SOIL REPORT FOR THE PROPOSED VENETIA SOLAR ENERGY FACILITY, LIMPOPO PROVINCE, SOUTH AFRICA

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Prepared for:
SAVANNAH ENVIRONMENTAL (PTY) LTD
UNIT 606, EGLIN OFFICE PARK
14 EGLIN RD, SUNNINGHILL, GAUTENG
PO BOX 148, SUNNINGHILL, 2157
SOUTH AFRICA
TEL: +27 (0)11 2346621
www.savannahsa.com

Prepared by:
OUTENIQUA GEOTECHNICAL SERVICES cc
26 COVE ST, KNYSNA
PO BOX 3186, GEORGE INDUSTRIA, 6536
SOUTH AFRICA
TEL: +27 (0)44 3820502
www.outeniqualab.co.za

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List of abbreviations

AMSL:	Above mean sea level
ECO:	Environmental Control Officer
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Programme
ER:	Engineer’s representative
Ma:	Million years
MW:	Megawatt
NEMA:	National Environmental Management Act 107 of 1998
NGL:	Natural ground level
PV:	Photovoltaic

1. INTRODUCTION

1.1. Background info

BioTherm Energy (Pty) Ltd "(BioTherm") is in the process of investigating the feasibility of a solar energy facility on a portion of Farm 102 (Gotha) located approximately 75km west of Musina in the Limpopo Province of South Africa. The proposed activity is defined as the establishment of a solar energy facility and associated infrastructure, including the construction of photovoltaic (PV) or concentrated photovoltaic (CPV) panels, a new substation, up to 400kV in size, with overhead power-lines evacuating power to the nearby Venetia Substation, access roads/tracks, underground cabling, a workshop, storeroom and a control building. The facility is to be constructed in two phases. First, a generating facility of up to 20MW will be constructed (Phase 1); this may be later expanded by an additional 75MW exporting facility (Phase 2). The proposed solar energy facilities will connect to either the existing Venetia substation, located to the north of the site, or to the existing overhead power-line, located on the site (which would therefore include the construction of a new 400kV substation).

1.2. Legislation

In terms of the Environmental Impact Assessment (EIA) regulations published in terms of Section 24(5) of the National Environmental Management Act (NEMA, Act No. 107 of 1998), the applicant requires authorisation from the National Department of Environmental Affairs (DEA) in consultation with the relevant Provincial Department for the undertaking of the proposed project.

This specialist study is undertaken in accordance with Regulation 17 of the NEMA.

1.3. Terms of reference

Savannah Environmental has been appointed by BioTherm to carry out the required environmental impact assessments for the proposed activities. Savannah Environmental has appointed Outeniqua Geotechnical Services to conduct a study of the soil cover and assess any associated potential impacts as a result of the proposed development.

The following scope of work has been given:

- Conduct a site visit in order to make observations regarding the physical aspects of the site (geology, soil types, topography, vegetation, etc.), surface processes (weathering, erosion and hydrology) and land use.
- Describe the physical aspects of the site, the present land use and the agricultural potential.
- Identify and quantify the potential environmental impacts on the soil cover that may be associated with the proposed activity.
- Provide mitigating measures for inclusion in the Environmental Management Programme (EMP).

1.4. Limitations

Information provided in this specialist report has been based on information provided by the BioTherm, Savannah Environmental (Pty) Ltd, published scientific literature and maps. The proposed site was visited briefly but no detailed soil investigation or mapping was conducted. The information provided in this report is deemed adequate for the EIA process.

1.5. Authors credentials & declaration of independence

The authors of this report are independent consultants with no financial or vested interest in the proposed development, other than remuneration for work performed in the compilation of this report.

Iain Paton is a professional engineering geologist, registered with the South African Council for Natural and Scientific Professions (Pr Sci Nat # 400236/07), with 14 years experience in the built environment, including 3 years experience specifically relating to renewable energy projects. Iain Paton is a member of the South African Institute of Engineering and Environmental Geologists (SAIEG) and the Geotechnical Division of the South African Institute of Civil Engineering (SAICE).

Theodore Robertson is an agricultural consultant and farmer with a National Diploma in Agriculture (Soil Science) and over 35 years experience in agricultural consulting.

2. SITE DESCRIPTION

2.1. Location

The proposed development is located on a portion of Farm Gotha 102 which is located in the Musina Local Municipal area (Vhembe District) in the Limpopo Province of South Africa. The farm is situated approximately 75km west of Musina and approximately 35km northeast of Alldays and the site access point is opposite the entrance to Venetia Diamond Mine (see **Figure 1**). The area under consideration for the development(s) is larger than what is required for either of the facilities. This is done so that any significant environmental sensitivities identified can be avoided in the final placement of infrastructure.

