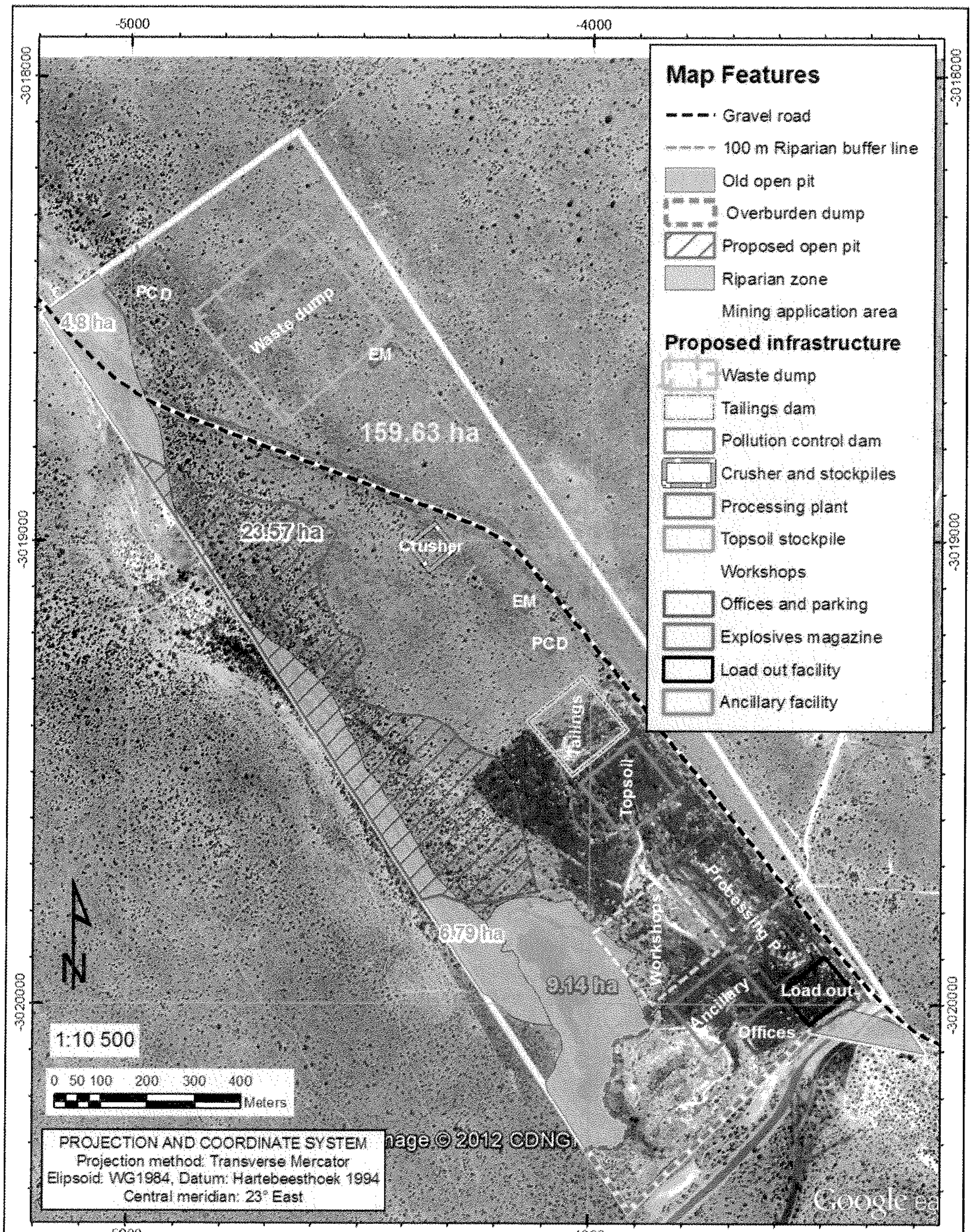


Figure 2: Study area, proposed infrastructure and key components influencing the proposed operation

4. METHODOLOGY

4.1 Preparation of field maps

ArcGIS Geographic Information System (GIS) software was used to process all available data for accurate surveying. The coordinates of the mining application area was obtained from an electronic file received from Irene Lea Environmental and Hydrogeology. A shapefile, containing the extent of the mining application area and localities of proposed infrastructure was generated.

The shapefile was superimposed on a Google Earth image as well as 1:50 000 scale topographic sheets. A grid of field observation points were generated at a density of 150 x 150 m. 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 both aerial and topographic background data were printed to use during the field assessment.

4.2 Soil classification

The soils were investigated by means of auger holes to a depth of 2400 mm or the depth of refusal. The soils were described and classified according to the South African Taxonomic Soil Classification System (Soil Classification Working Group, 2nd edition 1991). A total of 54 auger observations were made at predetermined grid points. A further 48 physical observations were made to delineate the riparian zone. 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 mater from one horizon to another resulting in the development of grey sandy E-horizons and grey clay G-horizons.

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

The soil properties that were used in the soil classification are discussed in Appendix B.

4.3 Soil sampling and analyses

The A and B or E or G-horizons (0-250 and 300-700mm) 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). Soils types were classified into the following categories for areas that exclude wetlands:

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

4.5 Agricultural potential classification

The classification of agricultural potential of soils was based on soil properties noted during auger observations such as effective soil depth, texture, terrain unit, slope, soil wetness and disturbances. The effective soil depth is the main soil characteristic 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 soils with an effective depth deeper than 900 mm.
- **Moderate** - well-drained and moderately well-drained soils with an effective depth of 600- 900 mm.
- **Low** - well-drained and moderately well-drained soils with an effective depth less than 600 mm or leached, grey, sandy soils showing evidence of periodic percolating water tables, or black and grey clay soils showing evidence of poor internal drainage or very sandy soils in low rainfall areas.

4.6 Wetland and riparian delineation

Wetland and riparian zones are 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.

Auger observations are made systematically in transects towards the wetland at 50 m intervals in order to locate the point from where clear evidence of wetness occurs within 500 mm from surface. 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, version 9.3.1. 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 23° East meridian, WG1984 Elipsoid and Hartebeesthoek 1994 Datum.

4.10 Impact assessment

This assessment evaluates the effects of the proposed project on the soil environment. Each potential impact was assessed according to the following criteria:

- **Magnitude** is a measure of the degree of change in a measurement or analysis which is classified as minor/negligible, low, moderate, high or very high.
- **Scale/Geographic extent** refers to the area that could be affected by the impact and is classified as none, site only, local, regional, national, or international.
- **Duration** refers to the length of time over which an environmental impact may occur: i.e. Immediate (less than 1 year), short-term (0 to 7 years), medium term (8 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project) or permanent.
- **Probability of occurrence** is a description of the probability of the impact actually occurring as improbable (less than 5 % chance), low probability (5 % to 40 % chance), medium probability (40 % to 60 % chance), highly probable (most likely, 60 % to 90 % chance) or definite (impact will definitely occur).
- **Direction** of an impact may be positive, neutral or negative with respect to the particular impact.

- **Reversibility** is an indicator of the potential for recovery of the endpoint from the impact.
- **Frequency** describes how often the impact may occur within a given time period and is classified as low, medium or high frequency. Seasonal considerations should be discussed where these are important in the evaluation of the impact.

The significance of the identified impacts was determined using the approach summarized in Table 1. This incorporates two aspects for assessing the potential significance of impacts (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998), namely occurrence and severity, which are further sub-divided as shown in Table 1.

Table 1: Impact assessment methodology

OCCURRENCE		Severity	
Probability of occurrence	Duration of occurrence	Magnitude (severity) of impact	Scale / extent of impact

To assess each impact, the following four ranking scales are used:

PROBABILITY	DURATION
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	

SCALE	MAGNITUDE
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 - Local	4 - Low
1 - Site only	2 - Minor
0 - None	

The significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 150 significance points (SP). The impact significance points are assigned a rating of high, medium or low with respect to their environmental impact as follows:

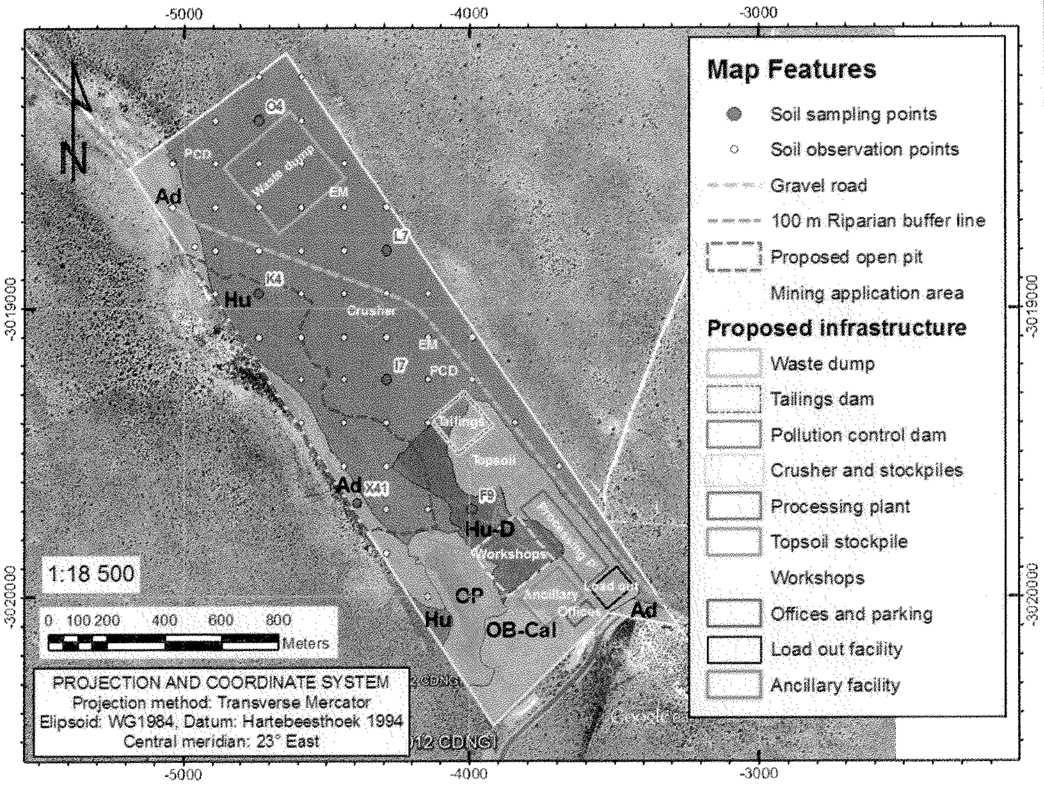
SP >75	Indicates **high** environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates **moderate** environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates **low** environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

Potential impacts were assessed using the above calculation and rating system, and mitigation measures were proposed for all relevant project phases (construction to decommissioning).

5. SURVEY RESULTS

5.1 Dominant soil types

Soil types were mapped based on soil information gathered by means of auger observations on a 150 x 150 meter pre-determined grid. A total of 3 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: **Hu**, **Hu-D** and **Ad**. The localities and extent of the soil types are shown on the soil map, Figure 3.



SOIL LEGEND (Abbreviated soil legend, for full legend refer to the soil report)

Soil Type Code	Dominant & subdominant Soil Form and Family	Terrain unit and slope	Summarized description of terrain and soil type	Summarized description of soil horizons sequences	Land Capability	Area (ha)	Area (%)
Hu	*Hutton 3100	Gently undulating sand dunes (3-6% slopes) with occasional fairly flat crests and footslopes (1-2% slopes).	Very deep (> 2400 mm), red, well-drained, aeolian sand (wind transported sand)	A red, sandy Orthic A-horizon (0-250 mm), overlying a red, sandy B1-horizon (250-2400+ mm).	Grazing	99.34	62.23
Hu-D	*Hutton 3100	Fairly flat footslope (1-3% slope) within old mining area, covered with a thin layer of gravel rock material	Very deep (> 2400 mm), red, well-drained, aeolian sand (wind transported sand) covered with gravel rock fragments during previous mining operation.	100-400 mm gravel rock overburden, overlying a red, sandy Orthic A-horizon (0-250 mm), overlying a red, well-drained, sandy B1-horizon (250-2400+ mm).	Grazing	11.18	7.0
Ad	*Addo 2111 Prieska 2110	Dry, concave drainage line, 75-150m wide, 0.5% slope in flow direction and 1-10% slopes on edges.	Deep, (1000-1500+ mm), pale yellow, well-drained, calcareous sandy soils in a natural drainage line, underlain by soft or hard carbonate.	A pale, yellowish brown, sandy Orthic A-horizon (0-250), overlying a pale brownish yellow, calcareous, sandy Neocarbonate B1-horizon (250-1000+), overlying a soft or hard carbonate B2-horizon.	Riparian zone	12.64	7.92
OB-Cal	*Hutton 3100 (not assessed)	Overburden dump, approximately 1-6 m high consisting mainly of calcrete rock material.	Soils below the overburden dump could not be assessed but are probably deep, red sandy soils similar to soil type Hu.	Soils below the overburden dump could not be assessed but are probably deep, red sandy soils similar to soil type Hu.	Wilderness	27.33	17.12
OP	-	Old open pit with vertical high wall to the west, approximately 15-20 m deep. Partly filled with water.	No soil	No soil	Wilderness	9.14	5.73
* Dominant soil form and family					Total	159.63	100.0

Figure 3: Detailed soil map of the Perth Mining Application Area

Two non soil related units were also included in the soil legend and are symbolized as **OB-Cal** and **OP**. **Unit OB-Cal** comprises the area covered mainly with calcrete overburden material which was previously removed from the existing open pit. The thickness of the calcrete layer varies from 1 to approximately 20 m and the soils below could therefore not be assessed. Unit **OP** comprises the footprint of the old open pit where all topsoil were removed. The localities of the 54 auger observation points are shown on the soil map, Figure 3, as yellow and red dots. The auger observations, shown as red dots, were sampled and chemically analysed.

The soil types are summarised in the soils legend (Table 2) in terms of the following aspects:

- Dominant and subdominant soil forms and families;
- Average effective soil depth;
- The estimated clay content of the A and B or E or G-horizons;
- The derived texture class;
- A description of the terrain unit and slope, a broad description of the dominant soil form;
- A description of the soil horizon sequences;
- The soil's derived land capability and wetland zone classification; and
- The area and percentage comprised by each soil type.

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

SOIL LEGEND												
Soil Type Code	Dominant & subdominant Soil Form and Family	Effective Soil Depth (mm)	% Clay per horizon	Texture Class	Terrain and slope	Summarized description of the dominant soil type	Summarized description of soil horizons sequences	Agricultural Potential	Land Capability	Erodibility	Area (ha)	Area (%)
Hu	*Hutton 3100	>2400	A: 4-8 B1: 4-8	Sand	Gently undulating sand dunes (3-6% slopes) with occasional fairly flat crests and footslopes (1-2% slopes).	Very deep (> 2400 mm), red, well-drained, aeolian sand (wind transported sand)	A red, sandy Orthic A-horizon (0-250 mm), overlying a red, sandy B1-horizon (250-2400+ mm).	Low	Grazing	Low	99.34	62.23
Hu-D	*Hutton 3100	>2400	A: 4-8 B1: 4-8	Sand	Fairly flat footslope (1-3% slope) within old mining area, covered with a thin layer of gravel rock material	Very deep (> 2400 mm), red, well-drained, aeolian sand (wind transported sand) covered with gravel rock fragments during previous mining operation.	100-400 mm gravel rock overburden, overlying a red, sandy Orthic A-horizon (0-250 mm), overlying a red, well-drained, sandy B1-horizon (250-2400+ mm).	Low	Grazing	Low	11.18	7.0
Ad	*Addo 2111 Prieska 2110	1000-1500+	A: 4-8 B1: 4-8	Sand	Dry, concave drainage line, 75-150m wide, 0.5% slope in flow direction and 1-10% slopes on edges.	Deep, (1000-1500+ mm), pale yellow, well-drained, calcareous sandy soils in a natural drainage line, underlain by soft or hard carbonate.	A pale, yellowish brown, sandy Orthic A-horizon (0-250), overlying a pale brownish yellow, calcareous, sandy Neocarbonate B1-horizon (250-1000+), overlying a soft or hard carbonate B2-horizon.	Very low	Riparian zone	Moderate-high	12.64	7.92
OB-Cal	*Hutton 3100 (not assessed)	-	-	-	Overburden dump, approximately 1-6 m high consisting mainly of calcrete rock material.	Soils below the overburden dump could not be assessed but are probably deep, red sandy soils similar to soil type Hu.	Soils below the overburden dump could not be assessed but are probably deep, red sandy soils similar to soil type Hu.	None	Wilderness	-	27.33	17.12
OP	-	0	-	-	Old open pit with vertical high wall to the west, approximately 15-20 m deep. Partly filled with water.	No soil	No soil	None	Wilderness	-	9.14	5.73
* Dominant soil form and family										TOTAL	159.63	100.0

5.2 Other soil qualities derived from soil properties

The soil qualities derived from the soil properties for each soil type are summarised in Table 3. The soil qualities were rated as high, moderate and low with classification in-between these.

