SOIL, AGRICULTURAL POTENTIAL, LAND CAPABILITY AND LAND USE STUDY FOR THE GRUISFONTEIN MINING PROJECT, SITUATED ON THE FARM GRUISFONTEIN 230-LQ, NEAR LEPHALALE, LIMPOPO PROVINCE

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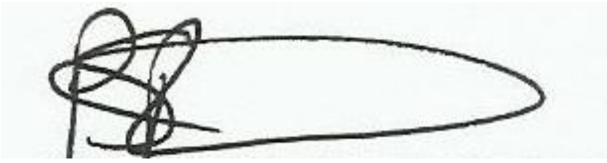
Soil Science Society of South Africa (SSSSA)
South African Soil Surveyors Organisation (SASSO)
South African Wetland Society (SAWS)

DECLARATION

I, Petrus Stephanus Rossouw, declare that I –

- act as an independent specialist consultant in the field of soil science;
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- have and will not have any vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.



PETRUS STEPHANUS ROSSOUW

Table A Legal Requirements for All Specialist Studies Conducted

Legal Requirement		Relevant Section in Specialist study
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of-	
	(i) the specialist who prepared the report; and	**Appendix A**
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	**Appendix A**
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	**Page ii**
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	**Sections 1 and 2**
(cA)	an indication of the quality and age of base data used for the specialist report;	**Section 3**
(cB)	a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	**Section 4.3, Section 5**
(d)	the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	**Section 3.1**
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	**Section 3**
(f)	details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	**Section 4 and 5**
(g)	an identification of any areas to be avoided, including buffers;	**N/A**
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	**Section 5**
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	**Section 3**
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	**Section 4 and 5**
(k)	any mitigation measures for inclusion in the EMPr;	**Section 5.3**
(l)	any conditions for inclusion in the environmental authorisation;	**Section 5.3**
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	**Section 5.3.5**
(n)	a reasoned opinion	**Section 5.6**
	whether the proposed activity, activities or portions thereof should be authorised;	**Section 5.6**
	regarding the acceptability of the proposed activity or activities; and	**Section 5.6**
	if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	**Section 5.1 to Section 5.4**
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	**N/A**
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	**N/A**
(q)	any other information requested by the competent authority.	**N/A**

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1 TERMS OF REFERENCE

Jacana Environmental cc contracted Rossouw and Associates Soil and Water Science (Pty) Ltd to conduct a soil, agricultural potential, land use and land capability study, with emphasis on the impact of coal mining and related activities on the soil environment, for the Gruisfontein coal mining project.

2 INTRODUCTION

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2.1. Survey Area Location

The study area is situated on the farm Gruisfontein 230-LQ, approximately 50 km from Lephalale, as the crow flies, in the Limpopo Province. The size of the surveyed area is approximately 830 ha. **Figure 1** is a locality map. **Figure 2** is satellite photo indicating the farm boundary**.**

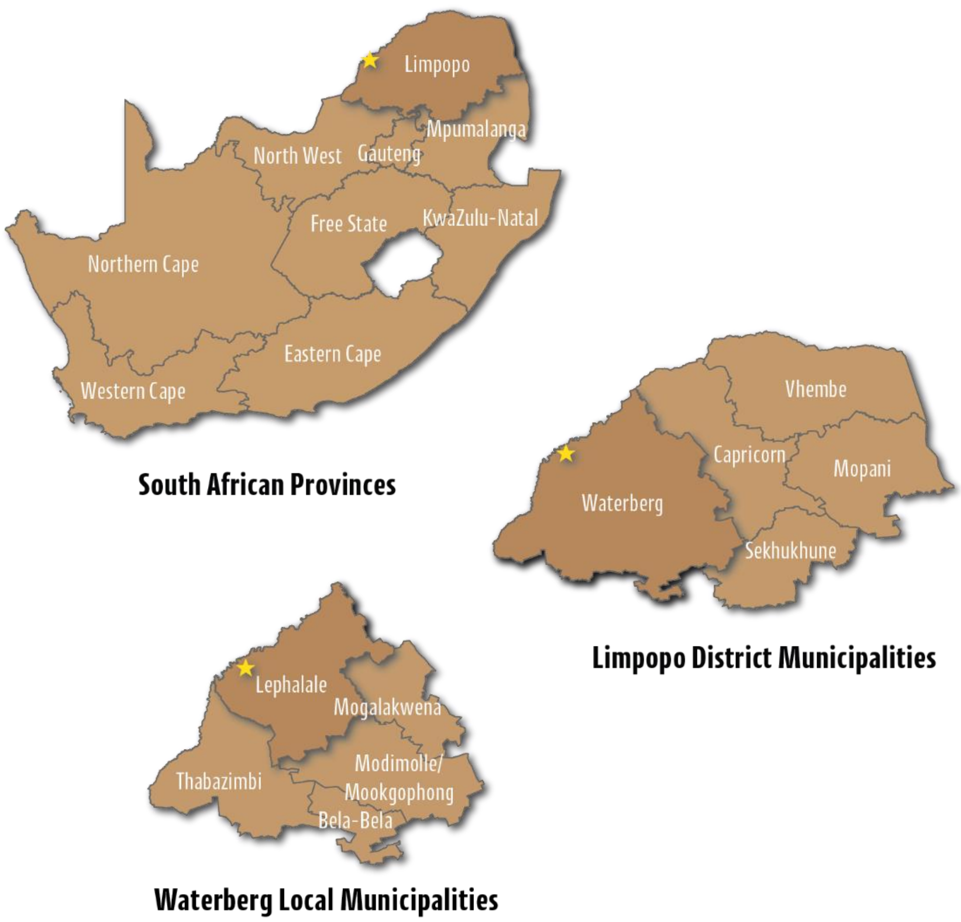

Figure 1 Locality map

Figure 2 Image indicating the farm boundary

2.2. Aims of the Study

The study aims to:

- Assess the agricultural potential, land use and land capability of the areas to be impacted by the proposed development through a detailed soil survey;
- Determine the impact of the mining related infrastructure on the soil environment;

- Propose mitigation measures to negate the negative impact of the mining related impact on the soil environment.

3 METHODOLOGY

3.1. Soil Survey

The study area was traversed and observations regarding the landscape and occurrence of soils were made continuously. The study was undertaken during January 2019. Specific soil characteristics were noted and logged. Augering was done to a maximum of 1500 mm. The soils were classified according to the South African Soil Classification System (Soil Classification Working Group, 2018). Specific emphasis was placed on the identification of the following aspects as these aid in an assessment of the pedohydrology and agricultural potential of the area:

- Fe(II)/Fe(III) layered double hydroxides (green rusts) that is indicative of moderate conditions of reductions (Eh values of -0.5 to +0.5 V) and usually encountered in wetland soils;
- The accumulation of ferrihydrate, lepridocrosite, goethite and hematite in vesicular nodules (mottling) owing to the reduction of Fe(III) to Fe(II), under conditions of a fluctuating water table, which leads to the mobilisation of Fe;
- The occurrence of grey colours, especially where mottling is not present, as a further indication of Fe mobilisation and semi-permanent or permanent conditions of water saturation;
- The occurrence of bleached soil horizons that indicate lateral drainage of water;
- The occurrence of gleyed soil horizons that can be indicative of a permanent water table;
- The occurrence of uniform red and yellow colouration that is indicative of well drained areas;
- Signs of Mn mobilisation and/or precipitation as an indication of a fluctuating water table;
- The occurrence of smectite clays that lead to swelling and shrinking characteristics in soil and is conducive to saturated flow in the dry state but not in the wet state;
- Textural changes, and other aspects, in the soil profile that will influence saturated and unsaturated flow of water.
- Occurrence of layers that impede water flow.

3.2. Criteria Used to Asses Agricultural Potential and Land Capability Classes

The assessment of agricultural potential rests primarily on the identification of soils that are suited to crop production, specifically lemon and macadamia tree production. In order to qualify as high potential soils, they must have the following properties:

- Deep profile for adequate root development,
- Deep profile and adequate clay content for the storing of sufficient water so that plants can weather short dry spells,
- Adequate structure (loose enough and not dense) that allows for good root development,
- Sufficient clay or organic matter to ensure retention and supply of plant nutrients,

- Limited quantities of rock in the matrix that would otherwise limit tilling options and water holding capacity,
- Adequate distribution of soils and size of high potential soil area to constitute a viable economic management unit, and
- Good enough internal (within the soil profile) and external (out of the soil profile) drainage if irrigation practices are considered. Drainage is imperative for the removal (leaching) of salts that accumulate in profiles during irrigation and fertilization.

In addition to pedological characteristics, climatic and soil chemical characteristics need to be assessed to determine the agriculture potential of a site. The latter entails determining the soil fertility levels of the soils, as well as an assessment of any factors that may inhibit plant growth. Saline and other forms of soil pollution, such as heavy metal contamination and acid/neutral/alkaline mine drainage (in mining areas), can adversely affect the production potential of the area. It is especially important to determine soil salinity in areas where irrigation is envisaged as poor irrigation scheduling often leads to a built up of salts in the soil. In these cases, the sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) are used to measure soil sodicity. Soil pollution through acid/neutral/alkaline mine drainage or other industrial activities was not assessed as the area has never been mined and industrial or mining activity was no encountered near the site.

The soil fertility levels of the area can be amended with soil ameliorants such as lime, organic matter and fertiliser. The more important factor governing the agricultural potential and land capability of the area, apart from soil salinity levels, is the of pedohydrological characteristics as noted above.