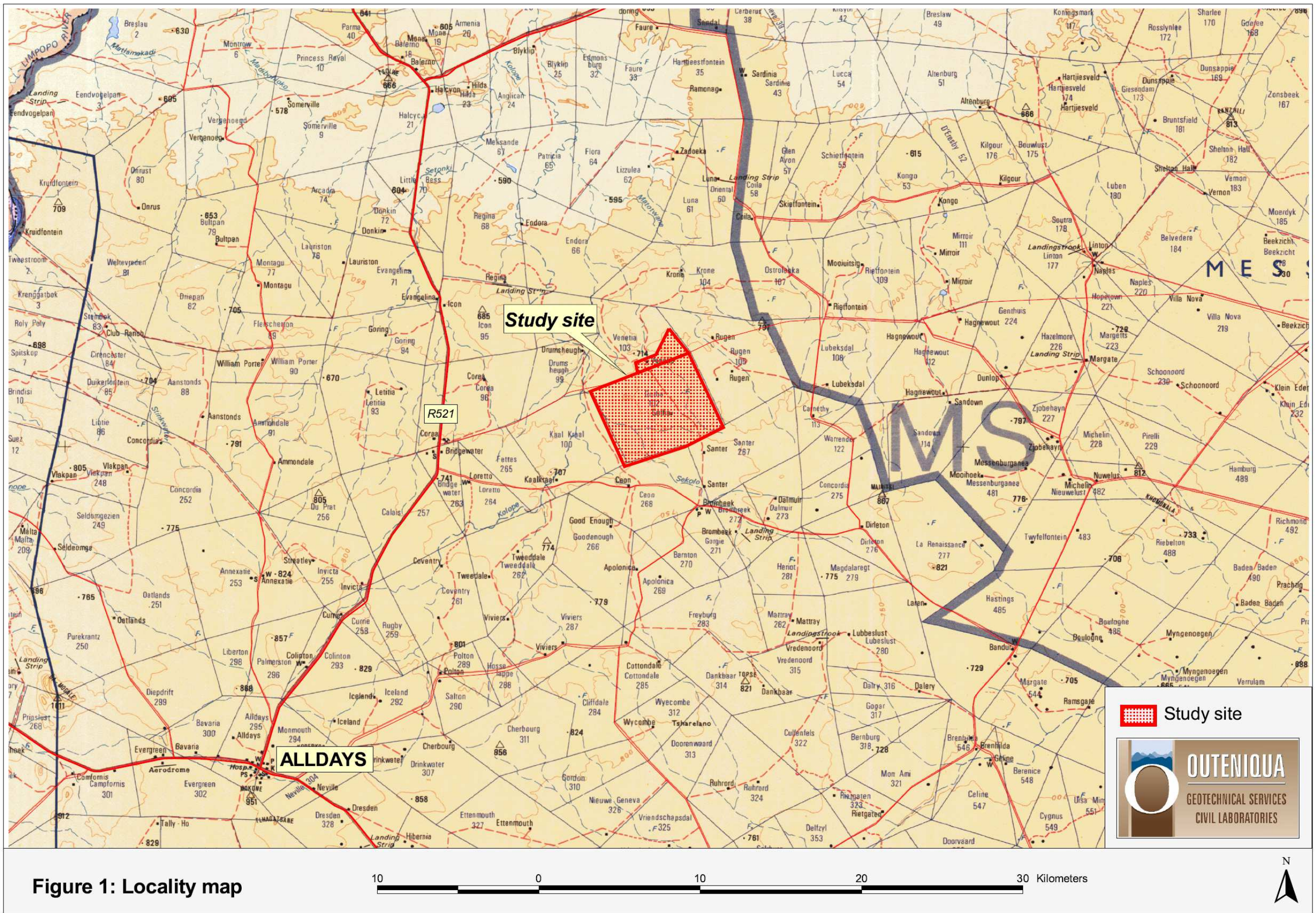

Figure 1: Locality map

2.2. Topography, climate, & vegetation cover

The proposed site is situated in the northern central portion of the farm on slightly undulating plains of low relief (see **figure 2**). The study area drains to the west and east into minor ephemeral tributaries of the Kolope River which flows northwards through the Mapungubwe National Park into the Limpopo River 30km to the north of the site.

The climate of the area is generally dry (Wienert No. 5-10) with an average annual rainfall of less than 400mm.[3] Most rainfall occurs in the hot summer months between November and March. Rain occurs approximately ±10 days per annum and most of the rain falls during thunderstorms over a short period of time. Mean summer temperatures vary between 24 and 28°C with a maximum of 42°C. Minimum temperatures for the winter vary between +3.5 to -3.5°C. Evapotranspiration is high during the summer months.[2]

The vegetation type of the area is Musina Mopane Bushveld which typically consists of Mopane trees, Baobab, various thorn tree species and long grass.[1]

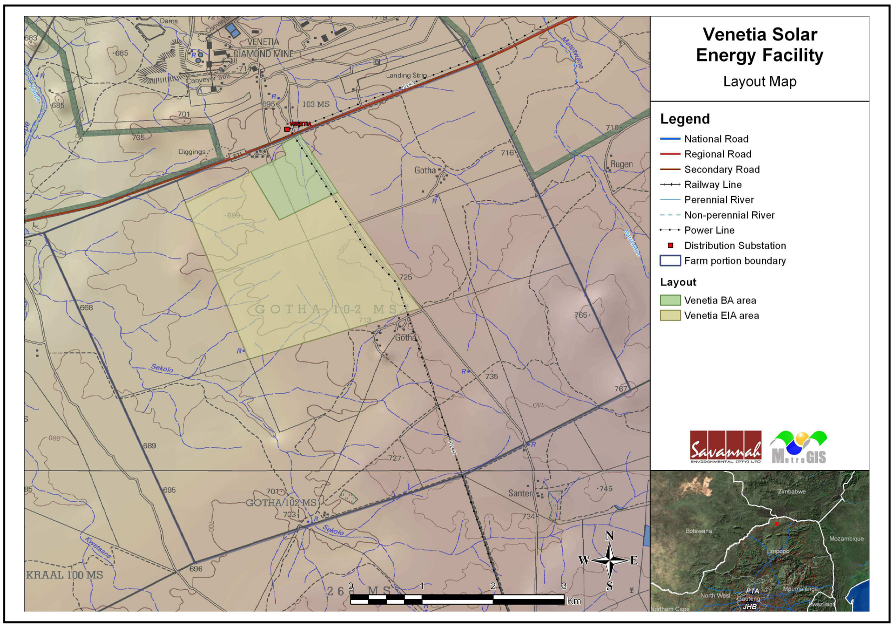

Figure 2: The location of the proposed site.

2.3. Geology and soil cover

The study area is situated within the Limpopo metamorphic belt which joins the Kaapvaal craton to the south with the Zimbabwe craton to the north. The belt consists of high-grade metamorphic rocks that have undergone a long cycle of high temperature and pressure deformation that ended approximately 2 billion years ago, after the stabilisation of the adjacent cratons.

The majority of the farm Gotha is underlain by gneiss, quartzite and granulite of the Malala Drift Group of the Beit Bridge Complex (see **Figure 3**) which forms part of the Limpopo belt. These rocks have been intruded locally by younger diabase dykes. The south western portion of the farm is underlain by significantly younger sedimentary rocks (mudstone, shale) of the Karoo Supergroup.

The bedrock is sporadically overlain by Quaternary soil cover which typically has a coarse gravelly or sandy texture as mechanical weathering processes are dominant in the dry climate. The soil types are broadly classified according to the Universal Soil Classification as SM and GM types (poorly graded silty sands and poorly graded silty gravels with non-plastic fines, respectively). The thickness of the soil cover is generally less than 0.5m thick and outcrops of the underlying basement rock are common. Thicker deposits of sandy soil are located along dry river channels.

