GEOLOGICAL REPORT

SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED AMAKHALA EMOYENI WIND ENERGY FACILITY NEAR BEDFORD, EASTERN CAPE PROVINCE, SOUTH AFRICA

Technical Report No: OGS2010-07-20-2

August 2010

PREPARED BY:

OUTENIQUA GEOTECHNICAL SERVICES
PO BOX 3186
GEORGE INDUSTRIA
6536

PREPARED FOR:

SAVANNAH ENVIRONMENTAL (PTY) LTD
PO BOX 148
SUNNINGHILL
2157

List of abbreviations and definitions

The study area:	The area as delineated on **Figure 1**
EIA:	Environmental Impact Assessment
WEF:	Wind Energy Facility
EMP:	Environmental Management Plan
MPRD:	Minerals and Petroleum Resources Development Act 28 of 2002
AMSL:	Above mean sea level
Ma:	Million years
NGL:	Natural Ground Level
EPO:	Environmental Protection Officer
Jurassic:	The geological time period from 200 to 145 Ma ago
Permian:	The geological time period between 300 and 250 Ma ago

1. INTRODUCTION

1.1. Background

Windlab Developments South Africa (Pty) Ltd is in the process of carrying out the Impact Assessment phase of the EIA for the proposed Amakhala Emoyeni Wind Energy Facility (WEF) near Bedford in the Eastern Cape. The proposed activity is defined as the establishment of a wind energy facility and associated infrastructure. The proposed WEF would include:

- Up to 350 wind turbines and foundations to support them;
- Underground cables between the turbines, where practical;
- Up to 3 substations to facilitate the connections between the WEF and the existing power lines;
- Internal access roads between the turbines.

The proposed activity is located on the farm portions: Portion 1, 2 and remainder of Farm 222, Portion 3 of Farm 203 (Platt House), Remainder of Farm 205 (Kop Leegte), Portion 1 of Farm 206 (Normandale), Remainder of Farm 168 (Stompstaart Fontein), Remainder of Farm 224 (Taai Fontein), Remainder of Farm 221 (Leeuw Fontein), Portion 2 and remainder of Farm 223 (Paarde Kloof), Remainder of Farm 227 (Wilgem Bush), Remainder of Farm 225, Portion 1, 2 and remainder of Farm 218 (Brakke Fonteyn), Remainder of Farm 259, Remainder of Farm 260, Portion 5 of Farm 149 (Great Knoffel Fonteyn), Remainder of Farm 242, Portion 1 and remainder of Farm 220 (Brak Fontein), Remainder of Farm 219 (Vogel Fonteyn), Remainder of Farm 169 (Olive Woods Estate), Portion 3 of Farm 141 (Brakfontein), Portion 1 of Farm 187 (Kleine Knoffel Fonteyn). No alternative areas have been proposed. The power line for the facility will connect to the existing Eskom grid.

1.2. Legislation

In terms of the EIA regulations published in terms of Section 24(5) of the National Environmental Management Act (NEMA, No 107 of 1998), the applicant (DNA Wind Farm (Pty) Ltd) requires authorisation from the National Department of Environmental Affairs (DEA) (in consultation with the Eastern Cape Department of Economic Development and Environmental Affairs (DEDEA)) for the undertaking of the proposed project.

Legislation specifically relating to the geological environment is contained within the Minerals and Petroleum Resources Development Act 28 of 2002. In terms of the Act, each mine, quarry, borrow pit and sand winning operation must have an EMP report which may affect the operations should it be necessary to obtain local construction materials for access roads and foundations.

1.3. Terms of reference

Savannah Environmental (Pty) Ltd has been appointed by the applicant to carry out the EIA process for the proposed activity. Specialist geological input is required in order to assess the environmental impacts on the geology and soil profile over the study area. Savannah Environmental (Pty) Ltd has appointed Outeniqua Geotechnical Services to conduct a specialist geological study of the study area.

The following broad scope of work has been given:

- Carry out a desk-top study of available information pertaining to the geology and soil types of the study area and the environmental impacts on the geological environment that are likely to be associated with the proposed activity.
- Conduct a brief site visit to collect visual data pertaining to the geology, soil types and potential soil degradation issues.
- Conduct a geological impact assessment and prepare a report on the findings.

The following aspects are covered in this report:

- A description of the environment that may be affected by the activity (the study area);
- A description of the geology and soil types in the study area;
- Assess the potential environmental impacts on the soil profile and other geological features (with emphasis on erosion and soil degradation);
- Provide mitigating measures for the EMP.