Table 3: Other Derived soil properties

Soil Type (Code)	Current fertility Status	Dry land crop production potential	Irrigation potential
Hu	Moderate-low	Very low	Very low
Hu-D	Moderate	Very low	Very low
Ad	Moderate-high	Very low	Very low
OB-Cal	Not assessed	Very low	Very low
OP	No soil	None	None

5.3 Soil chemistry

The soil analytical results of representative samples collected from the A-horizon (0-200 mm) and B-horizon (300-700 mm) are shown in Table 4. Results of undisturbed red sandy soils are highlighted in green and results of soils in the riparian zone and disturbed mining area are highlighted in blue. The positions of the sampling points are shown in Figure 3 and coordinates are included in Appendix D.

The averages of base cations [potassium (K), calcium (Ca) magnesium (Mg) and sodium (Na)] as well as phosphorus and pH were calculated for both undisturbed and disturbed areas and highlighted in yellow and pink respectively.

Table 4: 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)
				mg/kg	mg/kg	mg/kg	mg/kg					
				Ammonium acetate				cmol(+)/kg	%	ohm		
Undisturbed, red, well-drained sandy soils												
I7	Hu3100	A	0-200	49	232	81	0.62	-	-	2100	3.1	5.94
		B	300-700	52	201	105	0.31	-	-	4820	1.2	6.76
K4	Hu3100	A	0-200	31	371	60	0.36	-	-	2320	2.2	7.41
		B	300-700	34	303	68	0.28	-	-	4860	1.3	7.74
L7	Hu3100	A	0-200	48	159	34	0.34	-	-	7030	1.6	7.18
		B	300-700	61	133	22	0.24	-	-	10540	1.2	7.18
O4	Hu3100	A	0-200	128	185	74	2.2	-	-	3080	1.6	6.96
		B	300-700	68	235	113	6.7	-	-	2560	1.3	7.06
Average				**59**	**227**	**70**	**1.4**				**1.7**	**7.03**
Soils in riparian zone												
41	Ad2111	A	0-200	127	3251	194	0.26	-	-	2020	3.2	8.72
		B	300-700	172	3509	431	111.6	-	-	180	3.1	8.16
Soils in disturbed mining area												
F9	Hu3100	A	0-200	35	573	334	5.5	-	-	2620	1.8	8.7
		B	300-700	52	507	299	10.3	-	-	2490	1.4	8.54

*Analysis conducted when pH is below 5.5

5.3.1 Soil fertility status

The averages of the base cations (K, Ca, Mg, Na) as well as phosphorus and pH of the **undisturbed soils** (highlighted in yellow, Table 4) were compared to general fertility guidelines (Fertilizer Association of South Africa, 2003) in Table 5.

Table 5: Soil fertility compared to broad fertility guidelines

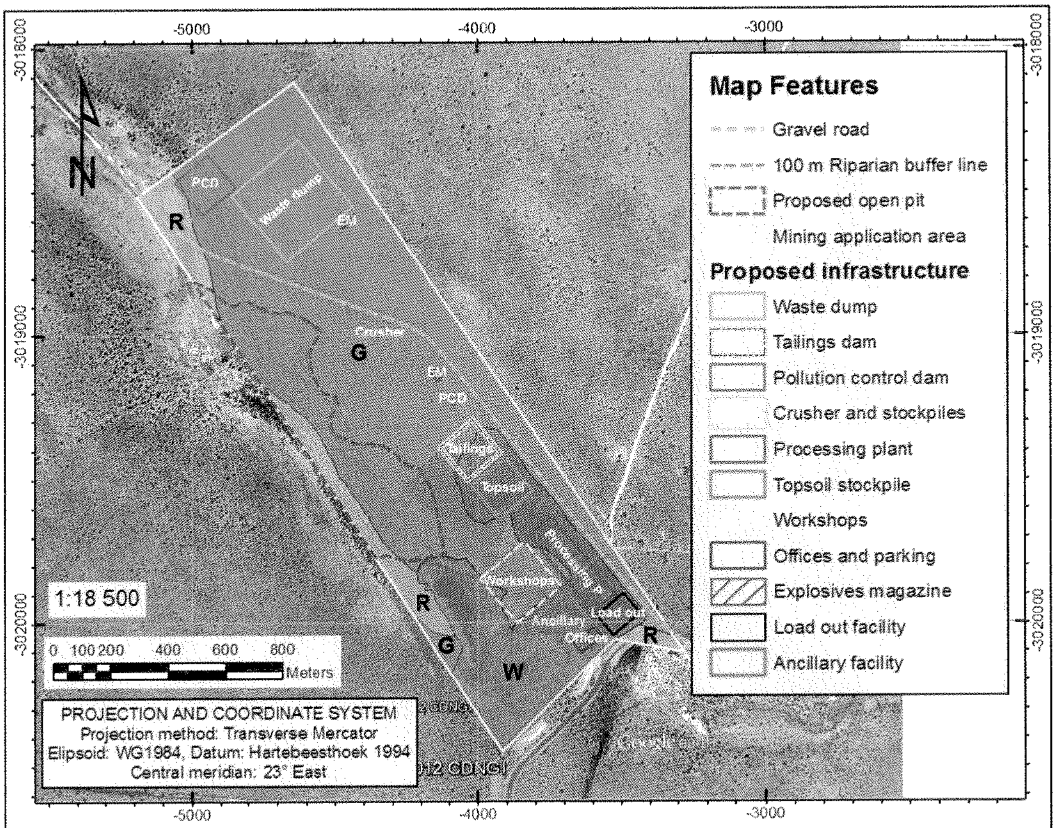
<table>
<tr><th colspan="6">Guidelines (mg/kg)</th><th rowspan="2">Average calculated in Table 4 (mg/kg)</th><th rowspan="2">Status</th></tr>
<tr><th colspan="2"></th><th colspan="2">Low</th><th colspan="2">High</th></tr>
<tr><td colspan="2">Potassium (K)</td><td colspan="2"><40</td><td colspan="2">>250</td><td>59</td><td>Moderate-low</td></tr>
<tr><td colspan="2">Calcium (Ca)</td><td colspan="2"><200</td><td colspan="2">>3000</td><td>227</td><td>Moderate-low</td></tr>
<tr><td colspan="2">Magnesium (Mg)</td><td colspan="2"><50</td><td colspan="2">>300</td><td>70</td><td>Moderate-low</td></tr>
<tr><td colspan="2">Sodium (Na)</td><td colspan="2"><50</td><td colspan="2">>200</td><td>1.4</td><td>Low, which is positive</td></tr>
<tr><td colspan="2">Phosphorus (P)</td><td colspan="2"><5</td><td colspan="2">>35</td><td>1.7</td><td>Low</td></tr>
<tr><td colspan="6">pH(H_2O)</td><td></td><td></td></tr>
<tr><td>Very acid</td><td>Acid</td><td>Slightly acid</td><td>neutral</td><td>Slightly alkaline</td><td>Alkaline</td><td></td><td></td></tr>
<tr><td><4</td><td>5-5.9</td><td>6-6.7</td><td>6.8-7.2</td><td>7.3-8</td><td>>8</td><td>7.03</td><td>Neutral</td></tr>
</table>

The averages of base cations (K, Ca and Mg) are moderate-low. The average sodium (Na) content of 1.4 mg/kg is low, which is positive and indicates an absence on sodic soil conditions. The average pH value of 7.03 indicates neutral soil conditions and is within the optimal range of 6.8-7.2. The average phosphorus content of 1.7 mg/kg is very low but is normal for unfertilized sandy soils.

The averages of the base cations of soils in the riparian zone (highlighted in blue) are somewhat to substantial higher, which indicates an accumulation of salts in the lower lying landscape. The average pH value of 8.4 indicates alkaline soil conditions. The low phosphorus content in the A and B-horizon reflects normal concentrations in unfertilized sandy soils.

5.4 Land capability and agricultural potential

The location and extent of land capability classes within the mining application area are shown on the land capability map Figure 4.



LEGEND: LAND CAPABILITY								
Land Capability (Code)	Internal drainage	*Soil type code	Broad soil description	Agricultural potential	Area (ha)	Area (%)	Area per class (ha)	Area per class (%)
Arable (A)	Well-drained		No soils in this category		0	0	0	0
	Moderately well-drained		No soils in this category		0	0		
Grazing (G)	Well-drained	Hu	Very deep (> 2400 mm), red, aeolian sand (wind transported sand)	Low	99.34	62.23	110.52	69.23
		Hu-D	Very deep (> 2400 mm), red, well-drained, aeolian sand covered with a thin layer of gravel rock fragments from previous mining operation	Low	11.18	7.0		
	Moderately well-drained		No soils in this category		0	0		
Riparian (R)	Well-drained	Ad	Deep, (1000-1500+ mm), pale yellow, calcareous sandy soils in a natural drainage line, underlain by soft or hard carbonate	Very low	12.64	7.92	12.64	7.92
	Somewhat poorly to poorly		No soils in this category		0	0		
Wilderness (W)	Dumps	OB-Cal	Overburden dump approximately 1-6 m high consisting mainly of calcrete rock material	None	27.33	17.12	36.47	22.85
	Open pits	OP	Old open pit with vertical high wall to the west, approximately 15-20 m deep. Partly filled with water	None	9.14	5.73		
*See soil map, Figure 3				Total	159.63	100.0	159.63	100.0

Figure 4: Land capability map of the Perth Mining Application Area

The land capability and agricultural potential were determined from the soil types and classed according to the following categories:

- Arable potential
    - Well drained soils,
    - Moderately well-drained soils;

- Grazing potential
    - Well drained soils,
    - Moderately well-drained soils;
- Wetland and riparian zones
    - Imperfectly drained soils,
    - Somewhat poorly to poorly drained soils; or
    - Well-drained (riparian zones)
- Wilderness
    - Rocky areas.
    - Disturbed areas

Table 6 shows the land capability classes and associated soil types which were grouped into each land capability class, a broad description of the soil type, the agricultural potential, and the area and percentage comprised by individual soil types within each land capability class as well as the total per land capability class.

Table 6: Land capability classes, soils and agricultural potential

Land Capability (Code)	Internal drainage	*Soil type code	Broad soil description	Agricultural potential	Area (ha)	Area (%)	Area per class (ha)	Area per class (%)
Arable (A)	Well-drained	No soils in this category			0	0	0	0
	Moderately well-drained	No soils in this category			0	0		
Grazing (G)	Well-drained	Hu	Very deep (> 2400 mm), red, aeolian sand (wind transported sand)	Low	99.34	62.23	110.52	69.23
		Hu-D	Very deep (> 2400 mm), red, well-drained, aeolian sand covered with a thin layer of gravel rock fragments from previous mining operation.	Low	11.18	7.0		
	Moderately well-drained	No soils in this category			0	0		
Riparian (R)	Well-drained	Ad	Deep, (1000-1500+ mm), pale yellow, calcareous sandy soils in a natural drainage line, underlain by soft or hard carbonate.	Very low	12.64	7.92	12.64	7.92
	Somewhat poorly to poorly	No soils in this category			0	0		
Wilderness (W)	Dumps	OB-Cal	Overburden dump, approximately 1-6 m high consisting mainly of calcrete rock material.	None	27.33	17.12	36.47	22.85
	Open pits	OP	Old open pit with vertical high wall to the west, approximately 15-20 m deep. Partly filled with water.	None	9.14	5.73		
*See soil map, Figure 3				**Total**	**159.63**	**100.0**	**159.63**	**100.0**

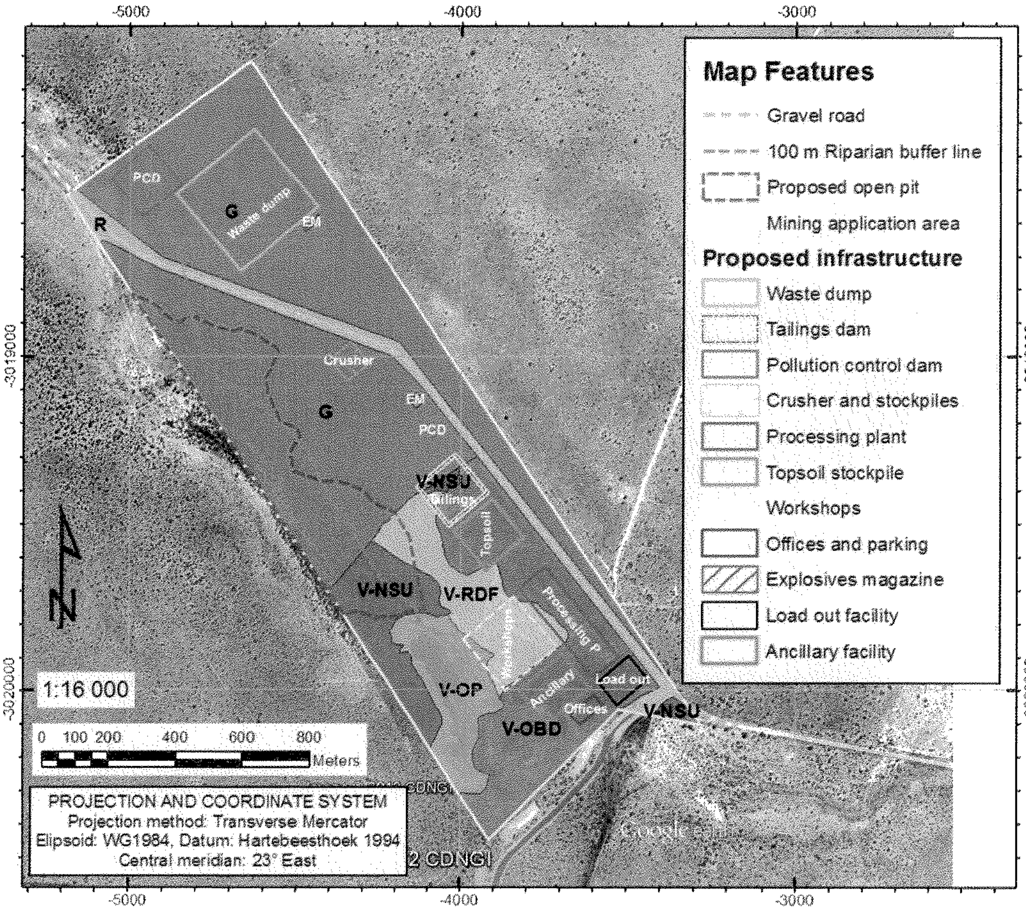
5.5 Wetland and riparian delineation

Land capability was assessed in categories of arable land, grazing land, **wetland and riparian zones** and wilderness land. Wetland and riparian zones were therefore delineated as part of the land capability assessment based on soil properties by means of systematic auger observations towards the wetland or riparian zone 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 the riparian zone are summarized in Table 6 and the locality and extent and are shown on the land capability map Figure 4. A 100 m riparian buffer zone is indicated with a blue dotted line. (See Appendix C for details on soil properties related to wetland zones).