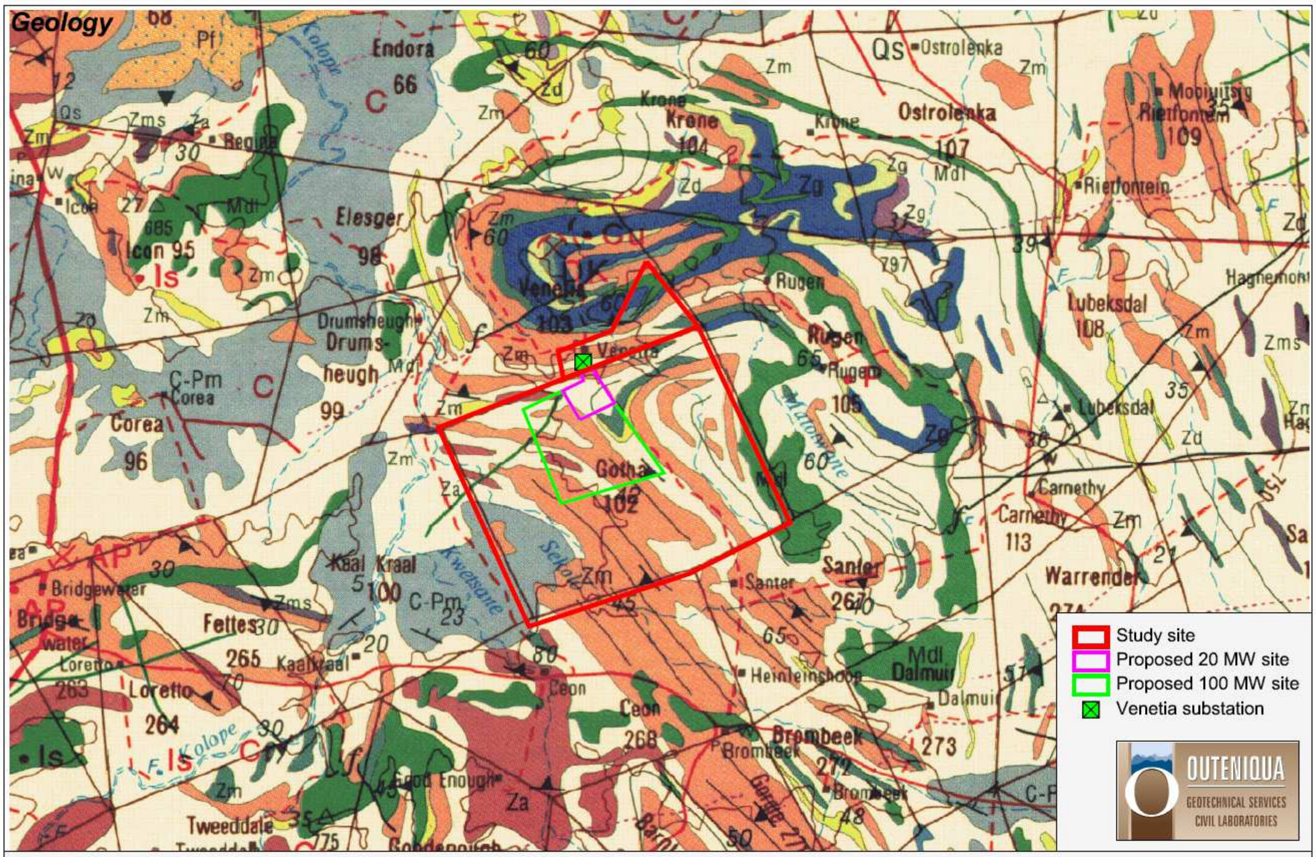

Figure 3: Geological Map

LITHOLOGY	LITOLOGIE
Qs	Sandy soil ( ); sand ( ); alluvium ( ); calcrete ( ); scree ( ); high-level gravel ( ) / Sanderige grond ( ); sand ( ); alluvium ( ); kalkreet ( ); puin ( ); hoëterrasgruis ( )
Tc	Consolidated soil / Gekonsolideerde grond
Jd	Dolerite; dyke ( ) / Doleriet; gang ( )
Jg	Granite dyke ( ) / Granietgang ( )
Jl	Basalt; quartzite ( ); tuffaceous quartzite ( ) / Basalt; kwartsiet ( ); tufagtige kwartsiet ( )
Ŕct	Fine-grained whitish to pinkish sandstone / Fynkorrelrige wit tot rooskleurige sandsteen
Ŕcr	Fine-grained, white and red mottled argillaceous sandstone / Fynkorrelrige, wit en rooi gevlekte kleiige sandsteen
Ŕb	Brick-red to purplish mudstone and siltstone / Roesrooi tot perserige moddersteen en sliksteen
Ŕk	White feldspathic sandstone, grit and conglomerate / Wit veldspatiese sandsteen, grintsteen en konglomeraat
Ŕs	Multi-coloured siltstone, sandstone and mudstone / Veelkleurige sliksteen, sandsteen en moddersteen
Pf	White feldspathic sandstone, grit and conglomerate / Wit veldspatiese sandsteen, grintsteen en konglomeraat
C-Pm	Mudstone, shale, carbonaceous shale, sandstone, conglomerate, coal seams; locally diamictite or conglomerate at base / Moddersteen, skalie, koolstofhoudende skalie, sandsteen, konglomeraat, steenkoollae; plek-plek diamiktiet of konglomeraat aan basis
Mdi	Diabase; dyke ( ) / Diabaas; gang ( )
Mf	Sandstone; basalt ( ) / Sandsteen; basalt ( )
Mm	Basalt, very minor clastic and pyroclastic rocks / Basalt, ondergeskikte klastiese en piroklastiese gesteentes
Mn	Red shale, shaly sandstone, sandstone, quartzite / Rooi skalie, skalieagtige sandsteen, sandsteen, kwartsiet
Ms	Basalt; minor sandstone ( ) / Basalt; ondergeskikte sandsteen ( )
Mst	Basalt; shale, tuffaceous shale, quartzite, grit ( ) / Basalt; skalie, tufagtige skalie, kwartsiet, grintsteen ( )
Mw	Pink quartzite, minor conglomerate and shale / Rooskleurige kwartsiet, ondergeskikte konglomeraat en skalie
Rb	Porphyroblastic gneiss; minor enderbitic and tonalitic gneisses / Porfiroblastiese gneis; ondergeskikte enderbitiese en tonalitiese gneise
Rz	Leucocratic quartzo-feldspathic gneiss / Leukokratiese kwarts-veldspaatgneis
Za	Dark- to light-grey or pink in places porphyroblastic, biotite gneiss / Donker- tot liggrys of rooskleurige, plek-plek porfiroblastiese, biotietgneis
Zd	Metaquartzite, minor magnetite quartzite and massive magnetite; leucocratic quartzo-feldspathic gneiss ( ); metapelite ( ); amphibolite, mafic granulite ( ); marble, calc-silicate rocks ( ) / Metakwartsiet, ondergeskikte magnetietkwartsiet en massiewe magnetiet; leukokratiese kwarts-veldspaat gneis ( ); metapeliet ( ); amfiboliet, mafiese granuliet ( ); marmer, kalksilikaatgesteentes ( )
Zg	Marble, calc-silicate rocks; metaquartzite ( ); leucocratic quartzo-feldspathic gneiss ( ); metapelite ( ); amphibolite, mafic granulite ( ) / Marmer, kalksilikaatgesteentes; metakwartsiet ( ); leukokratiese kwarts-veldspaat gneis ( ); metapeliet ( ); amfiboliet, mafiese granuliet ( )
Zm	Leucocratic quartzo-feldspathic gneiss, in places garnetiferous; metaquartzite ( ); pink granitoid hornblende gneiss ( ); felsic granulite ( ); metapelite ( ); amphibolite, minor mafic granulite ( ); marble, calc-silicate rocks ( ) / Leukokratiese kwarts-veldspaatgneis, plek-plek granaatdraend; metakwartsiet ( ); rooskleurige granietagtige horingblendegneis ( ); felsiese granuliet ( ); metapeliet ( ); amfiboliet, ondergeskikte mafiese granuliet ( ); marmer kalksilikaatgesteentes ( )
Zmm	Metasyenite / Metasiëniet
Zms	Meta-anorthosite, metaleucogabbro; minor ultramafic rocks / Meta-anortosiet, metaleukogabbro; ondergeskikte ultramafiese gesteentes
Zs	Leucocratic, light- and dark-grey biotite gneiss / Leukokratiese, lig- en donkergrys biotietgneis