In addition to this, a preliminary indication of the potential geotechnical constraints on the proposed project is provided. These constraints may impact on the engineering design of access roads and foundations, and include such issues as founding conditions and problem soils, groundwater problems, excavatability, sources of natural construction material, etc.

1.4. Limitations

Information provided in this specialist report has been based on information provided by Savannah Environmental (Pty) Ltd, published scientific literature and maps. The study area was visited briefly but no detailed soil investigation (trial pits, soil testing), geomorphological or geohydrological assessment or verification of the existing geological mapping was conducted. The information provided in this report is deemed adequate for the EIA process and preliminary planning phase but further geotechnical information may be required for the detailed design phase.

1.5. Authors credentials & declaration of independence

The author of this report, Iain Paton of Outeniqua Geotechnical Services cc (OGS), is an independent professional engineering geologist (Pr Sci Nat # 400236/07) of 12 years experience in the mining, petroleum and construction industries. Iain Paton declares that he does not have any financial interest in the undertaking of the activity, other than remuneration for work performed in the compilation of this specialist report. OGS has no vested interest in the proposed activity and will not engage in conflicting activity associated with the project.

2. SITE DESCRIPTION

2.1. Location

The study area is located approximately 10km southwest of the town of Bedford in the Eastern Cape (see **Figure 1**). Bedford is approximately 175 km north Port Elizabeth.

