A SPECIALIST REPORT ON THE SOILS, AGRICULTURAL POTENTIAL AND LAND CAPABILITY FOR THE PROPOSED GLENCORE EASTERN MINES WASTE STORAGE FACILITIES, LIMPOPO PROVINCE

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SOILS AND LAND CAPABILITY REPORT

April 2020

Conducted on behalf of:

Glencore Eastern Mines

Compiled by:

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Declaration

I, Barend Johannes Henning, declare that -

- I act as the independent specialist;
- I will perform the work relating to the project in an objective manner, even if this results in views and findings that are not favourable to the project proponent;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this project, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998; the Act), regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the project proponent and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the project; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority or project proponent;
- All the particulars furnished by me in this document are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of specialist
Company: Exigo Sustainability (Pty) Ltd.
Date: April 2020

Notations and terms

Aerobic: Having molecular oxygen (O_2) present.

Agricultural means land zoned for agricultural use.

Anthropogenic: Of human creation

Arable means land that can produce crops requiring tillage; land so located and constituted that production of cultivated crops is economical and practical.

Alluvium (from the Latin, alluvius, from alluere, "to wash against") is loose, unconsolidated (not cemented together into a solid rock) soil or sediments, which has been eroded, reshaped by water in some form, and redeposited in a non-marine setting. Alluvium is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel. When this loose alluvial material is deposited or cemented into a lithological unit, or lithified, it would be called an alluvial deposit.

Base status: A qualitative expression of base saturation. See base saturation percentage.

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

Biota: Living things; plants, animals, bacteria

Bottomland: The lowlands along streams and rivers, on alluvial (river deposited) soil.

Calcareous: Containing calcium carbonate.

Catena: A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic conditions, but having different characteristics due to variation in relief and drainage.

Carbonate can refer both to carbonate minerals and carbonate rock (which is made of chiefly carbonate minerals), and both are dominated by the carbonate ion, CO_3^{2-}. Carbonate minerals are extremely varied and ubiquitous in chemically precipitated sedimentary rock. The most common are calcite or calcium carbonate, $CaCO_3$, the chief constituent of limestone (as well as the main component of mollusc shells and coral skeletons); dolomite, a calcium-magnesium carbonate $CaMg(CO_3)_2$; and siderite, or iron(II) carbonate, $FeCO_3$, an important iron ore. Sodium carbonate ("soda" or "natron") and potassium carbonate ("potash") have been used since antiquity for cleaning and preservation, as well as for the manufacture of glass.

Chroma: The relative purity of the spectral colour, which decreases with increasing greyness.

Effective soil depth means the depth of soil material that plant roots can penetrate readily to obtain water and plant nutrients; the depth to a layer that differs sufficiently from the overlying material in physical or chemical properties to prevent or seriously retard the growth of roots.

Erosion: The group of processes whereby soil or rock material is loosened or dissolved and removed from any part of the earth's surface.

Fertilizer: An organic or inorganic material, natural or synthetic, which can supply one or more of the nutrient elements essential for the growth and reproduction of plants.

Fine sand: (1) A soil separate consisting of particles 0,25-0,1mm in diameter. (2) A soil texture class with fine sand plus very fine sand (i.e. 0,25-0,05mm in diameter) more than 60% of the sand fraction.

Fine textured soils: Soils with a texture of sandy clay, silty clay or clay.

Floristic: of flora (plants).

Floodplain: Wetland inundated when a river overtops its banks during flood events resulting in the wetland soils being saturated for extended periods of time.

Gley: Soil material that has developed under anaerobic conditions as a result of prolonged saturation with water. Grey and sometimes blue or green colours predominate but **mottles** (yellow, red, brown and black) may be present and indicate localised areas of better aeration.

High potential means prime or unique.

Horizon: See soil horizons.

Hydric soil: Soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hue (of colour): The dominant spectral colour (e.g. red).

Land means the total natural environment of the exposed part of the earth's surface, including atmosphere, climate, soils, vegetation and the cultural environment.

Land capability: The ability of land to meet the needs of one or more uses under defined conditions of management.

Land type: A class of land with specified characteristics. In South Africa it has been used as a map unit denoting land, mappable at 1:250,000 scale, over which there is a marked uniformity of climate, terrain form and soil pattern.

Land use: The use to which land is put.

Mottles: Soils with variegated colour patters are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Organic soil material: Soil material with a high abundance of undecomposed plant material and humus. According to the Soil Classification Working Group (1991) an organic soil horizon must have at least 10% organic carbon by weight throughout a vertical distance of 200 mm and be saturated for long periods in the year unless drained. According to the Soil Survey Staff (1975) definition, in order for a soil to be classed as organic it must have >12% organic carbon by weight if it is sandy and >18% if it is clay-rich.

Pedology: The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.

Perched water table: The upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.

Permanent irrigation means the availability for, and regular artificial application of, water to the soil for the benefit of growing crops. Application may be seasonal.

Prime means the best land available, primarily from the national perspective, but with allowance of provincial perspectives; land best suited to, and capable of, consistently producing acceptable yields of a wide range of crops (food, feed, forage, fibre and oilseed), with acceptable expenditure of energy and economic resources and minimal damage to the environment (and is available for these uses).

Seasonally wet soil: Soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season, but is predominantly dry during the dry season.

Sedges: Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.

Sodic soil: Soil with a low soluble salt content and a high exchangeable sodium percentage (usually EST > 15).

Soil drainage classes describe the soil moisture conditions as determined by the capacity of the soil and the site for removing excess water. The classes range from very well drained, where excess water is removed very quickly, to very poorly drained, where excess water is removed very slowly. Wetlands include all soils in the very poorly drained and poorly drained classes, and some soils in the somewhat poorly drained class. These three classes are roughly equivalent to the permanent, seasonal and temporary classes

Soil family means a defined subdivision of a soil form representing a greater degree of uniformity than the form itself.

Soil form means the highest category in the South African soil classification system; soil forms are defined in terms of kind and sequence of diagnostic horizons; the soil form implies, inter alia, physical and hydrological properties which provide an indication of land-use possibilities and constraints; In the 1991 Edition, titled "Soil Classification: A Taxonomic System For South Africa", 73 soil forms are recognized.

Soil horizons: Layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e. soil material that has different characteristics).

Soil profile: The vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991).

Soil saturation: The soil is considered saturated if the water table or **capillary fringe** reaches the soil surface (Soil Survey Staff, 1992).

Swelling clay: Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried. The latter are also known as heaving soils.

Temporarily wet soil: The soil close to the soil surface (i.e. within 50 cm) is wet for periods > 2 weeks during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.

Terrain unit classes: Areas of the land surface with homogenous form and slope. Terrain may be seen as being made up of all or some of the following units: crest (1), scarp (2), midslope (3), footslope (4) and valley bottom (5).

Texture, soil: The relative proportions of the various size separates in the soil as described by the classes of soil texture shown in the soil texture chart (see diagram on next page). The pure sand, sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided according to the relative percentages of the coarse, medium and fine sand subseparates.

Topsoil clay content means the average percentage clay-sized material (<0.002 mm) in the uppermost part of the soil; that is, the part ordinarily moved in tillage, or its equivalent in uncultivated soils, ranging in depth from about 100 to 300 mm; frequently designated as the “plough layer” or the “Ap horizon”.

Unique agricultural land means land that is or can be used for producing specific high-value crops. It is usually not prime, but important to agriculture due to a specific combination of location, climate or soil properties that make it highly suited for a specific crop when managed with specific farming or conservation methods. Included is agricultural land of high local importance where it is useful and environmentally sound to encourage continued agricultural production, even if some or most of the land is of mediocre quality for agriculture and is not used for particularly high-value crops.

Vertic, diagnostic A-horizon: A-horizons that have both, a high clay content and a predominance of smectitic clay minerals possess the capacity to shrink and swell markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet

Water regime: When and for how long the soil is flooded or saturated**.**

List of abbreviations

Abbreviation	Description
ARC	Agricultural Research Council
CARA	Conservation of Agricultural Resources Act
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DENC	Department of Environmental Affairs and Nature Conservation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme Report
ENPAT	Environmental Potential Atlas
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information Systems
GPS	Geographical Positioning System
ISCW	Institute for Soil, Climate and Water
MAE	Mean Annual Evaporation
MAMSL	Meter Above Mean Sea Level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NC	Northern Cape
NEMA	National Environmental Management Act
PQ4	Priority Quaternary Catchment
SADC	Southern African Development Community
SANBI	South African National Biodiversity Institute
WHO	World Health Organisation

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1 ASSIGNMENT

Exigo Sustainability was appointed by Glencore Eastern Mines to conduct a soil potential and land capability study as part of the EIA phase (Mining Right Application) for the proposed residue deposit project on Glencore Eastern Mines, within the Fetakgomo Greater Tubatse Local Municipality, Greater Sekhukhune District Municipality, Limpopo Province.

This report is compiled to include new infrastructure and expansions of existing infrastructure at existing mines. The following is a summary of what is included in this report:

- Thorncliffe mine:
  - New Waste Storage Facility (WSF) (Co-disposal between Tailings and Waste rock) and associated Pollution Control Dam (PCD)
  - Filter press for tailings dewatering prior to deposition
- Helena Mine:
  - Waste Rock Dump (WRD) on footprint of existing Paste Tailings Storage Facility (TSF) site as well as a new silt trap and PCD.
- Stormwater management infrastructure at both mine sites.

The main purpose of this study was solely to assess the agricultural potential and value of the soil types on the site. This assessment is essential as it will contribute to meeting the requirements of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) in compliance with EIA Regulation of 2014 (as amended), promulgated in terms of Section 24 (5) of NEMA.

The assignment is interpreted as follows: Compile a study on the soil potential of the soil forms of the proposed development site according to guidelines and criteria set by the National Department of Agriculture. The study will include a detailed soil assessment and interpretation. In order to compile this, the following had to be done:

1.1 Information Sources

The following information sources were obtained:

- All relevant maps through GIS mapping, and information (previous studies and agricultural databases) on the land use, soils, agricultural potential and land capability of the area concerned;
- Requirements regarding the agricultural potential survey and prime or unique agricultural land as requested by the NDA;
- Obtain relevant information of land type, geology and soil types of the area. This includes

information on the soil potential, clay percentage, soil depth and soil forms, as classified by the Environmental Potential Atlas of South Africa (Institute for Soil, Climate and Water, Agricultural Research Institute);

- Obtain information of the prevailing land use and agricultural activities being practiced in the larger area of the neighbouring properties;
- Obtain an aerial photograph of the area to help in the interpretation and identification of major soil types and land uses in the study area.

1.2 Regulations governing this report

1.2.1 National Environmental Management Act, 1998 (Act No. 107 of 1998) - Regulation No. R982

This report was prepared in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Gazette No. 38282 Government Notice R. 982. Appendix 6 – Specialist reports includes a list of requirements to be included in a specialist report:

1. A specialist report or a report prepared in terms of these regulations must contain:
    a. Details of
        i. The specialist who prepared the report; and
        ii. The expertise of that specialist to compile a specialist report, including a curriculum vitae;
    b. A declaration that the specialist is independent in a form as may be specified by the competent authority;
    c. An indication of the scope of, and purpose for which, the report was prepared;
    d. The date and season of the site investigation and the relevance of the season to the outcome of the assessment;
    e. A description of the methodology adopted in preparing the report or carrying out the specialized process;
    f. The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;
    g. An identification of any areas to be avoided, including buffers;
    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;

i. A description of any assumptions made and any uncertainties or gaps in knowledge;

j. A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;

k. any mitigation measures for inclusion in the EMPr;

l. any conditions for inclusion in the environmental authorisation;

m. any monitoring requirements for inclusion in the EMPr or environmental authorisation

n. a reasoned opinion –

   i. As to whether the proposed activity or portions thereof should be authorised and

   ii. If the opinion is that the proposed activity 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;

o. A description of any consultation process that was undertaken during the course of preparing the specialist report;

p. A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and

q. Any other information requested by the competent authority.

1.2.2 Other related legislation

The natural resources of South Africa constitute a national asset, which is essential for the economic welfare of present and future generations. Economic development and national food security depend on the availability of productive and fertile agricultural land, and are threatened by the demand for land for residential and industrial development. Urban and rural planning needs to be integrated rather than sectorial and fragmentary. The use of agricultural land for other purposes should therefore be minimised. Currently the retention of productive agricultural land is administrated through the SUBDIVISION OF AGRICULTURAL LAND ACT, 1970 (ACT NO. 70 OF 1970) which controls the subdivision of agricultural land and its use for purposes other than agriculture. In the near future the use of these scares resources will be regulated through the SUSTAINABLE UTILISATION of AGRICULTURAL RESOURCES BILL. One of the object of the new Bill is to provide for the use and preservation of agricultural land, especially "prime and unique agricultural land" by means of prescribe criteria in terms of which agricultural land may be used for purposes other than agriculture, in collaboration with principles as laid down in the Development Facilitation Act, 1995 (Act No. 67 of 1995) and also in collaboration with the Land Use Bill, 2001. The prescribe criteria shall relate to the importance of the continued use of those agricultural resources for agricultural purposes in general particularly taking into consideration the use of prime and unique agricultural land or its agricultural importance relative to a particular province or area. Different criteria may be prescribed from time to time and such criteria may differ from province and area.

1.3 Terms of reference

1.3.1 Objectives

The objectives of this report are as follows:

- Conduct a soil survey on the proposed development site and identify the different soil types / forms present on the site;
- From the soil survey results link the optimal land use and other potential uses and options to the agricultural potential of the soils by classifying the soils into different Agricultural Potential classes according to the requirements set by the Department of Agriculture, South Africa. From these results soils maps and an agricultural potential map will be compiled;
- Discussion of the agricultural potential and land capability in terms of the soils, water availability, grazing capacity, surrounding developments and current status of land.
- Identify potential impacts of the development on the soils and provide mitigation measures to manage these impacts.