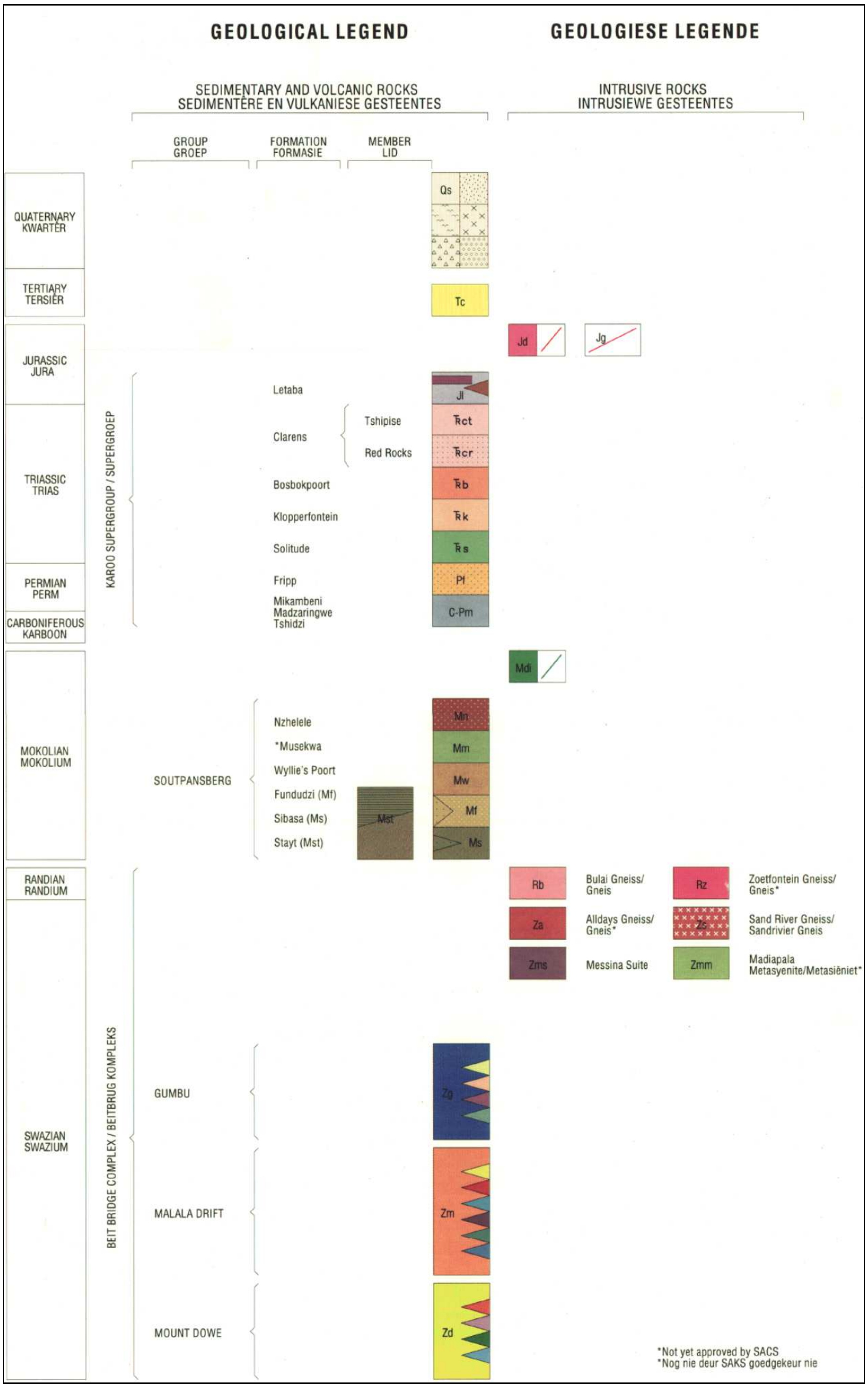

Figure 3: Geological map and legend.

2.4. Hydrology and water erosion potential

The farm is located within the A63E Quaternary catchment of the Limpopo water management area (WMA). The mean annual precipitation is 300-400mm and the mean annual evaporation (S-Pan) is 2000-2200mm.[3]

Water erosion potential is directly related to the hydrology of the site which is largely controlled by the geology and soil types. Infiltration of rainfall into the ground is largely determined by the soil thickness and permeability. Infiltration is inversely proportional to run-off, and therefore in areas where infiltration into the ground is high, run-off is generally low, up to a point where the amount of rainfall exceeds the infiltration rate, and beyond that point excess rainfall ends up as run-off. Run-off is the primary trigger of erosion.

The soil cover over the study area is typically thin with good drainage characteristics but saturation will be reached quickly during peak rainfall periods, resulting in overland flow. The soils are also highly erodible and significant erosion can be expected along natural drainage lines where run-off is concentrated. Elsewhere moderate levels of erosion can be expected during peak rainfall events.

2.5 Land use, land capability and agricultural potential

The current land use on the proposed site is grazing livestock only (cattle, sheep, goats and game) and there is no crop production. There is no irrigation water available in the area and dry land crop/pasture production under low rainfall and high transpiration rates, is a high risk and therefore not sustainable.

The land capability classification, which is an indication of agricultural potential and includes both soil capability and climate factors, is: non-arable, moderate potential grazing land. The natural vegetation on this property is utilized by beef cattle, a few small stock units (SSU) and by a large proportion of game. The game consists of a minimum of 400 impala, 150 kudu and other species. Based on the figures presented to the author by the farmer, a carrying capacity of approximately 4 hectares per large stock unit (LSU) is viable during normal years. Some supplementary fodder is fed during the winter months.

The dominant soils are shallow (100 – 300mm) and consists of sand to sandy loam Glenrosa soils (± 40%) and Hutton and Clovelly soils (35%) with depths up to 800mm with similar textures. Limestone (Coega soils) occurs frequently within the landscape on the low ridges with low growing Mopani shrub on it. All the above soils are of apedal nature. In the low lying floodplains, Oakleaf soils with a sandy loam texture and depths up to 1200mm are found. Rock outcrops frequently occur over the site which would hamper tilling. Soil depth and texture, together with effective rainfall, determine the production of fodder for a particular situation. The low seasonal rainfall, high transpiration rates, shallow depth on a dominant portion of the area (± 40 – 50%) contribute to the relatively low fodder production potential of the area.

Agricultural potential is primarily determined by the suitability of the soil profile to support crop production. The soil needs to be adequately thick to support root development and the drainage characteristics needs to be good to prevent chemical crusting on the surface. In addition to the soil characteristics, climatic factors are also important because the annual rainfall needs to be adequate to sustain a viable crop production. The combined effect of shallow soils, low rainfall and high evaporation rates result in a serious limitation to agricultural potential and therefore the agricultural potential is limited to beef and game production on natural vegetation.

3. IMPACT ASSESSMENT

The impact assessment aims to identify potential impacts that the proposed activities may have on the soil and assess the significance of the various impacts. In addition to this, possible mitigating measures are explored which could limit the effect of negative impacts.