Land capability classes were determined using the guidelines outlined in Section 7 of The Chamber of Mines Handbook of Guidelines for Environmental Protection (Volume 3, 1981). The Chamber of Mines pre-mining land capability system was utilised, given that this is the dominant capability class classification system utilized in the mining and industrial fields. The following land capability classes are identified:

- Wetland:
  - Land with organic soils or;
  - A horizon that is gleyed throughout more than 50 % of its volume and is significantly thick, occurring within 750mm of the surface.
- Arable Land:
  - Land, which does not qualify as a wetland;
  - The soil is readily permeable to the roots of common cultivated plants to a depth of 750mm;
  - The soil has a pH value of between 4,0 and 8.4;
  - The soil has a low salinity and SAR;
  - The soil has a permeability of at least 1,5-mm per hour in the upper 500-mm of soil;
  - The soil has less than 10 % (by volume) rocks or pedocrete fragments larger than 100-mm in diameter in the upper 750-mm;
  - Has a slope (in %) and erodibility factor (K) such that their product is <2.0; and

  - Occurs under a climatic regime, which facilitates crop yields that are at least equal to the current national average for these crops or is currently being irrigated successfully.
- Grazing land:
  - Land, which does not qualify as wetland or arable land;
  - Has soil, or soil-like material, permeable to roots of native plants, that is more than 250-mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100-mm; and
  - Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants, utilizable by domesticated livestock or game animals on a commercial basis.
- Wilderness land:
  - Land, which does not qualify as wetland, arable land or grazing land.

The criteria stipulated for the Wetland land capability class is overridden by the criteria stipulated in the Wetland Delineation Guidelines (Department of Water Affairs and Forestry, 2005) as this is a) a more recent publication and b) based on a better understanding of wetland processes. The criteria stipulated for soil depth under the Arable land capability class is ignored as lemon and macadamia trees can flourish in soil much shallower than 750 cm.

3.3. Criteria used to assess the Irrigation Potential of the Soils

To assess the irrigation potential of the soils of the area, the FAO's irrigation classification system is used. The FAO classifies soils into the following five classes in terms of irrigation potential:

- Class 1. Highly suitable for irrigation, few or no limitations and preconditions. Topography is flat, soils are well drained, of moderate permeability and deep, medium textured with a high water-holding capacity.
- Class 2. Suitable for irrigation with slight limitations (such as undulating topography), moderately well drained, moderately slow or moderately rapid permeability or moderate depth of soil.
- Class 3. Low suitability with moderately severe limitations, imperfect or somewhat excessively drained soils, slow or rapid permeability or shallow soils.
- Class 4. Not suitable for irrigation under most conditions with severe limitations.
- Class 5. Soils with severe limitations, not recommended at all, such as soils in natural water ways, river plains, soils presently eroded or soils showing signs of a permanent or potential water table.

3.4. Criteria used to assess the Erodibility of the Soils

Soil erodibility is taken into account in the determination of agricultural potential. The nomograph by Wischmeier, Johnson and Cross (1971) is used to determine the erodibility factor (k-factor). This method is used for the purposes of this report to enable a discussion of the recommendations made by the Bioresource Programme: A Natural Resources Classification System for KwaZulu-Natal, Natural Resources Section, Cedara, 1995, 1999). The latter document employs the Wischmeier, Johnson and Cross (1971) nomograph.

3.5. Chemical and Physical Analyses of Soil Samples

Representative soil samples were collected and subjected to the following analyses:

- Soil pH is determined in the supernatant liquid of an aqueous suspension of soil after having allowed the sand fraction to settle out of suspension.
- Water soluble major cations and anions were determined in a saturated paste extract.
- Exchangable/weakly complexed major cation levels were determined through extraction with a NH_4-Acetate.
- Plant available P was determined using the Bray 1 method.
- Soil texture was determined through sedimentation with a hydrometer and with sieves.

It was decided not to determine NO_3, NO_2 or NH_4 content of the soils as these ions must be analysed for within 24 hours after sample collection for accurate results. The levels of N-compounds are expected to be low but can easily be rectified using N-based fertilisers.

3.6. Rainfall and Temperature Data

Rainfall and mean annual temperature data for the area were obtained from the Department of Agriculture (AGIS) and is indicated in **Figure 3, 4** and **5**. The site falls within the 401 to 600 mm rainfall area and exhibits mean annual minimum and maximum temperatures of 4.1 to 6 °C and 31.1 to 33 °C, respectively.