1.3.2 Limitations and assumptions

- In order to obtain a comprehensive understanding of the dynamics of the soils of the study area, surveys should ideally be replicated over several seasons and over a number of years. However, due to project time constraints such long-term studies are not feasible;
- The large study area did not allow for the finer level of assessment that can be obtained in smaller study areas. Therefore, data collection in this study relied heavily on data from representative, homogenous sections of soils, as well as general observations, aerial photograph analysis, generic data and a desktop analysis;

2 STUDY AREA

2.1 LOCATION AND DESCRIPTION OF ACTIVITY

The project area is on the Eastern Limb of the Bushveld Complex between Roossenekal (28 km) and Steelpoort (23 km), and is situated approximately 50 km north-west of the town of Lydenburg in the Limpopo Province of the Republic of South Africa. The nearest rural town is Ga-Malekane (also known as Kokwaneng) which is 15 km north-west of the mine.

Glencore Eastern Mines consist of the following mines/projects:

- Thorncliffe mine
- Helena Mine
- Magareng Mine

The project involves the following as part of the expansion of the current mining operations (Figure 2)

- New infrastructure at the existing mines proposed:
- Thorncliffe mine:
    - New Waste Storage Facility (WSF) (Co-disposal between Tailings and Waste rock) and associated Pollution Control Dam (PCD)
    - Filter press for tailings dewatering prior to deposition
- Helena Mine:
    - Waste Rock Dump (WRD) on footprint of existing Paste Tailings Storage Facility (TSF) site as well as a new silt trap and PCD.
- Stormwater management infrastructure at both mine sites.

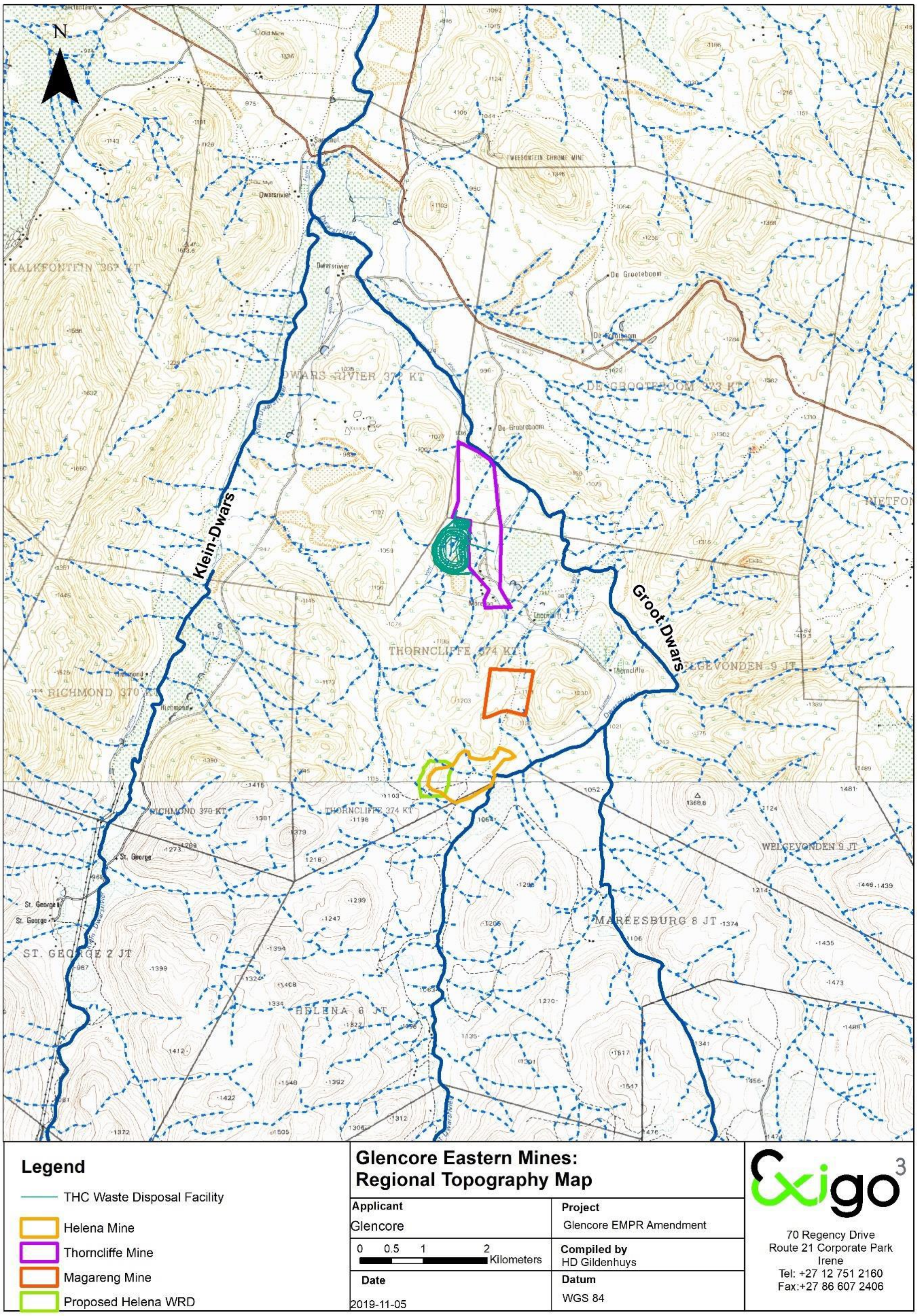


Figure 1. Regional Location Map

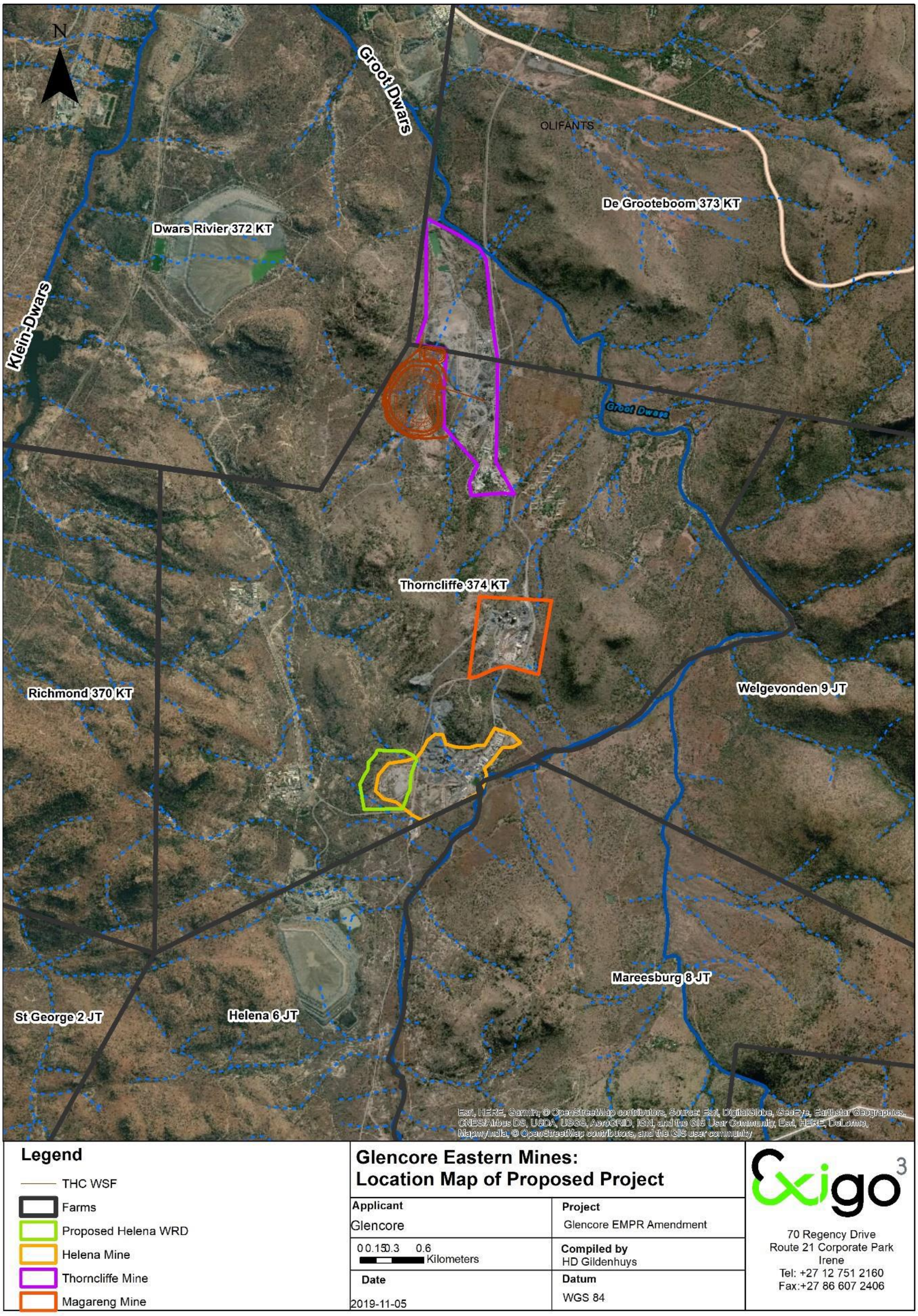


Figure 2. Satellite image showing the project area (Google Pro, 2010) and proposed activities

2.2 CLIMATE

Solar radiation, temperature, and precipitation are the main drivers of crop growth; therefore agriculture has always been highly dependent on climate patterns and variations. Since the industrial revolution, humans have been changing the global climate by emitting high amounts of greenhouse gases into the atmosphere, resulting in higher global temperatures, affecting hydrological regimes and increasing climatic variability. Climate change is projected to have significant impacts on agricultural conditions, food supply, and food security.

Climate for the Sekhukune Mountain Bushveld as described by Mucina & Rutherford (2006), indicate the area to have mainly summer rainfall with a mean annual precipitation of between 500 and 700mm. The mean monthly rainfall for the area varies between 4.8 mm and 105 mm, with maximum precipitation occurring in January. About 50 to 80 rain days per year may be expected, occurring mostly during November to March. Hail is less frequent than on the Highveld. The rainfall is unreliable.

Average daily maximum temperatures are about 32°C in January and 22°C in July. Average daily minima are about 18°C in January and 4°C in July. Days are often oppressive in summer, whereas winter nights can be very cold. Frost occurs on average during June to August. Winds are mainly light to moderate and blow from the north-easterly sector except for short periods during thunderstorms or weather changes when they have a southerly component.

2.3 GEOLOGY AND SOIL TYPES

Geology is directly related to soil types and plant communities that may occur in a specific area (Van Rooyen & Theron, 1996). A Land type unit is a unique combination of soil pattern, terrain and macroclimate, the classification of which is used to determine the potential agricultural value of soils in an area. The land type units represented within the study area include the Ib30, Ib31 and Dc31 land types (Land Type Survey Staff, 1987) (ENPAT, 2001). The land type, geology and associated soil type is presented in Table 1 below as classified by the Environmental Potential Atlas, South Africa (ENPAT, 2000).

Table 1. Land types, geology and dominant soil types of the proposed development site

Landtype	Soils	Geology
Ib30	Miscellaneous land classes, rocky areas with miscellaneous soils	Ferrogabbro, ferrodiorite and magnetitite (Upper zone) and gabbro, norite and anorthosite (Main zone) of the Rustenburg Layered Suite of the Bushveld Complex; some Nebo granite.
Ib31	Miscellaneous land classes, rocky areas with	Gabbro, norite, anorthosite, pyroxenite, bronzitite and harzburgite of the Rustenburg Layered Suite, Bushveld

Landtype	Soils	Geology
	miscellaneous soils	Complex.

The soils are generally shallow and varies between soils of a colluvial nature i.e. Glenrosa, Family Dumisa to Mispah form, Family Myhill. Rockiness varies between 30% to 70% (Glenrosa) and 65% on the Mispah form. The soils are derived from norite and have a moderate (15-35%) to high (>35%) clay content, depending on their position in the landscape. The soil depth varies between shallow gravelly soils in the rocky terraces (<450mm) and non-perennial drainage channels, to deeper loamy - clay soils on the plains (450-750mm).

2.4 HYDROLOGY AND DRAINAGE

The regional topography is rugged with steep slopes and incised valleys that strike east to west and north-east to south-west. The highest elevation is at 1500 mamsl to the south of the study area and the lowest at 850 mamsl in the north-eastern and north-western boundaries of the study areas, which is along the Klein- and Groot Dwars Rivers. The topographic gradient is steep and ranges between 1.7 % and 5 %. The floodplains along the major riverbanks are relatively flat.

2.5 LAND USE AND EXISTING INFRASTRUCTURE

The current land-use of the proposed development site is mining with the neighbouring areas being used for grazing by livestock as well as small scale subsistence crop cultivation. The major land use of the study area as classified by the Environmental Potential Atlas of South Africa (2000) is vacant / unspecified land.

2.6 VEGETATION

2.6.1 Biomes

The project area lies within the Savanna Biome. The Savanna Biome is the largest biome in Southern Africa. It is characterized by a grassy ground layer and a distinct upper layer of woody plants (trees and shrubs). The environmental factors delimiting the biome are complex and include altitude, rainfall, geology and soil types, with rainfall being the major delimiting factor. Fire and grazing also keep the grassy layer dominant.

2.6.2 Vegetation types

2.6.2.1 Mucina & Rutherford (2006) Classification

The most recent classification of the area by Mucina & Rutherford shows that the proposed development site is classified as Sekhukhune Mountain Bushveld. The Sekhukune Mountain Bushveld has a least threatened conservation status with 0.4% conserved and nearly 15% transformed. Transformation is mainly through dryland subsistence cultivation and urban built up.

The vegetation structure of the Sekhukune Mountain Bushveld varies from open to dense woody layer, with associated woody and herbaceous shrubs and closed to open grass layer. The landscape topography is mainly moderate to steep slopes on mountainsides and sometimes deeply incised valleys. Flat terrain occurs dispersed in between the sloping terrain.