The potential impacts of the proposed developments at this stage are only on a portion of the total farm. The proposed activity could carry potentially negative direct impacts in terms of soil degradation (erosion, excavation/removal, loosening, compaction, contamination/pollution, etc.) and agricultural potential. The activity may also lead to indirect impacts such as dust pollution and siltation away from the site. The severity or significance of the various impacts is a factor of the nature and extent of the activity. Negative impacts on soil and are dominantly related to the construction phase with insignificant additional impacts in the post construction and decommissioning phases.

Potential positive impacts could potentially include a *reduction* in soil erosion in areas where new engineering solutions are put in place to rectify certain existing problems, such as improved drainage along poorly constructed and maintained roads. Other positive impacts relating to the geological environment on a regional/national scale could include a reduction in the demand for non-renewable energy sources (such as coal or uranium).

3.1. Soil degradation

Soil degradation is the negative alteration of the natural soil profile, usually directly or indirectly related to human activity. Soil degradation negatively affects soil formation, natural weathering processes, moisture levels and soil stability. This could, in time, have a significant effect on agricultural potential and biodiversity. Soil degradation is a term which encompasses erosion (i.e. due to water and wind), soil removal, mixing, wetting, compaction, pollution, salinisation, crusting, and acidification.

Soil erosion is a natural process whereby the ground level is lowered by wind or water action and may occur as a result of *inter alia* chemical processes and/or physical transport on the land surface.[1] Soil erosion induced or increased by human activity is termed *accelerated erosion* and is an integral element of global soil degradation. Accelerated soil erosion is generally considered the most important impact in any development due to its potential impact on a local and regional scale (i.e. on and off site) and as a potential threat to global biodiversity. Soil erodability – the susceptibility of soil to erosion – is a complex variable, not only because it depends on soil chemistry, texture, and characteristics, but because it varies with time and other variables[8], such as mode of transport (i.e. wind or water).

Erosion of soil due to water run-off is generally considered as being more important due to the magnitude of the potential impact over a relatively short period of time, which can be very difficult to control or reverse. Erosion by water occurs when the force exerted on the soil by flowing water exceeds the internal shear strength of the soil and the soil fails and becomes mobilised into suspension. Erosion potential is typically increased in areas where soil is loosened and vegetation cover is stripped (such is the case on most construction sites). Removal of vegetation (ground cover) may increase the risk of soil erosion, making the soil less fertile and less able to support the regeneration of vegetation in future.

Erosion sensitivity can be broadly mapped according to the potential severity of erosion if land disturbing activities occur and this is generally affected by the geology, soil types and topography. Generally speaking, thick deposits of unconsolidated or partly consolidated fine-grained soils of low plasticity occurring along drainage lines, on moderate to steep slopes or at the base of steep slopes are most vulnerable to severe levels of erosion due to water run-off. Areas where these factors occur simultaneously are typically called "highly sensitive" areas.

Specifically relating to the site in question, the geological map (**Figure 3)** indicates that the study area is partially underlain by unconsolidated Quaternary sandy soils. Certain parts of the site have been identified as being sensitive in terms of erosion (see **Figure 4**). **Table 1** broadly outlines the erosion sensitivity as a function of topography and geology.

Table 1: Water erosion sensitivity

Sensitivity Level	Topography/Geology	Comments/Recommendations
High	Natural drainage lines/watercourses, steep slopes (high relief areas)	No-go areas without special mitigating measures. Erosion presently taking place.
Medium	Moderately to gently undulating hills and plains (low relief areas) where unconsolidated sediment occurs	Moderate levels of erosion will occur if land-disturbing activities take place (construction). Mitigating measures to be applied to minimise impact.
Low	Areas where rock outcrops at surface	Minor erosion will naturally occur. Normal mitigating measures apply.

During peak rainfall events, excess run-off may result in significant erosion along drainage lines (see **Figure 6**) and in areas that are cleared of vegetation, although in the case of the proposed development, full vegetation clearing is not envisaged across the entire site (vegetation will be shortened/maintained to prevent spread of fire and shadows on the panels).

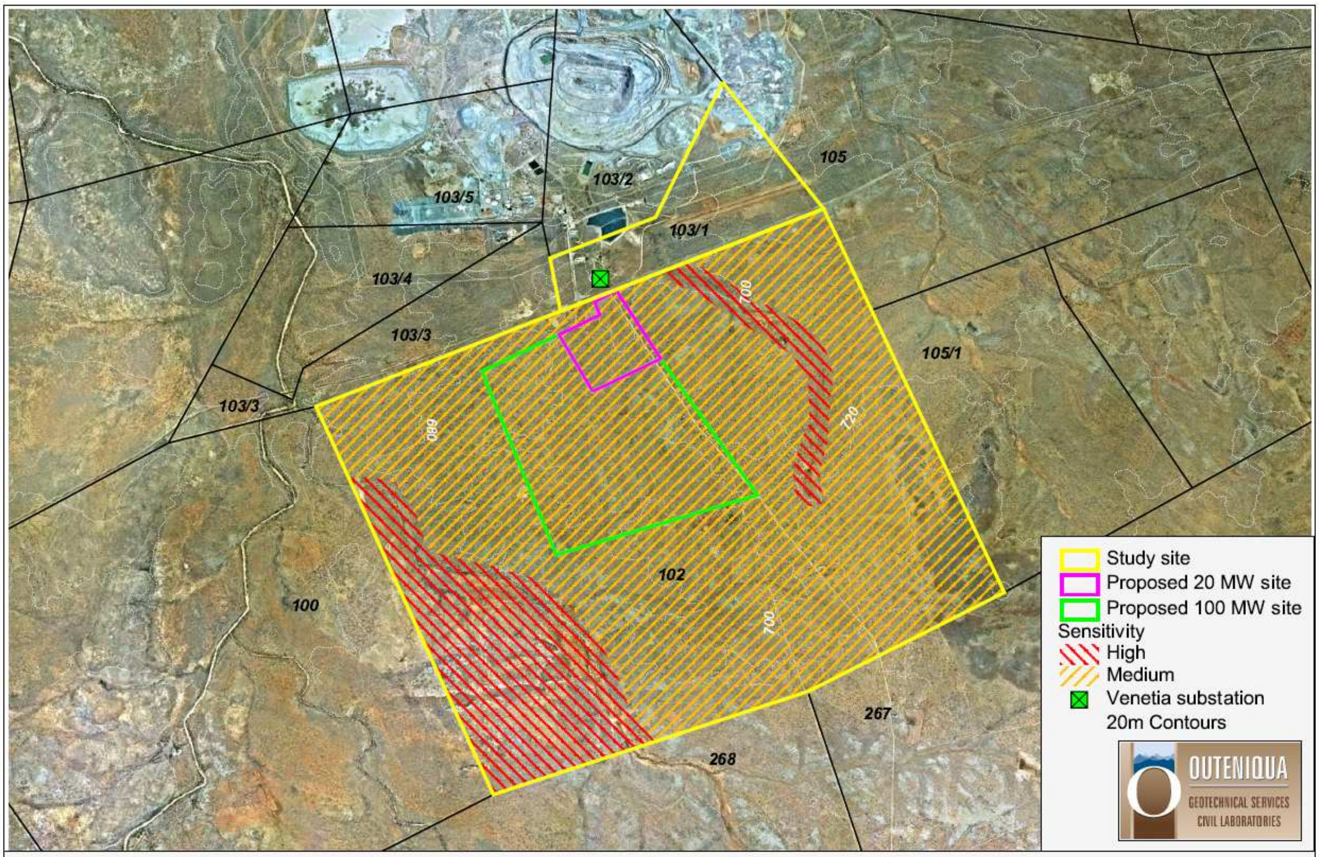

Figure 4: Erosion sensitivity map

Figure 5: Photo of the typical terrain and vegetation on the study area.