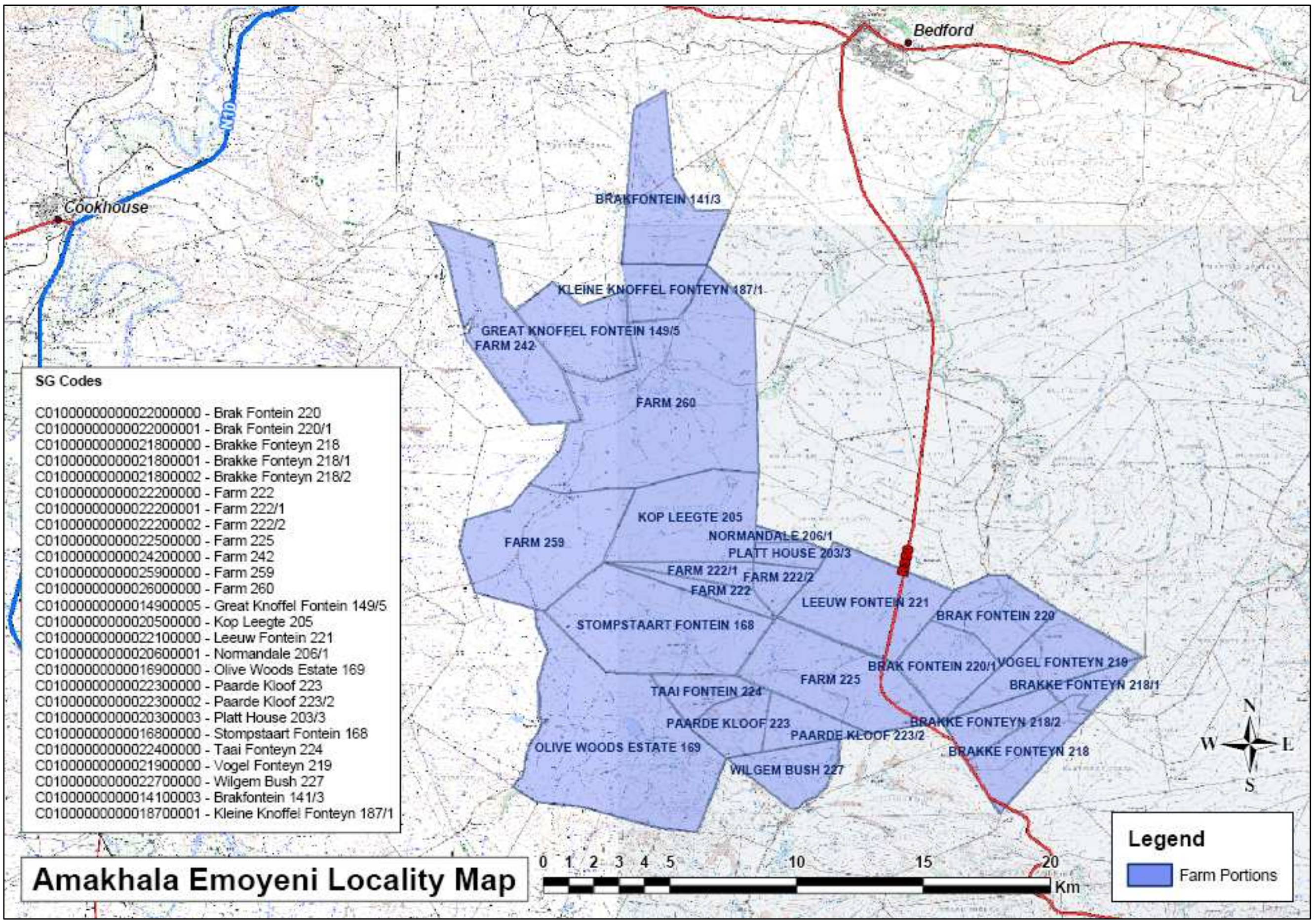

Figure 1: Locality map of study area (purple shaded areas)

2.2. Topography, climate & vegetation cover

The study area stretches across an undulating upland area to the southeast of Cookhouse and to west of the eNyara River. The slope gradients are typically low to moderate (1-7°) and the altitude ranges from approximately 600m to 870m AMSL. The majority of the study area falls within the catchment area of the eNyara River but the southernmost portion of the study area drains into the Great Fish River, which flows eastwards. The eNyara River eventually flows into the Great Fish River about 65km southeast of the study area (See **Figure 2**).