2.6.2.2 Sekhukhuneland Centre of Endemism

The site forms part of the Sekhukhuneland Centre of Endemism (SCOE). The importance to evaluate the vegetation on the site as part of the Sekhukhuneland Centre of Endemism cannot be underestimated. Most of southern Africa's endemic plants are concentrated in only a few, relatively small areas, known as regions or centres of endemism. Not only do these centres hold clues to the origin and evolution of the botanical diversity within a particular area, but these are also areas that, if conserved, would safeguard the greatest number of plant species (Van Wyk & Smith, 2001). Sekhukhuneland have been identified through previous studies as one of the most important centres of endemism in the Mpumalanga and Limpopo Provinces. The centre falls within the rainfall shadow of the Drakensberg Escarpment, and it is relatively more arid than the areas to the east. The endemic plants of this area are primarily edaphic specialists that are derived from a unique ecology. The substrate consists of heavy soils derived from the norite, pyroxenite and anorthosite formations that predominate over the region. Endemics are both herbaceous and woody with endemism high in the Anacardiaceae, Euphorbiaceae, Liliaceae and Lamiaceae (Van Wyk & Smith, 2001). The site lies inside the Sekhukhuneland Centre of Endemism and the shallow, rocky areas of the development site can be considered especially sensitive as part of the centre of endemism, and will almost certainly show similar vegetation patterns to the endemic regions, especially since the vegetation is still in a natural state. Other important attributes of this region's flora are summarized in table 2 below:

Table 2. Attributes of the Sekhukhuneland Centre of Plant Endemism

Centre of Endemism Size:	5449.4km2
Total Number of Species / Taxa:	± 2200
Endemic / Near endemic taxa:	>100
Rate of endemism:	4.5%
Area in Limpopo Province:	2794km2
Proportion in Limpopo Province:	51.7%
Total % transformed:	28.57%

3 GUIDELINES FOR AGRICULTURAL POTENTIAL

3.1 Moisture Availability

The moisture availability of soils is an aspect which recently has become an important factor to consider when cultivating crops under dry-land conditions. Moisture and water availability will be affected by a temperature increase, regardless of any change in rainfall. Higher temperatures increase the evaporation rate, thus reducing the level of moisture available for plant growth, although other climatic elements are involved. A warming of 1°C, with no change in precipitation, may decrease yields of wheat and maize in the core cropping regions such as the US by about 5%. A very large decrease in moisture availability in the drier regions of the world would be of great concern to the subsistence farmers that farm these lands. Reduced moisture availability would only exacerbate the existing problems of infertile soils, soil erosion and poor crop yields. In the extreme case, a reduction in moisture could lead to desertification. The classes as classified for South Africa are shown in Table 3.

Table 3. Moisture availability classes as derived from seasonal rainfall and evaporation

Moisture availability class	Summer rain season (R/0.25PET)	Winter rain season (R/0.4PET)	Agricultural Potential
1	>34	>34	Conducive to rain-fed arable agriculture
2	27-34	25-34	Conducive to rain-fed arable agriculture
3	**19-26**	**15-24**	**Conducive to rain-fed arable agriculture**
4	12-18	10-14	Marginal for rain-fed arable agriculture
5	6-12	6-9	Conditions too dry for rain-fed arable agriculture
6	<6	<6	Conditions too dry for rain-fed arable agriculture

The soils on the proposed development site are classified as class 4, which suggest that climatic conditions are marginal to rain-fed arable agriculture.

3.2 Soil classification of the site from ARC databases

The Agricultural Research Institute uses specific soil characteristics to indicate the suitability of soils for arable agriculture.

These characteristics for the site are as follows;

- Structurally favourable soils: Soils with structure favouring arable land use scarce or absent;
- Soil association:
  - Section of proposed WRD and ventilation shaft: Rock with limited soils (association of Leptosols, Regosols, Durisols, Calcisols and Plinthosols)
  - Section of proposed WRD and WSF: Soils with a marked clay accumulation (association of Luvisols, Planosols and Solonetz. In addition one or more of

Plinthosols, Vertisols and Cambisols may be present)

- Soil pH: 5.5-7.4;
- Prime agricultural activity for the area: Grains

Since the classification of the soil characteristics is based on a broad-scale desktop study of the general area, a thorough investigation of the soil types of the proposed development site is necessary for a more accurate classification of the soils. The main aim of the study is to identify the soil types on site and evaluate their specific characteristics to determine the agricultural potential of the soils. The study will thus reduce the scale at which soils for the area was previously.

3.3 National assessment criteria

3.3.1 Agricultural Potential of soils in South Africa

The essence of identifying high potential agricultural land in South Africa is to retain prime area for agricultural development and to retain as much productive areas as possible for the future. South Africa is dominated by shallow soils which are predominantly sandy. This poses a severe inherent limitation to crop production. The poor quality of the soil is due to the influence of the parent material in which they were formed. According to Laker (2005), South Africa has only 13 % (approximately 14 million ha) arable land, of which only 3 % is considered to be high potential. Inferring from the international requirement of about 0.4 ha arable land to feed an individual person, South Africa could produce enough food to feed only 35 million people on the available 14 million hectares of arable land. In line with this goal, the Department of Agriculture has developed a set of criteria to define potential and prime areas for agricultural development in South Africa. By definition, based on Part 1 of the Regulation of Conservation of Agricultural Resources Act 43 of 1983, an agricultural land in the Limpopo Province and specifically in the grid square in which the project site falls is considered high potential if the land:

1. Is under permanent irrigation; or
2. Can be classified into one of the following soil forms:
    a. Avalon
    b. Bainsvlei
    c. Bloemdal
    d. Clovelly
    e. Glencoe
    f. Hutton

g. Oakleaf

h. Pinedene

i. Shortlands

j. Tukulu And

3. The effective soil depth is equal to or greater than 900mm; and

4. Topsoil clay content between 10 and 35%.

High potential here means prime or unique. Prime refers to the best available land, mainly from the national perspective, suited to and capable of consistently producing acceptable yields of a wide range of crops (food, feed, forage, fibre and oilseeds), with acceptable expenditure of energy and economic resources and minimal damage to the environment. Unique agricultural land means land that is or can be used for producing specific high value crops.

Permanent irrigation means the availability for, and regular artificial application of, water to the soil for the benefit of growing crops. The application may be seasonal.

The classification of the National Department of Agriculture indicate that the site lies in a quarter degree grid square (QDS) with HIGH ARABLE POTENTIAL. The soil potential classification of the Department of Agriculture is based on broad-scale mapping (QDS) and the actual field study will refine the classification based on on-site conditions. The aim of this study should therefore be to refine the classification of the site at ground level.

3.3.2 Land capability of soils in South Africa

Scotney et al. (1991) within the concept of land capability defines land capability as ―the extent to which land can meet the needs of one or more uses under defined conditions of management, without permanent damage. Land capability is an expression of the effect of physical factors (e.g. terrain form and soil type), including climate, on the total suitability and potential for use for crops that require regular tillage, for grazing, for forestry and for wildlife without damage. Land capability involves the consideration of (i) the risks of damage from erosion and other causes, (ii) the difficulties in land use caused by physical factors, including climate and (iii) the production potential‖ (Scotney et al., 1991).

The current land capability data set that is used as the national norm indicates that there are little or no soils in South Africa that are not subject to limitations. Most of the country‘s soils have moderate to severe limitations largely due to limited soil depth or moderate erodibility, caused by sandy texture or slopes. It was determined that nowhere in South Africa do best soil and good climate classes coincide (Schoeman et al, 2002).

The land capability classes used for the South African Agricultural Sector are indicated in Table 4, while Table 5 indicate limitations and land use potential for the Land Capability classes.

Table 4. Land capability classes (Schoeman *et al.* 2002)

Land Capability Class	Increased intensity of use									Land Capability Groups
I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable land
II	W	F	LG	MG	IG	LC	MC	IC	-	
III	W	F	LG	MG	IG	LC	MC	-	-	
IV	W	F	LG	MG	IG	LC	-	-	-	
V	W	-	LG	MG	-	-	-	-	-	Grazing land
VI	W	F	LG	MG	-	-	-	-	-	
VII	W	F	LG	-	-	-	-	-	-	
VIII	W	-	-	-	-	-	-	-	-	Wildlife

W - Wildlife
LG - Light grazing
IG - Intensive grazing
MC - Moderate cultivation
VIC - Very intensive cultivation
F - Forestry
MG - Moderate grazing
LC - Light cultivation
IC - Intensive cultivation

Table 5. Land capability Classes: Limitations & land use

Land Capability Class	Definition	Conservation Need	Use suitability
I	No or few limitations. Very high arable potential. Very low erosion hazard.	Good agronomic practice.	Annual cropping.
II	Slight limitations. High arable potential. Low erosion hazard.	Adequate run-off control.	Annual cropping with special tillage or ley (25%)
III	Moderate limitations. Some erosion hazards.	Special conservation practice and tillage methods.	Rotation of crops and ley (50 %).
IV	Severe limitations. Low arable potential. High erosion hazard.	Intensive conservation practice.	Long term leys (75 %)
V	Watercourse and land with wetness limitations.	Protection and control of water table.	Improved pastures or Wildlife
VI	Limitations preclude cultivation. Suitable for perennial vegetation.	Protection measures for establishment e.g. Sod-seeding	Veld and/or afforestation
VII	Very severe limitations. Suitable only for natural vegetation.	Adequate management for natural vegetation.	Natural veld grazing and afforestation
VIII	Extremely severe limitations. Not suitable for grazing or afforestation.	Total protection from agriculture.	Wildlife

From the databases of Department of Agriculture the site has the following land capability (Figure 3):

Class VIII: Wilderness Land – Most of the site

Class III: - Moderate Potential Arable land – small sections of valleys and plains

These aspects still need to be confirmed at ground level though.

Criteria for determining land capability of a piece of land are based on soil and land characteristics.

These criteria related back to hazards or limitations to land use and are as follows:

- Slope %;
- Clay %;
- Effective rooting depth;
- Permeability;
- Signs of wetness;
- Rockiness;
- Soil surface crusting;

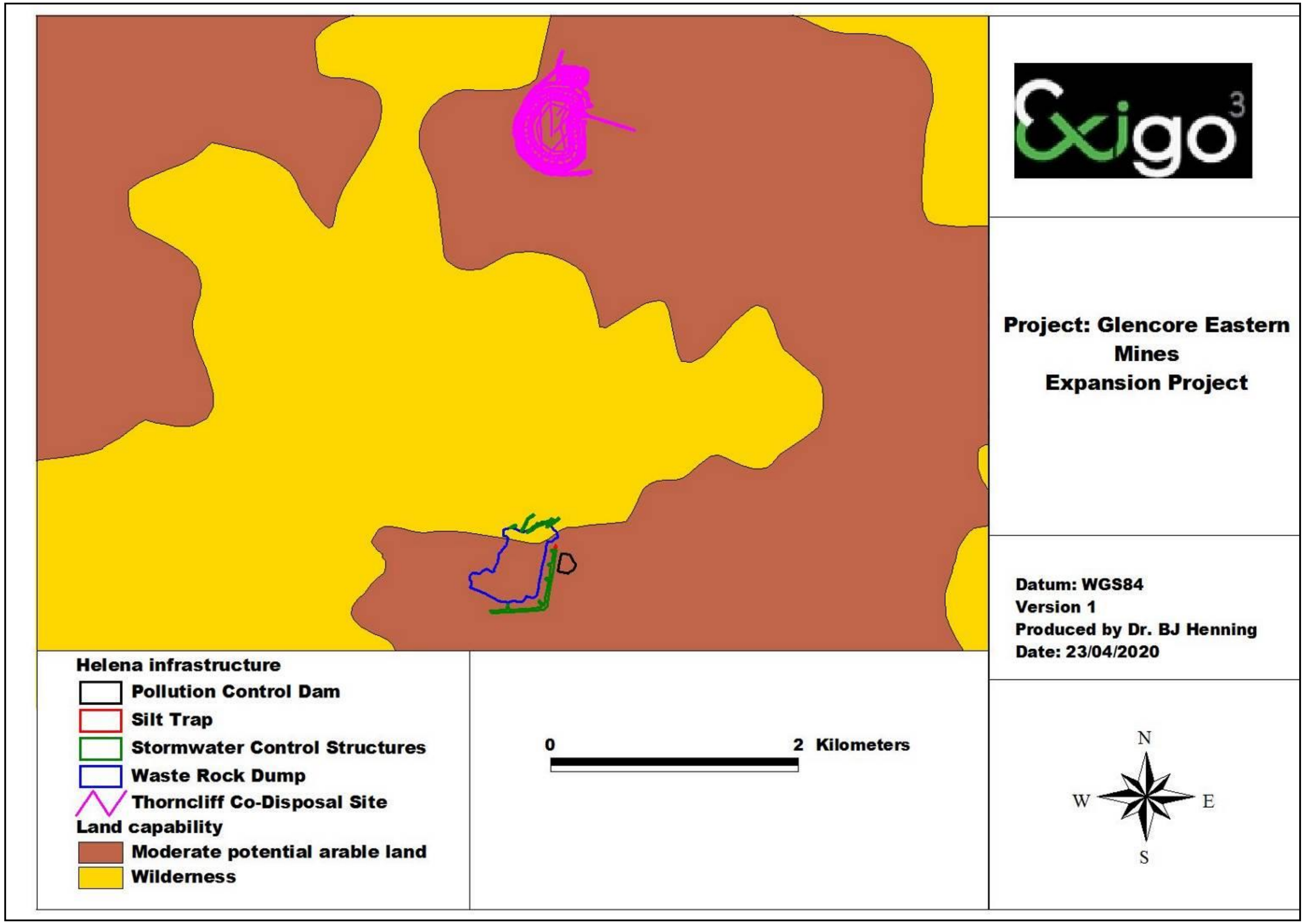


Figure 3. Land capability classes for the site as classified by the ARC: Source: [Web] http://www.agis.agric.za/agismap_atlas/AtlasViewer)

4 METHODS

The assessment of agricultural potential and land capability of the study area was based on a combination of desktop studies to amass general information and then through site visit for status quo assessment, soil sampling and characterization, and also the validation of generated information from the desktop studies:

- Definition of parameters of land as stipulated by the Subdivision of Agricultural Land Act, No. 70 of 1970 and the Amended Regulation of Conservation of Agricultural Resources Act No. 43 of 1983;
- Classification of high potential agricultural land in South Africa compiled by the Agricultural Research Council (Schoeman, 2004) for the National Department of Agriculture;
- Long-term climatic data record of the study area, obtained from Weather SA.
- Geophysical features of the site using Geographical Information System;
- Moisture availability class, determined through seasonal rainfall and fraction of the potential evapotranspiration (ARC, 2002);
- Field visit to the project site for general observation, survey of the farm in terms of vegetation, soils, water resources, terrain type and infrastructural profile;
- Previous and current land use of the farm and that of the neighbourhood;
- Other agro-ecological factors prevailing in the area;
- Agricultural potential of the property;
- Possible crop productivity or value of the farm for grazing purposes.