Figure 6: Small erosion donga along a dry channel in the northwestern corner of the study area.

3.2. Reduction in agricultural potential

The agricultural potential of the site is considered low and the proposed activity will not have any significant effect on this status. Some relocation of agricultural infrastructure (fences, camps, water points, etc) and stock may be required to accommodate the proposed development, but this is not considered to have a significant impact on production apart from minor loss of grazing land.

3.3. Assessment of impacts

The environmental assessment aims to evaluate the impacts that the proposed activities will have on the environment and attempts to provide mitigating measures to minimise negative impacts.

3.3.1. Methodology of assessment

Direct, indirect, and cumulative negative impacts are assessed in terms of the following criteria:

- The nature of the impact - what causes the impact, what will be impacted and how it will be impacted;
- The extent of the impact - whether it is local (limited to the immediate area or site of the development) or regional (on a scale of 1 to 5).
- The duration of the impact – whether it will be very short (less than 1 year), short (1-5 years), medium (5-15 years), long (>15 years) or permanent (on a scale of 1 to 5, respectively).
- The magnitude, quantified on a scale of 0-10, where 0 is small and will have no impact on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will have a slight impact on processes, 6 is moderate and will result in processes continuing, but in a modified way, 8 is high and processes are altered the extent that they temporarily cease, and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The probability of occurrence, which describes the likelihood of the impact actually occurring (on a scale of 1 to 5 – very improbable to definite).

- The significance, which is determined through a synthesis of the characteristics described above and is assessed as low, medium or high.
- The status, which is described as positive, negative or neutral.
- The degree to which the impact can be reversed.
- The degree to which the impact may cause the irreplaceable loss of resources.
- The degree to which the impact can be mitigated.
- The possibility of significant cumulative impacts of a number of individual areas of activity.
- The possibility of residual impacts existing after mitigating measures have been put in place

The significance is calculated by combining the criteria in the following formula:
S = (E+D+M) P

Where:
S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability
The significance weightings for each potential impact are as follows:

<30 points: **Low** (i.e. where this impact would not have a direct influence on the decision to develop in the area);
30-60 points: **Moderate** (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated);
>60 points: **High** (i.e. where the impact will influence the decision to develop in the area).

3.3.1. Potential impacts on the proposed site

There are no site alternatives under consideration but the facility can be moved within the study area to minimise impacts on any potentially sensitive areas. The do-nothing alternative will have no negative impact on the local soil but there will also be no positive impact on the reduction in demand for non-renewable energy sources on a national scale (e.g. coal).

The proposed photovoltaic (PV)/concentrated photovoltaic (CPV) technology typically makes use of a light-weight frame upon which the PV panels are attached. The frame is usually anchored to the ground by means of steel poles which are emplaced into pre-drilled holes or screwed into the ground (screwpiles). Alternatively, shallow concrete pads are cast to secure the top structure. In any case, minimal earthworks are involved in the foundations and the frames can be erected on moderate slopes without resorting to significant earthworks.

An assessment of the individual potential direct impacts on the soil and agricultural potential of the site is tabulated in **Table 2**.

Table 2: Potential direct impacts

Nature: Soil degradation (soil removal, mixing, compaction, etc) due to the construction of foundations for structures (PV panels, buildings, substations, powerlines).

	Without mitigation	With mitigation
Extent	Local (1)	Local (1)
Duration	Short term (2)	Very Short term (1)
Magnitude	Minor (2)	Minor (2)
Probability	Definite (5)	Definite (5)
Significance	**Low (25)**	**Low (20)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes.	
Mitigation:	» Rehabilitate topsoil & vegetation around site after construction.	
Cumulative impacts:	» The cumulative impact of earthworks in the area is considered low at this stage due to the low density of development in the area. Further development of the area may have increasing impact on the natural soil.	
Residual impacts:	» Minor loss of soil under structures.	

Nature: Soil degradation (soil removal, mixing, compaction, etc) due to the construction of new access roads.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Long term (4)	Long term (4)
Magnitude	Low (4)	Minor (2)
Probability	Definite (5)	Definite (5)
Significance	**Moderate (45)**	**Moderate (35)**
Status	Negative	Negative
Reversibility	Irreversible	Reversible
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes.	
Mitigation:	» Use existing roads if possible/practical. » Minimise the length and width of new access roads (preferably just gravel tracks). » Maintain access roads in good condition, preventing detours due to bad road conditions	
Cumulative impacts:	» The cumulative impact of earthworks in the area is considered low at this stage due to the low density of development in the area. Further development of the area may have an increasing impact on the natural soil.	
Residual impacts:	» Minor loss of structures under roads.	

Nature: Soil degradation due to pollution of soil by contaminants used on site during construction (e.g. fuel, oil, chemicals, cement).		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Very short term (1)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Probable (3)

Significance	**Low (18)**	**Low (12)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	
Mitigation:	» Control use and disposal of potential contaminants or hazardous materials. » Remove contaminants and contaminated topsoil and replace topsoil in affected areas.	
Cumulative impacts:	» The cumulative impact of soil pollution is considered low at present due to the undeveloped nature of the area but further development may have an increasing impact.	
Residual impacts:	» Minor loss of soil potential	

Nature: Soil degradation due to increased soil erosion by wind and/or water on construction areas.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Long term (4)	Short term (1)
Magnitude	Moderate (6)	Low (4)
Probability	Very probable (4)	Very probable (4)
Significance	**Moderate (44)**	**Low (24)**
Status	Negative	Negative
Reversibility	Practically irreversible	Practically irreversible
Irreplaceable loss of resources?	Practically irreplaceable	Practically irreplaceable
Can impacts be mitigated?	Yes.	
Mitigation:	» Minimise size of the construction footprint/camp. » Restrict activity outside of construction camp areas. » Implement effective erosion control measures around site. » Carry out earthworks in phases across site to reduce the area of exposed ground at any one time. » Protect and maintain denuded areas and material stockpiles to minimise erosion and instability	
Cumulative impacts:	» The cumulative impact of soil erosion is considered low at present due to the undeveloped nature of the area but further development may have an increasing impact on soil erosion.	
Residual impacts:	» Minor localised erosion.	