5.6 Pre-mining land use

The current land uses within the mining application area are summarized in Table 7 and the localities and extents are shown in Figure 5.



LEGEND – PRE-MINING LAND USE					
Land Use Code	Pre-mining Land Use		Unit Count	Area (ha)	Area (%)
G	Natural grazing – mainly used for cattle		2	91.54	57.35
R	Gravel road and fenced off edges		1	9.93	6.22
V-OP	Vacant: Fenced-off old mining area, currently abandoned.	Old open pit	1	9.14	5.73
V-OBD		Overburden dump, consisting mainly of calcrete	1	27.77	17.4
V-RDF		Old rock dump footprint, surface covered with a thin layer of fractured rock	1	11.18	7.00
V-NSU		Undisturbed – no specific use	3	10.07	6.32
		TOTAL	9	159.63	100.0

Figure 5: Current land use map of the Perth Mining Application Area

Table 7: Pre-mining land uses

<table>
<tr><th>Land Use Code</th><th colspan="2">Pre-mining Land Use</th><th>Unit Count</th><th>Area (ha)</th><th>Area (%)</th></tr>
<tr><td>G</td><td colspan="2">Natural grazing – mainly used for cattle</td><td>2</td><td>91.54</td><td>57.35</td></tr>
<tr><td>R</td><td colspan="2">Gravel road and fenced off edges</td><td>1</td><td>9.93</td><td>6.22</td></tr>
<tr><td>V-OP</td><td rowspan="4">Vacant: Fenced-off old mining area, currently abandoned.</td><td>Old open pit</td><td>1</td><td>9.14</td><td>5.73</td></tr>
<tr><td>V-OBD</td><td>Overburden dump, consisting mainly of calcrete</td><td>1</td><td>27.77</td><td>17.4</td></tr>
<tr><td>V-RDF</td><td>Old rock dump footprint, surface covered with a thin layer of fractured rock or ore</td><td>1</td><td>11.18</td><td>7.00</td></tr>
<tr><td>V-NSU</td><td>Undisturbed – no specific use</td><td>3</td><td>10.07</td><td>6.32</td></tr>
<tr><td colspan="3">TOTAL</td><td>9</td><td>159.63</td><td>100.0</td></tr>
</table>

5.7 Historical agricultural production

Crop yields vary from farm to farm and field to field due to various factors such as soil types and climatic conditions e.g. annual precipitation, temperature, day lengths, heat units etc. Due to the very low rainfall of the region, crop farming is not viable and possible land uses are restricted to livestock and wildlife farming.

The carrying capacity of the area was broadly assessed by Rehab Green cc during the time of the soil assessment based on dominant grass species and basal cover and are summarized in Table 8.

Table 8: Historical agricultural production

Product	*Soil Types)	Derived soil potential	Potential Yield
Crop farming (not suitable)	Hu, Hu-D, Ad	Low	-
Grazing	Hu, Hu-D, Ad	Low	12-15 ha/lsu
* See soil map Figure 3			

5.8 Evidence of misuse

The old mining site, which are not rehabilitated poses a health and safety risk to humans and animals and caused all possible soil, land capability and land uses to remain ceased, which is at this stage a serious setback to the environment.

6. PROCEDURES FOR STRIPPING AND HANDLING OF SOIL

6.1 Principles in stripping and handling of topsoil

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 topsoil and 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 influences the post-mining land capability and consequently determines the degree of deterioration from pre-mining to post-mining land capability. It also directly determines the possible post-mining land uses.

Stripping and stockpiling of topsoil, shaping of spoils and replacing of topsoil should therefore take place according to a plan which should be well managed and progressively adapted according to circumstances. The following should be included in topsoil stripping and stockpiling plans:

- ***Prevent stripping and 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 soil physical and chemical properties and a decline in 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 types 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 substantial e.g. the clay content of red and yellow brown soils often differ with up tot 20% within the same field. Mixing of different soil types result 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 obtain the highest post-mining soil potential for re-vegetation.*** The higher soil fertility of the A-horizon, especially phosphorus and carbon contents, declines significantly when it is mixed with the B-horizon resulting poorer re-vegetation success. It also increases the susceptibility to compaction and hard setting. The A-horizons 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 implication for the mine and only requires planning and continuing management. It is therefore crucial to strip according to guidelines and depths as described in the following sections. The soil horizons and properties influencing stripping and stockpiling procedures are discussed in Appendix E.

6.2 Construction phase

The erection of mining infrastructure will have impacts on the soil, land capability and land use during the construction phase. The following procures for topsoil stripping and handling during the operational phase should be followed:

- ***Buildings and conveyers***. All excess topsoil which might be excavated for the foundations of these structures should be stored for later rehabilitation.
- ***Sidings, haul roads and ore stockpiles***. Soil pollution should be prevented at all times. Wherever coalliferous material or any material with a potential polluting ability will be dumped and handled, the footprint should be covered with at least 300 mm subsoil or soft overburden material (calcrete can be used) and the edges should be elevated (berm) to prevent pollution beyond the footprint.
- ***Discard, tailings and waste dumps***. At least 1000 mm of topsoil should be removed and stored for later rehabilitation. Borrow pits may not be made on a later stage in order to get topsoil for rehabilitation of the dump. The footprint should be compacted and sealed/lined, it should be free draining and all seepage should be channeled to pollution control dams.
- ***Pollution control dams***. The A-horizon (0-300 mm) and B-horizon of the topsoil should be stripped and stored separately for later rehabilitation. Materials with a potential polluting ability such as most ores may not be used to stabilized the base or wall embankments of the dam (calcrete can be used). The base of the dams should be lined with a geomembrane.

6.3 Operational phase (Open Pit)

In practice, even with optimal rehabilitation procedures applied, 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 prevent degradation of soil characteristics and to re-establish the highest possible post-mining land capability.
The following stripping, stockpiling and replacing procedures needs to be executed precisely:

- Two different soil types occur in the proposed open pit area that needs to be stripped and stockpiled separately. The extent and location of the soil types that should be stripped and stockpiled separately is highlighted in green (soil types Hu and Hu-D) and blue (Soil type Ad) in Figure 6. Soil types Hu and Hu-D are similar but soil type Hu-D are covered with a thin layer of ore and small dumps of waste rock and need to be cleaned thoroughly before soil stripping commences.
- The boundaries of the soil types that should be stripped at different depths and/or stockpiled separately, as shown in Figure 6, should be surveyed and staked at 50 m intervals before any soil stripping commences. This can be done by the surveyor or soil specialist. The stake points are shown in Figure 6 as yellow dots at intervals of 50 m and the coordinates are provided in Appendix D.
- The 2 proposed topsoil stockpiles, consisting each of a section for the A and B-horizon is outlined in green and blue in Figure 6. These stockpile positions or alternative positions, needs to be surveyed and staked by the mine surveyor. The most suitable stockpile positions should be determined by the mining

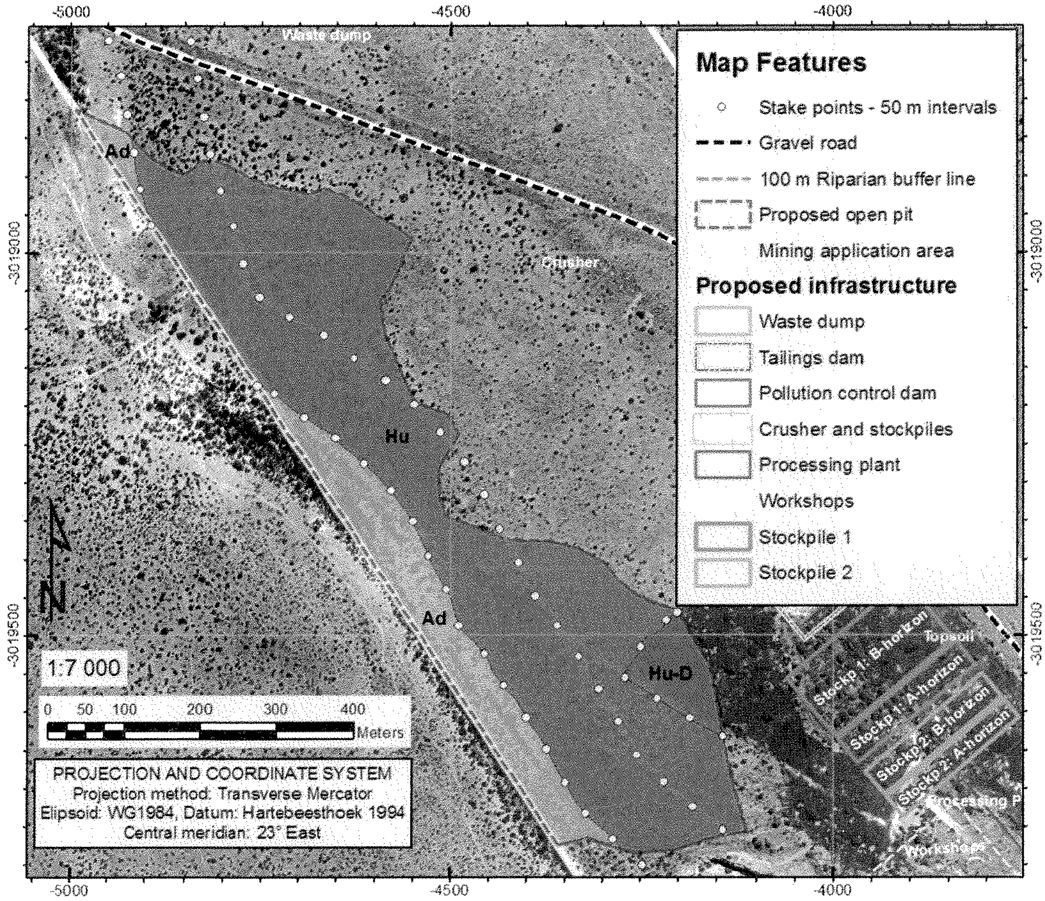
engineer considering the mining block sequence of the mine plan.

- The A and B-horizon should be stripped and stockpiled separately as specified in the guidelines for the rehabilitation of mined land (Chamber of Mines of South Africa, 2007). The A and B-horizon sections should be marked with a signboard. The size of the stockpiles should be based on the soil volume per stockpile as indicated in Figure 6 and no height restriction is proposed.
- All soil material above the calcrete layer has to be stockpiled or directly replaced at a backfilled section. Due to the thickness of the soil layer and large quantities of soil it will be necessary to implement a rollover mining method which implies that rehabilitation takes place concurrently with the mining process.
- Before topsoil can be replaced, the 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, and are 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.
- The backfilled surface should first be replaced with soil of the B-horizons. Care should be taken to tip enough soil per square unit to reinstate the total required B-horizon thickness at once. The dumped soil heaps should thus only be levelled to reach the required horizon/soil thickness. This will prevent compaction in the lower profile which can not be alleviated afterwards. Spreading of soil over far distances and repeated traversing should be avoided. Caterpillar tracked equipment is preferred to use for levelling of the B-horizons due to the large quantities of soil that needs to be handled and less compaction caused by these tracks. Bowl scrapers cause enormous compaction and may not be used.
- When the roll-over mining system kicks in and the point is reached where soils are stripped and directly replaced, without stockpiling, the following method should be implemented. The A-horizon of 1 mining strip should be stored at the final mining strip and the B-horizon should be tipped and levelled on the area to be rehabilitated (properly levelled spoil surface). The A-horizon of the next mining strip should then be tipped and levelled on top of the replaced B-horizon and the roll-over system can continue like this. The stored A-horizon of the first mining strip should then be replaced on the B-horizon of the last mining strip.
- After the B-horizon is replaced, the surface should be loosened to a depth of approximately 300 mm with normal agricultural equipment, preferably a multiple teeth implement. This is very important to prevent a compacted layer between the A and B-horizons which will be similar to a plough sole which dramatically reduces the effective soil depth and restrict root development.
- The A-horizon should then be tipped systematically over the loosened B-horizons surface and spread evenly. Replacing the A-horizon involves much smaller quantities of soil and a combination of a lighter dozer and grader should be used. Graders have the ability to create a more even surface with less traversing than a dozer, without creating too much compaction.
- The replaced topsoil thickness should progressively be monitored during replacement to verify if it is similar to the replacing depth provided in Figure 6 and to prevent that shortages of topsoil are not encountered.
- 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 rehabilitated sections should be re-vegetated with a grass mixture dominated by local climax species in early summer to stabilize the soil.
- 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.

The soil types that should be stripped and stockpiled either separately or together are shown in Figure 6. The figure includes a table that shows the stripping depths, the areas and percentages as well as the total soil volume per soil type based on the stripping depth. It also shows the replacing depth (topsoil thickness) and post-mining land capability class. This was determined by calculating the total soil volume per soil group (stockpile), divided by the original area which was stripped. This implies that if more than 1 soil type, which were stripped at different depths, are stockpiled together, it will be replaced at 1 average depth. It further shows the stake points on soil boundaries at 50 m intervals.



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

Soil group and stockpile no.	Soil Types	*Strip depth (m)	Area (ha)	Area (%)	Soil volume (m^3)	Post-mining: Replacing Depth (m)	Post-mining: Replacing Area (ha)	Post-mining: Land capability
Stockpile 1 (Red, well-drained Aeolian sand)	**Hu**	Total sand layer	18.17	77.07	436080 (2.4 m depth)	Total original sand layer	19.19	Grazing
	Hu-D	Total sand layer	1.02	4.34	24480 (2.4 m depth)			
		TOTAL	**19.19**	**81.41**	**460560**			
Stockpile 2 (Pale, yellowish brown, calcareous sand in riparian zone)	**Ad**	1.0	4.39	18.59	43900	1.0	4.39	Riparian
		TOTAL	**4.39**	**18.59**	**43900**			
		Grand Total	**23.58**	**100.00**	**504460**		**23.58**	

*The soils were assessed up to a depth of 2.4 m. However the total sand layer up to the calcrete layer should be stripped and stockpiled. The calcrete and topsoil layer should be replaced in the same sequence. No soil may be pushed into the pit to get rid of.

Figure 6: Soil stripping and stockpile guide for the open pit

The criteria for soil stripping and replacing within the open pit areas are summarised in Table 9 for the various soil types.

Table 9: Criteria for soil stripping and replacing within open pit areas

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

	Pre-mining					Post-mining		
Soil group and stockpile no.	**Soil Types**	***Strip depth (m)**	**Area (ha)**	**Area (%)**	**Soil volume (m^3)**	**Replacing Depth (m)**	**Replacing Area (ha)**	**Land capability**
Stockpile 1 (Red, well-drained, Aeolian sand)	**Hu**	Total sand layer	18.17	77.07	436080 (2.4 m depth)	Total original sand layer	19.19	Grazing
	Hu-D	Total sand layer	1.02	4.34	24480 (2.4 m depth)			
		TOTAL	**19.19**	**81.41**	**460560**			
Stockpile 2 (Pale, yellowish brown, calcareous sand in riparian zone)	**Ad**	1.0	4.39	18.59	43900	1.0	4.39	Riparian
		TOTAL	**4.39**	**18.59**	**43900**			
		Grand Total	**23.58**	**100.00**	**504460**		**23.58**	

*The soils were assessed up to a depth of 2.4 m. However the total sand layer up to the calcrete layer should be stripped and stockpiled. The calcrete and topsoil layer should be replaced in the same sequence. No soil may be pushed into the pit to get rid of.

6.3.1 Post-mining land capability commitments

The post-mining land capability class will mainly be determined 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 is slope, compaction and reduction of soil quality due to contamination of soils by subsoil, soft overburden or spoil material.