4.1 Soil surveys

The site surveys were conducted during November 2016 and May 2017. After a thorough investigation of an aerial photograph of the area and visual assessment of the specific sites and areas surrounding the sites, the following was done:

- Field observations were randomly made in the accessible, with specific emphasis on the resource area;
- Since the soils do not qualify as high potential soils according to Department of Agriculture databases, only soil physical characteristics were used to verify the potential of the soils at small-scale and therefore no chemical analyses of the soils was considered necessary;

- Slopes were analysed to determine the viability to cultivate crops in specific areas;
- The following soil physical and chemical characteristics were analysed through physical investigation:
    - Soil Depth (soil auger used);
    - Soil clay content (land type memoirs);
    - Soil texture and general structure.

4.2 Data recorded of surveys included:

- A description of the soil types and profiles identified on the sites;
- Specific soil characteristics on the proposed development sites and areas surrounding the sites;
- Photographs of the soil profiles and associated vegetation were taken and are included as part of the photographic guide.

4.3 Data processing

A broad classification of the soil types on the farm was done. A soil map indicates the dominant soil types identified by using a Geographic Positioning System (GPS) to locate sampled points on the topographical map of the farm. Soils were classified according to the Taxonomic Soil Classification System for South Africa, 1991. The following attributes were recorded and taken into consideration at each of the sites where samples were collected:

- Soil Type;
- Soil Depth;
- Soil clay content;
- Estimated soil texture class and soil structure;
- Slope;
- Moisture availability;
- Agricultural potential.

The agricultural potential of the soils were determined by using the specified guidelines stated above. The actual soil depth, clay content, slope, moisture potential and soil form were evaluated to determine the agricultural potential status. The soil characteristics and norms used to determine the agricultural potential of the soils were obtained from the National Department of

Agriculture, which created criteria for high potential agricultural land in South Africa (Schoeman, 2004) as stated in previous discussion in the report.

5 RESULTS

The proposed development site show variation in terms of soil characteristics and soil types identified during the survey. The classification of soils on the farm was based on land type description and the Binomial System for South Africa, which classifies soils into forms and families based on the diagnostic horizon of the soil profile (Macvicar, 1991). Exposed soil profile characteristics created by road cuttings in the field were also used in describing the local soil form. In addition, a soil auger was used to assess soil depths and for sampling (if not limited by depth) at pre-determined distances during a walk-over survey on the property. Soil identification and classification of the dominant soil type were done. The soil type and profile identified on the site will be discussed in detail in the following section.

The soils were classified into broad classes according to the dominant soil form and family as follows:

- Very shallow exposed bedrock outcrops / Shallow Mispah soil form occurring throughout the study area on the undulating plains and ridges;
- Shallow, gravelly soils of the Glenrosa / Hutton soil form along the plateaus and slightly undulating terrain of the study area;
- Black clayey / alluvial soils of the Oakleaf / Rensburg soil forms associated with drainage channels and floodplains;
- Degraded areas where the topsoil has been disturbed and often removed (old mining areas / haul roads – not described in this section under soil forms)
- Red / black clayey soils of the Hutton / Arcadia soil forms

The geological formations and vegetation patterns showed a strong correlation to the major soil units mapped in the study area. The location of the soil forms in the landscape is presented in figure 4, 5, 6 and 7 (WSF, WRD and ventilation shafts), while the land capability map is indicated in figure 8, 9, 10 and 11 for the different infrastructure (WSF, WRD and ventilation shafts).

5.1 Shallow, rocky soils of the Glenrosa or Mispah soil form associated with outcrops and ridges

Binominal Classification S.A.: Mispah / Glenrosa / bedrock soil form

Description: The soils are generally shallow and derived from gabbro or quartzite ridges in the project area. All three these soil forms can be categorised in the international classification group of lithic soil forms. In lithic soil forms the solum is dominated by rock or saprolite (weathered rock). These soils have sandy to sandyloam texture, while topsoil structure is apedal and the profiles are very shallow. Exposed rocks and boulders are spread on the soil surface throughout the area.

The soil in this area is often weakly structured, sandy to loamy and forms a mosaic of shallow Glenrosa soils and very shallow rocky soils (Mispah soil form), with the outcrops mostly consisting of bedrock. The Mispah and Glenrosa soils found on this section of the site are widespread and shallow in depth, although it has a medium clay content.

Landscape: Rocky ridges / undulating slopes (Photograph 1)

Depth: 50-200mm

Texture: Sandy to sandy loam soils

Average Clay Content: 8-15%

Agricultural Potential: Low potential soils, due to the shallow nature of the soils and sloping terrain, making these areas are not suitable for crop cultivation under arable conditions. The orthic A-horizon of the lithic soil group is unsuitable for annual cropping or forage plants (poor rooting medium since the low total available moisture causes the soil to be drought prone). These topsoils are not ideal for rehabilitation purposes for they are too shallow and/or too rocky to strip. Topsoil stripping and stockpiling of the "shallow‟ soils should only be attempted where the surface is not too rocky.

Land capability: The grazing potential of these areas is moderate-low. The most suitable and optimal utilization of the area would be grazing by small livestock or game species.

Photograph 1. Shallow soils associated with outcrops and ridges in the project area

5.2 Shallow / medium depth red-yellow apedal soils of the Glenrosa / Hutton Soil Forms

Binominal Classification S.A.: Hutton soil form; Glenrosa soil form

Description: The Hutton soils found on the site occur in pockets throughout the study area on plateaus and slightly undulating plains. The shallow Hutton soil forms are especially dominant in the southern and western section of the study area where the underlying bedrock is dolomite or chert. The Hutton soil form on site varies from shallow to deeper and has a medium to high clay content. The relatively high magnesium and iron content of the parent rocks from which these soils are derived, impart the strong red colours noted. Where it becomes very shallow the soil are classified as Glenrosa soil form.

Landscape: Plains / Plateaus (Photograph 2)

Depth of soil forms: 100-400 (Glenrosa, Hutton, Photograph 3)

Texture: Sandyloam

Vegetation: Pristine grassland / woodland associated with plateaus / undulating plains

Average Clay Content: 10-15% (Hutton); 6-15 (Glenrosa)

Agricultural Potential: Moderate potential soils depending on soil depth and size of land available for sustainable arable agriculture. Soils vary from shallow and sandy in some areas (Glenrosa, Hutton soil form) to deeper with a higher clay content (Hutton soil form). The red apedal Hutton soil with higher clay content in the topsoil has a high water holding capacity. Under the climatic conditions these soils would however not sustain arable crop production. Considering that the amount of land that is needed to economically sustain arable agriculture, the soil type described above cannot be considered as viable for crop production. The many old cultivated fields confirm that crop cultivation over the longer term is not a financially viable option under the prevailing climatic conditions.

Land capability: Livestock and / or game grazing are viable due to the slightly higher nutrient and organic content of the topsoil in grassland areas that support a mixture of palatable and unpalatable species.

Photograph 2. Shallow Hutton / Glenrosa soil forms in the low-lying valleys of the project area

Photograph 3. Profile of the shallow Hutton soil in the project area

5.3 Black or dark grey clayey Soils associated with the drainage channels and floodplains of the Oakleaf, Rensburg and Valsrivier soil forms

Binominal Classification S.A.: Oakleaf, Rensburg and Valsrivier soil forms

Description: The soils are generally dark grey to black in the topsoil horizons, and high in transported clays, and show pronounced mottling on gleyed backgrounds in the subsoils. These soils occur within the zone of groundwater influence. The soils are alluvial and are deep (>1,2m) with an orthic A and neocutanic B with signs of wetness in the horisons. Brown A horizon and red-brown B horizon. The soils are slightly sensitive to erosion. The subsoil is more sensitive to erosion and should preferably not be exposed.

Landscape: Bottomlands (drainage channel and floodplains) (Photograph 4)

Depth: >1200mm

Texture: Sandyclay to Sandyclayloam

Average Clay Content: 10-30%

Agricultural Potential: Zero potential soils, due to the soil wetness these areas are not suitable for crop cultivation under arable conditions.

Land capability: The grazing potential of these low-lying areas is high due to the palatable grasses growing throughout the year on these soils. The only limiting factor may be that livestock movement is limited during the wet season when the clay expands, causing livestock to get stuck in the muddy conditions. Soils are very sensitive and prone to erosion. A specific strategy is needed to prevent damage to these soils considering that overgrazing and trampling has already caused some degradation of the floodplains.

Photograph 4. Water course and riparian woodland in the project area

5.4 Red / black clayey soils of the Hutton / Arcadia soil forms

Binominal Classification S.A.: Hutton soil form; Arcadia soil form

Description: Deeper clayey soils in the eastern section of the WSF sites. The Hutton soils (red apedal soils) found on the site occur in pockets in combination with the Arcadia soil forms (Black clayey soils)

Landscape: Plains (Photograph 5)

Depth of soil forms: 400-1200

Texture: Sandyloamclay to clay

Vegetation: Marula – sickle bush – sweet thorn woodland

Average Clay Content: 20-40%)

Agricultural Potential: Moderate potential soils depending on soil depth and size of land available for sustainable arable agriculture. The red apedal Hutton soils or black clayey Arcadia soils with a higher clay content in the topsoil has a high water holding capacity. Under the climatic conditions these soils would however not sustain arable crop production. Considering that the amount of land that is needed to economically sustain arable agriculture, the soil type described above cannot be considered as viable for crop production.

Land capability: Livestock and / or game grazing are viable due to the slightly higher nutrient and organic content of the topsoil in grassland areas that support a mixture of palatable and unpalatable species.