Nature: Impact on existing land-use.		
	Without mitigation	
Extent	**Local (1)**	
Duration	**Long term (4)**	
Magnitude	**Minor (2)**	
Probability	**Probable (4)**	
Significance	**Low (28)**	
Status	**Negative**	

Reversibility	**Reversible**	
Irreplaceable loss of resources?	**No**	
Can impacts be mitigated?	**No**	
Mitigation:	Not possible	
Cumulative impacts:	» The cumulative impact on land use is considered low at present due to the low intensity land-use practised on the site.	
Residual impacts:	» Insignificant temporary loss of grazing land while facility is in use.	

Nature: Reduction in agricultural potential.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Long term (4)	Long term (4)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (4)	Probable (4)
Significance	**Low (28)**	**Low (28)**
Status	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	No	
Mitigation:	Not possible	
Cumulative impacts:	» The cumulative impact of a reduction in the agricultural potential is considered low at present due to the low potential of the area.	
Residual impacts:	» Minor loss of grazing land while facility is in use.	

An assessment of the potential <u>indirect</u> impacts associated with the proposed development is tabulated in **Table 3**.

Table 3: Potential indirect impacts

Nature: Degradation of waterways due to increased siltation downstream from site.		
	Without mitigation	***With mitigation***
Extent	Regional (3)	Local (1)
Duration	Long term (4)	Long term (4)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Moderate (33)**	**Low (21)**
Status	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation:	» Install anti-erosion measures such as silt fences, geosynthetic erosion protection, and/or flow attenuation along watercourses below construction	

	sites. » Strictly control activity near water courses/natural drainage lines as sediment transport is higher in these areas. » Minimise increased run-off from hard surfaces (PV panels) by channelising and capturing rainwater for re-use (rainwater harvesting)
Cumulative impacts:	» The cumulative impact of siltation in the area is considered low at present but further development may have an increasing impact on siltation of waterways.
Residual impacts:	» Minor localised movement of soil across site

Nature: Increased dust pollution from construction sites affecting surroundings.		
	Without mitigation	***With mitigation***
Extent	Regional (2)	Local (1)
Duration	Very short term (1)	Very short term (1)
Magnitude	Low (4)	Minor (2)
Probability	Highly probable (4)	Highly probable (4)
Significance	**Low (28)**	**Low (16)**
Status	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	Yes, minor	Yes, insignificant
Can impacts be mitigated?	Yes	
Mitigation:	» Apply dust control measures such as straw bales or dampen dusty denuded areas.	
Cumulative impacts:	» The cumulative impact of dust in the area is considered low.	
Residual impacts:	» Minor localised dust pollution	

Nature: Reduction in demand for non-renewable energy sources.		
	Without mitigation	***With mitigation***
Extent	National (3)	n/a
Duration	Long term (4)	n/a
Magnitude	Moderate (6)	n/a
Probability	Very probable (4)	n/a
Significance	**Moderate (52)**	n/a
Status	Positive	
Reversibility		
Irreplaceable loss of resources?		
Can impacts be mitigated?		
Mitigation:		
Cumulative impacts:	» The cumulative positive impact on a national scale is considered very high.	
Residual impacts:		

3.4. Impact Statement

The most significant potential negative impacts are that of soil degradation. However, if these impacts are successfully mitigated the negative impacts will be out-weighed by the positive impact on the demand for non-renewable energy.

3.5. Environmental Management Programme (EMP) guidelines for earthworks

Negative impacts can be mitigated to a large degree by the implementation of an appropriate and effective EMP. The following generic guidelines relate specifically to the earthworks contract:

3.5.1. Earthworks

1. Prior to earthworks (including site clearance) starting on the site, a plant search and rescue operation should be undertaken as per the requirements set out in the EMP.
2. All earthworks shall be undertaken in such a manner to minimise the extent of any impacts caused by such activities.
3. Defined access routes to and from the area of operations as well as around the area of operation shall be adhered to.
4. No equipment associated with the activity shall be allowed outside of these areas unless expressly permitted by the Environmental Control Officer (ECO).
5. Mechanical methods of rock breaking, including Montabert-type breakers and jackhammers, have noise and dust impacts, and must be addressed in the EMP.
6. Residents shall be notified at least one week prior to these activities commencing, and their concerns addressed.
7. Chemical breaking shall require a method statement approved by the Engineer's Representative (ER).

3.5.2. Topsoil

1. Prior to construction, the topsoil areas to be disturbed should be stripped to a depth to be confirmed by the ER and set aside for spreading to all areas to be reinstated after the construction. Temporary topsoil stock piles must be covered with net, shade cloth or straw bales to protect them.
2. Once all grades have been finalised and prepared, topsoil should be spread evenly to all affected areas to be re-vegetated.

3.5.3. Erosion and Sedimentation Control

1. During construction, the contractor shall protect areas susceptible to erosion by installing necessary temporary and permanent drainage works as soon as possible and by taking other measures necessary to prevent the surface water from being concentrated in streams and from scouring the slopes, banks or other areas.
2. A method statement shall be developed and submitted to the ER to deal with erosion issues prior to bulk earthworks operations commencing.
3. Any erosion channels developed during the construction period or during the vegetation establishment period shall be backfilled and compacted and the areas restored to a proper condition.

4. Stabilisation of cleared areas to prevent and control erosion shall be actively managed. The method of stabilisation shall determine in consultation with the ECO. Consideration and provision shall be made for the following methods (or combination):
   a) Brush cut packing
   b) Mulch or chip cover
   c) Straw stabilising
   d) Watering
   e) Planting/sodding
   f) Hand seed-sowing
   g) Hydroseeding
   h) Soil binders and anti erosion compounds
   i) Gabion bolsters & mattresses for flow attenuation
   j) Geofabric
   k) Hessian cover
   l) Log/ pole fencing
5. Traffic and movement over stabilised areas shall be restricted and controlled and damage to stabilised areas shall be repaired and maintained to the satisfaction of the ECO.
6. Anti-erosion compounds shall consist of all organic or inorganic material to bind soil particles together and shall be a proven product able to suppress dust and erosion. The application rate shall conform to the manufacturer's recommendations. The material used shall be approved by the ECO.

3.5.4. Drilling and Jack-Hammering

1. The contractor shall submit a method statement detailing his proposals to prevent pollution during drilling operations. This shall be approved by the site manager prior to the onset of any drilling operations.
2. The contractor shall take all reasonable measures to limit dust generation as a result of drilling operations.
3. Noise and dust nuisances shall comply with the applicable standards according to the Occupational Health and safety (Act No. 85 of 1993).
4. The Contractor shall ensure that no pollution results from drilling operations, either as a result of oil and fuel drips, or from drilling fluid.
5. All affected parties shall be informed at least one week prior to the onset of the proposed drilling/jackhammering operations, and their concerns addressed.
6. Drill coring with water or coolant lubricants shall require a method statement approved by the Site Manager.
7. Any areas or structures damaged by the drilling and associated activities shall be rehabilitated by the contractor to the satisfaction of the site manager.