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 density 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 9. A final post-mining land capability map needs to be compiled and should be submitted for closure purposes.

6.4 Decommissioning phase

The following procedures for topsoil stripping and handling during the decommissioning phase should be followed:

- ***Remaining mined areas***. All remaining mined areas will be rehabilitated as described in section 6.3.
- ***Buildings and conveyers***. The footprint should be thoroughly cleaned and all building ruble and waste material should be removed. The footprint should be loosened by ripping actions. The topsoil should be ameliorated according to soil analyses and the footprint should then be re-vegetated with a grass mixture dominated by local climax species.
- ***Sidings, haul roads and ore stockpiles***. The footprint should be thoroughly cleaned and all ore and subsoil material should be removed to a suitable disposal facility. The footprint should be loosened by ripping actions. The topsoil should be ameliorated according to soil analyses and the footprint should then be re-vegetated with a grass mixture dominated by local climax species.

- ***Pollution control dams***. The footprint should be thoroughly cleaned from slurry and loosened by ripping actions before the subsoil, and then topsoil are replaced. The topsoil should be ameliorated according to soil analyses and the footprint should then be re-vegetated with a grass mixture dominated by local climax species.

7. ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Construction phase

The construction of mining related infrastructure such as a waste dump, tailings dam, pollution control dams, crusher, processing plant, topsoil stockpile, workshop, offices, explosives magazines and a load out and ancillary facility will have impacts on soil, land capability and land use during the construction phase. Minor soil disturbances will take place during the construction phase and a principal to store all excavated soil, to be used for rehabilitation, should be followed. The impacts are summarized in Table 10.

7.2 Operational phase

Stripping and stockpiling of topsoil within the proposed open pit footprint will take place during the operational phase. A rollover mining method will be impemented and backfilling, leveling of spoil and soft overburden material and replacing of topsoil will commence during the operational phase . The impact assessment and ranking are summarized in Table 11.

7.3 Decommissioning phase

At the end of the operational phase all impacts on soil, land capability and land use should have taken place. Areas not rehabilitated during the operational phase should be rehabilitated by which all impact should be mitigated as far as possible.

Table 10: Impact assessment – Construction phase

1. Nature of impact – Erection of removable structures such as a processing plant, offices, crusher , workshop and loading facilities								
Impact No	**Receptor**	**Impact and result**	**Magnitude**	**Scale**	**Duration**	**Probability**	**Significance calculation**	**Mitigation**
1	**Soil**	**Excavation of soil for foundations of structures will result in:** • Disturbance of natural soil horizon sequences.	The magnitude will be **very high** because the upper part of the soil profile of the entire footprint of the facility will be disturbed for the lifespan of the structure. (Very high - 10)	The impact will be confined to the footprint of the proposed structures. (site only - 1)	The impact will be of **long term** nature and will remain for the lifespan of the structure. (Long term - 4)	The impact will definitely occur. (Definite – 5)	(10+1+4)x5= 75 Significance = High	• All excavated topsoil will be stored to be used for rehabilitation during the decommissioning phase. • Topsoil and underlying material will be stripped and stored separately as described in section 6.1-6.3. The significance after mitigation can be low depending on how precise the procedures in section 6 are executed.
2	**Soil**	The structure covering the soil surface completely will result in: • Loss of the natural functioning of the soil as a growth medium and habitat for fauna and flora	The magnitude on the natural functioning of the soil as a growth medium and habitat for fauna and flora will be **very high** because structures will cover the surface completely. (Very high - 10)	The impact will be confined to the footprint of the proposed structures (site only - 1)	The impact will be of **long term** nature and will remain for the lifespan of the structure. (Long term - 4)	The impact will definitely occur. (Definite – 5)	(10+1+4)x5= 75 Significance = High	• The structures will be demolished and the footprints thoroughly cleaned as soon as the structure served its purpose. • The footprint will be rehabilitated by replacing the stored subsoil and topsoil in the original sequence • The soil fertility will be ameliorated according to soil analysis after replacing and leveling (before seeding/re-vegetation). • Re-vegetation of the footprint with a grass mixture dominated by local climax species. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.

3	**Soil**	• Loss of original soil fertility.	The magnitude on soil fertility will be **low** although covering the soil surface will hamper the natural replenishing and recycling of nutrients via fauna and flora. (Low - 4)	The impact will be confined to the footprint of the proposed structures. (site only - 1)	The impact will be of **long term** nature and will remain for the lifespan of the structure. (Long term - 4)	The impact will definitely occur. (Definite – 5)	(4+1+4)x5=45 Significance = Moderate	• Soil amelioration will be done after replacement of the topsoil according to soil analyses and the soil fertility will be maintained by an annual fertilizing program until the area can be declared as self sustaining. The environmental consequence after mitigation will be low.
4	**Land capability**	• The original land capability classified as grazing potential will cease completely until the structures are demolished and the footprints are rehabilitated.	The magnitude of the impact will be **very high** because the original land capability will cease completely for the entire lifespan of the structure until rehabilitation takes place. (Very high - 10)	The impact will be confined to the footprint of the proposed structures. (site only - 1)	The impact will be of **long term** nature and will remain for the lifespan of the structure. (Long term - 4)	The impact will definitely occur. (Definite – 5)	(10+1+4)x5= 75 Significance = High	• Stripping, storing and replacing of topsoil as described in section 6.1- and 6.3. • Soil amelioration will be done after replacement of the topsoil according to soil analyses and soil fertility will be maintained by means of an annual fertilizer program until self sustaining. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.
5	**Land use**	• The current possible land uses will cease completely until the structures are demolished and the footprints rehabilitated.	The magnitude of the impact will be **very high** because the current possible land uses will cease completely for the entire lifespan of the facility until rehabilitation takes place. (Very high - 10	The impact will be confined to the footprint of the proposed structures. (site only - 1)	The impact will be of **long term** nature and will remain for the lifespan of the facility. (Long term - 4)	The impact will definitely occur. (Definite – 5)	(10+1+4)x5= 75 Significance = High	• Stripping, stockpiling and replacing of topsoil as described in section 6.1-6.3. • Soil amelioration will be done after replacement of the topsoil according to soil analyses and soil fertility will be maintained by means of an annual fertilizer program until self sustaining. • Re-vegetation of the area with local climax grass species. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.

Table 11: Impact assessment – Operational phase

1. Nature of impact – Stripping and stockpiling of topsoil at the footprint of the proposed open pit								
Impact No	**Receptor**	**Impact and result**	**Magnitude**	**Scale**	**Duration**	**Probability**	**Significance calculation**	**Mitigation**
1	**Soil**	**Stripping of topsoil will result in:** • Loss of the original spatial distribution of soil types and soil horizon sequences.	The magnitude will be **very high** because the soil horizon sequences and physical properties at the entire footprint of the open pit will be disturbed. (Very high - 10)	The impact will be confined to the footprint of the open pits. (site only - 1)	The impact will be of **long term** nature and will start when topsoil is stripped during the operational phase and will remain until rehabilitation takes place by which the impact will be alleviated to some extent depending on quality of rehabilitation. (Long term - 4)	The impact will **definitely** occur. (Definite - 5)	(10+1+4) x5 =75 Significance = High	• Topsoil will be stripped, stockpiled and replaced based on soil types and depths as shown in Figure 6 and Table 9 and as described in section 6.1-6.3 • The original soil horizon sequences will be reconstructed as far as possible by stripping and stockpiling the A and B-horizons separately and by replacing it in the same sequence. The significance after mitigation can be lower depending on how precise the procedures in section 6 are executed.
2	**Soil**	• Loss of original effective soil depth and soil volume.	The magnitude on effective soil depth and volume will be **very high** because the total stripped area will basically have no effective soil depth until rehabilitation takes place. (Very high - 10)	The impact will be confined to the footprint of the open pits. (site only - 1)	The impact will be of **medium to long term** nature and will start when topsoil is stripped during the operational phase and will remain until rehabilitation takes place during either the operational or decommissioning phase. (Medium term - 3)	The impact will **definitely** occur. (Definite - 5)	(10+1+3) x5 =70 Significance = Moderate	• The footprint of the opencast and areas to be stripped will be contained as far as possible. • The topsoil will be replaced at depths fairly similar to pre-mining conditions as described in section 6.1-6.3 and Table 9. The significance after mitigation can be lower depending on how precise the procedures in section 6 are executed.
3	**Soil**	• Loss of original topography and drainage pattern	The magnitude will be **high** because the original topography and surface drainage pattern will remain completely changed until the open pits are backfilled and rehabilitated.	The impact will be confined to the footprint of the open pits.	The impact will be of **medium to long term** nature and will start when topsoil is stripped during the operational phase and will remain until rehabilitation takes place during either the	The impact will **definitely** occur.		• The open pit will be backfilled similar to the original elevation and topography. • The spoil surface will be shaped to ensure a free draining surface and a continuation of the pre-mining surface drainage pattern. • Replacing of topsoil as described in section 6.1-6.3.

			(High - 8)	(site only - 1)	operational or decommissioning phase. (Medium term - 3)	(Definite - 5)	(8+1+3)x5=60 Significance = Moderate	The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.
4	**Soil**	• Loss of original soil fertility.	The magnitude on soil fertility will be **low** although stripping and stockpiling of soil will hamper the natural replenishing and recycling of nutrients via fauna and flora. (Low - 4)	The impact will be confined to the footprint of the open pits. (site only - 1)	The impact will be of **medium to long term** nature and will start when topsoil is stripped during the operational phase and will remain until rehabilitation takes place during either the operational or decommissioning phase. (Medium term - 3)	The impact will **definitely** occur. (Definite - 5)	(4+1+3)x5=40 Significance = Moderate	• Soil amelioration will be done after replacement of the topsoil according to soil analyses and the soil fertility will be maintained by an annual fertilizing program until the area can be declared as self sustaining. The environmental consequence after mitigation will be low.
5	**Land capability**	• The original land capability classified as grazing will cease completely until the open pits are backfilled and rehabilitated.	The magnitude of the impact will be **very high** because the original land capability will cease completely until the open pits are backfilled and rehabilitated. (Very high - 10)	The impact will be confined to the footprint of the open pits. (site only - 1)	The impact will be of **medium to long term** nature and will start when topsoil is stripped during the operational phase and will remain until rehabilitation takes place during either the operational or decommissioning phase. (Medium to long term - 4)	The impact will **definitely** occur. (Definite - 5)	(10+1+4)x5 =75 Significance = High	• Topsoil will be stripped and stockpiled per soil type and at depths as shown in Figure 6 and as described in section 6.1-6.3. • The open pit will be backfilled similar to the original elevation and topography. • The spoil surface will be shaped to ensure a free draining surface and a continuation of the pre-mining surface drainage pattern. • The topsoil will be replaced at depths fairly similar to pre-mining conditions as described in section 6.1-6.3 and Table 9. • Soil amelioration will be done after replacement of the topsoil according to soil analyses and soil fertility will be maintained by means of an annual fertilizer program. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.
6	**Land use**	• The current possible land uses will cease	The magnitude of the impact will be **very high**	The impact will be confined to	The impact will be of **medium to long term**	The impact will **definitely**		• Topsoil will be stripped at depths and per soil type as shown in Figure 6 and

		completely until the open pits are backfilled and rehabilitated.	because the current possible land uses will cease completely until the open pits are backfilled and rehabilitated. (Very high - 10)	the footprint of the open pits. (site only - 1)	nature and will start when topsoil is stripped during the operational phase and will remain until rehabilitation takes place during either the operational or decommissioning phase. (Medium to long term - 4)	occur. (Definite - 5)	(10+1+4)x5 =75 Significance = High	Table 9 and as described in section 6.1-6.3. • The open pit will be backfilled similar to the original elevation and topography. • The spoil surface will be shaped to ensure a free draining surface and a continuation of the pre-mining surface drainage pattern. • The topsoil will be replaced at depths fairly similar to pre-mining conditions as described in section 6.1-6.3 and Table 9. • Soil amelioration will be done after replacement of the topsoil according to soil analyses and soil fertility will be maintained by means of an annual fertilizer program. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.
2. Nature of impact – Natural soils covered by stockpiles and dumps (topsoil, subsoil, soft overburden, hard overburden and waste)								
7	**Soil**	• Severe soil compaction by the weight of dumped material.	The magnitude of the impact will be **medium** because the natural soil physical status will be altered negatively. (Moderate - 6)	The impact will be confined to the footprint of the dumps and stockpiles. (site only - 1)	The impacts will be of **medium to long term** nature and will commence during the operational phase and will remain until the stockpiles and dumps are removed which will probably be during the decommissioning phase. (Medium to long term - 4)	The impact will definitely occur. (Definite - 5)	(6+1+4)x5=55 Significance = Moderate	• Alleviation of compaction at the footprint of dumps and stockpiles after removal by ripping actions. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.
8	**Land capability**	• Covering the natural soil surface with dumps and stockpiles will cause the land capability to cease completely.	The magnitude of the impact will be **very high** because the land capability will cease completely until the stockpiles and dumps are removed.	The impact will be confined to the footprint of dumps and stockpiles.	The impacts will be of medium to long term nature and will commence during the operational phase and will remain until the stockpiles and dumps are removed which will	The impact will definitely occur at the footprint of any dump or stockpile.		• All stockpiles will be removed during the rehabilitation process. • Alleviation of compaction at the footprint of dumps/stockpiles by ripping actions. • Amelioration of topsoil according to soil analysis. • Re-vegetations with grass mixture

			(High - 10)	(site only - 1)	probably be during the decommissioning phase. (Medium to long term - 4)	(Definite - 5)	(10+1+4)x5 =75 Significance = High	dominated by local climax species. • Annual maintenance of soil fertility by fertilizer applications. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.
9	**Land use**	• Covering the natural soil surface with dumps and stockpiles will cause all possible land uses to cease completely.	The magnitude of the impact will be **very high** because all possible land uses will cease completely until the stockpiles and dumps are removed. (High - 10)	The impact will be confined to the footprint of the dumps and stockpiles. (site only - 1)	The impacts will be of long term nature and will commence during the operational phase and will remain until the stockpiles and dumps are removed which will probably be during the decommissioning phase. (Medium to long term - 4)	The impact will definitely occur at the footprint of any dump or stockpile. (Definite - 5)	The impact will definitely occur at the footprint on any dump or stockpile. (10+1+4)x5= 75 Significance = High	• All stockpiles will be removed during the rehabilitation process. • Alleviation of compaction at the footprint of dumps/stockpiles by ripping actions. • Amelioration of topsoil according to soil analysis. • Re-vegetation with a grass mixture dominated by local climax speicies. • Annual maintenance of soil fertility by fertilizer applications. The environmental consequence after mitigation can be low depending on how precise the procedures in section 6 were executed.

8. CONCLUSIONS

The following conclusions are made from the study:

8.1 Soils and land capability (Figures 3 and 4 and Table 6)

- ***No areas were classified as arable land.***

- ***Approximately 69.23% of the mining application area is classed as grazing land capability with low agricultural potential.*** The grazing potential soils consists of very deep, well-drained, red aeolian sand, dominated by the Hutton soil form, symbolized as soil types Hu and Hu-D comprising 62.23 and 7.0 % of the mining application area respectively.

- ***No areas were classed as wetland.***

- ***Approximately 7.92% of the study area is classed as riparian land with very low agricultural potential.*** The soils in the riparian zone consists of deep, pale yellow, calcareous, sandy soils underlain by soft or hardpan carbonate, dominated by the Addo soil form, symbolized as soil type Ad.

- ***Approximately 22.85% of the study area is classed as wilderness land with no agricultural potential.*** These sections consists of the existing open pit, symbolized as unit OP, comprising 5.73% of the mining application area and areas covered by overburden material, symbolized as unit OB-Cal, comprising 17.12% of the mining application area.