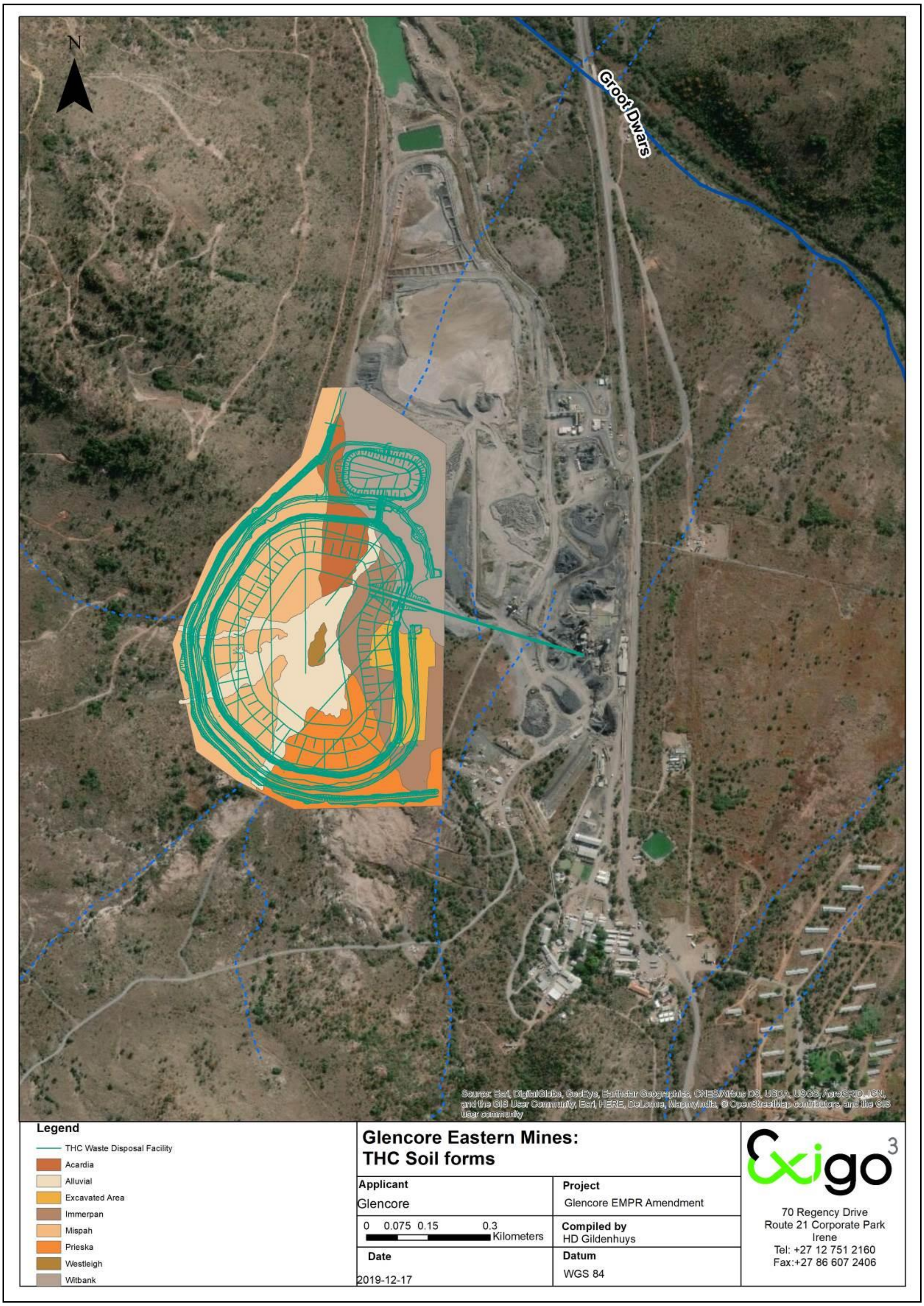


Figure 4. Soil form map for the proposed Thorncliffe Waste Disposal Facility

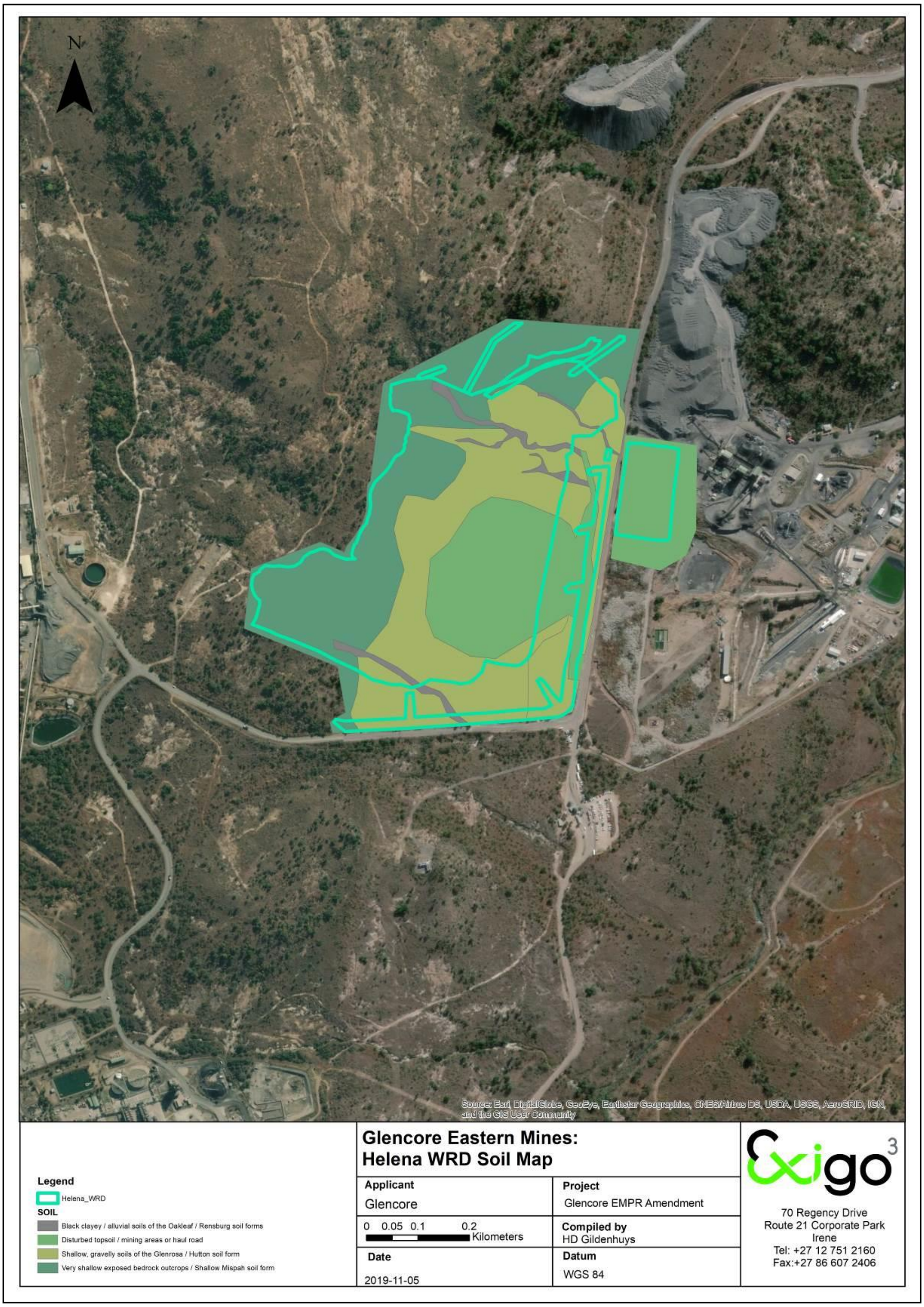


Figure 5. Soil form map for the proposed Helena WRD expansion site

6 AGRO-ENTERPRISE AND LAND CAPABILITY

Land capability is a system that was developed by the U.S. Department of Agriculture in the 1950s. It separates soils into classes of increasing land use limitations. Criteria used in the original system related only to soil physical properties and not soil fertility. If land capability is to be utilised in the agricultural sector, soil fertility parameters alongside yield data need to be taken into account. Increasingly this has been the case with the development of soil potential mapping.

6.1 Climatic conditions

The area is expected to receive an annual total rainfall between 400 and 500mm, of which most fall from October to April. This amount is considered LOW and unsuitable for crop cultivation under arable conditions. The high variability in rainfall distribution within the area could however render dry land farming a risky venture, even under irrigated conditions considering the sandy and shallow nature of the soils which has a low water holding capacity.

The project site is thus dry which would contribute to moisture stress condition during crop growth and development. The potential of groundwater is relatively low to sustain a high water demanding irrigated cropping, expected at the project site.

6.2 Crop production

The soils of the project site vary from being shallow and rocky in the ridges to sandy on the surrounding plains, with isolated areas where deeper, more fertile soils occur associated with the plains and valleys of the project site.

The typical landscape of the project site is dominated by shallow, rocky soils associated with rocky ridges or very sandy / gravelly soils associated with plateaus, ridges and footslopes. These soils have a low clay content and water holding capacity, and in combination with the climatic conditions render this section of the proposed development site unfavourable for effective crop production which could result from high moisture demands by planted crops.

The isolated pockets of ravines have shallow sandy-clay or clay soils that are seasonally flooded or have a perched water table. These areas are unsuitable for crop cultivation.

The climatic conditions in combination with the shallow nature of the soils render the study area unfavourable for effective crop production which could result from high moisture demands by planted crops. The study area is also expected to receive an annual total rainfall of about 400 mm which is relatively low and highly variable. In addition, the farm is considered to be located in an area which is marginal for rain-fed arable crop production. Economically viable farming is thus restrictive to irrigated cropping due the high risk that could be associated with dry-land farming. Higher day temperatures in summer months may hamper soil moisture storage for crop use. At present no irrigation or functional centre pivots occur on the property.

6.3 Livestock production / wildlife grazing

The natural vegetation in the study area has a grazing capacity that varies from low (shallow, rocky or sandy soils) to medium (seasonally wet soils, deeper loamy soils). The grazing capacity map of the Department of Agriculture for the study area is presented in Figure 7. The different sections of the study area can support grazing according to the soil nutrient content as follows:

- The shallow, rocky soils associated with the slopes of outcrops has low quality grazing and at present game species utilize these areas, especially during the early summer months (September to December) when the grasses resprout in burned areas.
- The deep sandy and gravelly soils associated with the footslopes, valley floors and plateaus has low quality grazing with limited potential for livestock farming. These areas are however suitable grazing for specialized grazers such as sable antelope.
- The red-yellow apedal soils associated with the study area has a medium potential for livestock grazing due to the slightly higher nutrient content of the soil supporting a mixture of palatable and unpalatable grasses. Grazing value decreases as the season changes from summer to winter though, with the lowest grazing potential available to livestock at the end of the season.
- The seasonally wet soils of the study area support palatable grass species and these areas have a medium suitability for livestock or game grazing. These soils have a good water holding capacity and grass species that grow in these areas vary from having a medium to high palatability depending on the seasonal changes.

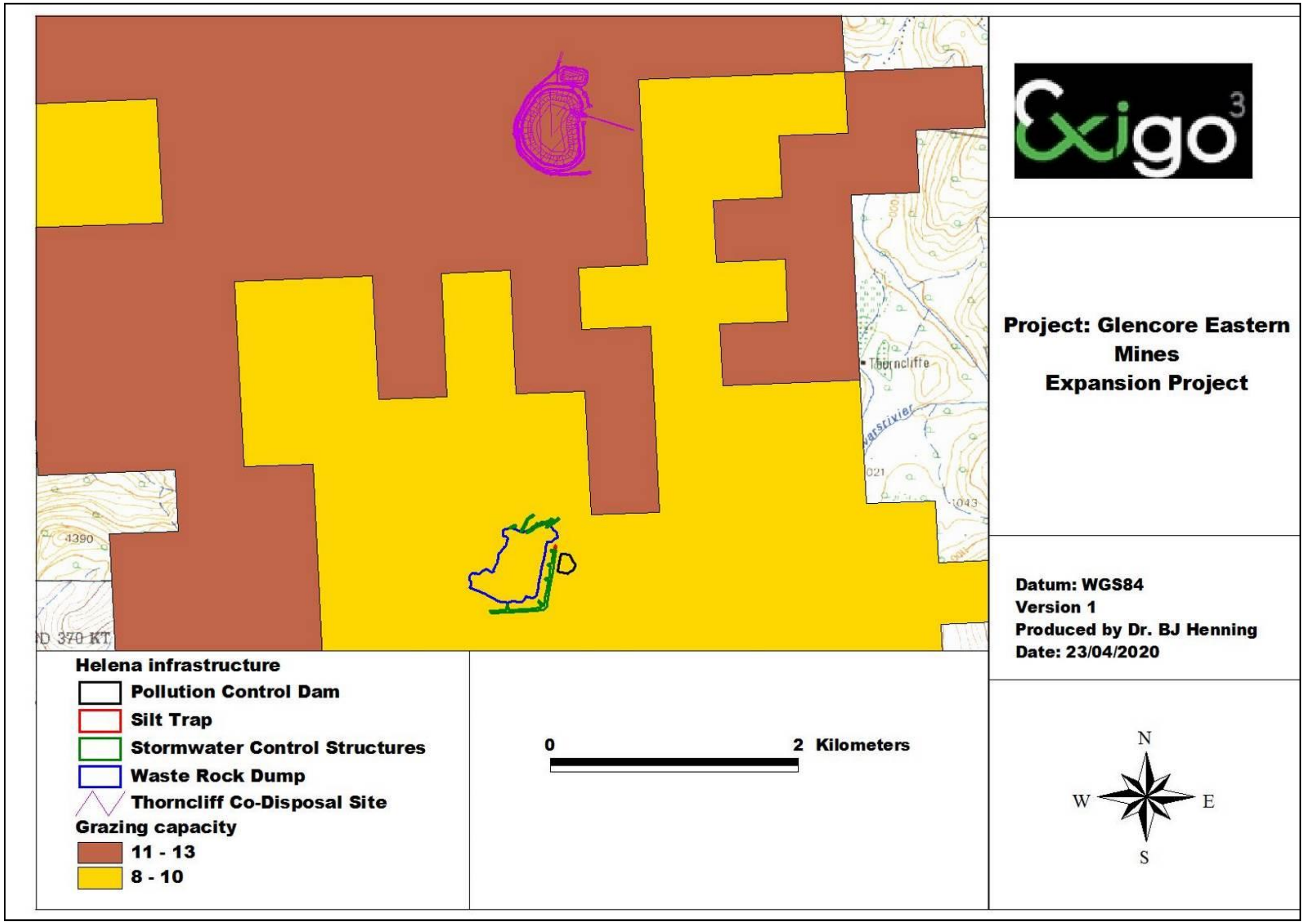


Figure 6. Grazing capacity map of the study area 1993 database Source: [Web] http://www.agis.agric.za/agismap_atlas/AtlasViewer)