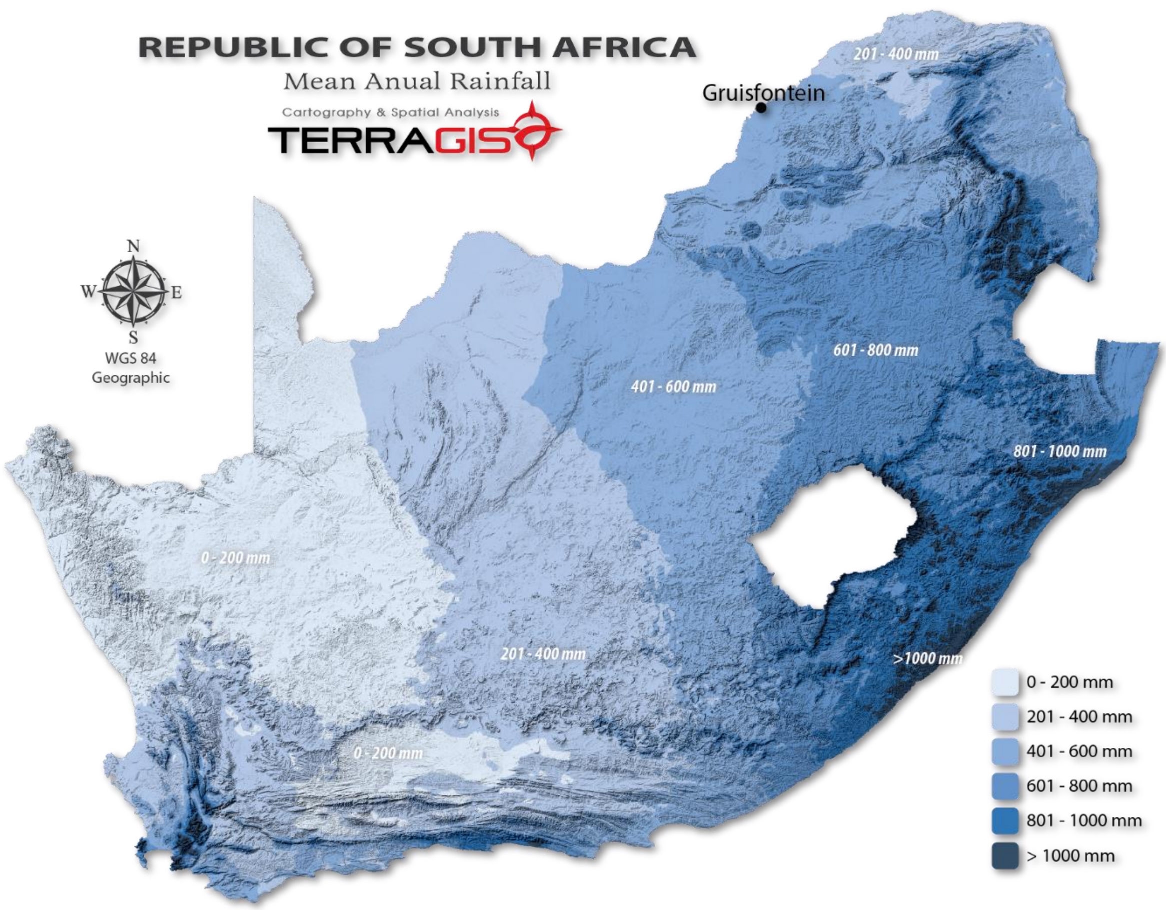

Figure 3 Rainfall map

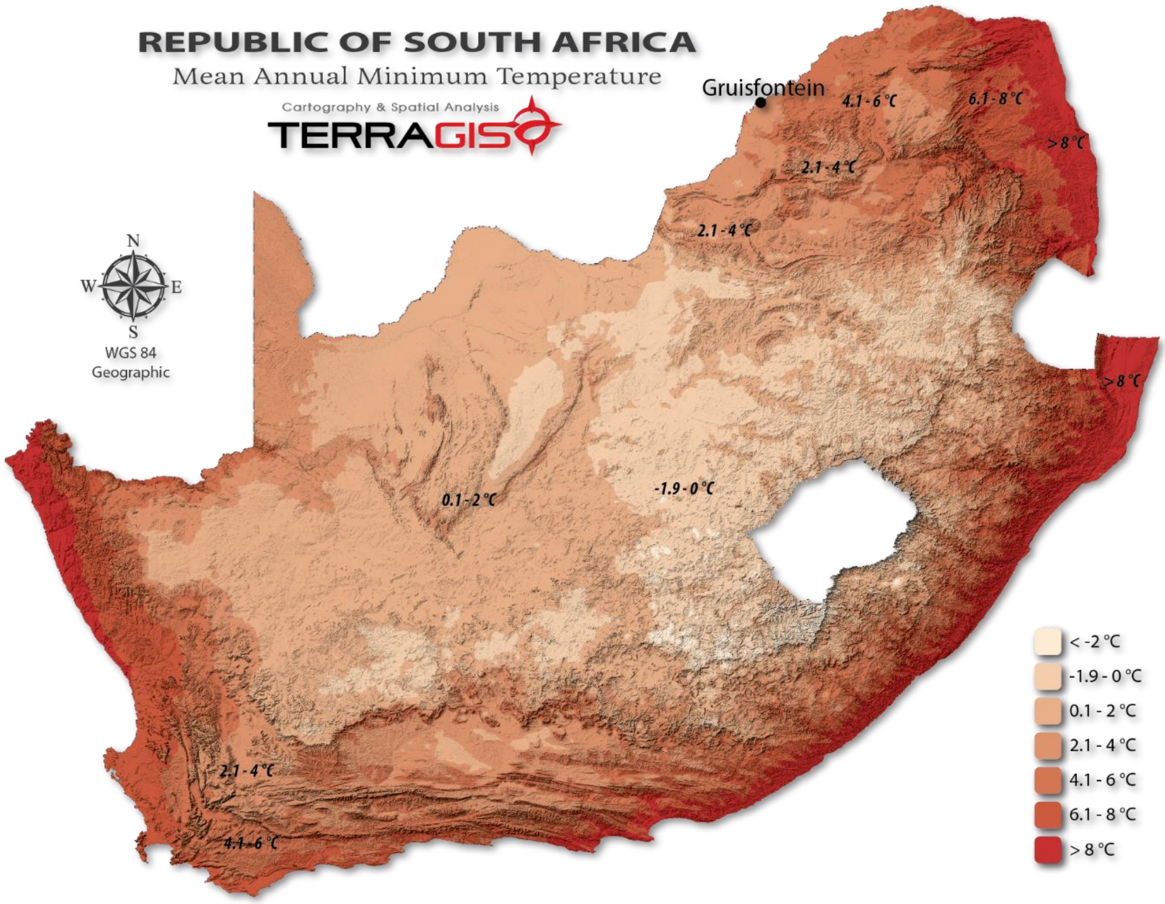

Figure 4 Mean annual minimum temperature map

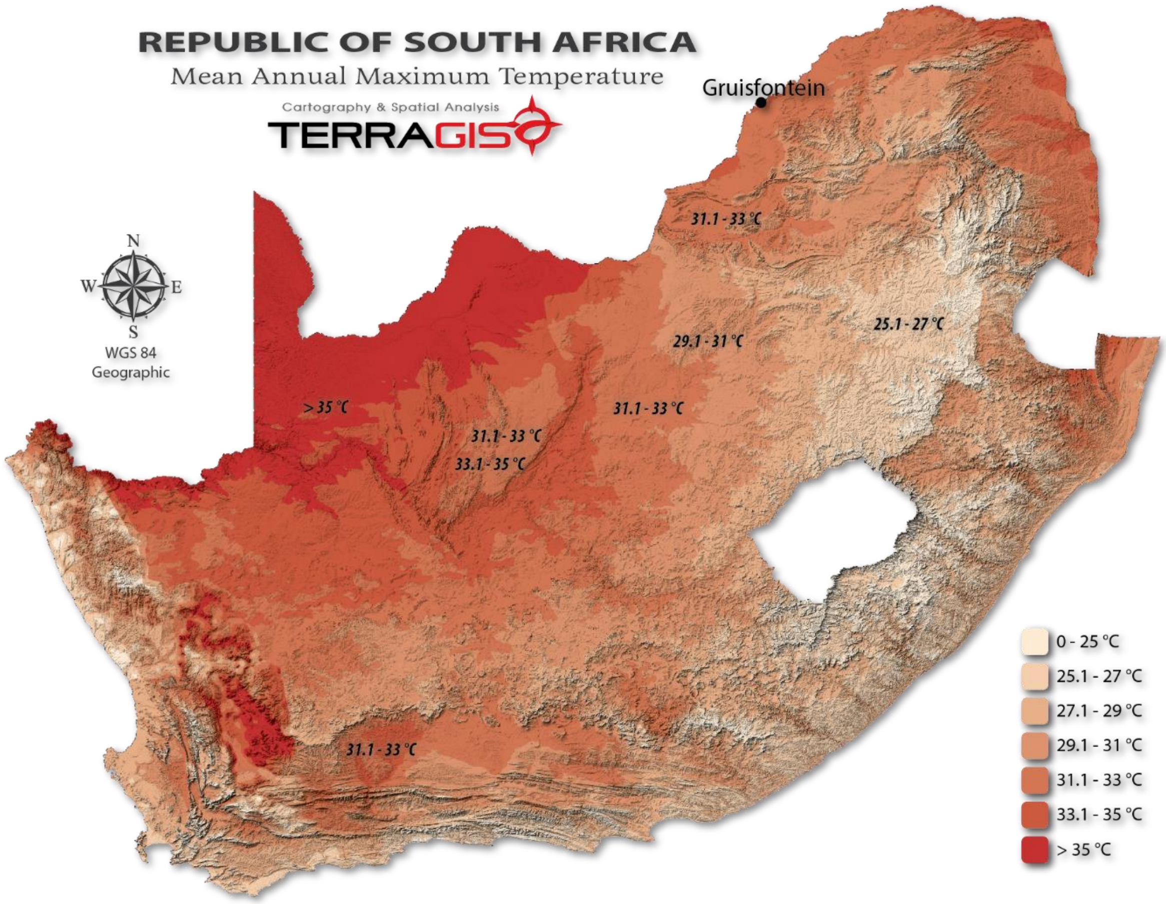

Figure 5 Mean annual maximum temperature map

3.7. Criteria used to assess the Impact Rating

The following elucidates the logic behind the impact tables.

3.7.1. Nature of the Impact

The impact of the mining and other activities on the soil environment is classified as either positive or negative. A positive impact is regarded as a benefit to the soil environment while a negative impact is regarded as a detrimental impact.

3.7.2. Type of Impact

The impact on the soil environment is classified a direct, indirect or cumulative. The impact classification can be summarised as:

- *Direct Impact* is a reaction that is caused by the direct interaction of a planned action or activity on the receiving environment, e.g. the discharge of water into a water stream, the discharge of waste material onto land or the excavation of a pit for mining purposes. This type of impact is usually in close proximity to the action or activity.
- *Indirect Impact* is a reasonably foreseeable reaction that is indirectly caused as a result of a planned action or activity, the effects/ impacts are usually later in time and farther removed from the action or activity. Examples include rainwater leaching

through a discard dump to pollute underground water, changes in patterns of land use, changes in population density or growth rate.

- *Cumulative Impact* is the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions, regardless of undertakings by other industries, mines, developments or persons. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

3.7.3. Grouping of the Impact

Two groups of impacts can occur:

- Routine Impacts that occur as a result of expected and planned project activities; and
- Non-Routine Impacts that occur as a result of an unexpected and unplanned project activity. Usually occurs in emergency events or unforeseeable natural events such as flooding after an exceptionally heavy rainfall in a usually dry environment.

3.7.4. Certainty or Probability that the Impact will occur

Table 1 summarises the probability classes.

Table 1 Certainty classes

Certainty	Description	Rating
Unlikely	Less than 40% sure that the impact or benefit will occur.	1
Possible	Between 40% and 70% sure that the impact or benefit will occur.	2
Probable	Between 70% and 90% sure that the impact or benefit will occur.	3
Definite	Over 90% sure that the impact or benefit will occur.	4

3.7.5. Spatial Extent

The extent of the impact refers to the spatial scale of the impact or benefit of the proposed project and the area over which it extends. **Table 2** summarises the classes associated with the spatial extent of the impact.

Table 2 Spatial extent classes

Certainty	Description	Rating
Site specific	Effects felt within the site boundary area.	1
Local	Effects are felt within 5 km radius from the site boundary area.	2
Regional	Effects are felt within a 50 km radius from the site boundary area.	3
National	Effects are felt beyond a 50 km radius from the site	4

Certainty	Description	Rating
	boundary area within South Africa.	

3.7.6. The Duration of the Impact

The duration of the impact refers to the time scale of the impact or benefit in terms of the period of time that the surrounding environment will be affected or altered by the proposed project as summarised in **Table 3**.

Table 3 Duration classes

Certainty	Description	Rating
Short term	Less than five years	1
Medium term	Between five and 20 years	2
Long term	Between 21 and 40 years	3
Permanent	Permanent	4

3.7.7. Reversibility of the Impact

Reversibility refers to the time it would take to reverse or undo the impact under discussion. These classes are summarised in **Table 4**.

Table 4 Duration classes

Certainty	Description	Rating
Short term	Less than five years	1
Medium term	Between five and 20 years	2
Long term	Between 21 and 40 years	3
Permanent	Permanent	4

3.7.8. Severity or Intensity of the Impact

The severity is the attempt to quantify the magnitude of the impact whether positive or negative, which is associated with the proposed project. The scale therefore accounts for the extent and magnitude but is subject to the value judgement as illustrated in **Table 5**.

Table 5 Severity classes

Status	Severity	Description	Rating
Negative	Slight	1. Minor deterioration, 2.Short to medium term duration, 3.Mitigation is easy, cost effective and quick.	1
	Moderate	1. Moderate deterioration, 2. Medium to long term duration, 3. Fairly easy to mitigate.	2
	Severe	1. Marked deterioration; 2. Long term duration, 3. Serious and severe impact, 4. Mitigation is very expensive, difficult or time consuming.	3
	Very severe	1. Substantial deterioration, 2. Irreversible or permanent, 3. Cannot be mitigated.	4

Status	Severity	Description	Rating
Positive	Slight	1. Minor improvement, 2. Short to medium term duration.	1
	Moderate	1. Moderate improvement, 2. Medium to long duration.	2
	Beneficial	1. Large Improvement, 2. Long term duration.	3
	Very beneficial	Permanent improvement.	4

3.7.9. The Significance of the Impact

The significance of a positive or negative impact describes and evaluates the importance of that impact in accordance with the scope of the project. Impacts can be described and evaluated in terms of their type, extent, complexity, intensity and duration. This evaluation criterion provides a basis for comparison and the application of judgement. The significance of an impact is calculated as follows (**Table 6** summarises the significant classes):

(Severity + Reversibility + Duration + Spatial) x Certainty = Significance

Table 6 Significant classes

Significant	Description		Rating
	Positive	Slightly beneficial impact, which constitutes a minor improvement; Short term duration; Enhancement measures to be implemented to increase the effect of the positive impact.	-
Low (1 – 2)	Negative	Marked deterioration; Short to medium term duration; Effects are not substantial. Society and/or specialists view the change as unimportant; Mitigation is easy, cheap or quick.	5-15
	Positive	Marked improvement; Short to medium term; Enhancement measures to be implemented to increase the effect of the positive impact.	
Moderate (2 – 3)	Negative	Constitutes as medium to long term effect; Effects are real but not substantial; Society and/or specialist do not view the impact as substantial and very important; Mitigation is fairly easily possible.	16 - 35
	Positive	Marked improvement; Medium to long term; Effects are real, but not substantial; and Enhancement measures to be implemented to increase the effect of the positive impact.	
High (3-4)	Negative	Long term effect; Society and specialist view the change as very serious; The reversibility of the impact is long term; Mitigation is very expensive, difficult and time consuming.	36-63
	Positive	Long term effect; Society and specialist view the change as very positive; Enhancement measures to be implemented to increase the effects of the positive impact.	
Very high (4)	Negative	Constitutes as a permanent change to the environment; Society and/or specialist view the change as very serious; The impact cannot be reversed; The impact cannot be mitigated.	64
	Positive	Constitutes as a permanent change to the environment; Society and specialist view the change as very positive; Impacts cannot be reversed.	