8.2 Pre-mining land use (Figure 5 and Table 7)

- ***Approximately 57.35% of the mining application area is utilized for grazing purposes (mainly cattle).***

- **The gravel road and fenced off edges occupy 6.22% of the mining application area.**

- **The fenced off old mining area comprises 36.45% of the study area consisting of an old open pit, overburden dump, old ore stockpile footprint and vacant areas.**

8.3 Impact assessment

Soil stripping and replacing, no matter whether it is stockpiled or immediately replaced, will always have a high potential degrading impact on soil, post-mining land capability and land use. Poor rehabilitation generally leads to an enormous deterioration from pre-mining to post-mining land capability and agricultural potential in South Africa. The degree of degradation will **always** depend on the **precise execution, management and monitoring** of the rehabilitation procedures.

The major impacts on soil, land capability and land use during the construction and operational phases are identified as:

Construction phase

Soil horizon sequences will be **disturbed due to the erection of structures such as a** pollution control dams, a crusher, processing plant, workshop, offices, explosives magazines and a load out and ancillary facility. The topsoil will be disturbed to some extent and the soil surface will be covered completely. The impacts at the footprint of the structure will be:

- Disturbance of natural soil horizon sequences.
- Loss of the natural functioning of the soil as a growth medium and habitat for fauna and flora
- Loss of original soil fertility.
- A complete cease of all land capability e.g. grazing.
- A complete cease of all current possible land uses.

The environmental significance of these impacts was rated as high during the lifespan of the structure but can be mitigated to acceptable levels at the end of the lifespan of the structure.

Operational phase

The impact will be the complete removal and stockpiling of topsoil at the footprint of the proposed open pit which will result in:

- Loss of the original spatial distribution of soil types and soil horizon sequences
- Loss of original effective soil depth and soil volume.
- Loss of original topography and drainage pattern
- Loss of original soil fertility.
- A complete cease of all land capability e.g. grazing or riparian.
- A complete cease of all current possible land uses.

The environmental significance of these impacts was rated as high until rehabilitation takes place during both the operational or decommissioning phase. The environmental significance after mitigation is hard to predict because it is solely dependent on the quality of rehabilitation. The environmental significance can however be mitigated to acceptable levels if the procedure in section 6 and the recommendations in section 9 are strictly followed.

8.4 Proposed mine plan

The proposed mine plan is shown on Figures 3, 4, 5 and 6 in order to evaluate possible impacts or conflicts by proposed infrastructure in terms of soils, land capability and land uses. The following conclusions were made:

- ***The existing mine plan does not indicate dedicated topsoil stockpiles for different soil types and soil horizons.*** This issue was addressed and dedicated stockpiles for different soil types and horizons is shown on Figure 6 and should be incorporated in the updated mine plan.

- ***The proposed open pit includes sections of the riparian zone.*** The riparian zone was accurately delineated based on soil properties, topography and vegetation indicators. Stake points were generated at 50 m intervals on the eastern riparian edge as well as a 100 m buffer line as shown in Figure 6. The coordinates of the stake points are provided in Appendix D. The extent of riparian zone within the proposed open pit is shown in Figures 4 and 6.

- ***The most northern proposed pollution control dam is situated on the edge of a dune with a slope of 14%.*** This locality might need to be re-evaluated.

- ***Various proposed infrastructure is located on the existing overburden dump shown as unit V-OBD on Figure 5.*** It was indicated by the mine that the footprints of these planned structures will be thoroughly cleaned before structures are erected.

9. RECOMMENDATIONS

- The soil, land capability and land use information on Figures 3, 4, 5 and 6 should be used to refine the proposed mine plan.

- The stripping plan, Figure 6 includes the soils within the riparian zone but it is subject to authorization by the relevant government divisions.

9.1 Requirements for successful rehabilitation

In order to guarantee successful rehabilitation, the procedures in section 6 need to be executed and the following is required:

- Soil boundaries of soil types that should be stripped and stockpiled separately should be staked at 50 m intervals before any soil stripping commences.
- Soil types should be stripped at stripping depths as specified on Figures 6 and Table 9.
- Topsoil should be stockpiled on 2 stockpiles as specified on Figure 6 to accommodate 2 soil groups namely red aeolian sand of undulating dunes and pale, yellowish brown, calcareous sand of the riparian zone. Each stockpile should consist of separate sections for the A and B-horizons.
- The spoils should be leveled to a free draining surface, similar to the pre-mining topography, before topsoil is replaced during rehabilitation.
- Topsoil should be replaced evenly over spoils during rehabilitation at depths as specified in Figure 6 and Table 9.
- The A and B-horizons should be reconstructed in the original sequence as specified by the procedures in section 6.
- The replaced topsoil should be ameliorated according to soil analysis before seeding and re-vegetation take place.
- Rehabilitated areas should be re-vegetated as soon as possible with a grass mixture dominated by local climax species in order to stabilize the soils.
- Soil erosion on the rehabilitated areas should be monitored and remediate if necessary until the area can be declared as stabilized and self sustaining.
- A post-mining soil depth and land capability evaluation should be done by a soil specialist registered at the Council for Natural Scientific Professions (SACNASP). A post-mining land capability map should be compiled and submitted for closure purposes.

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APPENDIX A
SOIL CLASSIFICATION SYSTEM

The classification system categorise soil types in an upper soil Form level which are subdivided in 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 were then symbolized e.g. Hu and referred to as soil type Hu. The soil Form and Family were often further categorized based on effective soil depth, terrain unit and slope and a numerical number was 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 was 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 was 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 periodic 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 part 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 which are characterized by grey, leached, sandy horizons and mottled plinthic horizons.

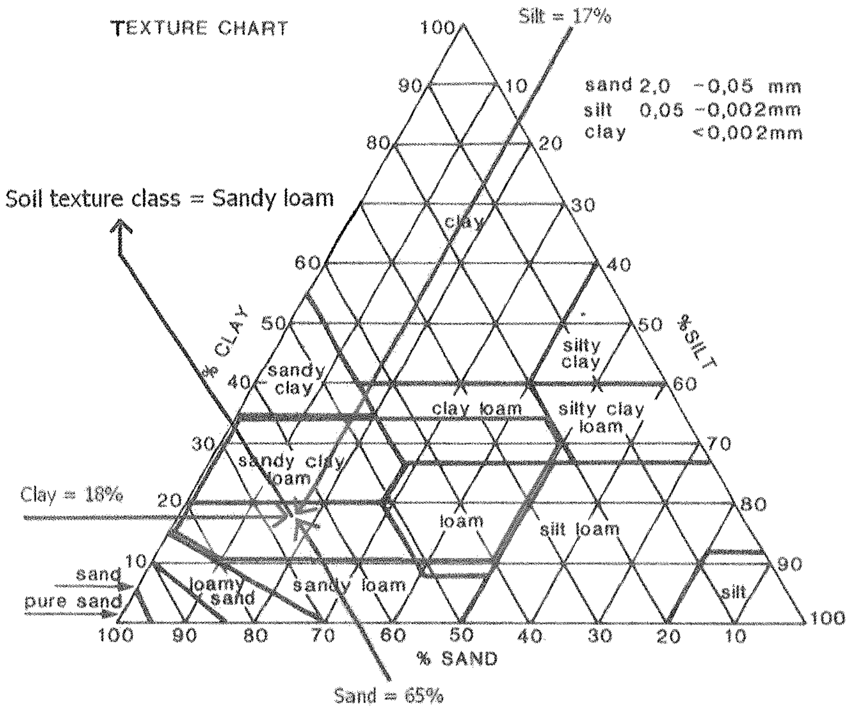
Poorly drained soils mostly display impeded internal drainage in the upper and lower part of the soil profile e.g. E, plinthic and G-horizons and are the result of long term to permanent wetness in the soil profile and are characterized by grey, leached, sandy horizons, mottled plinthic horizons and 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 the diagram below) 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 need to be evaluated together with other soil properties.


TEXTURE CHART
Silt = 17%
sand 2,0 -0,05 mm
silt 0,05 -0,002mm
clay <0,002mm
Soil texture class = Sandy loam
clay
% CLAY
% SILT
sandy clay
silty clay
clay loam
silty clay loam
sandy clay loam
Clay = 18%
loam
silt loam
sand
pure sand
loamy sand
sandy loam
silt
% SAND
Sand = 65%

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 takes 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 1 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 slight 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 appears usually 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 looses its dark colour in the dry state and the grey colour of the soil particles became 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 quarts 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 AND STAKE POINTS

Table D1: Coordinates of soil sampling points

Coordinates of Soil Sampling Points				
Soil sampling point	Projected Coordinate System **Elipsoid:** WGS 1984 **Coordinate system:** LO23 **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)
F9	3019700.000	3990.000	-27.289417	22.959697
I7	3019250.000	4290.000	-27.285355	22.956668
K4	3018950.000	4740.000	-27.282646	22.952124
L7	3018800.000	4290.000	-27.281294	22.956670
O4	3018350.000	4740.000	-27.277231	22.952126
X41	3019676.598	4392.532	-27.289204	22.955631

Table D2: Coordinates of stake points on 100m wetland buffer line and soil type boundaries

Stake Point No	Projected Coordinate System Elipsoid: Wgs 1984, Coordinate sytem: LO 29, Datum: Hartebeesthoek 1994		Stake Type
	X (m)	Y (m)	
S1	3019836.38	4213.305	Soil boundary
S2	3019801.026	4246.965	Soil boundary
S3	3019768.756	4284.925	Soil boundary
S4	3019734.161	4320.949	Soil boundary
S5	3019693.226	4348.912	Soil boundary
S6	3019649.542	4373.2	Soil boundary
S7	3019607.774	4400.385	Soil boundary
S8	3019567.104	4428.992	Soil boundary
S9	3019525.336	4455.386	Soil boundary
S10	3019488.554	4488.817	Soil boundary
S11	3019441.454	4504.617	Soil boundary
S12	3019397.605	4528.564	Soil boundary
S13	3019352.333	4549.785	Soil boundary
S14	3019312.506	4579.696	Soil boundary
S15	3019275.805	4613.514	Soil boundary
S16	3019243.691	4651.754	Soil boundary
S17	3019216.086	4693.189	Soil boundary
S18	3019185.658	4732.639	Soil boundary
S19	3019174.916	4755.243	Soil boundary
S20	3018964.918	4893.886	Soil boundary
S21	3018917.03	4908.264	Soil boundary
S22	3018867.987	4917.76	Soil boundary
S23	3018818.852	4926.745	Soil boundary
S24	3018769.492	4934.702	Soil boundary
S25	3018722.473	4950.967	Soil boundary
S26	3018677.829	4973.005	Soil boundary
S27	3018631.2	4991.043	Soil boundary
S28	3018582.459	5001.758	Soil boundary
S29	3018533.675	5012.413	Soil boundary
S30	3018486.756	5029.381	Soil boundary
S31	3018446.208	5057.991	Soil boundary
S32	3018427.383	5071.154	Soil boundary
S33	3019633.478	4140.964	Soil boundary
S34	3019609.408	4184.744	Soil boundary
S35	3019582.947	4227.163	Soil boundary
S36	3019556.005	4269.284	Soil boundary
S37	3019515.466	4248.717	Soil boundary

S38	3019481.959	4215.515	Soil boundary
S39	3019470.3	4201.343	Soil boundary
R1	3019755.496	4141.298	100 m Riparian buffer line
R2	3019725.493	4181.116	100 m Riparian buffer line
R3	3019692.75	4218.58	100 m Riparian buffer line
R4	3019657.801	4254.01	100 m Riparian buffer line
R5	3019614.232	4278.511	100 m Riparian buffer line
R6	3019571.293	4303.994	100 m Riparian buffer line
R7	3019528.976	4330.397	100 m Riparian buffer line
R8	3019488.895	4359.224	100 m Riparian buffer line
R9	3019449.018	4388.951	100 m Riparian buffer line
R10	3019405.114	4410.454	100 m Riparian buffer line
R11	3019361.596	4435.067	100 m Riparian buffer line
R12	3019316.309	4456.256	100 m Riparian buffer line
R13	3019274.063	4482.25	100 m Riparian buffer line
R14	3019235.167	4513.668	100 m Riparian buffer line
R15	3019199.572	4548.672	100 m Riparian buffer line
R16	3019167.336	4586.805	100 m Riparian buffer line
R17	3019139.335	4627.866	100 m Riparian buffer line
R18	3019108.353	4666.985	100 m Riparian buffer line
R19	3019084.659	4710.733	100 m Riparian buffer line
R20	3019058.111	4753.082	100 m Riparian buffer line
R21	3019014.637	4773.124	100 m Riparian buffer line
R22	3018966.299	4785.804	100 m Riparian buffer line
R23	3018919.435	4803.132	100 m Riparian buffer line
R24	3018871.198	4816.142	100 m Riparian buffer line
R25	3018822.075	4825.245	100 m Riparian buffer line
R26	3018772.686	4832.99	100 m Riparian buffer line
R27	3018723.82	4842.962	100 m Riparian buffer line
R28	3018677.358	4861.24	100 m Riparian buffer line
R29	3018632.729	4883.318	100 m Riparian buffer line
R30	3018585.648	4899.942	100 m Riparian buffer line
R31	3018536.391	4908.362	100 m Riparian buffer line
R32	3018488.173	4921.56	100 m Riparian buffer line
R33	3018441.644	4939.613	100 m Riparian buffer line
R34	3018400.452	4966.969	100 m Riparian buffer line
R35	3018377.057	4984.322	100 m Riparian buffer line

APPENDIX E
SOIL HORIZONS PROPERTIES INFLUENCING STRIPPING AND STOCKPILING PROCEDURES

The stripping procedures aim, with consideration of practical limitations, to reconstruct the original horizons 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 thousand of years in a specific sequence and is the result of soil genesis (weathering) of the parent rock driven by climatic conditions (temperature and moist) 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.