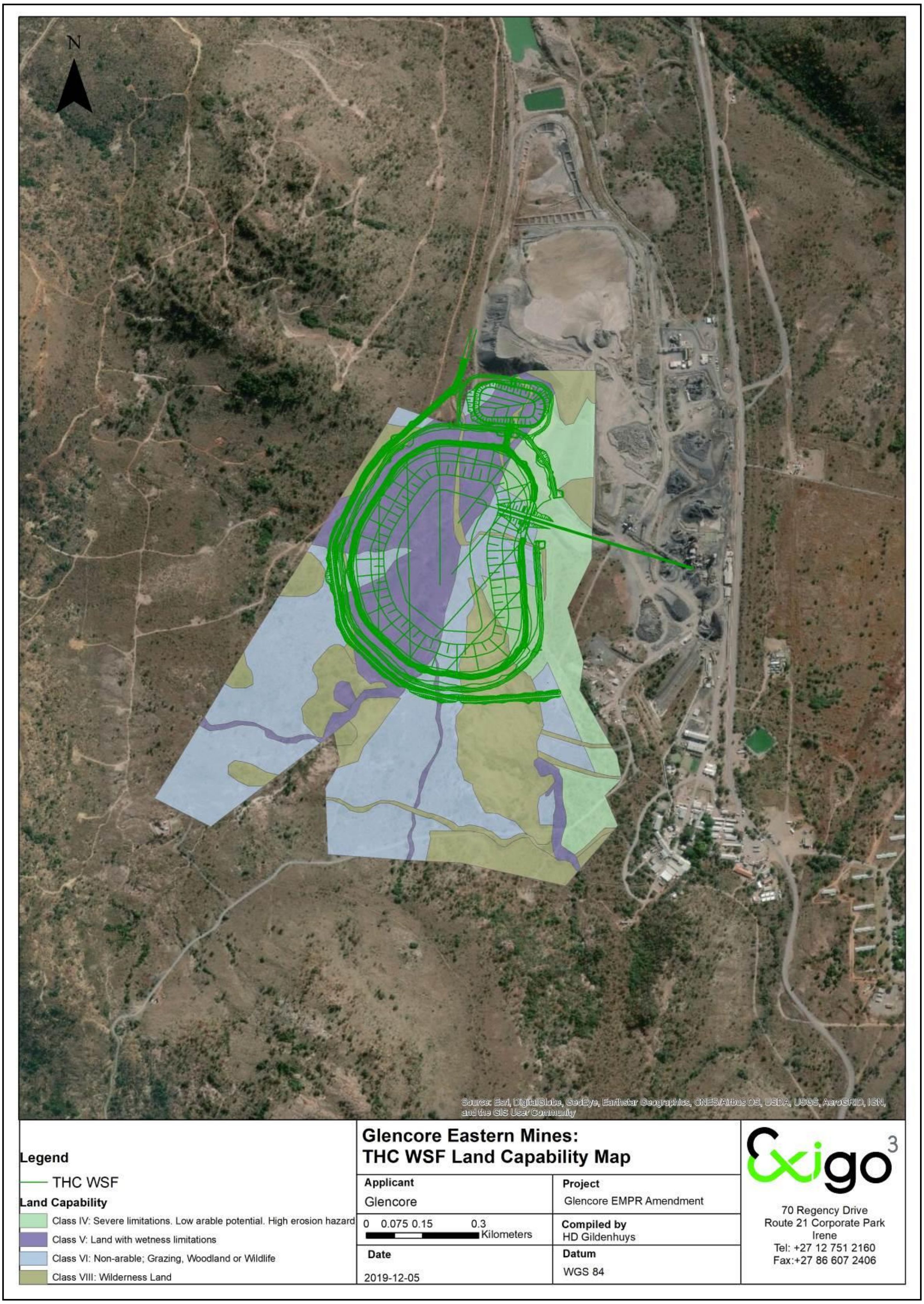


Figure 7. Land capability map of the proposed Waste Storage Facility site

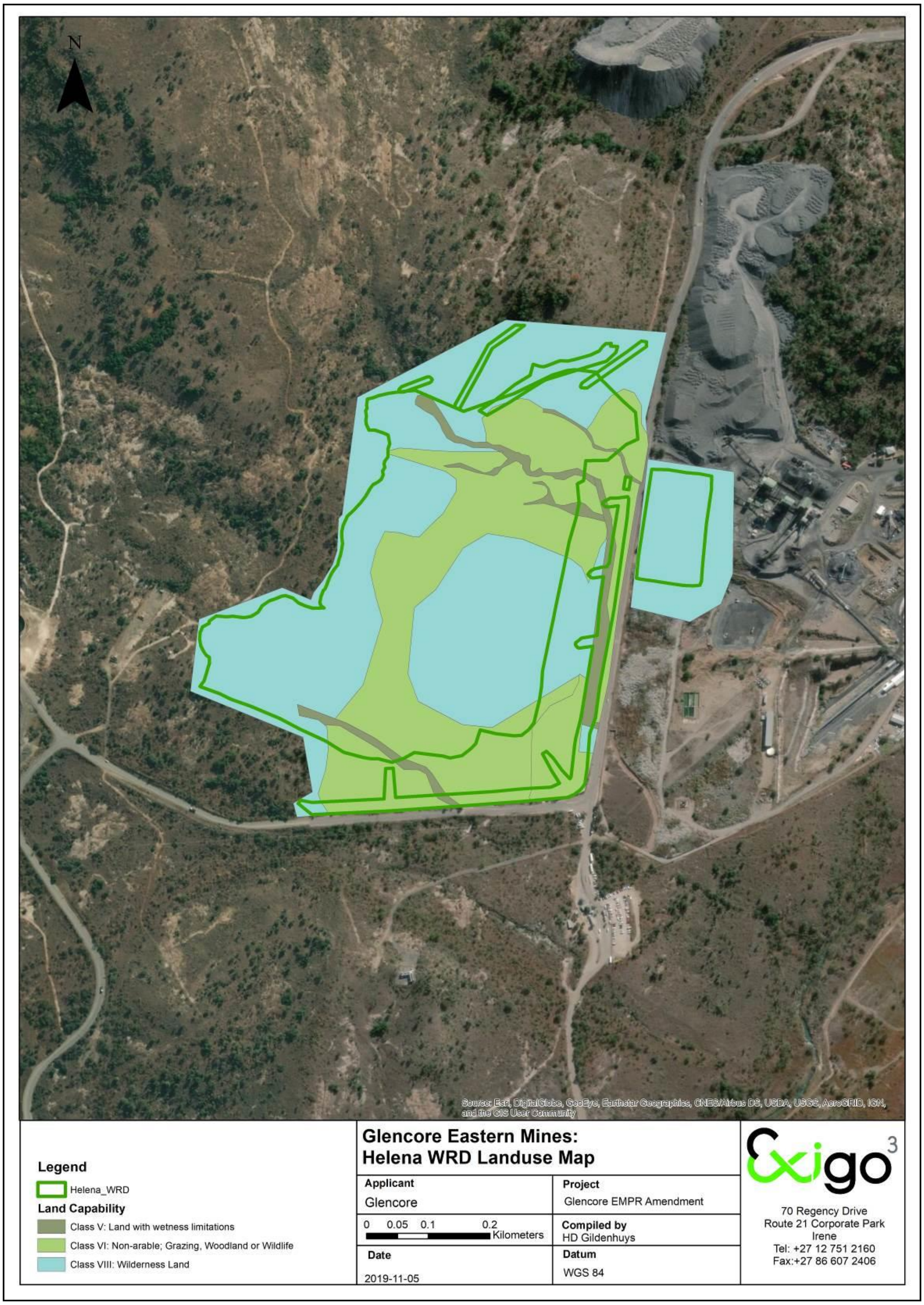


Figure 8. Land capability map of the proposed Helena expansion site

7 ANTICIPATED SOIL IMPACTS

The objective of this section was to identify impacts and provide a list of actions and potential impacts associated with the various mining phases namely the planning and design phase, construction phase, operational phase, decommission phase and closure phase for the various mining components:

- Waste rock dumps;
- Tailings disposal facilities
- Pollution control dams

The impacts associated with the mining development on the soils and land capability will depend on the specific area where the mining activities will take place. Any mining activities on the shallow rocky soils (throughout most parts of the site) on plains and plateaus will have a low impact on the soil potential or land capability, with only marginal erosion risks that can be managed though proper mitigation measures. The mining activities that will take place along the flatter terrain associated with the valley floors and plains where deeper, clayey soils occur will not have any negative impact on crop production and local food security as a result of the seasonally wet conditions, and any potential impacts (compaction, erosion) on these low-lying areas will be easier to mitigate. The section below described the impacts associated with the mining development on the soils and land capability in more detail.

7.1 PLANNING AND DESIGN PHASE

Planning and design is necessary to ensure that mitigation and impact management can be effectively implemented and minimise impacts in future. The planning and design phase of the mine will involve the following actions:

- Layout avoidance of sensitive soil types associated with steep slopes, floodplains, soils with high erosion / compaction risk ;

No specific direct impacts will occur on the soils of the area during this phase.

7.2 Construction Phase

The development of the residue deposits covers the period of time when considerable changes take place as the mine infrastructure and facilities are constructed. The most immediate impacts are seen as disruptions and disturbances to soil include stripping of topsoil and exposure of soils sue to site clearance for construction of the WSF, access and haul roads and other mining related infrastructure. This is usually a significant change to the visual appeal of the area.

Exposure of rocks, ore and soils to rainfall and wind may lead to atmospheric contamination by dusts and increased erosion of the site and sedimentation of local water courses. An increase in the movement of construction vehicles will result in an increase in the dust levels in the area. The following impacts will occur during the construction phase of the mine:

- **Soil compaction** occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few large pores and have a reduced rate of both water infiltration and drainage from the compacted layer. In addition, the exchange of gases slows down in compacted soils, causing an increase in the likelihood of aeration-related problems. Finally, while soil compaction increases soil strength-the ability of soil to resist being moved by an applied force-a compacted soil also means that roots must exert greater force to penetrate the compacted layer. In the case of mining activities associated with the proposed fluorspar mine during construction, soil compaction will be caused by regular heavy vehicle movement (wheel impact) and laydown areas of stockpiles on soils. If mitigating measures are not implemented the effect of the compaction will negatively affect soil structure of soils on the site.
- **Soil erosion and sedimentation**: Mining activities may further result in widespread soil disturbance and is usually associated with accelerated **soil erosion**, particularly in the study area during the summer months that receives high rainfall. Soil is especially prone to erosion once the topsoil has been stripped, leaving the soil exposed to wind and water erosion. Any soils left exposed throughout the construction phase could lead to significant erosion of the soils in the vicinity of the mining development. Soil, sediments and associated contaminants are transported into streams, rivers and other water bodies, resulting in the loss or alteration of habitats for aquatic organisms, as well as changes in water quality. The hardened surfaces and compacted soils of the development area will also lead to an increase in surface run-off during storm events which will likely be discharged via stormwater outlet points, concentrating flows leaving the development area. Soil erosion also promotes a variety of terrestrial ecological changes associated with disturbed areas, including the establishment of alien invasive plant species, altered plant community species composition and loss of habitat for indigenous fauna and flora.
- **Soil pollution:** Construction work of the magnitude contemplated for the proposed mine will always carry a substantial risk of soil pollution, with large construction vehicles contributing substantially due to oil and fuel spillages. Building waste, batching plants, sewage and domestic waste are also potential contributors to this problem. If not promptly dealt with, spillages or accumulation of waste matter can contaminate the soil and surface or ground water, leading to potential medium/long-term impacts on soil chemical composition.
- **Soil destruction** is a form of soil degradation that involves the total destruction of natural soil bodies and all the parameters that led to the formation of the soil. Stripping of the topsoil during construction will remove the fertile layer of the soil. This will result in the loss of the soil carbon content as well as soil micro-organisms that support the soil nutrient cycles.

- **Loss of land capability:** This impact involves the loss of land available for farming and tourism: The area where the mine is proposed is located in an area used for game farming and livestock grazing, although some mining activities also occur in the broader area. The land in general has a low to almost zero capability for crop cultivation and can mostly be utilized as grazing for wildlife. The construction of the proposed mine will result in a total loss of the land capability. The mining operations will have a negative impact initially and will reduce the percentage of land available for livestock grazing and agricultural activities done. The surface area of the mine to be disturbed is however relatively small and therefore the impact will not be as significant as anticipated.

7.3 Operational Phase

The routine operational phases account for most of the environmental impacts associated with mining and are considered to have the greatest potential to drive environmental change. The extent to which mining operational activities act as drivers of environmental change depends in part on the type, scale, duration and magnitude of the activities, and the sensitivity of the receiving environment.

The removal and storage (stockpiling) of ore in the operational phase is usually the most intensive activity on any mine operation. The process involves exposure of ore bodies, followed by loading and transportation of the ore to the stockpile sites. These activities are characterized by large-scale disturbance due to noise and generation of dust from the movement of vehicles and possible wind-blown dust from stockpiles at the recovery plant.

Typical activities of the operational phase will include:

- Storage of tailings and waste rock on the co-disposal Waste Storage Facility;
- Disposal of waste rock on WRD;
- Transporting of people and equipment;
- Transportation of product off-site;
- Transportation of supplies to the site;
- Handling and storage of hazardous materials and substances;
- Domestic waste generation, storage and disposal;
  - Water storage facilities;
  - Hazardous waste storage and disposal;

A short description of the impacts associated with the operational phase is included below:

- In the case of mining activities associated with the proposed project, soil compaction will be caused by regular heavy vehicle movement (wheel impact) and laydown areas of stockpiles and waste rock dumps on soils.
- The hardened surfaces and compacted soils of the mining development area will also lead to an increase in surface run-off during storm events which will likely be discharged via

stormwater outlet points, concentrating flows leaving the mining area. This can lead to erosion and channel incision in the water courses and change the in-stream habitat. This could result in higher velocity flows with greater erosive energy which can result in channel incision and gully erosion downstream within the channel and floodplain wetlands. The bare side slopes of the soil stockpiles and steep slopes associated with soil stockpiles will result in erosion of the stockpiles and movement of the eroded sediment into the drainage channels that eventually feed the Dwars River to the south of the site leading to increased sedimentation within the wetlands and possible changes to flow and vegetation. The sediment is likely to deposit out where gradients flatten, generally sites of wetlands.

- During the operational phase heavy machinery and vehicles as well as sewage and domestic waste would be the main contributors to potential soil pollution problems.
- The operation of the proposed mine will result in a total loss of the land capability. The mining operations will have a negative impact initially and will reduce the percentage of land available for livestock grazing and agricultural activities done, but will partially recover after successful rehabilitation provides good grazing. The mining activities that will reduce the land capability during the operational phase of the mine include the dumping of waste rock, opencast mining and laydown of stockpiles.

7.4 Decommissioning and Closure Phases

The decommissioning phase starts when all the economically exploitable mineral reserves in an area have been extracted. The actions which mark this phase include:

- Cessation of mining;
- Removal of mine infrastructure

The closure phases of the mine involve rehabilitation actions to mitigate impacts caused during the construction and operational phase of the mine. Some of the rehabilitation actions include the following:

- Ripping and rehabilitation of all haul roads;
- Rehabilitation of the WSF;
- Seeding of ripped and rehabilitated surfaces;

The major impacts on the soils during these phases are as follows:

- Soil compaction is likely to occur over much of the rehabilitated areas as a consequence of the storage and placement of soil and the change in structure following placement. In the case of mining activities associated with the proposed mine during the closure phase, it will be reduced as a result of rehabilitation activities, although compaction will still be caused by regular heavy vehicle movement during rehabilitation.

- The poor soil cover associated with rehabilitated areas also renders the site more susceptible to erosion and soil loss. It is probable that these soils will be transferred through the rehabilitated landscape into the draining water courses and receiving water bodies as described earlier. The rehabilitation of the site and decreased surfaces will however still reduce the risk of erosion and sedimentation carried into the rivers during the closure phase, compared to the other phases. Soil compaction is likely to occur over much of the rehabilitated area as a consequence of the storage and placement of soil and the change in structure following placement.
- During the closure phase of the mine the risk of spillages are still pertinent, although the impact will mainly be limited to potential spillages from vehicles. The impact will therefore be greatly reduced as a result of concurrent rehabilitation and removal of potential spillage sources (sewage plant, heavy machinery).
- Although the cleared areas will eventually be re-vegated, it is not anticipated that grazing areas that was lost to mining will be remediated to such an extent that the land capability will return.