4. RESULTS AND DISCUSSION

4.1. Soil Survey

Figure 6 illustrates the dominant soil forms for the area. The different soil polygons indicated on the map show the soils that dominate the area. The boundary lines, indicated on the map, between soil forms should be seen as a gradient of transition as opposed to an abrupt change.

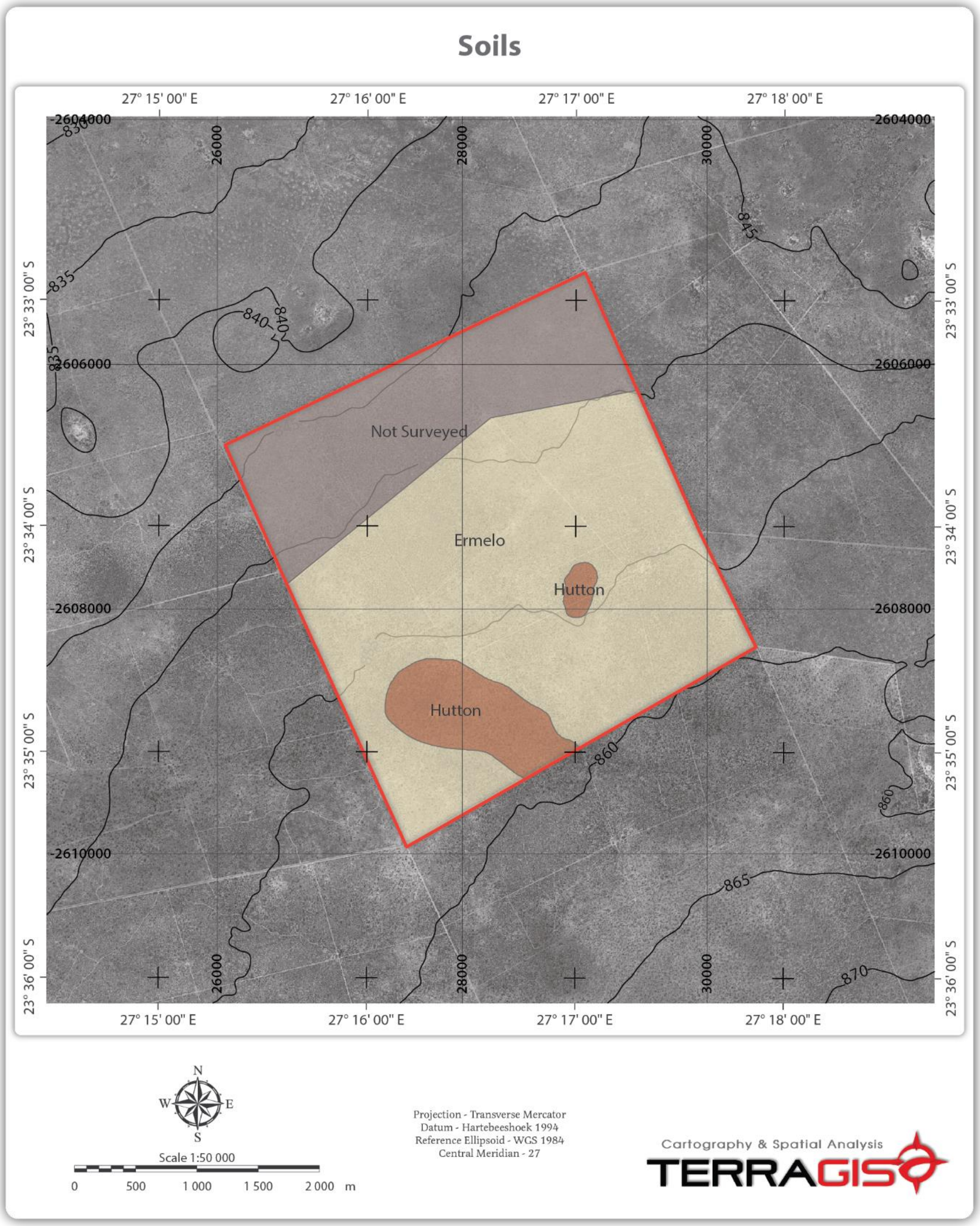

Figure 6 Soil map for the study area

The following soil forms were identified:

- The Hutton soil form (Hu) comprises an orthic A-horizon overlying a red apedal B-horizon. The red apedal B-horizon has macroscopically weakly developed structure or is altogether without structure and reflects weathering under well drained, oxidised conditions. The clay fraction is dominated by non-swelling 1:1 clay minerals and the red colour of the soil is ascribed to iron oxide coatings on individual soil particles that are dominated by hematite. These soils are predominantly deeper than 150 cm.

- The Ermelo soil form (Er) comprises an orthic A-horizon overlying a yellow brown apedal B-horizon. The latter horizon shows the same characteristics as the red apedal B-horizon with the exception that it displays a yellow colouration owing to the Fe mineral fraction containing less than 15 % hematite (Fe_2O_3). The yellow colouration is ascribed to goethite (FeOOH).

Both soil forms are sandy in nature (the Hutton soils display a somewhat higher silt content), deeper than 150 cm at all augering sites (approximately 724 holes were augered), exhibit good internal and external drainage (high saturated hydraulic conductivity), uniform colouration, no occurrence of rocks or layers impeding root development, no occurrence of free carbonates (*in situ* testing with a 10 % HCl solution was conducted) and no signs of regular water logging at any depth in the profile. **Figure 7** illustrates some of these characteristics.

a.

b

c.

d

Figure 7 Photos indicating the colouration of the Hutton soil form (a.) and Ermelo soil form (b.), the augering depth of the soils (c.) and typical veld type (d.)

Table 7 summarises the hectares comprised by each soil form. None of the soils encountered on site showed hydromorphic characteristics within the top 50 cm of the soil profile.

Table 7 A summary of the hectares which each soil form comprises

Soil form	**Hectares**
Ermelo	739
Hutton	91
Total	**830**

4.2. Hydropedological Functioning

The area is characterised by sandy, well drained soils which evolved under oxidising conditions. Hydromorphic soils or signs of wetness (i.e. mottles, bleaching, gleying) were not encountered. The soils show a high infiltration rate and a high saturated hydraulic conductivity.

After and during rainfall events, water rapidly infiltrates the soils and percolates through the profile. The matric potential of these sandy soils is low and therefore the water holding capacity of the soils is low. The slightly elevated silt and clay content of the Hutton soils should result in soils with a slightly higher water holding capacity – compared to the soils of the Ermelo soil form. The slight increase in clay and silt content in the Hutton soils corresponds with the more frequent occurrence of thorn trees (i.e. *Acacia* species) whereas broad-leaved trees (i.e. *Terminalia* species) dominates the soils of the Ermelo soil form.

Surface run-off can occur during high intensity rainfall events where the rate of rainfall surpasses the infiltration rate of the soils. The area is undulating and accumulation of water at low points is not prolonged enough to cause changes in the soil morphological features.

Small (less than 2 m in diameter) depressions were noted. **Figure 8** contains three examples of such depressions. These depressions may sporadically contain water. It is postulated that these depression are wet directly after a rainfall event, but dries out relatively quickly – probably within days if not hours. Augering was done at these sites and no signs of prolonged water logging (i.e. mottles, bleaching, gleying) were noted. An increase in silt and clay content was noted within the first one centimeter of the soil. Deeper augering reveals soils similar in morphology to that of the surrounding area.

a.

b.

c.

Figure 8 Small depressions (<2 m in diameter) encountered on site where water ponding occurs sporadically

4.3. Current Land Use and Impacts

The area is mainly used as a game and cattle farm. **Figure 9** illustrates a kudu spoor (a.) and cattle farming (b. and c.). The site has suffered little serious impact.

4.4. Soil Chemical and Physical Characteristics

Table 8 summarises the chemical and physical properties of representative soil samples. The ammonium acetate extraction method is used to determine neutral salt dissolvable mineral phases and ions sorped onto the exchanged complex of the soils in such a way that they are extracted using a weak complexing agent. This extraction method is used to assess the plant availability of major cationic nutrients. Bray 1 is used to assess the plant available phosphate levels.

Ideal levels for maize production of Ca, Mg, K and PO_4 should be in the order of 300-400 mg/kg, 50-80 mg/kg, 100-120 mg/kg and 20 – 40 mg/kg, respectively. The soils of the area exhibit lower levels of Ca, Mg, K and PO_4 than is required by maize. This can be amended with soil ameliorants.