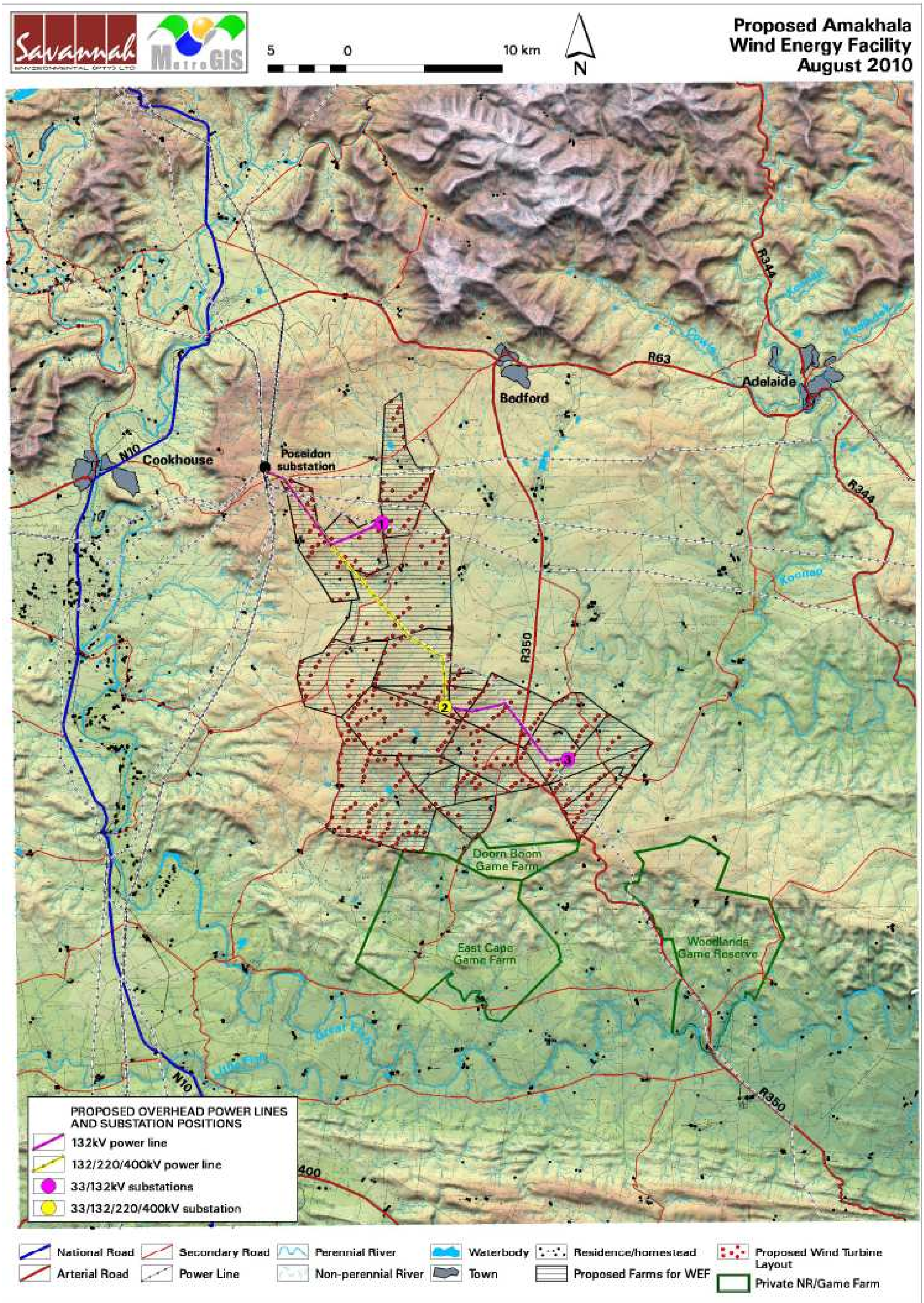

Figure 2: Topographical map showing the proposed layout of infrastructure

The climatic N-number for the area, which is approximately 4, indicates that the climate is semi-humid to semi-arid and thus both chemical and mechanical weathering processes are involved[6]. The Thornthwaite moisture index map[5] indicates a moisture index of approximately -20, which marks the boundary between semi-arid and semi-humid regions.

Analysis of aerial photographs indicates that the vegetation cover is thin over much of the study area but is generally thicker along drainage lines. The Vegetation Map of SA[7] indicates that the vegetation type over most of the study area is Bedford Dry Grassland and the southern portion of is Great Fish Thicket.

2.3. Geology & soil types

The study area stretches across both the Graaff-Reinet (Sheet 3224) and King Williamstown (sheet 3226) 1:250 000 Geological maps. These maps indicate that the study area is underlain by Permian Balfour and Middleton Formations of sedimentary rocks (Adelaide Subgroup - Beaufort group – Karoo Supergroup). These two formations typically have very similar lithology and are mapped as one unit on the older King Williamstown map. The newer Graaff-Reinet map distinguishes between the two but this is of academic importance only. Both formations consist of essentially greenish (or blueish) grey and greyish-red mudstones and sandstones.

Intrusive rocks are limited to minor exposures of transgressive dolerite sills of Jurassic age in the northern and southern portions of the study area.

Rock outcrops or very shallow rock occurs over approximately 60% of the study area, specifically on the upland areas and areas of moderate to high relief. The hardness of the various rock types acts as a control on the development of the landscape. The hard, resistant dolerite has aided the preservation of prominent hills in the area from the forces of erosion which attempt to level the landscape. The sandstone units within the Middleton and Balfour Formations are coarser grained, harder and less prone to weathering than the mudstones. Hard sandstone layers produce resistant ledges and cliffs and the mudstones typically crumble on steep slopes (slaking), producing concave cliff-faces and slopes. Soft argillaceous rocks (mudstones) are also more susceptible to chemical weathering. Natural drainage lines also tend to develop in weaker rocks types, fractures or fault lines.

Soil type, texture and thickness are generally controlled by the parent rock type, topography and climate of the area. Soil thickness will be affected by erosional processes on steep slopes and depositional processes on low-lying areas of low relief. Soils on steep slopes are generally restricted to thin, coarse-grained transported soils (talus gravel deposits). On low relief terrain, the deposition of thicker, finer accumulations of transported soil (hillwash and colluvium) is common and this also aides the formation of residual soils, which are formed by the chemical weathering of the parent rock.

Observations made at the proposed sites of the individual turbines, which are generally planned on the upland areas of low relief, suggest that shallow rock exists over most of the sites and the transported soil horizon is generally, particularly in the southern region. The development of residual soil is likely to be limited to low-lying areas.