8 QUANTITATIVE IMPACT ASSESSMENT

Table 6 indicate the impacts described above and specific ratings of significance the impact will potentially have on the ecosystem during the proposed mining activities according to the layout plan of the mining development:

Table 6. Quantitative impact assessment for the various mining components and mining phases on the soils and land capability

Nr	Impact	Activity	Without or With Mitigation	Nature (Negative or Positive Impact)	Probability		Duration		Scale		Magnitude/ Severity		Significance		Mitigation Measures	Mitigation Effect
					Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Score	Magnitude		
Planning Phase																
1	Delay of mining onset	Obtaining of IWUL for crossings (wetland soils) and mining layout on sensitive soils	**WOM**	**Negative**	Definite	5	Short term	1	Local	1	High	8	50	Moderate	Apply and obtain IWUL from DWS after liaison with relevant officials and site visit to the area	Can be avoided, managed or mitigated
			WM	**Negative**	Highly Probable	4	Short term	1	Local	1	Medium	6	32	Low		Can be reversed
Construction Phase																
2	Soil compaction	Heavy machinery and vehicle movement on site	**WOM**	Negative	Definite	5	Permanent	5	Local	1	High	8	70	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Low	2	35	Low		Can be reversed
3	Soil erosion and sedimentation	Topsoil & subsoil stripping, exposure of soils, ore and rock to wind and rain during construction causing erosion and sedimentation in wetlands	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be avoided, managed or mitigated
4	Spillages of harmful substances	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Long term	4	Site	2	Low	2	16	Negligible		Can be reversed
5	Soil destruction and sterlization	Topsoil & subsoil stripping	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	High	8	65	High		Can be reversed
6	Loss of land capability	Topsoil & subsoil stripping	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be reversed
Operational Phase																
7	Soil compaction	Heavy machinery and vehicle movement on site, laydown areas of WRDs and stockpiles	**WOM**	Negative	Definite	5	Permanent	5	Regional	3	High	8	80	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Site	2	High	8	70	High		Can be avoided, managed or mitigated
8	Soil erosion and sedimentation in wetland / water courses	Increased hardened surfaces around infrastructure, laydown areas of WRDs and stockpiles as well as WSF	**WOM**	Negative	Definite	5	Permanent	5	Regional	3	High	8	80	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Site	2	Medium	6	48	Moderate		Can be avoided, managed or mitigated
9	Spillages of harmful substances leading to water pollution in wetlands	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible		Can be reversed
10	Soil destruction and sterlization	Topsoil & subsoil stripping	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Medium	6	55	Moderate		Can be reversed

Nr	Impact	Activity	Without or With Mitigation	Nature (Negative or Positive Impact)	Probability		Duration		Scale		Magnitude/ Severity		Significance		Mitigation Measures	Mitigation Effect
					Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Score	Magnitude		
11	Loss of land capability	Topsoil & subsoil stripping,	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be reversed
Closure and Decommissioning Phase																
12	Improvement of eroded soils and compaction / backfilling of pits	Rehabilitation of mining site	**WOM**	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to section 9 of report	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be reversed
13	Soil erosion and sedimentation	Demolition of mining infrastructure / Cessation of mining / rehabilitation of mining site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible		Can be avoided, managed or mitigated
14	Soil compaction	Heavy machinery and vehicle movement on site	**WOM**	Negative	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Low	2	35	Low		Can be reversed
15	Spillages of harmfull substances	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Medium term	3	Regional	3	Medium	6	48	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Site	2	Low	2	10	Negligible		Can be avoided, managed or mitigated
Post-Closure Phase																
16	Improvement of soil compaction and erosion	Natural processes	**WOM**	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to section 9 of report	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be reversed
17	Soil erosion and sedimentation	Exposed surfaces / unrehabilitated areas on site post closure / poor monitoring during LoM	**WOM**	Negative	Highly Probable	4	Medium term	3	Site	2	Medium	6	44	Moderate	Refer to section 9 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Local	1	Low	2	8	Negligible		Can be avoided, managed or mitigated

9 SOILS AND LAND CAPABILITY MANAGEMENT PLAN AND MITIGATION MEASURES FOR THE PROPOSED GLENCORE EASTERN MINES PROJECT

A management system has been developed to comply with the objectives and principles set out in this document. This system is based on the principle of managing the potential environmental impacts using the best available technology, not entailing excessive cost. In this way, the technology is effective, but does not seriously impair economic stability of the development. Management measures required for the different phases of the mine which relates to biodiversity is presented in Table 7 below.

Table 7. Soils and Land Capability Management Plan to be implemented as part of the Environmental Management Programme Report for the Glencore Eastern Mines Expansion Project

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
				Planning and Design phase					
Pre-mining	clearing through sensitive soils and road crossings across wetlands / water courses	Soils	Delay of mining onset	National Water Act Section 21 C and I	Obtaining of IWUL for crossings and mining through water courses / wetlands	Application forms completed as obtained from DWS	• Apply and obtain IWUL from DWS after liaison with relevant officials.	2 years	Environmental Assessment Practitioner (EAP)
				Construction Phase					
Support infrastructure, WSF and WRD	Heavy machinery and vehicle movement on site	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans • To limit soil loss and compaction	Keep mining development footprint restricted to layout plans	• Soil should be handled when dry during removal and placement to reduce the risk of compaction; • Vegetation (grass and small shrubs) should not be cleared from the site prior to mining activities or construction (except if vegetation requires relocation as determined through an ecology assessment). This material is to be stripped together with topsoil as it will supplement the organic and possibly seed content of the topsoil stockpile depending on the time of soil stripping (whether plants are in seed or not); and • During construction, sensitive soils with high risk of compaction (e.g. clayey soils) must be avoided by construction vehicles and equipment, wherever possible, in order to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. • Rip and/or scarify all compacted areas. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment.	Continuous	Contractor / ECO
Support infrastructure, WSF and WRD	Topsoil & subsoil stripping	Soils	Soil erosion and sedimentation	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• To prevent the loss of soil through the expansion of the WRD • To prevent the loss of topsoil capability during stockpiling • To prevent the contamination of soils due to spillages of reagents • To prevent soil erosion	Management of storm water on site; Minimize time that soil is left exposed after vegetation is cleared that will cause erosion and sedimentation	• Construction during the rainy season should be closely monitored and controlled. • Soil that is to be impacted upon during the development will be removed and stockpiled for rehabilitation purposes. • Temporary access roads provided during construction will be cleared from topsoil which will be stockpiled. Once construction is complete the temporary access roads will be ripped and the topsoil placed back over the disturbed areas. If required, the areas will be hydro seeded. • Soil should only be used for rehabilitation purposes and not for other uses for example construction of roads. • Sediment trapping, erosion and storm water control should be addressed by a hydrological engineer in a detailed storm water management plan; • Measures must be put in place to ensure that the energy of storm-water that is to be released into any watercourse is dissipated; • Checks must be carried out at regular intervals to identify areas where erosion is occurring. The storm water management infrastructure needs to be inspected on a monthly basis, as well as after storms. Appropriate remedial action, including the rehabilitation of the eroded areas, and where necessary, the relocation of the paths causing the erosion, are to be undertaken. Any debri's blocking drainage canals will be removed and any damaged sections repaired. • Channels and drains will be kept clean to ensure that their capacity	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							and stability are adequate for storms of maximum intensity. This will be done annually prior to the onset of the rainy season. • The soil that is stripped during construction should be stockpiled in layers and protected by berms to prevent erosion • Cover disturbed soils as completely as possible, using vegetation or other materials; • Rehabilitation: revegetate or stabilise all disturbed areas as soon as possible. Indigenous trees can be planted in the buffer zone of the proposed developments to enhance the aesthetic value of the site and stabilize soil conditions; • The vegetative (grass) cover on the soil stockpiles must be continually monitored in order to maintain a high basal cover. Such maintenance will limit soil erosion by both the mediums of water (runoff) and wind (dust); • Conservation of topsoil should be prioritized on site and done as follows: • Topsoil should be handled twice only - once to strip and stockpile, and secondly to replace, level, shape and scarify; • Stockpile topsoil separately from subsoil; • Stockpile in an area that is protected from storm water runoff and wind. Excavated and stockpiled soil material are to be stored and bermed on the higher lying areas of the footprint area and not in any stormwater drainage channels or areas where it is likely to erode or cause siltation. • Topsoil stockpiles should not exceed 2.0 m in height and at slopes not exceeding 18 degrees and should be protected by a mulch cover where possible; • Maintain topsoil stockpiles in a weed free condition; • Stockpiles shall be seeded with a cover of native vegetation. • Topsoil should not be compacted in any way, nor should any object be placed or stockpiled upon it; • Stockpile topsoil for the minimum time period possible i.e. strip just before the relevant activity commences and replace as soon as it is completed.		
Support infrastructure, WSF and WRD	Heavy machinery & vehicle movement on site	Soils	Spillages	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	• To prevent contamination of soil due to the spillages of hydrocarbons and reagents used in the process and during transportation of these substances • To reduce the risk of contamination of soils due to increased fuel deliveries	Active monitoring of potential spillages	• This risk of spillages of reagents and hydrocarbons on the soil during transportation can be reduced with proper maintenance of vehicles. This would include a rigorous and proactive maintenance program • This risk can be further reduced through an adequate program of training of drivers and crews. This would include defensive driver training, basic vehicle maintenance, and emergency control of spills. In order for the vehicle crews to be adequately able to control any spills at an early stage, the vehicles must be properly equipped with spill containment equipment (booms, sandbags, spades, absorbent pads, etc.). Responsibility for training lies with the transport contractor. Adequate training, maintenance, and equipment of transport crews should be included as a requirement for transport contracts. • The hydrochloric acid tanks are contained within an epoxy-coated, concrete lined and bermed facility that has been designed to contain 110% of the volume of the tanks in the event of a spill. This eliminates the potential impacts to soils from spills of hydrochloric acid. • Spills from the tailings thickener will flow by gravity to the mine reclaim water ponds at the southern toe of the existing fines residue deposit. From there they will be pumped back to the processing plant. . The area that would be affected by such a spill has already been impacted by the mining operation. • All employees will be trained in cleaning up of a spillage. The necessary spill kits containing the correct equipment to clean up spills will be made available at strategic points in the plant area	Continuous	Contractor / ECO
Support	Topsoil & subsoil	Soils and	Soil destruction and sterlization	CONSERVATION OF	• Prevent edge effects	Keep mining development	• No specific mitigation can be applied during the construction phase of	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
infrastructure, WSF and WRD	stripping,	land capability		AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Keep mining development footprint restricted to layout plans	footprint restricted to layout plans	the mine to prevent soil destruction, although an important measures should be the correct handling and stockpiling of topsoil as discussed in section 11 of this report.		
Support infrastructure, WSF and WRD	Topsoil & subsoil stripping, Clearing of vegetation for WSF through wetlands and water courses as well as road crossings	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans	Keep mining development footprint restricted to layout plans	• No specific mitigation can be applied during the construction phase itself to prevent loss of land capability considering that the land use will change to industrial/mining. This however, does not prevent the mine from ensuring that disturbance and clearing should be confined to the footprint areas of the mine and not over the larger area. This can be done in the following ways: o Corridors should be secured around the mining footprint areas to ensure the current land use (grazing) can continue in a functional way during mining. o All development activities should be restricted to specific recommended areas and strict buffer zones should be applied around the sensitive areas. The Environment Control Officer (ECO, could be Mine Environmental Superintendent) should demarcate and control these areas. Unnecessary bulldozing through the veld should be avoided. o Disturbed land to be rehabilitated as soon as the activities have ceased.	Continuous	Contractor / ECO
OPERATIONAL PHASE									
Support infrastructure, WSF and WRD	Heavy machinery and vehicle movement on site, laydown areas of WRDs and stockpiles	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• During operation, sensitive soils with high risk of compaction (e.g. clayey soils) must be avoided by construction vehicles and equipment, wherever possible, in order to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. Vehicles should also stick to haul roads when dumping of waste rock and topsoil are done. • Rip and/or scarify all compacted areas on a continuous basis. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment. • Refer to mitigation measures needed during the construction phase that are similar to the mitigation measures for impacts during the operational phase.	Continuous	Contractor / ECO
	Laydown areas of WRDs and stockpiles, crushing and stockpiling	Soils	Increased Soil erosion and sedimentation;	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices. • All mitigation measures related to dust and air quality as included in the air quality specialist report should be adhered to; • Protect sloping areas and drainage channel banks that are susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas; • Repair all erosion damage as soon as possible to allow for sufficient rehabilitation growth; • Gravel roads must be well drained in order to limit soil erosion. • Rehabilitation: revegetate or stabilise all disturbed areas as soon as possible. Indigenous trees can be planted in the buffer zone of the proposed development to enhance the aesthetic value of the site and stabilize soil conditions; • The vegetative (grass) cover on the soil stockpiles (berms) must be continually monitored in order to maintain a high basal cover. Such maintenance will limit soil erosion by both the mediums of water (runoff) and wind (dust); o Conservation of topsoil should be prioritized on site and done as follows: o Topsoil should be handled twice only - once to strip and	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							stockpile, and secondly to replace, level, shape and scarify; ○ Stockpile topsoil separately from subsoil; ○ Stockpile in an area that is protected from storm water runoff and wind; ○ Topsoil stockpiles should not exceed 2.0 m in height and should be protected by a mulch cover where possible; ○ Maintain topsoil stockpiles in a weed free condition; ○ Topsoil should not be compacted in any way, nor should any object be placed or stockpiled upon it; ○ Stockpile topsoil for the minimum time period possible i.e. strip just before the relevant activity commences and replace as soon as it is completed. • Also refer to mitigation measures needed during the construction phase.		
	Laydown areas of WRDs and stockpiles, materials handling and transportation, crushing and stockpiling	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Vehicle maintenance only done in designated areas – spill trays, sumps to be used and managed according to the correct procedures. • Vehicles and machines must be maintained properly to ensure that oil spillages are kept to a minimum. • Fuel and oil storage facilities should be bunded with adequate storm water management measures. • Routine checks should be done on all mechanical instruments for problems such as leaks, overheating, vibration, noise or any other abnormalities. All equipment should be free of obstruction, be properly aligned and be moving at normal speed. Mechanical maintenance must be according to the manufacturer's instructions • Refer to mitigation measures needed during the operational phase that are similar to the mitigation measures for impacts during the construction phase	Continuous	Contractor / ECO
	Topsoil & subsoil stripping, opencast mining	Soils and land capability	Soil destruction and sterlization	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• The most desired approach during all of the mining phases is to continually rehabilitate the soils to the best possible state – taking into account the current technology and knowledge available as well as the financial means to conduct such rehabilitation. The rehabilitation of soils to pre-mining conditions is basically impossible though. Refer to section 11 of this document for a detailed discussion on the rehabilitation of topsoil after stripping. • Refer to mitigation measures needed during the operational phase that are similar to the mitigation measures for impacts during the construction phase	Continuous	Contractor / ECO
	Topsoil & subsoil stripping	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures needed during the operational phase that are similar to the mitigation measures for impacts during the construction phase • Rehabilitation should take place on a continuous basis where after the land would become partially available again as grazing.	Continuous	Contractor / ECO
DECOMMISSIONING PHASE									
Support infrastructure, WSF and WRD	Demolition of mining infrastructure; Heavy machinery and vehicle movement on site	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure, Heavy machinery and vehicle movement on site	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure / Cessation of mining /	Soils	Increased Soil erosion and sedimentation;	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
	Rehabilitation of mining site	Soils	Improvement of eroded soils and compaction		Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Storm water control measures will be maintained. • The rehabilitation plan will include specific engineering designs to control water run-off from any rehabilitated areas. Maintenance will involve regular checks until all vegetation is established and the structures become stable. • Rehabilitated disturbed land and the rehabilitated residue deposits will be maintained until closure. Also refer to mitigation during construction and operations	Continuous	Contractor / ECO
CLOSURE PHASE & POST CLOSURE PHASES									
Support infrastructure, WSF and WRD	Rehabilitation	Soils	Improvement of soils and repair of erosion damage through revegetation over time	NEMA Regulation 543 Section 32	• To ensure that the mining areas rehabilitated according to prescriptions • To shape and prepare the rehabilitation areas to blend in with the surrounding environment. • To rehabilitate all disturbed areas to a suitable post closure land use • To manage the social impact of closure on personnel who became redundant due to closure • To keep all the post closure monitoring in place and to ensure that the necessary reporting is done to the authorities and interested and affected parties	Rehabilitate within development footprint to ensure revegetation and rehabilitation impacts are kept within the mining footprint areas	• All land exposed by the demolition of infrastructure and other disturbed land associated with the project will be rehabilitated. • Terraces and buildings will be shaped and demolished where necessary and prepared for re-vegetation. • Rehabilitate all the land where infrastructure has been demolished. Plant vegetation species for rehabilitation that will effectively bind the loose material and which can absorb run-off from the mining areas. • Monitor the establishment of the vegetation cover on the rehabilitated sites to the point where it is self-sustaining. • The spread of invader species on disturbed land will be controlled until the perennial vegetation recovers. • Protect rehabilitation areas until the area is self-sustaining. • Water management facilities will stay operational and maintained and monitored until such a stage is reached where it is no longer necessary. • The mining areas will be shaped to make it safe. • All the monitoring and reporting on the management and rehabilitation issues to the authorities will continue until closure of the mine is approved. • Soil that has been contaminated by spillage seepage and tailings will be sampled and analysed. If required it will be treated, ameliorated or removed to a suitable disposal site. • Diversion canals and cut-off trenches will be maintained to ensure that they are both stable and functional. • All roads not required for access shall be ripped and planted with endemic vegetation. • Landscaping and rehabilitation of the tailings storage and waste rock facilities • The mine will continue to submit information for the period after decommissioning activities have ceased, until the time that closure is approved by authorities. • After mining operations have ceased, quarterly reports on the progress of the final rehabilitation will be submitted until final closure is approved by the authorities	Continuous	Ecologist / ECO
	Rehabilitation	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• During closure, sensitive soils with high risk of compaction (e.g. clayey soils) must be avoided by vehicles wherever possible, in order to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. • Rip and/or scarify all compacted areas on a continuous basis. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							establishment. Other soil rehabilitation measures are discussed in section 11. • Soil should be sampled and analysed prior to replacement during rehabilitation. If necessary, and under advisement from a suitably qualified restoration ecologist, supplemental fertilisation may be necessary.		
	Rehabilitation	Soils	Soil erosion and sedimentation	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO
	Rehabilitation	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO
	Rehabilitation	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Once mining activities have ceased, disturbed areas should be rehabilitated and the grazing capacity restored as high as possible. The rehabilitation of the soils and revegetation is discussed in section 11 of this report. • Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO