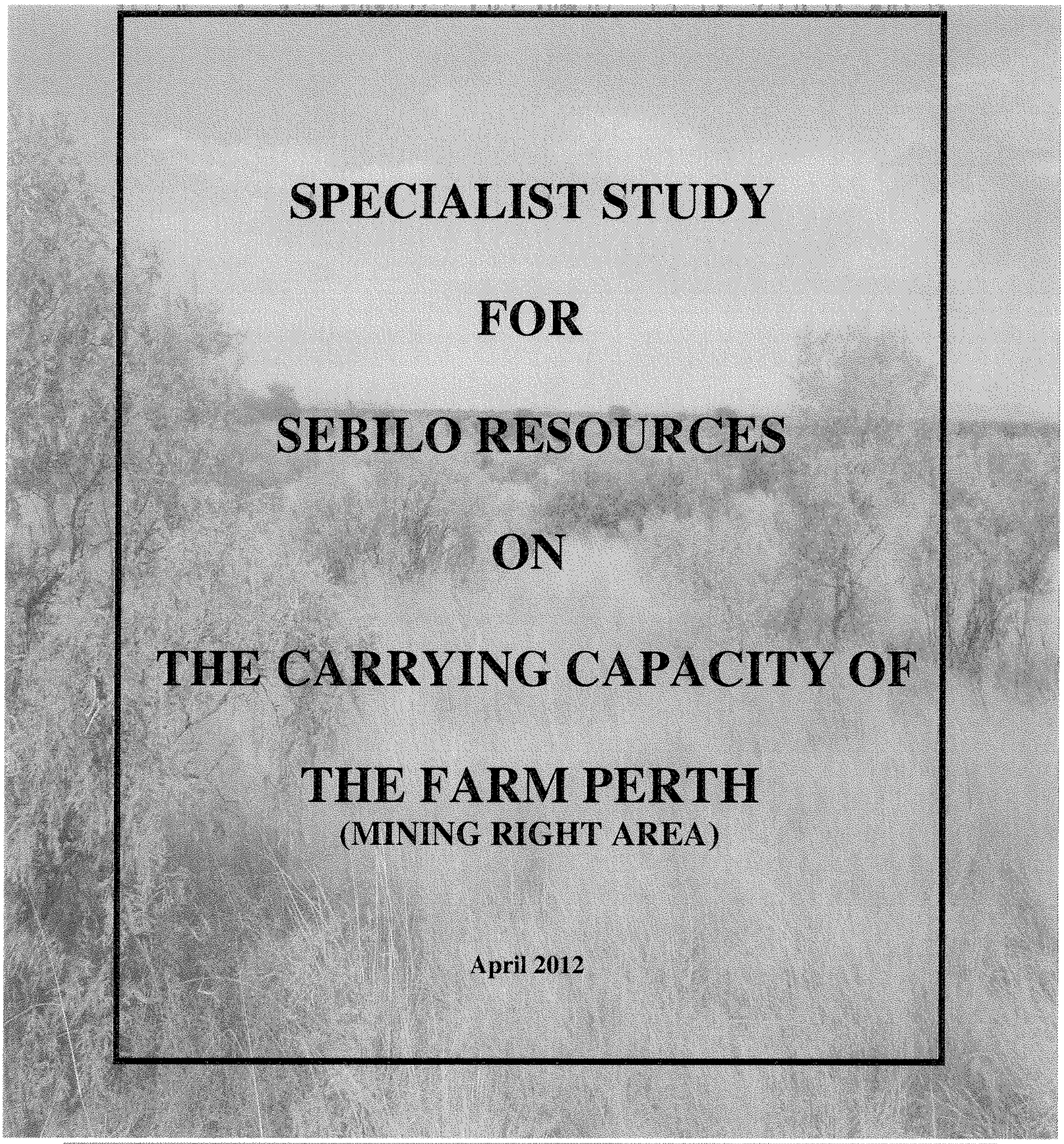
The term topsoil in these guidelines refers to the A, B, E and G-horizons of the soil profile as defined in the Taxonomic Soil Classification system for South Africa. The A-horizon comprises the upper part (0-300 mm) of the soil profile and the B1 and B2-horizon from 300 mm up to the stripping depth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

The A-horizon are 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 significant 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 emanation 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 it. It is 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 slow permeable horizons. Placing this horizon on the surface will result in high runoff, very low infiltration and poor plant growth.



SPECIALIST STUDY

FOR

SEBILO RESOURCES

ON

THE CARRYING CAPACITY OF

THE FARM PERTH

(MINING RIGHT AREA)

April 2012

Compiled by:

UMFAAN ECOLOGICAL CONSULTANTS

Dr. Faan van Wyk (PhD) ***Pr.Sci.Nat.***

E-mail: faanretha@telkomsa.net Mobile: 082 551 7782
Tel: 018 294 7971 Fax: 018 294 7971

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CARRYING CAPACITY OF THE MINING RIGHT AREA OF THE FARM PERTH

APRIL 2012

1 INTRODUCTION

A vegetation survey of two camps of the farm Perth indicated as part of the Mining right area was conducted on 26 March 2002.

The results of the different surveys will be discussed in detail. Carrying capacity of surveyed areas will be indicated as determined following the guidelines of:

- Fourie, J, 1976 (Keurkaart), Kruger, J A 1985 ('n Eenvoudige tegniek om die weidingskapasiteit van veld te bepaal) as well as Van Zyl, E A, 1986 (Veldtoestandbepaling).
- Esterhuizen, S, Botha, W, & Van der Westhuizen, M. 1997. Keurkaart vir Weikapasiteit- en Veldtoestandbepaling in die Kalahari duineveld.

Several officials of the Department of Agriculture in the Northern Cape as well as in the North West Province were also consulted and included:

- Dr. F P Jordaan – Dept. Agriculture, Conservation, Environment and Rural Development North West Provincial Government.
- Mr. Louis de Jager - Dept. Agriculture, Land reform and Rural Development, Northern Cape Provincial Government.
- Mr. Wynand Nel - Dept. Agriculture, Land reform and Rural Development, Northern Cape Provincial Government.
- Mr. Seppie Esterhuizen - Dept. Agriculture, Land reform and Rural Development, Northern Cape Provincial Government.

If necessary, situations (positive or negative) will be discussed and the specific areas will be mentioned.

This was a scientific evaluation; therefore the result of the audit is based on actual data collected during the survey.

It must be kept in mind that the carrying capacity of an area is not an exact figure and will change because grazing practices as well as varying climatic conditions can change most of the parameters indicated under point 3.

2 SURVEY METHOD

All the surveys were done using a Bridge point apparatus with ten pegs.

The plots were distributed at intervals of 20 - 30m (depending on the width of the area) in a straight line in order to cover a large area.

During the survey, in tact vegetation nearest to a peg, but within a 5cm radius is noted to determine frequency of occurrence of species. When there is no in tact vegetation within a 5cm radius, it is recorded as "bare ground".

When a peg hits a tuft, it is recorded as a hit to determine basal cover.

Crown cover (area covered by above ground material – leaves and inflorescences) is an estimated value recorded at each plot.

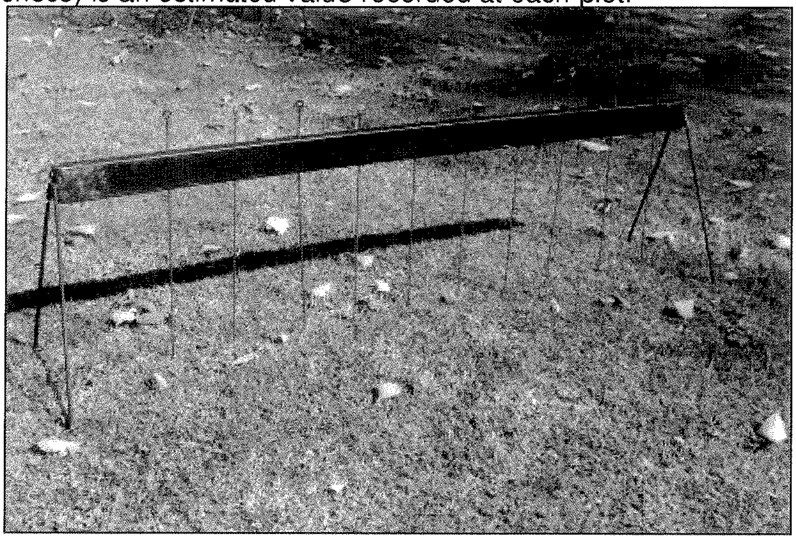

Figure 1: Bridge point apparatus used during surveys.

3 VELD CONDITION RATING AND CARRYING CAPACITY

The carrying capacity of all the areas were determined by applying a method developed by Esterhuizen, S, Botha, W, & Van der Westhuizen, M. 1997. Keurkaart vir Weikapasiteit- en Veldtoestandbepaling in die Kalahari duineveld.

The Veld condition rating and Carrying capacity of an area is determined by several factors including:

- Vegetation of the specific area, taking into consideration:
  - A - Botanical composition (0 – 10) (Species, Palatability, production)
  - B - Plant cover and perennial status (0 – 10) (Density, basal cover etc.)
  - C - Vitality of the vegetation (0 – 10)
  - D - Insect and rodent damage (0 – 10)
- Climatic conditions (long term average annual rainfall as well as rainfall of the specific season)

Veld condition rating (V) is calculated by applying the following formula:

$V = (A \times 0.75) + (B \times 0.1) + (C \times 0.1) + (D \times 0.05)$

After the Veld condition rating was determined, the Table attached as Appendix 1 is used to determine the carrying capacity of the area.

Information obtained from officials of the Department of Agriculture in the Northern Cape indicated that the average long term rainfall for the is ± 340 – 350mm per annum.

Rainfall figures obtained from Black Rock mine indicated that the rainfall for the 2010/11 (November 2010 – June 2011) season was 545mm (more than 200mm above average) while figures for part of the 2011/12 season (November 2011 – March 2012) was only 193.5mm (45% below average). It must be taken into consideration that the season is not completed.

Rainfall figures received from UMK mine indicated that the rainfall for part of the 2010/11 season (only January 2011 – June 2011) – (figures for October – December 2010 is not available) season was 342 mm (approximately average) while figures for the 2011/12 season (November 2011 – March 2012) was only 150mm (57% below average).

4 OBSERVATIONS AND COMMENTS

The vegetation of the area classified Musina and Rutherford (2006) as Veld type SVk 12 (Kathu Bushveld). The most important trees indicated are *Acacia erioloba*, *Acacia mellifera* subsp. *detinens, Terminalia sericea and Boscia albitrunca.* Grass species includes *Aristida meridionalis, Brachiaria nigropedata, Eragrostis lehmanniana, Stipagrostis ciliata, Schmidtia pappophoroides, Stipagrostis uniplumis, Aristida congesta, Eragrostis pallens,* and *Melinis repens.*

During the survey most of these species were identified. Important species identified and not included in the list of Musina and Rutherford (2006) are the following:

Trees: *Acacia haematoxylon* and *Ziziphus mucronata*
Shrubs: Grewia flava
Grasses: *Aristida stipitata*

Although clumps as well as individual plants of *Acacia mellifera* subsp. *detinens* are present, some of the plants were eradicated chemically (herbicides) by the farmer.

Only a few large specimens of *Acacia erioloba* and *Terminalia sericea* could be identified while the majority of the woody vegetation consists of *Acacia haematoxylon* and *Grewia flava* specimens. Both these species are utilized by cattle during some months of the year but was not taken into consideration during the determination of the carrying capacity of the areas.

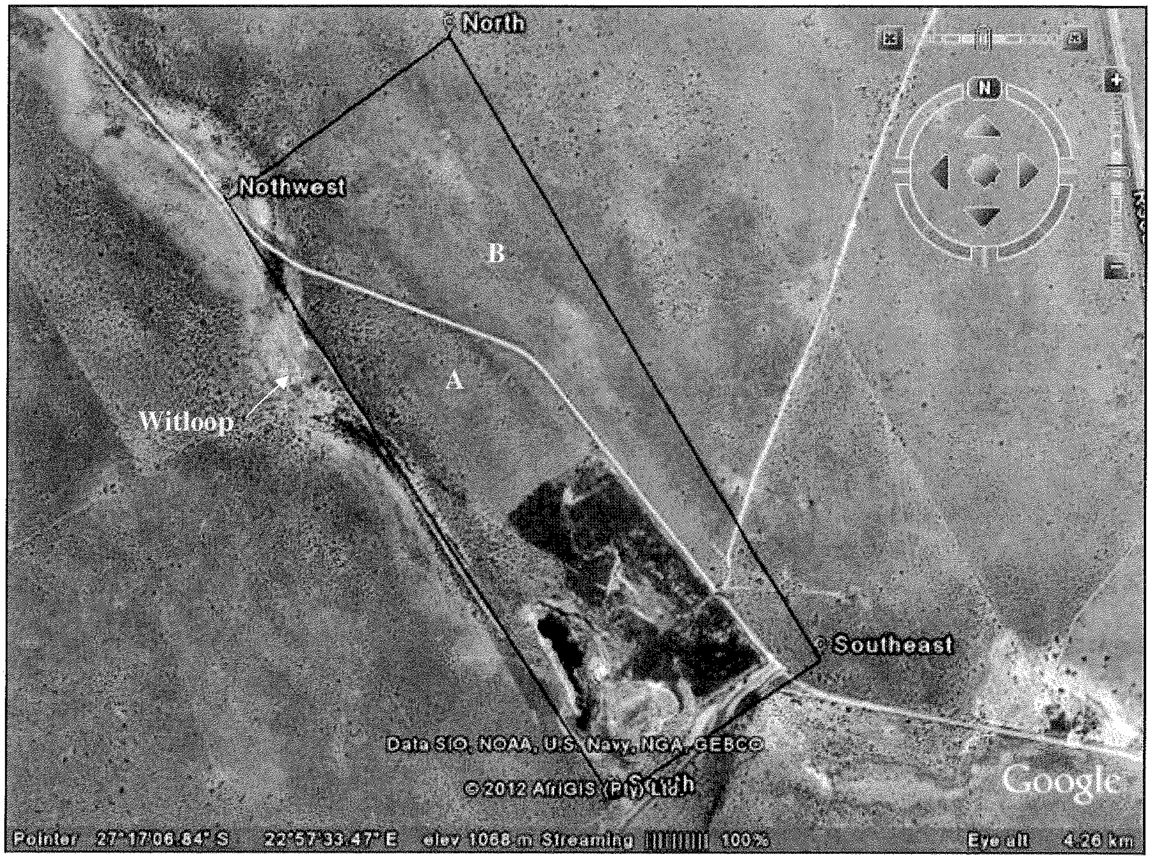

Figure 2: Google map indicating the Mining right area.

4.1 Area A – Mining area (south western side of the road – Bull camp) (Fig. 2)

Figure 3: Fairly flat area with open Savanna with *Acacia haematoxylon* and *Aristida meridionalis* the prominent species.

Figure 4: Western slope of the dune with open Savanna with *Acacia haematoxylon* and *Aristida meridionalis* the prominent species.

Figure 5: Top of a slope of the dune with open Savanna with a clump of *Acacia melifera subsp. detinens* and *Aristida meridionalis* the prominent species. Only the few Terminalia sericia trees occur in the area.

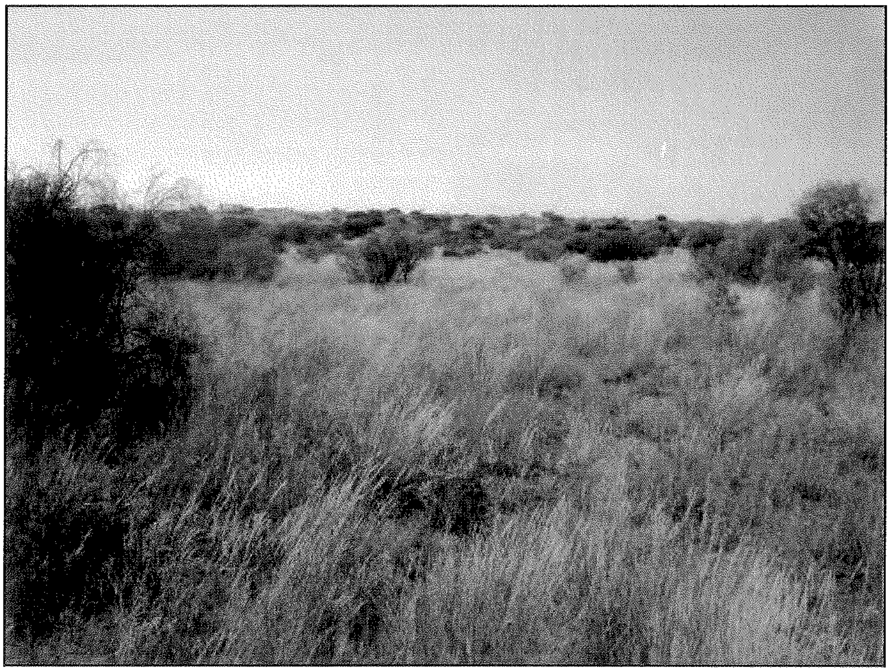

Figure 6: Fairly flat open Savanna with Aristida Western slope of the dune with open Savanna with *Acacia haematoxylon* and *Aristida stipitata* the prominent species.

Figure 7: Witloop area on the western border of the farm invaded by *Prosopis glandulosa* (Category 2 invader)

Figure 8: A totally bare surface under the *Prosopis glandulosa* trees.

This area is fenced and grazing can therefore be regulated.

The results of the survey are presented in Table 1.

Table 1: Data collected at Area A (south western side of the road – Bull camp) Fig. 2.