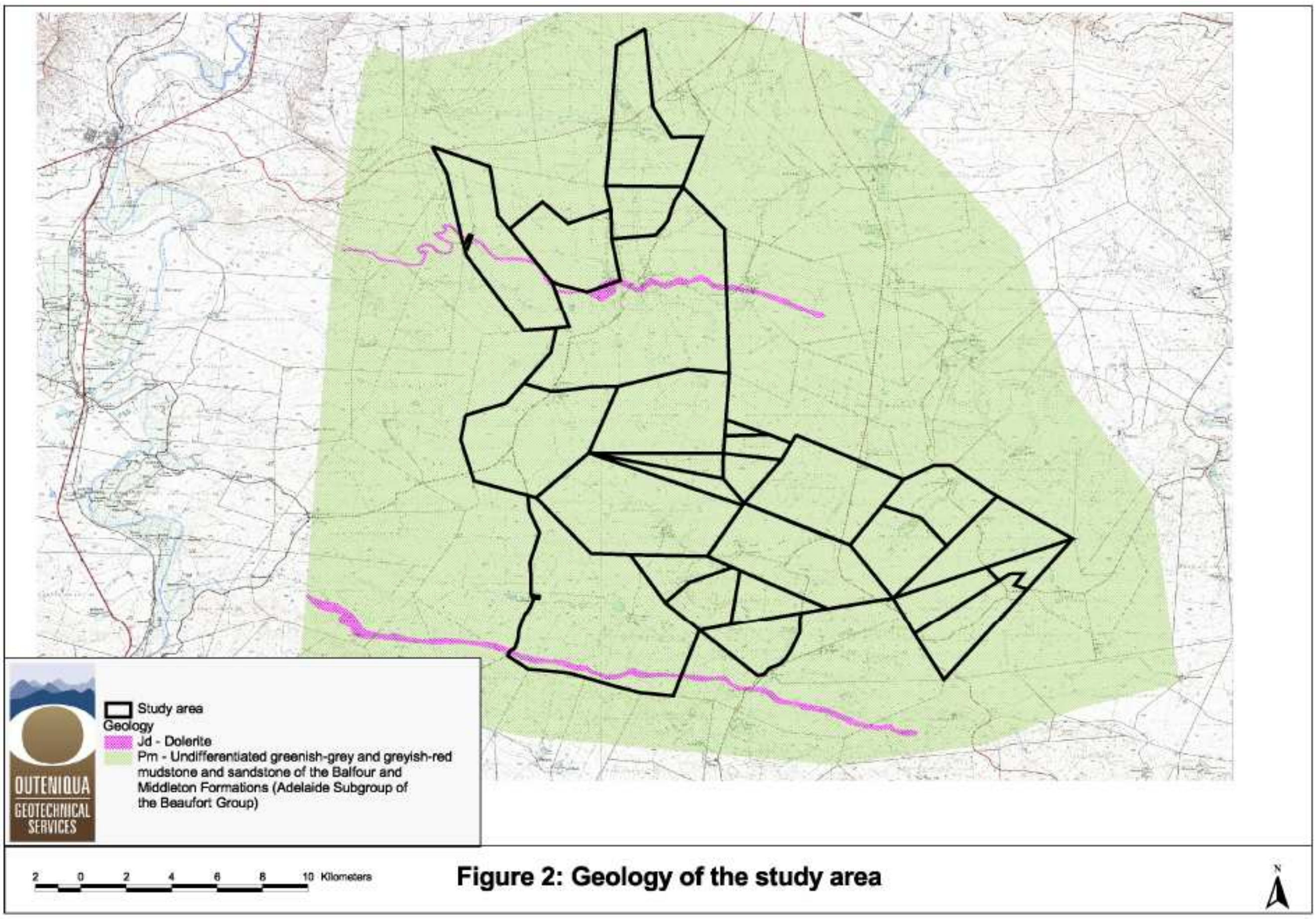

Figure 3: Geological map of the study area.

2.4. Hydrology

The hydrology of the study area plays an important role in the erosion potential. Rainfall, if not intercepted by vegetation or by artificial surfaces, falls on the earth where it may evaporate, infiltrate, lie in depression storage or end up as surface run-off. The permeability of the ground influences the percentage of rainfall which infiltrates. Where soil cover is thin or impermeable, infiltration will tend to be lower and vice versa. Surface run-off is generally inversely proportional to infiltration, ceteris paribus. Rainfall intensity and slope gradient influence the velocity and energy of the surface run-off. The energy of the hydraulic system and the soil texture and consistency are the main determining factors of the erosion potential. The presence of vegetation and other erosion inhibitors will tend to reduce the energy of the hydraulic system as well as providing an anchoring effect on the soil mass.

The transported soil cover on the steep slopes (colluvium, talus) is generally coarser grained and will be relatively permeable but the soil cover tends to be thin overlying rock, thus restricting infiltration. The coarse nature of this soil means that it will be less susceptible to erosion.

Run-off from upland areas will tend to concentrate in gullies along natural drainage lines which will join other small tributaries as it flows down and the velocity of the run-off will tend to decrease but volume will increase.

Lowland areas of low relief will tend to have thicker soil cover and but lower permeability due to finer soil texture. The hydraulic energy of run-off is generally lower in in distal areas but the fine-grained and unconsolidated nature of the transported soil in these areas means that a lower energy system can still cause erosion of the finer grained soil.