10 REHABILITATION MEASURES FOR SOIL STABILISATION AND PROTECTION

Rehabilitation can be defined as the return of disturbed areas to a safe, stable, productive and self-sustaining condition that promotes bio diverse land use. Land rehabilitation techniques can be used to speed up the time required to restore the impacted area back to its original, or better, state. To re-create and maintain a sustainable environment it is important to plan how the areas to be impacted by the Glencore Eastern Mines Expansion Project will be rehabilitated and revegetated.

10.1 Best practices in rehabilitation planning and management

Use of rehabilitation planning and environmental management that aims for sustainability is encouraged in all aspects of reclamation planning, design and implementation. Environmental Guidelines by the Department of Water Affairs and Forestry (DWAF), 2005 aims to guide environmental management during all phases of a project lifecycle.

These Environmental Best Practice Guidelines for; Planning; Construction, Operation and Decommissioning Planning provide a scientific-based, comprehensive and integrated strategies to also perform rehabilitation for developments and therefore mitigate against safety hazards and environmental degradation.

10.2 Cleared Indigenous Plant Material

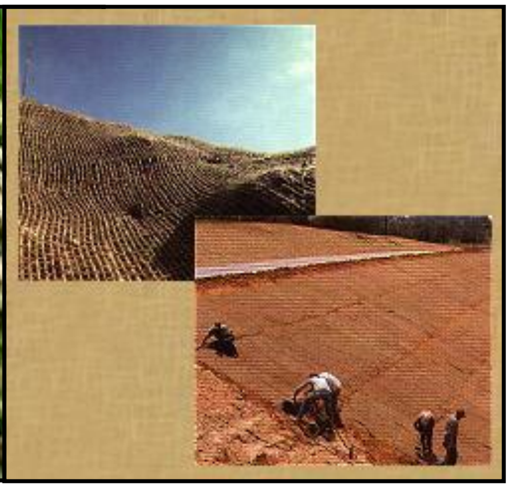
Where construction or rehabilitation activities are to commence in a specific area, certain indigenous plant material from the construction footprint area could be collected and bagged to be used in re-vegetation or as mulch during rehabilitation. To protect drainage areas and small streams as well as erosion prone areas, brush could be cut and used to *"brush pack"* these problem areas to protect it. This will also restrict movement of animals and humans over sensitive erosion probe areas until pioneer vegetation has established.

10.3 Topsoil, Stockpiles and backfilling

The manner in which topsoil and stockpiles are created and maintained is important with regards to the implementation of a successful rehabilitation process. Soil management practices must be adhered to in order to reduce soil loss and to encourage rehabilitation post-construction. The two most important aspects to consider when removing topsoil are the depth of soil to be removed and the conditions of storage.

The topsoil layer (0-25 cm) is important as it contains nutrients, organic material, seed, and communities of micro-organisms, fungi and soil fauna. The biologically active upper layer of soil is fundamental in the development of soils and the sustainability of the entire ecosystem. In the case of the study area very little areas with sufficient topsoil occur, and topsoil is limited to shallow depth. The correct handling of topsoil is vital in conserving the seed bank and nutrients which occur within this layer thereby ensuring successful rehabilitation.

- Topsoil must only be used for rehabilitation purposes and not for any other use example i.e. construction of roads.
- Previously excavated areas on the site should be backfilled with suitable topsoil, levelled to resemble the surrounding topography and slopes and scarified for re-vegetation/re-seeding.
- On steeper slopes rehabilitation measures may include systems such as soil terracing, berm creation, grass blocks, fascine work, gabion basket work, reno mattresses, retaining block mechanisms, sand bags, boulder and rock placement, stone pitching, and grading.
- Erosion control netting or matting (GeoJute or Bio-Jute) may be utilised on steep slopes to assist with soil retention, weed control and vegetation establishment. The netting material helps protect the soil from wind and water erosion, and the required rehabilitation plant material can be installed by making small incisions for planting. The netting is biodegradable and will eventually break down and form a mulch layer.



10.4 Compaction and Rehabilitation Measures

Soil compaction is often an effect of high traffic areas on development sites. It can become a major problem and can be recognized by:

- Excess surface moisture and slow drying soils due to deeper compaction preventing the percolation of water through the soil profile;

- Water runoff due to surface compaction preventing penetration and absorption (ponding of water), especially on banks and sloping surfaces.
- Large clear or sparsely covered areas devoid of a good vegetative cover due to hardened topsoil layers

The problems associated with compaction can be rehabilitated after mining has ceased as follows:

- Rip and/or scarify all disturbed areas, including roads that are no longer in use (preferably before the rainy season). Do not rip and/or scarify areas under wet conditions, as the soil will not loosen.
- Compacted soil can also be decompacted by “Rotary Decompactors” to effectively aerate soils for vegetation establishment.

10.5 Erosion Rehabilitation Measures

Water has the gift to sustain life, but also the potential to maim, damage and destroy if not managed correctly. Remedial actions must be established to ensure that potential erosion is addressed with an erosion control strategy towards long-term rehabilitation. It is important to take note of the following generic points regarding erosion risks in the study area:

- Soil loss will be greater during wetter periods. However, the provision of erosion control measures for the through the drier months of the year is equally as important;
- Soil loss from the site is proportionally related to the time the soils are exposed, prior to rehabilitation. The time from commencement of rehabilitation activities to finalization thereof should be limited. Rehabilitation efforts should commence as soon as practical;
- Construction staging and progressive/concurrent rehabilitation is important; and
- The extent of the disturbance that will take place will influence the risk and consequences of erosion on the site.
- Avoid over-wetting, saturation and unnecessary run-off during dust control activities and irrigation.
- Retain natural indigenous grass and shrubs and re-vegetate bare areas as soon as possible.

10.6 Re-Vegetation

Plant species that have been rescued or removed and relocated to the temporary nursery could be used in replanting rehabilitation areas.

Additional plant material (indigenous trees) as required should be sourced from local indigenous nurseries and specifications regarding plant sizes, heights and the installation process of these plants should be developed by the On Site ECO and Rehabilitation Specialist. Standard horticultural best practice would apply, with specific reference to the fact that the plant material would have to be in good condition, free from pests and diseases (any such plant would have to be removed from the site), well formed and well rooted, potting materials are weed free and with sufficient root cover. Groundcovers and sedges are often supplied in trays, and the same standards would apply.

- A grass seed specification for reseeding the rehabilitated areas is included below. Re-grassing should be undertaken (as far as possible) during the summer months, as germination and establishment is best at this time of year. Spring rains are also conducive to good germination results, and as such rehabilitation programmes should take these factors into consideration.
- There are two methods for seeding, hand broadcasting and hydro-seeding. The methods utilised will be site specific and the On Site ECO and Rehabilitation Specialist will determine them.
- In certain areas grass runners may be required, and grass sods where instant cover is necessary.
- A typical grass seed mixture (hand sowing) that could be implemented for rehabilitation activities will include: (specification 4-5kg/ha)
    - *Eragrostis tef* (Tef);
    - *Eragrostis curvula* (Weeping Love Grass);
    - *Digitaria eriantha* (Smutsvinger);
    - *Cynodon* spp. (Bermuda kweek);
    - *Panicum maximum* (Witbuffel);
    - *Chloris gayana* (Rhodes grass);
    - *Paspalum notatum (Bahia Grass)*

11 DISCUSSION & CONCLUSION

This study addresses the agricultural potential, land capability and general characteristics of the soils on the site for the development of the Glencore Eastern Mines expansion in the Limpopo Province. The results obtained from the study were done after field observations were done to verify the soil potential classified by the Department of Agriculture on a small scale.

By definition, based on Part 1 of the Regulation of Conservation of Agricultural Resources Act 43 of 1983, the proposed area, earmarked for the development of the mining expansion development can be classified as having soil potential that is mostly low. The soil forms identified in the study area and the subsequent land capability is summarised in Table 8.

Table 8. Soil forms, land capability and potential of the proposed mine

Soil Forms	Land capability
Very shallow exposed bedrock outcrops / Shallow Mispah soil form occurring throughout the study area on the undulating plains and ridges;	Class VII: Very severe limitations. Suitable only for natural vegetation
Shallow, gravelly soils of the Hutton or Glenrosa soil form along the plateaus and slightly undulating terrain of the study area	Class VI: Limitations preclude cultivation. Suitable for perennial vegetation.
Black clayey / alluvial soils of the Rensburg / Katspruit soil forms associated with drainage channels	Class V: Watercourse and land with wetness limitations
Black / red clayey soils of the Arcadia / Hutton soil forms	Class IV: Severe limitations. Low arable potential. High erosion hazard

The density of the vegetation and grazing capacity of the land would allow grazing of the area, especially on the larger farm portions that can sustain economically viable grazing. The proposed mining development will cause a loss of grazing value of the land, although site specific mitigation needs to be implemented.

The land capability of the site is mostly restricted to wildlife grazing due to the shallow and often sandy nature of the soils and location of pockets of seasonally wet soils in some areas. The potential impacts associated with the proposed development are soil disturbance (erosion, compaction), loss of land capability, soil destruction and sterilisation and soil pollution (spillages).

The site should subsequently be considered as being limited value grazing land with low potential for arable agriculture considering the climatic conditions and shallow soils.

Mitigation measures are provided in the report for the impacts and provided this management and rehabilitation measures stipulated in the report are strictly adhered to, the mining development could be supported.

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