If the soils are to be used for crop production purposes a detailed soil fertility and plant nutrition study should be conducted. Such a study falls outside the scope or purpose of this report.

a.

b.

c.

Figure 9 The farm is used as a game and cattle farm

Table 8 Soil chemical and physical characteristics

General					Ammonium Acetate					Texture		
Soil Horizon	**Soil form**	**pH(KCl)**	**EC**	**P(Bray 1)**	**K**	**Ca**	**Mg**	**Na**	**Org C**	**Sand**	**Silt**	**Clay**
			mS m^{-1}	**mg kg^{-1}**	**mg kg^{-1}**	**mg kg^{-1}**	**mg kg^{-1}**	**mg kg^{-1}**	**%**	**%**	**%**	**%**
Orthic A	Hutton	4.5	26.1	2	38	186	23	34	0.59	64	21	12
Red apedal B		4.8	24.3	3	39	189	21	54	0.51	70	18	9
Orthic A	Hutton transition to Ermelo	4.6	28.8	4	23	170	18	32	0.43	71	16	11
Red/yellow brown apedal B		5.2	22.3	4	32	145	16	31	0.41	80	12	6
Orthic A	Ermelo	4.8	24.7	1	15	129	19	25	0.44	79	11	5
Yellow brown apedal B		4.9	25.7	3	22	123	20	21	0.39	84	9	5

4.5. Irrigation Potential

The soils of the area are suited for irrigation and fall into Class 2 [Suitable for irrigation with slight limitations (such as undulating topography), moderately well drained, moderately slow or moderately rapid permeability or moderate depth of soil] or Class 3 [Low suitability with moderately severe limitations, imperfect or somewhat excessively drained soils, slow or rapid permeability or shallow soils}

To determine exactly which class the soils fall into, a detailed irrigation potential study should be conducted. Such a study should include measurements of infiltration rates (i.e. through double ring infiltrometer readings) and percolation rates (i.e. through Gaulph permeability testing) and must take the crop envisaged to be planted into account, as well as the water quality (amongst other factors).

The availability of ground/surface water will dictate if these soils can be irrigated. High temperatures and high evaporation rates dominate this area. Surface water is not present here. The Limpopo river is situated approximately 7 km north of the site. The groundwater level is approximately 17 to 22 meters below surface. Two boreholes are currently situated on the site. It is uncertain if these boreholes can yield enough water to irrigate large sections of land.

4.6. Land Capability

The soils fall into the arable land capability class. These soils are deep (>150 cm), exhibit adequate internal and external drainage, do not show rockiness or any other factor which could adversely affect plaughibility and are suited to irrigation.

It is uncertain if boreholes will yield adequate water supply for large scale irrigation to be possible. The sandy nature of the soils (low organic carbon and clay/silt content) probably manifests as a poor capacity to retain nutrients. Fertilisation and soil amelioration costs, as well as costs associated with irrigation, will be significant if the area was to be developed for crop production.

The rainfall, on average, is relatively low (401 mm to 600 mm per year) and high average temperatures (high evaporation) dictate that hydrophytic crops (most agricultural crops, especially broad leaved such as spinach, cabbage etc.) will suffer from draught stress under dry-land crop production. The crops that will be able flourish under dry-land crop production are drought resistant plants such as sisal.

5. ENVIRONMENTAL IMPACT ASSESMENT OF THE PROPOSED MINING ACTIVITIES

5.1. Description of the Impacts

Figure 10 illustrates the position of the proposed opencast including associated infrastructure, while **Figure 11** relates the area to be impacted to the soil forms encountered on the surveyed area. **Table 9** summarises the area to be impacted by the different types of infrastructure, as well as the open cast mining area. The proposed mining activities will impact low potential arable soils that comprise deep soils of the Ermelo and Hutton soil forms.

Table 9 Summary of the area (hectares) impacted upon by the proposed development

Infrastructure/Mining Area	**Soil Form**	**Area (Ha)**
3-year Temporary Discard Dump	Ermelo	4.3
CHPP Plant		2.1
Discard Dump		153.8
Electrical Substation		0.6
Explosives Magazine		1.4
Hard Overburden Dump		37.1
Internal Roads		11.3
Open Pit		125.4
Plant Infrastructure Area		1.2
Pollution Control Dam		2.6
Product Stockpile		0.6
RoM Stockpile		0.0
Soft Overburden Dump		14.1
Boxcut		2.4
3-year Temporary Discard Dump	Hutton	7.7
Boxcut		1.7
Bulk Water Supply Reservoirs		0.1
Hard Overburden Dump		2.9
Internal Roads		5.3
Office, Training & Parking		2.5
Open Pit		9.3
RoM Stockpile		1.0
RoM Tip		0.1
Soft Overburden Dump		4.1
Workshop & Wash bay		6.6
Total		**398.3**