3. GEOLOGICAL IMPACT ASSESSMENT

The geological impact assessment aims to assess the impact that the proposed development will have on the geological environment which includes the parent rock and the natural soil profile. Important or prominent geological features (geosites) that contribute to the aesthetic scenery or geological interest in the area, such as fossil sites, prominent rock outcrops or features, are also considered in the impact study. Geological features, such as caves, addits, middens, worship rocks, etc. which are important from historical, cultural, archaeological or religious heritage standpoint are not assessed in this report as they are generally covered in the Heritage Impact Assessment. Geohydrological assessments also do not form part of this study.

Although the Karoo rocks are known for their rich abundance of fossils, this cannot be accurately predicted and development planning cannot reasonably be halted unless a very important fossil assemblage is known to occur within the site or encountered during earthworks. At this stage, there are no known important or prominent geological features and the parent rock is unlikely to be detrimentally affected by the proposed activity, as there are no deep excavations planned at this stage. Borrow pit or quarry operations will be dealt with if and when required under the MPRD Act (see **Chapter 1.2**) and potential impacts on fossils will be identified through the specialist palaeontology assessment. Therefore, the impact on the natural soil profile is the primary focus of this study as it is important for the sustainability of ecosystems.

3.1. Soil degradation

Soil degradation is the removal, alteration or damage to soil and soil forming processes, usually due to human activity. The stripping of vegetation or disturbance to the natural ground level over disturbance areas will negatively impact on soil formation, natural weathering processes, moisture levels, soil stability, humus levels and biological activity. Soil degradation includes erosion (due to water and wind), salinisation, acidification, water-logging, pollution, soil mining and burial, compaction and crusting[8].

The proposed activity will include excavation or displacement of soil, stockpiling, mixing, wetting and compaction of soil and pollution and these activities carry potential negative direct impacts contributing to soil degradation. These activities could also cause negative indirect impacts such as increased siltation in other areas away from the site causing negative impact on water sources and agriculture with socio-economic repercussions. The severity or significance of the various impacts is related to the nature and extent of the activity. There are no known positive impacts relating to the geological environment and the impacts are dominantly related to the construction phase with very little additional impacts in the post construction and decommissioning phases.

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 geological 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 agricultural production and self sufficiency. 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 conditions.

The Erosion Index for South Africa[4] indicates that the area where the site is located has a moderate to high susceptibility to erosion. The erodibility index is determined by combining the effects of slope, geology of soil type, rainfall intensity and land use. Soil erosion concerns will be greatest at the foot of steep slopes where run-off velocity is high and soil types are typically fine-grained and unconsolidated. Erosion gulleys will tend to form along natural drainage lines where run-off is concentrated and where vegetation is limited or has been disturbed or damaged (e.g. due to overgrazing). Several erosion scars are mapped on the 1:50 000 topographical maps of the area and are visible on the aerial photographs. These features occur on the following farms: Vogelfonteyn 219 Paardekloof 223, Olive Woods Estate 169, Taaifontein 224, Stompstartfontein 168. These erosion scars have developed at the foot of moderately steep slopes where finer soils tend to accumulate and the run-off energy off the slopes is still high enough to take fine grained soil particles into suspension. As hydraulic energy dissipates down-slope, erosion tends to reduce and is generally limited to riverbanks. The severity of erosion is affected by, amongst other factors, the thickness, texture and consistency of the soil. The occurrence of rock outcrops, or areas with shallow rock, will have a significant limiting effect on the erosion potential of this area. Construction activity on slopes will tend to promote soil erosion and these areas will require more protection before, during and after construction.

The proposed development layout indicates that turbines are concentrated on upland areas of low relief. This is primarily to maximise wind energy but also to reduce construction access difficulty and improve stability of turbine foundations. These areas also tend to be less sensitive i.t.o. erodibility potential as the hydraulic energy is generally low and the unconsolidated transported soils are generally thinner. In summary, slopes steeper than 1:4 and areas associated with natural drainage lines (especially at the foot of steep slopes) should be avoided if possible. **Table 1** outlines the sensitivity in terms of erosion susceptibility.

Sensitivity Level	Area/Terrain	Comments/Recommendations
High	Natural drainage lines/ watercourses (including buffer zone 30m each side from centreline)	No-go areas without special mitigating measures
Moderate	Steep slopes (>1:4) and lowland areas below steep slopes (foothills)	Erosion is occurring in these areas – mitigating measures important
Low	High-lying areas of low relief, plateaus	No significant erosion taking place at present - Normal mitigating measures apply

Table 1: Erosion sensitivity

3.2. Degradation of parent rock

It is a common misconception that excavations into bedrock do not affect environment. Apart from the impact on the overlying soil, excavations into bedrock may result in unsightly scars, resulting in potential visual impacts. More importantly, deep or poorly planned excavations may potentially affect the stability of the surroundings, such as rock slides along road cuttings. Excavations into bedrock may also affect the geohydrology of an area and can even contaminate groundwater. Blasting operations associated with excavations into rock have obvious environmental issues, chiefly including noise pollution, dust, vibrations and chemical hazards.