No.	Species	Palatability	Perennial (P) Annual (A)	Frequency		Basal cover	
				Nearest point (5cm radius)	%	Hits	%
	Bare soil			279	69.75		
	Herbs			13	3.25		
1	Aristida meridionalis	Very low	P	12	3.00		
2	Stipagrostis uniplumis	Med	P	1	0.25		
3	Pogonarthria squarrosa	Med	A	2	0.50		
4	Melinis repens	High	A	6	1.50	1	0.25
5	Eragrostis lehmanniana	Med	P	65	16.25	4	1.00
6	Schmidtia pappophoroides	High	P	8	2.00		
7	Aristida stipitata	Very low	P	13	3.25		
8	Aristida congesta subsp. congesta	Low	A	1	0.25		
	TOTAL: 8		**P = 5 (62.5%) A = 3 (37.5%)**	**400**	**100**	**5**	**1.25**
	Estimated Crown Cover		**40%**				

Important info from the data is the following:

Bare ground frequency	69.75%
Perennial grasses frequency	24.75%
Annual grasses frequency	2.25%
% Perennial species found in survey	62.5%
% Annual species found in survey	37.5%
Basal cover	1.25%
Crown cover (estimate)	40%
High palatability	11.5% of grass cover.
Medium palatability	55.4% of grass cover
Low palatability	1.6% of grass cover
Very low palatability	20.7% of grass cover
Herbs	10.7% of the herb layer

Although nearly 67% of herb layer is Medium and High palatable grasses, it must be kept in mind that nearly 70% of the frequency of occurrence is bare ground. The large tufts of unpalatable grasses are giving the impression of a good cover (Fig. 3 – 6) while the opposite is demonstrated by the high bare ground result, low basal cover of 1.25% and Crown cover of 40%.

The Witloop area (Figures 7 & 8) was not taken into consideration in the survey because it is only a very small strip on the western border of Area A..

Carrying capacity of Area A

With the info above as well as observations made during the survey, the points scored for the different criteria are as follows:

A - Botanical composition	7
B - Plant cover	7
C - Vitality	8
E - Insect and rodent damage	8

Veld condition rating applying the formula (See point 3) is therefore **71.50**
Carrying capacity (350mm rainfall area) is therefore **14,5Ha/LSU** (Appendix 1)

4.2 Area B –North eastern side of the road (Fig. 2)

This area is also fenced and grazing is controlled.

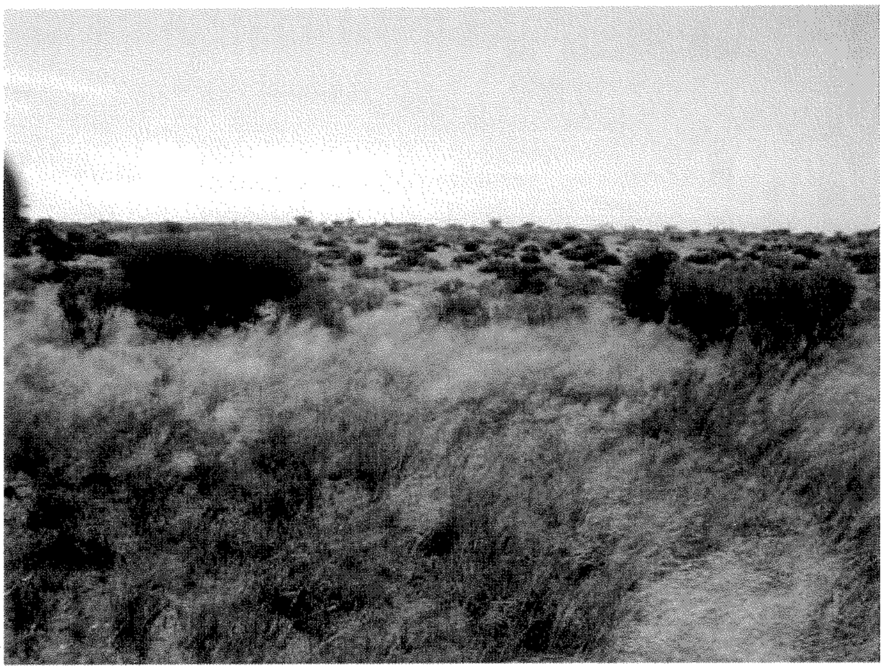

Figure 9: Area B - an open Savannna with a large component of *Aristida meridionalis*. *Acacia haematoxylon* is still the dominant woody species.

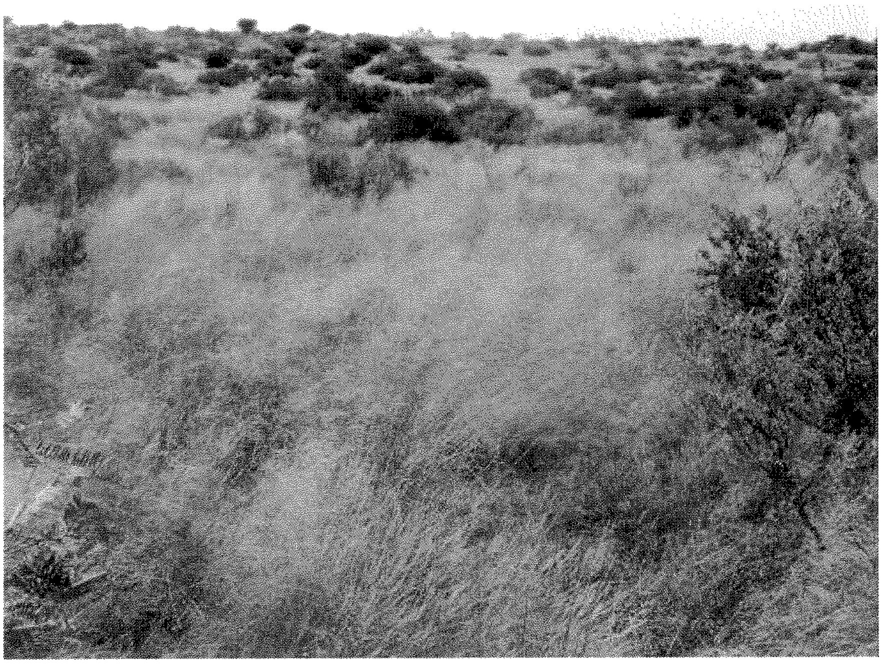

Figure 10: An indication of the domination of *Aristida meridionalis*.

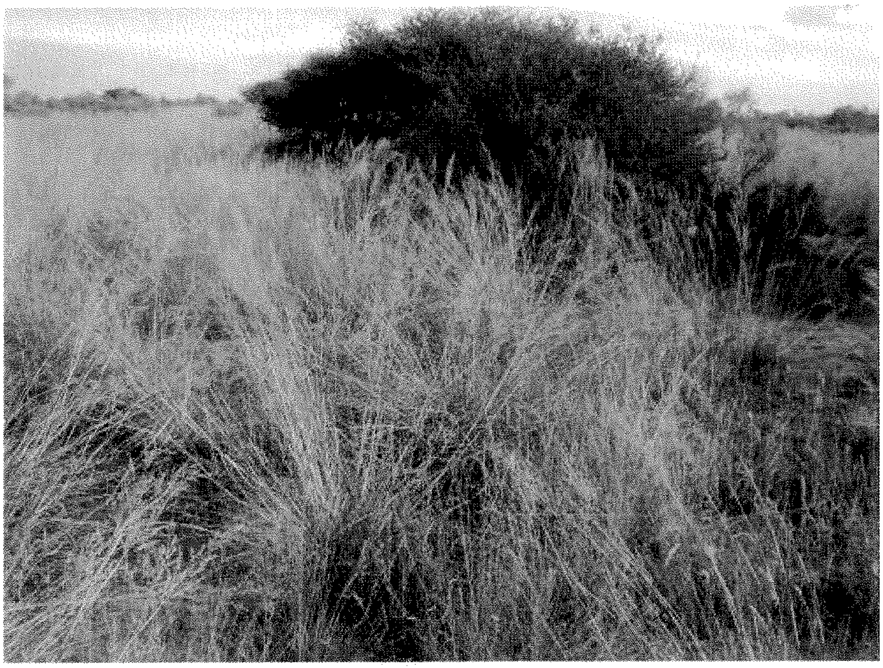

Figure 11: *Eragrostis pallens* with very low palatebility dominates on the top of the dune.

The results of the survey are presented in Table 2.

Table 2: Data collected at Area B (North eastern side of the road) Fig. 2.

No.	Species	Palatability	Perennial (P) Annual (A)	Frequency		Basal cover	
				Nearest point (5cm radius)	%	Hits	%
	Bare soil			349	87.25		
	Herbs			11	2.75		
1	Aristida meridionalis	Very low	P	9	2.25	5	1.25
2	Eragrostis pallens	Very low	P	8	2.00		
3	Eragrostis lehmanniana	Med	P	10	2.50	3	0.75
4	Schmidtia pappophoroides	High	P	8	2.00		
5	Aristida stipitata	Very low	P	5	1.25		
	TOTAL: 5		**P = 5 (100%) A = 0 (0%)**	**400**	**100**	**8**	**2.00**
	Estimated Crown Cover		40%				

Important info from the data is the following:

Bare ground frequency	87.25%
Perennial grasses frequency	10.00%
Annual grasses frequency	<1.00%
% Perennial species found in survey	100.00%
% Annual species found in survey	0.00%
Basal cover	2.0%
Crown cover (estimate)	40%
High palatability	15.7% of the herb layer
Medium palatability	19.6% of the herb layer
Low palatability	<1.0% of the herb layer
Very low palatability	43.1% of the herb layer
Herbs	21.6% of the herb layer

A positive result of the survey is that during the survey none of the annual species in the area could be recorded, indicating that the area is dominated by perennial species. The negative result is the fact that 43% of the vegetation is grass species with a very low palatability (Fig.10 & 11). Another negative result is the 87% bare ground frequency and an estimated crown cover of only 40%. Only 35% of the grass component is considered medium and high palatable material.

Carrying capacity of Area B (North eastern side of the road) Fig. 2

With the info above as well as observations made during the survey, the points scored for the different criteria are as follows:

A - Botanical composition 6.5
B - Plant cover 7
C - Vitality 8
E - Insect and rodent damage 8

Veld condition rating applying the formula (See point 3) is therefore **67.75.** Carrying capacity (350mm rainfall area) is therefore **15,0Ha/LSU** (Appendix 1)

5 CONCLUSION AND RECOMMENDATIONS

Table 3: Comparative table of the summarized data of the vegetation surveys

	Area A	Area B	AVERAGE
Bare ground (%)	69.75	87.25	**78.5**
Perennial species (%)	62.5	100.00	**81.25**
Annual species (%)	37.5	<1.00	**18.75**
Perennial frequency (%)	24.75	10.00	**17.36**
Annual frequency (%)	2.25	0.00	**1.13**
Basal cover (%)	1.25	2.00	**1.63**
Crown cover (estimate) (%)	40.0	40.0	**40.00**
Total species	12.0	5.0	**8.5**
High palatability	11.5	15.7	**13.5**
Medium palatability	55.4	19.6	**37.5**
Low palatability	1.6	<1.0	**0.8**
Very low palatability	20.7	43.1	**31.9**
Herbs	10.7	21.6	**16.15**
A – Botanical (1-10)	7	6.5	**6.25**
B – Plant cover (1-10)	7	7	**6.0**
C – Vitality (1-10)	8	8	**9.0**
D – Insect and rodent damage (1-10)	8	8	**8.0**
Veld condition rating (Formula)	71.50	67.75	**65.9**
Carrying capacity (ha/LSU) (App.1)	14.5	15.0	**14.75**

Surveys were conducted in the two areas indicated as part of the mining right area.

Detail of the data collected during the surveys are presented in Tables 1 – 2 and summarized in Table 3.

According to the presented data, the average percentage bare ground in the two areas is ±70%, and a low basal cover of 1.63% was recorded although the general appearance of the vegetation as can be seen in figures 2 to 11 indicates the opposite, dense vegetation with high vitality. This phenomenon can be ascribed to the large tufts of grass species with very low palatability such as *Aristida meridionalis, Aristida stipitata* and *Eragrostis pallens* that is dominating large areas.

The species diversity in both areas is very low and only 8.5 species on average were recorded in the survey, although 15 grass species could be identified in the areas.

What is important to note is that only 44% of the herb layer includes species with medium and high palatability while 32% is low and very low palatable species while herbs with *Elephanthorrhiza elephantina* (Elephant's root / Elandsboontjie) the dominant herb contributes 16% to the herb layer.

In spite of the results of this survey as indicated in this report, it must be remembered that after the Veld condition rating is calculated, Carrying capacity is determined from Appendix 1 that is based on mean annual rainfall figures. This implies that during high rainfall seasons, the Carrying capacity of any area will be higher while the opposite will be true during low rainfall seasons.

Although not part of the investigation it must be noted that several invader plant species occur, especially in Area A where disturbance due to mining activities occur. The following species were identified:

Schinus molle	Pepper tree
Prosopis glandulosa	Honey Mesquite
Nicotiana glauca	Wild tobacco
Argemone ochroleuca	White-flowered Mexican poppy
Melia azedarach	Seringa
Salsola kali	Russia tumbleweed
Datura ferox	Large leafed thorn apple

Table 4: Grass species identified during the survey of 26 March 2012.

Species	Common name		Grazing value		Annual (A) Perennial (P)
Grasses	**English**	**Afrikaans**	**Palatability**	**Production**	
Aristida adscensiones	Annual three-awn	Eenjarige steekgras	Very low	Very low	A
Aristida congesta subsp. congesta	Tassel three-awn	Katstertsteekgras	Moderate low	Low	P
Aristida meridionalis	Giant three-awn	Langbeensteekgras	Very low	Low	P
Aristida stipitata	Long-awned Three-awn	Langnaaldsteekgras	Very low	Low	P
Anthephora argentea	Circle wool grass	Rondomgras	Very high	High	P
Cenchrus ciliaris	Blue Buffalo grass	Bloubuffelsgras	High	High	P
Enneapogon cenchroides	Nine-awned grass	Negenaaldgras	Moderate	Moderate, varying	A
Eragrostis echinochloidea	Tick grass	Bosluisgras	Moderate	Low	P
Eragrostis lehmanniana	Lehman's love grass	Knietjiesgras	Moderate	Moderate	P
Eragrostis trichophora	Hairy love grass	Harige-pluimgras	Moderate	Moderate low	P
Melinis repens	Natal red top	Fluweelgras	Moderate	Moderate	Biannual
Panicum kalaharense	Kalahari Buffalo grass	Kalahari buffelsgras	High	High	P
Pogonarthria squarrosa	Herringbone grass	Sekelgras	Very low	Low	A
Schmidtia kalihariensis	Kalahari sour grass	Kalahari suurgras	Moderate	Moderate low	A
Schmidtia pappophoroides	Sand quick	Sandkweek	High	High	P
Stipagrostis obtusa	Small Bushman grass	Kortbeenboesmangras	High	Low	P
Stipagrostis uniplumis	Silky bushman grass	Blinkaarboesmangras	Moderate	Moderate	P
TOTAL: 17			**High: 5 Moderate: 8 Low: 4**	**High: 4 Moderate: 6 Low: 7**	**P =12 A = 5**

Table 5: Tree and shrub species identified during the survey of 26 March 2012.