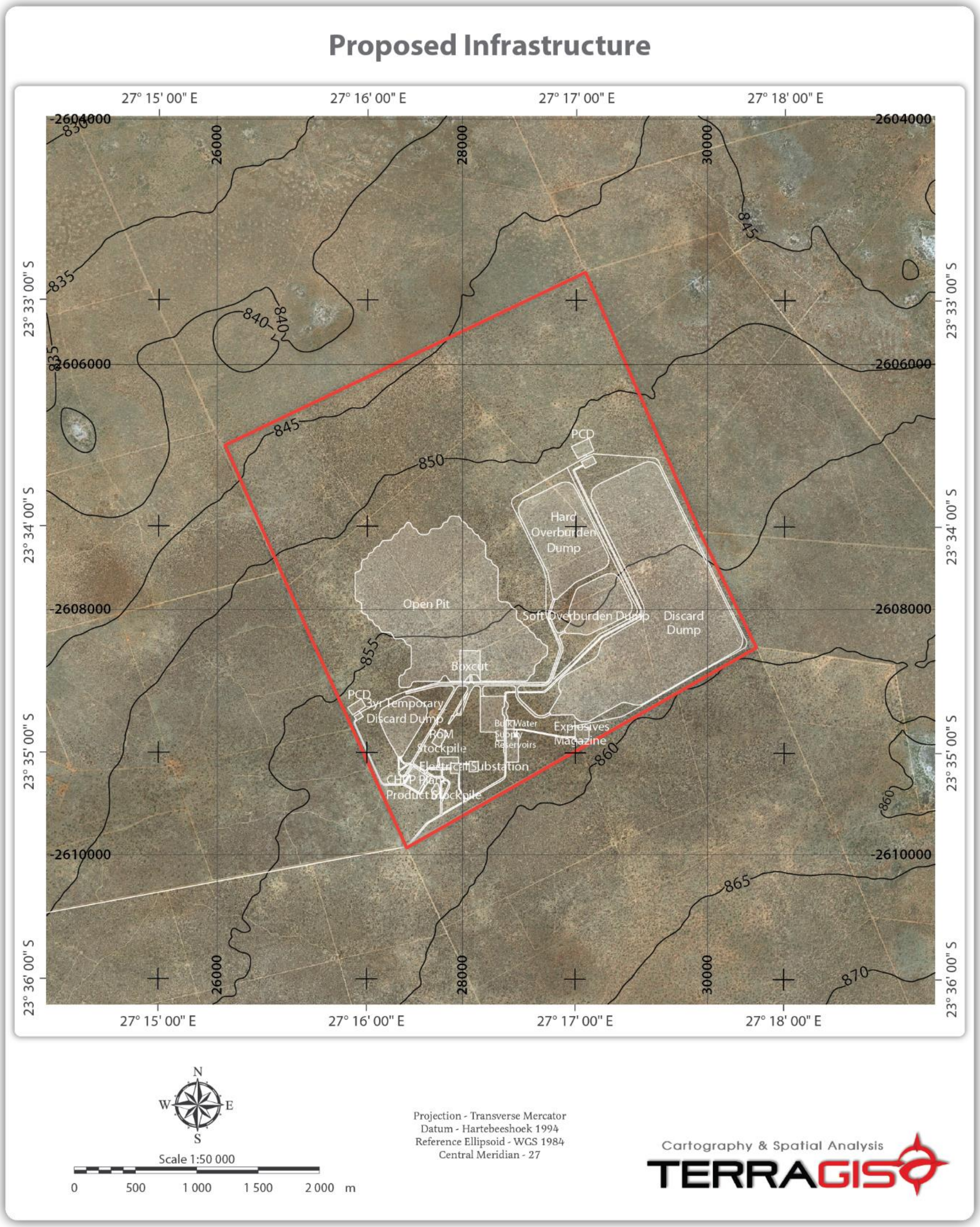

Figure 10 Map indicating the areas earmarked for mining and infrastructure

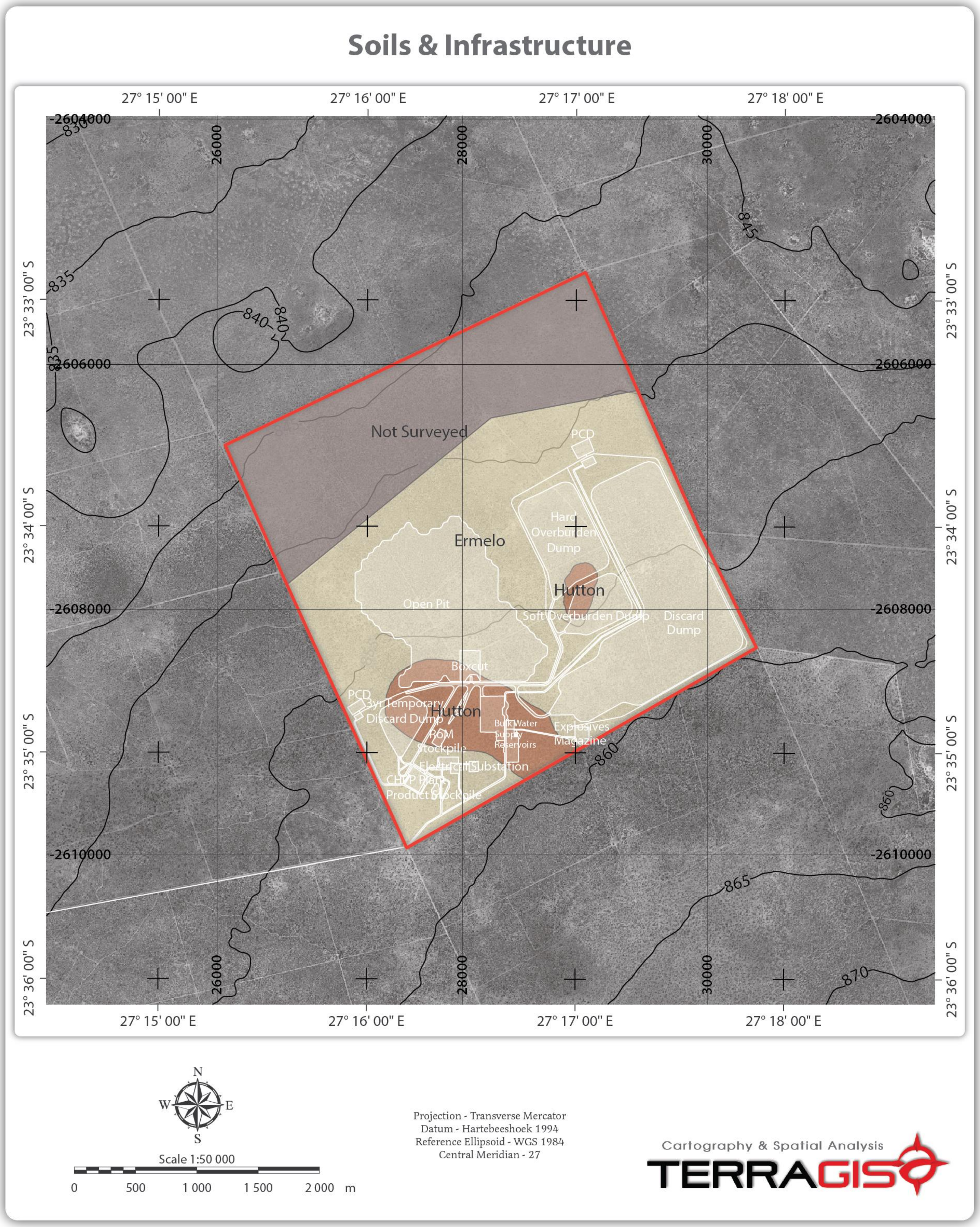

Figure 11 Map indicating the soil forms and areas that will be impacted by the envisaged mining activities

5.2. Nature of the Impact

5.2.1. Chemical Impacts

Soil pollution may emanate from the following:

- *Oxidation of stockpiled coal and waste material*: The storage of coal and waste rock, which can contain coaliferous material, can lead to the oxidation of metal-sulpide mineral surfaces and the production of acidic water depending on the acid base accounting of the material. During the oxidation process heavy metals and other problematic ions such as sodium and sulphate can be released (through mineral breakdown owing to mineral oxidation). If the acid to base ration of the coal and coaliferous waste is such that the ensuing leachate is acidic, a second step of heavy metal, sodium and sulphate mobilisation can occur, namely through mineral dissolution owing acidic conditions.

  These processes will occur in the areas where coal and waste are stockpiled. The soils in the vicinity of these areas do not have a high capacity to buffer chemical change. The soils are naturally low calcium-magnesium carbonates and have a limited capacity to neutralise acidic leachate. The soils do not contain high levels of clays which effectively sequester heavy metals, sulphates and sodium. The soils of the area exhibit a high infiltration and percolation capacity. The majority of the leachate from coal and discard dumps could impact on deeper lying soil layers and underground aquifers.

  This impact will occur during the operational and decommissioning phase and may extent after the life of mine if rehabilitation is not done properly. Pollution of the soil and surface water bodies may extend beyond the boundaries of the developments.

- *Hydrocarbon contamination* owing to vehicle and machinery breakdown or surface run-off from maintenance and wash bays can result in the contamination of soil and surface water. This could lead to soil toxicity. Such impacts are usually contained within the the boundaries of the development and can occur during the construction, operational and decommissioning phases.

- *Leaking of pollution control dams* could have a severe negative impact on the soil and surface water body environment. Seepage from pollution control dams is a common occurrence on mines and leads to soil and water contamination. This impact will occur during the operational and decommissioning phase and may extent after the life of mine if soils is contaminated and not remediated. Pollution of the soil and surface water bodies may extend beyond the boundaries of the development, especially if underground water bodies are affected. The soils of the area do not buffer chemical change effectively and is considered low in capacity to sequester contaminants.

- *Malfunctioning sewage treatment facilitates:* Spillage or leakage from sewage treatment facilities could lead to eutrophication of the surface water and salinisation of soils. This can occur during the construction, operational and decommissioning phases.

5.2.2. Physical Impacts

Physical impacts on the soil environment relates to:

- Compaction of the soil owing to vehicle traffic, road and infrastructure construction (during the construction, operational and decommissioning phase);
- Sterilisation of the soils of the areas to be development owing to the soils being covered by parking lots, offices, wash bays, workshops and other infrastructure (during the construction phase and operational phase).
- Erosion of the soil owing to vehicle traffic and increased surface run-off from the compacted areas (during the construction, operational and decommissioning phase);
- Removal (stripping) of soil where the infrastructure area is to be constructed.
- Removal of soil and overburden where the open-cast pit is to be excavated.
- Subsidence of the rehabilitated pit area during the decommissioning and closure phase

Soil compaction owing to vehicle traffic, road and infrastructure construction is especially pronounced in areas where the soils exhibit a fine sandy texture. Soil compaction results in a decrease of soil volume, aeration, water infiltration, water holding capacity, saturated hydraulic conductivity (hampers internal drainage) and an increase in soil density. This negatively impacts on plant root growth and development, thus leading to plants (crops and natural veld) being stunted and suffering from nutrient deficiencies and water stress. Culley, Dow, Presant and Maclean (1981) found that compaction resulted in:

- Silage corn yields being approximately 50 % lower during the first two years after construction in the right-of-way as opposed to adjacent areas not affected by pipeline construction;
- Smaller, but significant, lower yields were measured four years after construction in the right of way when compared to adjacent fields;
- Differences in midsummer corn and soya bean heights between the right of way and adjacent fields were 55 % during year one after construction and 25 % four years after construction.
- The impact of compaction on soil yield is significant over the first five years after construction, but considerable improvement in crop yields is noted over time.

The increased surface run-off from the compacted soils, coupled with the formation of preferential surface water flow paths owing to vehicle tracks and the sandy nature of the soils can lead to soil erosion. The low Na content and uniform nature of the soils will aid in combating erosion.

Stripping and stockpiling of topsoil where the infrastructure is to be constructed will result in:

- Loss of the original spatial distribution of natural soil forms and horizon sequences which cannot be reconstructed similarly during rehabilitation, especially in an area dominated by swelling and shrinking soils.
- Loss of natural topography and drainage pattern.
- Loss of original soil depth and soil volume.
- Loss of original fertility and organic carbon content.
- Exposure of soils to weathering, compaction, erosion, and chemical alteration of nutrients, particularly nitrogen.

The opencast pit will be mined through the so-called truck and shovel (stri-mining) method. This process of mining entails stripping, drilling, blasting, loading and hauling of overburden and coaliferous material to the waste dump and ROM stockpile or processing plant area. Approximately 30 to 100 m of overburden covers the coal seams.

The nature of the impact of opencast mining on the soil environment include the stripping and stockpiling of topsoil and the compaction of soils owing to heavy machinery traffic.

Stripping and stockpiling of topsoil will result in:

- Loss of the original spatial distribution of natural soil forms and horizon sequences which cannot be reconstructed similarly during rehabilitation.
- Loss of natural topography and drainage pattern.
- Loss of original soil depth and soil volume.
- Loss of original fertility and organic carbon content.
- Soil compaction from heavy machinery traffic during earthworks and rehabilitation will adversely affect effective soil depth, structure and density, thus influencing the pedohydrology and soil fertility of the area.
- Exposure of soils to weathering, compaction, erosion, and chemical alteration of nutrients, particularly nitrogen.
- Exposure of the soils to acidic, neutral or alkaline mine drainage that may be high in sulphates and heavy metals.
- Permanent changes in the hydrological functioning of the soils and the landscape.

Subsistence, especially sag subsidence, could also occur where material settling occurs in the case of filled-in opencast pits. These areas can hold water if the post mining or post subsidence topography lends itself thereto. Water will seep into these areas if the subsidence intersects the water table or if surface runoff is high. Very little can be done to combat subsidence in the mining environment.

5.3. Mitigation Measures

5.3.1. Timing of Construction

Construction should take place when the soils are dry and less prone to compaction. If construction takes place in the rainy season and when the soils are moist or saturated with water, vehicle traffic will result in rutting (sometimes to the extent that A- and B-horizons mix), excessive wheel slip will occur, puddles may form and tracks are more easily entrenched into the soil when the vehicles leave the right of way or haul roads. This is more of a concern in areas where high clay content soils occur. Nonetheless, timing construction to have as little impact as possible on the soil environment is recommended.

5.3.2. Rehabilitation of Compacted Soil

The soils that have been compacted by vehicle machinery leaving the right of way or dedicated haul roads should be monitored for compaction. A rehabilitation study for these areas should be commissioned.