The proposed activity in areas of high relief may have significant impact in this regard as the access roads may involve deep cut-and-fill operations. This will depend on the layout of access roads and the transportation requirements.

3.3. Degradation of geo-sites

Geo-sites are interesting or academically important geological exposures or features that require protection for obvious reasons and the environmental impact process needs to cater for these aspects, if they occur within the site. The occurrence of these sites is not always apparent unless the particular feature is well known (such as a prominent rock feature like the Maltese Cross in the Cederberg). Geo-sites that are less well-known or that have local or academic significance may be brought to light during the Public Participation Process. At this stage, there are no known geo-sites on the site.

3.4. Assessment of impacts

The proposed activity involves earthworks on numerous individual construction footprints around each turbine, substation, etc. and interleading gravel access roads. The proposed layout plan is shown in **Figure 2**. No alternative study area has been proposed but the structures can be shifted within the broader study area to accommodate sensitive areas, if these occur where structures are planned.

The most important geological issues are the direct impacts of soil degradation and erosion of topsoil from the area of activity. This would affect the ecosystems operating in the topsoil and the plant and animal species that depend on it for growth and survival. Other direct impacts would include the loss of agricultural potential of the area. The significance of these impacts obviously depends on the present quality of the topsoil and the agricultural potential of the area. The proposed positioning of turbines generally falls within areas of low-moderate sensitivity in terms of soil erosion.

Indirect impacts could include increased siltation in nearby streams and dams caused by an increase in erosion from the site and socio-economic impacts resulting from the loss of topsoil and lower agricultural potential.

Direct, indirect and cumulative 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).

3.4.1. Direct impacts

An assessment of the individual direct potential impacts associated with the proposed activity is outlined in **Table 2**.

Nature: Soil degradation – Removal or burial of topsoil (cut-and-fill) in disturbance areas (areas where construction activity takes place around proposed structures or along access roads) impacting on soil forming processes and resources.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Long term (4)**	**Medium term (3)**
Magnitude	**High (8)**	**Moderate (6)**
Probability	**Definite (4)**	**Definite (4)**
Significance	**Moderate (52)**	**Moderate (40)**
Status	**Negative**	**Negative**
Reversibility	**Partially reversible**	**Partially reversible**
Irreplaceable loss of resources?	**Yes, moderate**	**Yes, minor**
Can impacts be mitigated?	**Yes, to a certain extent**	
Mitigation:	• **Minimise disturbance areas.** • **Rehabilitate soil and vegetation after construction.**	
Cumulative impacts:	**Potential removal of soil/rock from foundations is 350 turbines x 600m^3=210 000m^3). This excludes earthworks for assembly platforms. This is the second wind farm in the area and there are possibly others planned in the future. The cumulative impact of topsoil removal and burial is considered moderate even with mitigation.**	
Residual impacts:	**Minor – slow regeneration of topsoil.**	

Nature: Soil degradation – Pollution, salinisation, acidification or water-logging of natural soil in construction areas affecting soil formation processes.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Medium term (3)**	**Short term (2)**
Magnitude	**Low (4)**	**Low (4)**
Probability	**Probable (3)**	**Probable (3)**
Significance	**Low (24)**	**Low (21)**
Status	**Negative**	**Negative**
Reversibility	**Partially reversible**	**Partially reversible**
Irreplaceable loss of resources?	**Yes, minor**	**Yes, minor**
Can impacts be mitigated?	**Yes**	
Mitigation:	• **Minimise disturbance areas.** • **Rehabilitate soil and vegetation.** • **Use spoil from excavations for landscaping or run off site – don't dump in piles.** • **Stage earthworks in phases across site so that exposed areas are minimised.** • **Keep to existing roads, where practical, to minimise impacts on undisturbed ground.**	
Cumulative impacts:	**Cumulative impact of soil pollution from all development in the area is considered low if mitigating measures are applied diligently.**	