3.5.5. Trenching

1. Trenching shall be kept to a minimum using single trenches for multiple service provision.
2. The planning and selection of trench routes shall be undertaken in liaison with the ER and cognisance shall be given to minimising the potential for soil erosion.
3. Trench routes with permitted working areas shall be clearly defined and marked with painted stakes prior to excavation.

4. The stripping and separation of topsoil shall occur as stipulated by the ER. Soil shall be stockpiled for use as backfilling as directed by the ER.
5. Trench lengths shall be kept as short as practically possible before backfilling and compacting.
6. Trenches shall be backfilled to the same level as (or slightly higher to allow for settlement) the surrounding land surface to minimise erosion. Excess soil shall be stockpiled in an area approved by the engineer.
7. Immediately after backfilling, trenches and associated disturbed working areas shall be planted with a suitable plant species and regularly watered. Where there is a particularly high erosion risk, a fabric such as Geojute (biodegradable) shall be used in addition to planting.

3.5.6. Dust

1. The contractor shall be solely responsible for the control of dust arising from the contractor's operations and for any costs against the employer for damages resulting from dust.
2. The contractor shall take all reasonable measures to minimise the generation of dust as a result of construction activities to the satisfaction of the site manager.
3. Removal of vegetation shall be avoided until such time as soil stripping is required and similarly exposed surfaces shall be re-vegetated or stabilised as soon as is practically possible.
4. Excavation, handling and transport of erodible materials shall be avoided under high wind conditions or when a visible dust plume is present.
5. During high wind conditions the site manager will evaluate the situation and make recommendations as to whether dust damping measures are adequate, or whether working will cease altogether until the wind speed drops to an acceptable level.
6. Where possible, soil stockpiles shall be located in sheltered areas where they are not exposed to the erosive effects of the wind. Where erosion of stockpiles becomes a problem, erosion control measures shall be implemented at the discretion of the site manager.
7. Vehicle speeds shall not exceed 40km/h along dust roads or 20km/h when traversing unconsolidated and non-vegetated areas.
8. Appropriate dust suppression measures shall be used when dust generation as unavoidable, e.g. dampening with water, particularly during prolonged periods of dry weather in summer. Such measures shall also include the use of temporary stabilising measures (e.g. chemical soil binders, straw, brush packs, clipping etc.)
9. Straw stabilisation shall be applied at a rate of one bale/ $10m^2$ and harrowed into the top 100mm of top material for all completed earthworks.

3.5.7. Imported Materials and Stockpiles

1. Imported materials shall be free of weeds, litter and contaminants.
2. Sources of imported material shall be listed and approved by the ER on site.
3. The contractor shall provide samples to the ER for approval.
4. Stockpile areas shall be approved by the ER before any stockpiling commences.

3.5.8. Summary of objectives and performance monitoring

A summary of the project components, potential impacts, mitigating measures and performance monitoring is outlined below.

OBJECTIVE: Minimise negative impact on soil degradation and agricultural potential

- » Soil degradation including erosion (by wind and water) and subsequent deposition elsewhere is of a concern in areas which are underlain by fine grained soil which can be mobilised when disturbed, even on relatively low slope gradients (accelerated erosion).
- » Uncontrolled run-off relating to the construction activity (excessive wetting, uncontrolled discharge, etc) will also lead to accelerated erosion and possible sedimentation along natural drainage lines or catchment areas.
- » Degradation of the natural soil profile due to excavation, removal or topsoil, stockpiling, wetting, compaction, pollution and other construction activities will affect soil forming processes and associated agricultural potential.

Project Component/s	• PV arrays and foundations to support them. • Access roads. • Underground cabling. • Storage and maintenance facilities and foundations to support them. • Overhead power lines and substation linking the facility to the electricity grid.
Potential Impact	• Soil removal. • Soil mixing, wetting, stockpiling, compaction. • Soil pollution. • Increased run-off and erosion. • Increased siltation along drainage lines. • Dust pollution.
Activity/Risk Source	• Earthworks & transportation across site. • Rainfall and concentrated discharge causing water erosion of disturbed areas. • Wind - erosion of disturbed areas.
Mitigation: Target/Objective	• Minimise soil degradation (removal, excavation, mixing, wetting, compaction, pollution, etc.). • Minimise erosion. • Minimise sediment transport downstream (siltation). • Minimise dust pollution.

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Identify areas of high erosion risk (drainage lines/watercourses, existing problem areas). Only special works to be undertaken in these areas to be authorised by ECO and Engineer's representative (ER)	ECO/ER	At design stage.
Identify construction areas for general construction work and restrict construction activity to these areas.	ECO/ER/Contractor	At design stage and during construction
Prevent unnecessary destructive activity within construction areas (prevent over-excavations and double handling)	ECO/ER/Contractor	During construction
Access roads to be carefully planned and constructed to minimise the impacted area and prevent unnecessary degradation of soil. Special attention to be given to roads	ECO/ER/Contractor	At design stage and during construction

Mitigation: Action/Control	Responsibility	Timeframe
that cross drainage lines and roads on steep slopes (to prevent unnecessary cutting and filling operations).		
Dust control on construction site through wetting or covering of cleared areas.	Contractor	Daily during construction
Minimise removal of vegetation which aids soil stability.	ECO/Contractor	Continuously during construction
Rehabilitate disturbance areas as soon as an area is vacated.	Contractor	Continuously during and after construction
Soil conservation - stockpile topsoil for re-use in rehabilitation phase. Protect stockpile from erosion.	Contractor	Continuously during construction
Erosion control measures- run-off control and attenuation on slopes (sand bags, logs), silt fences, stormwater channels and catch-pits, shade nets, soil binding, geofabrics, hydroseeding or mulching over cleared areas.	Contractor/ECO	Erection: Before construction Maintenance: Duration of contract
Where access roads cross natural drainage lines, culverts must be designed to allow free flow. Regular maintenance must be carried out	ECO/ER/Contractor	Before construction and maintenance over duration of contract
Control depth of excavations and stability of cut faces/sidewalls	ECO/ER/Contractor	Before construction and maintenance over duration of contract

Performance Indicator	» Only authorised activity outside construction areas » No activity in no-go areas. » Acceptable level of activity within construction areas, as determined by ECO. » Acceptable level of soil erosion around site, as determined by ECO. » Acceptable level of sedimentation along drainage lines, as determined by ECO. » Acceptable level of soil degradation, as determined by ECO. » Acceptable state of excavations, as determined by ER & ECO.
Monitoring	» Monthly inspections of the site by the ECO. » Monthly inspections of sediment control devices by the ECO. » Monthly inspections of surroundings, including drainage lines by the ECO. » Immediate reporting of ineffective sediment control systems by the ECO. » An incident reporting system will record non-conformances.

4. CONCLUSIONS

If suitable mitigating measures are applied, the proposed activity will have a low to moderate potential *negative* impact on the soil profile and the agricultural potential. The proposed development can potentially make a significant indirect *positive* impact on the geological environment in terms of a reduction in demand (and exploitation) for non-renewable energy sources on a national scale.

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