Where compaction has occurred owing to preparing the soil surface for the construction of infrastructure, ripping to a depth that will break the compaction layer can be done. This will happen during the decommissioning phase when infrastructure and roads are broken down and the soil rehabilitated. If vegetation cover does not return in a reasonable amount of time, mulching and seeding should be considered. Prior to ripping, a soil scientist should assess the situation and investigate the most effective way through which to break up the compaction layer.

5.3.3. Mitigation of Soil Pollution

The coal stockpile and waste rock dumps, pollution control dams, sewage treatment facilities, wash and maintenance bays, amongst others, must be maintained and regularly inspected in order to prevent seepage or spillages from occurring owing to negligence. An adequate monitoring program must be put in place which entails sampling of soils. Surface run-off water from the coal stockpile and waste rock dumps, as well as the wash and maintenance bays must be diverted to the pollution control dams or a similar storage facility. Subsurface drains or cut-off trenches from where water can be pumped to the pollution control dams can be constructed where the coal stockpile and waste rock dumps are to be situated.

In the case of an unforeseen spillage or contaminated seepage occurring, the following should be implemented:

- Contain the spill using berms and swales in the case of surface contamination (probably mostly applicable to the wash and maintenance bays and sewage treatment facilities).
- Contact a soil pollution expert to sample and analyse the soils and determine the nature and severity of the pollution, as well as to compile a remediation plan.

Monitoring of the soils surrounding the coal stockpile and waste rock dumps, as well as the pollution control dams are important. In the case of contamination, a soil chemist should be consulted in order to design a remediation plan.

5.3.4. Stripping and Stockpiling of Excavated Soil

The soils of the area are similar in characteristics and there is no need to stockpile the Ermelo and Hutton soils separately. It is, however, important to stockpile the A- and B- and C-horizons separately. The A-horizon comprises the top 0.3 m of the soils while the B-horizon comprises the soils at a depth 0.3m to soft rock (saprolite) and/or hard rock (see **Table 10**)

During stockpiling the organic matter in the soil decompose, microbial activity decreases and plant seeds and microbial survival structures lose viability with time. It is therefore recommended that stockpiles are utilised as soon as possible and definitely within 12-18 months, stockpile slopes not be more than 10 % for the soils of the area. Erosion of stockpile material must be managed (slope and orientation of stockpile, movement of surface water etc.).

When trenches, pits and other structures from where the removal and stripping of soil have occurred are to be in-filled, the soils should be placed in the pits in such a way that the horizon sequence resembles that of the soil prior to excavation. This means, the C-horizon (rock and saprolite) must first be placed after which the B-horizon will be placed and lastly the A-horizon will be placed, thus ensuring the most fertile soil layer being on top and least fertile layer at the bottom.

The post mining land capability (after rehabilitation) of the mining area should be similar as prior to mining or as per rehabilitation design developed by a competent person(s). The success of soil rehabilitation will determine the degree of land capability restoration that is possible. The choice of plants, management of plant systems and management of soil fertility is critical for the long-term success and economy of rehabilitation. Monitoring of certain soil, vegetation and climate parameters during rehabilitation is essential.

Management and promotion of soil fertility with fertilizer and amendments is an important aspect of rehabilitation and specifically re-vegetation. Plant nutrient deficiencies and mineral disorders in soil must be detected and rectified. Movement and mixing of soil may result in contamination by acid producing pyrite from coaliferous spoil and coal waste, making soil nutrient and acidity levels unpredictable. Soil analysis provides the best guide and a sound monitoring programme is regarded as mandatory for proper rehabilitation. Management of soil organic matter through organic amendments and the use of mulches should receive attention with the aim of improving functional microbial diversity, nutrient cycling and re-vegetation.

The aforementioned approach would be similar to the guidelines contained in "Guidelines for the rehabilitation of mined land. Draft for review by the steering committee, 14 Feb 2007" as drawn up by Phil Tanner (Chamber of Mines of South Africa / Coaltech 2020). This document contains detail regarding the rehabilitation procedures and approaches during open cast mining operations. Due to the volume of information contained in the aforementioned document it will not be repeated here.

Table 10 Stripping depths and volumes for opencast area

Soil form	Area to be impacted (Ha)	A-horizon stripping depth (m)	Stockpile number	Stockpile volume (m^3)	B-horizon stripping depth (m)	Stockpile number	Stockpile Volume (m^3)
Hutton/ Ermelo	135	0.3	A1	405 000	*1.2	B1	1 620 000
Total volume of stockpiled soil	**2 025 000 m^3**						
Note:	**Do not mix A- and B-horizons and especially not B-horizons and saprolite/rock**						

*Estimated (soil auguring was done to 1.5 m during the site visit, but the soil is probably much deeper)

5.3.5. Proposed Monitoring

Monitoring of water quality of pollution control dams and other related infrastructure should be conducted. Piezometers and/or shallow vadose sone boreholes should be installed in the vicinity of the pollution control dams (i.e. where toe seepage may occur) and monitored in terms of water level and water chemistry. This will serve as an early warning mechanism in relation to soil and land contamination.

A monitoring program must be compiled that measured the impact of dust suppression on the soil environment in the vicinity of haul roads, the discard dumps, the office area and any other area where dust suppression is practiced. This program must also take into consideration spillage of coaliferous material from trucks etc on the soil environment.

Discard dumps and coal storage yards must be monitored for leachate and seepage which could affect the soil environment. Washing and service bays should also be monitored, specifically relating to hydrocarbon contamination.

Stockpiled soil should be monitored for soil fertility levels and erosion.

5.4. Impact Rating

Table 11 to 13 summarise the impact rating assigned to each of the identified impacts if mitigation measures are not implemented.

Table 11 Predicted negative impact assessment of mining related activities on current land use

Description		**Type**	**Certainty**	**Extent**	**Duration**	**Reversibility**	**Severity**	**Significance**	**Significance class**
Prior to mitigation measures	Opencast mining and pollution control facilities (dams/dumps etc.)	Direct	4	1	4	4	2	**44**	High
	Infrastructure (buildings and roads)	Direct	4	1	4	3	2	**40**	High
With mitigation measures in place	Opencast mining and pollution control facilities (dams/dumps etc.)	Direct	3	1	3	4	2	**30**	Moderate
	Infrastructure (buildings and roads)	Direct	1	1	3	3	2	**9**	Low

Table 12 Predicted negative impact assessment of mining related activities on land capability and agricultural potential

Description		**Type**	**Certainty**	**Extent**	**Duration**	**Reversibility**	**Severity**	**Significance**	**Significance class**
Prior to mitigation measures	Opencast mining and pollution control facilities (dams/dumps etc.)	Direct	4	1	4	4	3	**48**	High
	Infrastructure (buildings and roads)	Direct	4	1	4	4	3	**48**	High
With mitigation measures in place	Opencast mining and pollution control facilities (dams/dumps etc.)	Direct	3	1	3	4	2	**30**	Moderate
	Infrastructure (buildings and roads)	Direct	1	1	3	3	2	**9**	Low

Table 13 Predicted negative impact assessment of mining related activities on the hydropedological functioning of the area

Description		**Type**	**Certainty**	**Extent**	**Duration**	**Reversibility**	**Severity**	**Significance**	**Significance class**
Prior to mitigation measures	Opencast mining and pollution control facilities (dams/dumps etc.)	Direct	4	2	4	4	3	**52**	High
	Infrastructure (buildings and roads)	Direct	4	1	4	4	2	**44**	High
With mitigation and rehabilitation measures in place	Opencast mining and pollution control facilities (dams/dumps etc.)	Direct	3	2	3	3	3	**33**	Moderate
	Infrastructure (buildings and roads)	Direct	2	1	2	1	1	**10**	Low

5.5. Post Mining Land Capability and Use

It is doubtful that the area affected by opencast mining will ever function in the same manner as is presently the case from a hydropedological perspective. Rehabilitated land tends to be rather permeable and large volumes of water may end up in the rehabilitated opencast pit. In addition, large sections of the soils will be disturbed and their hydropedological and chemical nature will be changed. Hard-setting and crusting are significant concerns and the post-mining landscape could exhibit a much different soil environment than is now the case. Soil contamination may also have major impact on the soil environment.

The soils are seen as low potential arable land, but the farm is used for grazing. The crop production potential of the area is a function of crop type (draught resistant crops in the case of dryland crop production) and water availability (in the case of crop production under irrigation). Rehabilitation, if done properly, should be able to restore the area to grazing land. The carrying capacity of such land cannot be postulated upon and may be lower than is currently he case.

5.6. Opinion

This author is uncomfortable delivering an opinion on whether or not development (in general and not pertaining to this project alone) should take place on a given piece of land. This is an opinion that can only be made when all potential future impacts in the near vicinity of the area under investigation have also been taken into consideration and when the long-term agricultural vision for the area is known. Consultants simply do not have this information at hand. Such information resides with the relevant authorities (i.e. DMR, DEA and DAFF) and is not accessible to everyone.

Nonetheless, the author sees no reason for the development not to take place. The area, although comprising deep soils, are not of high crop production potential (except if irrigated). Current land use entails cattle and game farming. It is doubtful that the post-mining landscape will resemble the pre-mining landscape, but some degree of functionality should return if rehabilitation is done in a responsible manner. The latter must be based on a detailed rehabilitation plan which falls outside the scope of an EIA and which must be commissioned once mining has started.