Species	Common name	
Trees and Shrubs	**English**	**Afrikaans**
Acacia erioloba	Camel thorn	Kameeldoring
Acacia haematoxylon	Grey Camel thorn	Vaalkameeldoring
Acacia hebeclada	Candle thorn	Trassiebos
Diospyros lycioides	Blue bush	Bloubos
Grewia flava	Raisin bush	Rosyntjiebos
*Melia azedarach	Seringa	Sering
*Nicotiana glauca	Wild tobacco	Wilde tabak
*Prosopis glandulosa	Honey Mesquite	Heuningprosopis
Rhus lancea	Karree	Karee
*Schinus molle	Pepper tree	Peperboom
Terminalia sericea	Silver cluster leaf	Sandgeelhout
Ziziphus mucronata	Buffalo thorn	Blinkblaar-wag-'n-bietjie

6 APPENDIX 1: Carrying capacity in ha/LSU according to rainfall and Veld condition rating.

TABEL 1. WEIDINGSKAPASITEIT IN ha/GVE VOLGENS REëNVAL EN VELDTOESTAND

Reënval	Veldtoestandaanslag									
(mm)	10	20	30	40	50	60	70	80	90	100
50	xx	xx	xx	xx	xx	xx	xx	88.0	78.0	70.5
75	xx	xx	xx	xx	93.5	78.0	67.0	58.5	52.0	47.0
100	xx	xx	xx	88.0	70.5	58.5	50.0	44.0	39.0	35.0
125	xx	xx	93.5	70.5	56.0	47.0	40.0	35.0	31.0	28.0
150	xx	xx	78.0	58.5	47.0	39.0	33.5	29.5	26.0	23.5
175	xx	xx	67.0	50.0	40.0	33.5	28.5	25.0	22.5	20.0
200	xx	88.0	58.5	44.0	35.0	29.5	25.0	22.0	19.5	17.5
225	xx	78.0	52.0	39.0	31.0	26.0	22.5	19.5	17.5	15.5
250	xx	70.5	47.0	35.0	28.0	23.5	20.0	17.5	15.5	14.0
275	xx	64.0	42.5	32.0	25.5	21.5	18.5	16.0	14.0	13.0
300	xx	58.5	39.0	29.5	23.5	19.5	16.5	14.5	13.0	11.5
325	xx	54.0	36.0	27.0	21.5	18.0	15.5	13.5	12.0	11.0
350	xx	50.0	33.5	25.0	20.0	16.5	14.5	12.5	11.0	10.0
375	93.5	47.0	31.0	23.5	18.5	15.5	13.5	11.5	10.5	9.5
400	88.0	44.0	29.5	22.0	17.5	14.5	12.5	11.0	10.0	9.0
425	82.5	41.5	27.5	20.5	16.5	14.0	12.0	10.5	9.0	8.5
450	78.0	39.0	26.0	19.5	15.5	13.0	11.0	10.0	8.5	8.0

xx = Te swak om diereproduksie te onderhou

Specialist Report: Ecological Assessment Of The Proposed Sebilo Perth Mine

Commissioned by

Irene Lea Environmental & Hydrogeology

Compiled by

EkoInfo CC

April 2012

EkoInfo CC
P.O. Box 72847
Lynwood Ridge
0040
Pretoria
Gauteng
RSA
http://www.ekoinfo.co.za

Member: Willem de Frey
Registration no: CC1995/34111/23

Tel: 012-365-2546
Fax: 012-365-3217
Email: wdefrey@ekoinfo.co.za

EkoInfo CC
www.ekoinfo.co.za
15 Years

CONTRIBUTING ASSOCIATES

Company	EkoInfo CC				
Person	Willem de Frey				
Qualifications	MSc WildlifeManagement –UP, 1999				
Field of expertise	Flora, Ecology, Soil, Wetlands, GIS				
Years experience	15 – Full time				
Professional Registration	Pr.Sci.Nat. - Botany & Ecology (400100/02)				
Component	Vegetation Ecology				
Telephone	012 365 2546				
Fax	012 365 3217				
Cell phone	082 579 5049				
Email	wdefrey@ekoinfo.co.za				
Logo	EkoInfo CC www.ekoinfo.co.za				

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Report Status	Version	File Route
Draft	1	Z:\projekte\Specialist_SebiloPerth_IreneLea\Reports\tx\EkoInfo CC Desktop Ecology_Vegetation_Sebilelo Perthv2.doc

1 EXECUTIVE SUMMARY

Irene Lea Environmental & Hydrogeology requested EkoInfo CC to do a desktop/ informative level, small scale/ coarse grain survey of a proposed mine site, near Hotazel in the Northern Cape. The total study area covered 160 ha. A site visit was done during March 2012.

The emphasis of the study was on literature and desktop review. **On a national level the study area is located with the least threatened Kathu Bushveld vegetation unit.** Based on the desktop review using satellite imagery, it was determined that the study area containted seven (7) out of a possible 18 clusters (vegetation communities) on a regional scale. A detailed description of these clusters was beyond the scope of this project. Available information from national data sources such as South African National Biodiversity Institute and Council of Geoscience, **it was determined that there is a low probability that 15 threatened Red Data plant occur n the area, but a high probability that 23 provincially protected, two nationally protected, sixteen (16) plants with medicinal properties and four alien invasive species could occur within the study area.**

The presence of a riparian wetland along the western boundary of the study area been confirmed. It was not asseses in detail and should be management in accordance with the National Water Act.

The literature – and desktop review section completed with regards to the fauna, indicated a moderate to high probability for 27 fauna species of concern to occur in the area. Due to the increase development of mines and solar power plants within the landscape the influence of these developments on habitat loss, habitat fragmentation and connectivity should be assessed.

In discussions with a conservation official of Northern Cape Province, it was confirmed that a permit will be required for the move or destruction of any provincially protected species. However, the Record of Decision (ROD) needs to be submitted with the permit application as well as the density (number of protected species) to be moved or destroyed. **Therefore the presence/ absence of the potentially present protected species based on the PRECIS data will have to be confirmed and there density determined; and permits obtained PRIOR to the commencement of construction.**

The most optimal period to do these assessments will be during the summer months.

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2 INTRODUCTION

Irene Lea Environmental & Hydrogeology approached EkoInfo CC to assist them with a desktop/ informative level/ small scale/ coarse grain ecological assessment for the proposed Sebilo Perth Mine, near Hotazel in the Northern Cape (Figure 1).

2.1 Scope of work/ Terms of reference

South Africa's National Environmental Management Act (NEMA No 107 of 1998) and National Environmental Management: Biodiversity Act (NEMBA No 10 of 2004) requires the protection and effective management of the environment with specific emphasis on ecosystem – and species diversity and specific systems such as wetlands.

Therefore the terms of reference relates to these broad objectives in providing:

1. An environmental overview of the areas in which the proposed site is located
2. The ecosystems associated with these proposed area
3. Species of concern such as threatened Red Data flora, nationally or provincially protected plants, medicinal plants and alien invasive species, which could occur in the area.

To achieve these objectives a literature and desktop review was done based on scientific and popular publications, small - and large-scale Geographic Information System (GIS) datasets and a site visit during March 2012.

The main objective was to assess the ecological sensitivity on a regional and local scale using a literature and desktop approach.

2. 1. Limitations

1. The site was visited during March 2012.
2. No plants were sampled during the site visit; only conspicuous vegetation/ habitat variation was noted and documented using digital photographs and video recordings. Therefore it was not possible to describe and map the vegetation communities present within the areas using recognised scientific methods such as the Braun-Blanquet approach.
3. The main sources of information for this report were international, national and regional data sources such as:
    a. International level – Digital Elevation Model (DEM) from ESRI World Dataset CD
    b. National level - 1: 250 000 or less scale wetland data from BGIS at SANBI[1]
    c. National level – 1: 250 000 or less scale landform data from BGIS at SANBI
    d. Regional level - 1: 250 000 scale geology data from the Council of Geoscience
    e. Regional level - 1: 250 000 scale land type data from the Institute for Soil, Climate and Water
    f. Regional level - 1: 250 000 scale vegetation data from the VEGMAP publication at SANBI
    g. Local level – 1: 50 000 scale topocadastral maps from the Surveyor – General
    h. Local level – 1: 50 000 or larger scale aerial image from Google Earth
4. The absence of 5 m or less contours significantly hampered the ability to assess the influence of the topography on the distribution of vegetation and the potential location of drainage zones and wetlands. Steep areas and drainage areas/ wetland represent microhabitat often associated with species of concern (Red Data, protected, medicinal), therefore in the absence of 5 m contours or less the presence/ distribution and extent of these sensitive habitats could not be effectively assessed.

[1] South African National Biodiversity Institute

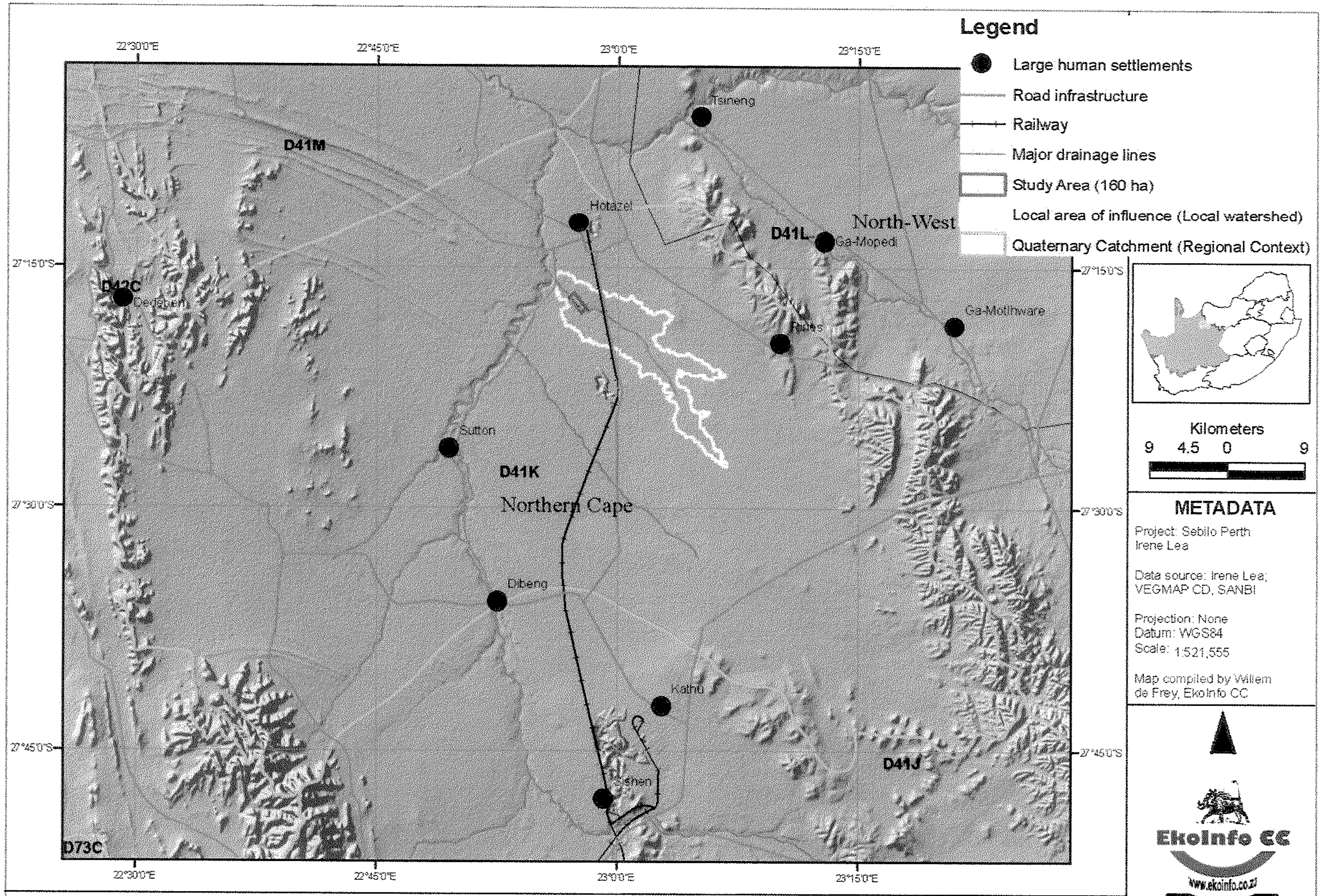

Figure 1: National and provincial orientation of the proposed Sebilo Perth Mine in the Northern Cape, South Africa

3 STUDY AREA

The study area is located to the south of the town of Hotazel (Figure 1). It covers a portion or portions of the original farm Perth 276 (Figure 2). The surface area of the original farm is 1978 ha, while the study area covers 160 ha or 8% of the original farm.

On a regional scale, the study area is located within quaternary catchment D41K (Figure 1). Quaternary catchment D41K has been evaluated to be intact[2], which implies that the quaternary catchment is in a pristine state.

3.1 Regional vegetation

The study area is located within the **least threatened** Kathu Bushveld regional vegetation unit (Figure 2) within the Savanna Biome. This unit[3] is described as follows:

STRELITZIA 19 (2006)

SVk 12 Kathu Bushveld

VT 16 Kalahari Thornveld and Shrub Bushveld (100%) (Acocks 1953). LR 30 Kalahari Plains Thorn Bushveld (86%) (Low & Rebelo 1996).

Distribution Northern Cape Province: Plains from Kathu and Dibeng in the south, through Hotazel, vicinity of Frylinckspan to the Botswana border roughly between Van Zylsrus and McCarthysrus. Altitude 960–1 300 m.

Vegetation & Landscape Features Medium-tall tree layer with *Acacia erioloba* in places, but mostly open and including *Boscia albitrunca* as the prominent trees. Shrub layer generally most important with, for example, *A. mellifera*, *Diospyros lycioides* and *Lycium hirsutum*. Grass layer is variable in cover.

Geology & Soils Aeolian red sand and surface calcrete, deep (>1.2 m) sandy soils of Hutton and Clovelly soil forms. Land types mainly Ah and Ae, with some Ag.

Climate Summer and autumn rainfall with very dry winters. MAP about 220–380 mm. Frost frequent in winter. Mean monthly maximum and minimum temperatures for Sishen 37.0°C and –2.2°C for December and July, respectively. See also climate diagram for SVk 12 Kathu Bushveld.

Important Taxa Tall Tree: *Acacia erioloba* (d). Small Trees: *Acacia mellifera* subsp. *detinens* (d), *Boscia albitrunca* (d), *Terminalia sericea*. Tall Shrubs: *Diospyros lycioides* subsp. *lycioides* (d), *Dichrostachys cinerea*, *Grewia flava*, *Gymnosporia buxifolia*, *Rhigozum brevispinosum*. Low Shrubs: *Aptosimum decumbens*, *Grewia retinervis*, *Nolletia arenosa*, *Sida cordifolia*, *Tragia dioica*. Graminoids: *Aristida meridionalis* (d), *Brachiaria nigropedata* (d), *Centropodia glauca* (d), *Eragrostis lehmanniana* (d), *Schmidtia pappophoroides* (d), *Stipagrostis ciliata* (d), *Aristida congesta*, *Eragrostis biflora*, *E. chloromelas*, *E. heteromera*, *E. pallens*, *Melinis repens*, *Schmidtia kalahariensis*, *Stipagrostis uniplumis*, *Tragus berteronianus*. Herbs: *Acrotome inflata*, *Erlangea misera*, *Gisekia africana*, *Heliotropium ciliatum*, *Hermbstaedtia fleckii*, *H. odorata*, *Limeum fenestratum*, *L. viscosum*, *Lotononis platycarpa*, *Senna italica* subsp. *arachoides*, *Tribulus terrestris*.

Biogeographically Important Taxa (Kalahari endemics) Small Tree: *Acacia luederitzii* var. *luederitzii*. Graminoids: *Anthephora argentea*, *Megaloprotachne albescens*, *Panicum kalaharense*. Herb: *Neuradopsis bechuanensis*.

Conservation Least threatened. Target 16%. None conserved in statutory conservation areas. More than 1% already transformed, including the iron ore mining locality at Sishen, one of the biggest open-cast mines in the world. Erosion is very low.

Remark One of the most strikingly dominant areas of fairly tall *Acacia erioloba* is centred on the town of Kathu, which was built around many of these trees.

Reference Smit (2000).

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[2] Nel, J., Maree, G., Roux, D., Moolman, J., Kleynhans, N., Silberbauer, M. & Driver, A. 2004. South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 2: River Component. CSIR Report Number ENV-S-I-2004-063. Council for Scientific and Industrial Research, Stellenbosch.

[3] MUCINA, L. & RUTHERFORD, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.