6. CONCLUSION

The following can be concluded:

1. The study area comprises soils of the Ermelo (89% of the site) and Hutton (11 % of the site) soil forms. These soils are sandy in nature (the Hutton soils display a slightly higher silt content), deeper than 150 cm at all augering sites (approximately 724 holes were augered), exhibit good internal and external drainage (high saturated hydraulic conductivity), are uniform in colouration, do not contain rocks or layers impeding root development, do not contain free carbonates (*in situ* testing with a 10 % HCl solution was conducted) and no signs of regular water logging at any depth in the profile was noted.
2. The soils fall into the arable land capability class. The soils can be irrigated if sufficient groundwater reserves are available (falls into Class2/3). Crop production under dry-land conditions is possible for crops adapted to a low rainfall and high evaporation environment. Sisal, ground nut and cotton are example of such crops – a detailed agricultural potential study based on precision farming principles should be conducted if crop production is to be considered. Most food crops,

especially broad-leafed vegetables, will suffer under dry-land cultivation. The area comprises low potential arable soils when dry-land cultivation is the only option. If areas large enough in size for it to be economically viable (this will depend on crop type, market size, transport costs etc.) can be irrigated, the soils fall into the high potential arable land class. The reason why these soils do not fall into the grazing land capability class when dry-land crop production is the only option is because i) the criteria for assessing land capability classes does not include climatic conditions and ii) draught resistant plants such as sisal can be planted here.

3. The proposed mining activities will impact arable soils that comprise deep soils of the Ermelo and Hutton soil forms. Impacts include stripping and stockpiling of topsoil and the compaction of soils during the construction of facilities such as discard dumps, overburden stockpiles, pollution and run-off control dams and any other possible footprint structures. Heavy machinery traffic on the soil surface and possible chemical pollution of soil through polluted water or seepage from certain geological materials could constitute further potential impacts on the soil.
4. The farm is currently used as a game and cattle farm.
5. The impact of the mining activities on the current land use will be high (significance rating of 44 for opencast area and 40 for infrastructure area). If mitigation and rehabilitation measures are to be implemented post-mining, the impact is predicted to be moderate to low (significance rating of 30 for opencast area and 9 for infrastructure area).
6. The impact of the mining activities on the land capability will be high (significance rating of 48 for opencast area and 48 for infrastructure area). If mitigation and rehabilitation measures are to be implemented post-mining, the impact is predicted to be moderate to low (significance rating of 30 for opencast area and 9 for infrastructure area).
7. The impact of the mining activities on the hydropedolgy will be high (significance rating of 52 for opencast area and 44 for infrastructure area). If mitigation and rehabilitation measures are to be implemented post-mining, the impact is predicted to be moderate to low (significance rating of 33 for opencast area and 10 for infrastructure area).
8. Monitoring of soil quality should be done throughout the life or mine and post-closure. This entails assessing soil contamination levels at selected areas (i.e. the vicinity of pollution control dams, stockpiles, wash-bays etc.) as well as the fertility levels of stockpiled soils. A soil chemist should be contacted when contamination occurs, and remediation actions are needed.
9. The soils of the Hutton and Ermelo soils can be stripped and stockpiled together. It is, however, important to stockpile the A- and B- and C/rocky-horizons separately. The soils should be placed in the pit, during rehabilitation, in such a way that the horizon sequence resembles that of the soil prior to excavation. This means, the C-horizon (rock and saprolite) must first be placed after which the B-horizon will be placed and lastly the A-horizon will be placed, thus ensuring the most fertile soil layer being on top and least fertile layer at the bottom.

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8. APPENDIX A CURRICULUM VITAE

1. **Name:** Petrus Stephanus Rossouw (PS/Mafunyane)
2. **Date of birth:** 9 February 1981
3. **ID number:** 8102095032088
4. **Languages:** Afrikaans (fluent), English (fluent), Sepedi/Sesotho/Setswana (Basic)
5. **Education:**

Institution	Degrees obtained
University of Pretoria (UP) (2008)	M.Sc. Agric. Soil Science ▪ Thesis title: Environmental extractability of chromium and nickel from soils of South Africa's Eastern Highveld ▪ Courses passed on 700 level: Soil chemistry, soil physics, plant nutrition and soil fertility
University of Pretoria (UP) (2004)	B.Sc. Agric. Soil Science ▪ Advanced courses: Soil chemistry, soil physics, soil dynamics, soil mineralogy and pedology, soil classification, soil water relations, natural product chemistry; environmental chemistry, physical chemistry, organic chemistry, inorganic chemistry, analytical chemistry.
	Courses passed for non-degree purposes
University of South Africa (UNISA) (2006 to 2008)	Advanced courses in Literary Theory, Theory of Poetry, Theory of Narrative, Theory of Drama, Creative writing (Afrikaans)
University of Pretoria (UP) (2004 to 2006)	Advanced courses in Afrikaans Text Editing, History of Afrikaans Poetry and History of Afrikaans Prose
	Short courses
University of Pretoria (UP) (Oct 2013)	Scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) and applications to environmental earth sciences
University of KwaZulu-Natal (UKZN) (Des 2010)	Advanced modelling of water flow and solute transport in the vadose zone with Hydrus

6. **Special interests**: Forensic soil chemistry; mechanisms of contaminant transport; mechanisms of soil chemical and mineralogical transformation in polluted environments; the capacity of soil to buffer chemical change, chemical and hydrological functioning of wetland systems

7. **Specialised skills/fields of expertise**: Design of land remediation and rehabilitation strategies for physically and chemically transformed soil; environmental soil and water chemistry; soil hydrology; critical evaluation of laboratory analytical procedures and development of specialised analytical methods for understanding project specific problems; laboratory and field based experimental design in order to address site specific problems.

8. **Experience:**

Date:	**Nov 2006 to May 2010**
Organisation:	Department of Plant Production and Soil Science, University of Pretoria
Position:	Research assistant
Date:	**2006 to June 2010**
Organisation:	TerraFirma Soil Science cc
Position:	Soil Scientist (Founding member/Co-director)
Date:	**Jul 2010 to April 2012**
Organisation:	Terra Soil Science cc
Position:	Environmental soil chemist and soil hydrologist
Date:	**Mei 2012 to current**
Organisation:	Rossouw and Associates - Soil and Water Science (Pty) Ltd
Position:	Director

9. **Society membership:** The South African Counsel for Natural Scientific Professionals (Registration number: 400194/12), Soil Science Society of Southern Africa (SSSSA), South African Soil Surveyors Organisation (SASSO), South African Wetland Society (SAWS)

10. **Presentations at national and international conferences:**
    - Rossouw, P.S. 2011. *Blue-green colouration in soil and its implications for understanding wetland hydrology.* Wetland Indaba, Didima lodge, Drakensberg, KwaZulu-Natal, South Africa
    - Rossouw, P.S., De Jager, P.C., Van der Waals, J.H. 2011. *Chromium(III) and nickel extractability as influenced by soil water potential levels.* Annual Combined Conference of the SASCP, SAWSS, SSSSA and SASHS, Pretoria, Gauteng, Republic of South Africa.
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    - Van der Waals, J.H., Rossouw, P.S., Potgieter, J.J.C., De Jager, P.C. 2007. *Uranium mobility in soil.* Annual Combined conference of the SASCP, SAWSS, SSSSA and SASHS, Badplaas, Mpumalanga, Republic of South Africa.

11. **Project grouping:**

Research project (2006 to 2010) – Funded by The South African Institute for Steel and Iron (SAISI) and conducted at the University of Pretoria (UP)
▪ Heavy metal dynamics in the soil environment ▪ First draft guidelines for the sustainable use of steel plant slag (aglime) in agriculture ▪ The phyto-availability of heavy metals
Research projects (2017) – In collaboration with the University of Pretoria (UP)
▪ Heavy metal attenuation in gold mine tailings affected soil
Research project (2018)- Funded by Rossouw and Associates and Imperata Consulting cc
▪ Carbonate chemistry and mineralogy in arid and semi-arid wetland systems ▪ Ecohydrology of semi-arid headwater and wetland systems
Consultancy projects – grouped (2006 to current)
▪ Soil and surface water pollution status assessment (heavy metals, salinization, hydrocarbons, biocides and asbestos) from coal washing plants, coal stockpiles, decanting mines, discard gold mine tailings dams, slag storage areas, zinc refinery plants, copper and chrome smelters, petroleum and other hydrocarbon storage facilities, fertiliser storage facilities, cattle feedlot areas, sewage plants and railroad facilities, including proposals for remediation and/or mitigation ▪ The capacity of soil to buffer chemical change in polluted environments (pollution emanating from coal mines, gold mines, steel plants and feedlots) ▪ Assessment of the chemical and hydrological functioning of wetland/peatland/mire systems ▪ Design and evaluation (feasibility assessment) of constructed wetlands to treat Cr(VI), F, P, N, SO_4 and cationic heavy metals contaminated water (industrial, mining and sewage effluent) ▪ Assessment of the chemical transformation (including pollution status) of soils/sediments in artificial wetland and lake system ▪ Hydrocarbon breakdown and transformation in soil and water bodies after spillages ▪ Wetland rehabilitation and design of artificial wetlands in the post-mining environment ▪ Suitability assessment of soils and saprolitic materials for use as water impermeable layers and topsoil layers to support vegetation in the rehabilitation of industrial waste dumps ▪ Wetland delineation (pedological and hydropedological studies) ▪ Baseline soil, land use, land capability and agricultural potential surveys (pedological studies) and impact assessments of mining, power line, housing, solar and wind power developments. ▪ Soil fertility and plant nutrition studies, including soil amelioration recommendations (Completed more than 250 projects)

12. **Other information:**
- Served on the reference committee of projects K5/2102 and K5/2052 of the Water Research Commission (WRC)
- Supervisor for a honours degree study conducted at the University of Pretoria on heavy metal attenuation in soil impacted by gold mine tailings material (T. Maruwane, 2017)

13. **Short courses completed not relating to natural science:**
- Film camera and lighting (2010) – CityVarsity, Johannesburg
- Creativity and creative writing: CE@UP, University of Pretoria (2008); Dr Riana Scheepers (2009)

14. **Contact information:**

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