Residual impacts:	**Minor negative – slow regeneration of vegetation & soil.**

Nature: Soil degradation – Mixing, dumping, stockpiling and compaction of topsoil affecting soil formation processes.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Medium term (3)**	**Very short term (1)**
Magnitude	**Low (4)**	**Low (4)**
Probability	**Highly Probable (4)**	**Highly Probable (4)**
Significance	**Moderate (32)**	**Low (24)**
Status	**Negative**	**Negative**
Reversibility	**Partially reversible**	**Partially reversible**
Irreplaceable loss of resources?	**Yes, moderate**	**Yes, minor**
Can impacts be mitigated?	**Yes, to a certain extent**	
Mitigation:	• **Prevent unnecessary excavations and stockpiling.** • **Restrict height of stockpiles to reduce compaction.** • **Restrict number of access roads and minimise traffic.** • **Rehabilitate soil and vegetation in areas of activity.** • **Keep to existing roads, where practical, to minimise impact on undisturbed ground.** • **Stage earthworks in phases to minimise exposed ground.**	
Cumulative impacts:	**The cumulative impact of soil mixing, etc from all development in the area is considered low if mitigating measures are adopted.**	
Residual impacts:	**Minor negative – slow regeneration of soil processes in and under topsoil**	

Nature: Soil degradation – Increased sheet, rill or gulley erosion and deposition down-slope due to the removal of vegetation and other activity in construction areas.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Medium term (3)**	**Very short term (1)**
Magnitude	**Moderate (6)**	**Low (4)**
Probability	**Highly probable (4)**	**Probable (3)**
Significance	**Moderate (40)**	**Low (18)**
Status	**Negative**	**Negative**
Reversibility	**Practically irreversible**	**Practically irreversible**
Irreplaceable loss of resources?	**Yes, moderate**	**Yes, minor**
Can impacts be mitigated?	**Yes**	
Mitigation:	• **Restrict zone of disturbance.** • **Implement effective erosion control measures.** • **Stage construction in phases to minimise exposed ground.** • **Keep to existing roads, where practical, to minimise impact on undisturbed ground.** • **Ensure stable slopes of stockpiles/excavations to minimise slumping**	
Cumulative impacts:	**The cumulative impact of soil erosion from all development in the area is considered low if mitigating measures are**	

	adhered to.
Residual impacts:	**Minor – Localised movement of sediment. Slow regeneration of soil processes**

Nature: Degradation of parent rock – Excavations and or blasting causing degradation to local geology and instability.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Permanent (5)**	**Permanent (5)**
Magnitude	**Low (4)**	**Minor (2)**
Probability	**Probable (3)**	**Probable (3)**
Significance	**Moderate (30)**	**Low (24)**
Status	**Negative**	**Negative**
Reversibility	**Irreversible**	**Irreversible**
Irreplaceable loss of resources?	**Yes, minor**	**Yes, minor**
Can impacts be mitigated?	**To a certain degree**	
Mitigation:	• **Restrict zone of disturbance and plan excavations carefully.** • **Plan any new access roads taking contour lines into consideration to minimise cutting and filling operations.** • **Keep to existing roads, where practical, to minimise impacts on undisturbed ground.**	
Cumulative impacts:	**The cumulative impact of rock degradation from all development in the area is considered low if mitigating measures are applied diligently.**	
Residual impacts:	**Minor – Some visual impact along access roads. Some noise impacts caused by blasting.**	

Table 2: Assessment of potential direct impacts

3.4.2. Indirect impacts

An assessment of the indirect potential impacts associated with the proposed activity is outlined in **Table 3** below.

Nature: Soil degradation - Deposition down-slope affecting soil forming processes and siltation of waterways and dams.		
	Without mitigation	**With mitigation**
Extent	**Local (1)**	**Local (1)**
Duration	**Permanent (5)**	**Permanent (5)**
Magnitude	**Moderate (6)**	**Low (4)**
Probability	**Probable (4)**	**Probable (3)**
Significance	**Moderate (48)**	**Low (30)**
Status	**Negative**	**Negative**
Reversibility	**Irreversible**	**Irreversible**
Irreplaceable loss of resources?	**Yes, moderate – depends on planning**	**Yes, minor**
Can impacts be mitigated?	**Yes, to a certain degree**	
Mitigation:	**Install anti-erosion measures such as silt fences in disturbance areas.**	

Cumulative impacts:	**The cumulative impact of siltation from all development in the area is considered low if mitigating measures are applied diligently.**
Residual impacts:	**Minor localised movement of soil across site**

Table 3: Assessment of potential indirect impacts

3.4.3 Impact statement

The overall impact of all the proposed activity on the geological environment is considered moderate without mitigating measures. With effective implementation of mitigating measures the impacts identified above can be reduced to a low level.

3.5. Mitigating measures

Negative impacts can be mitigated to a large degree by the implementation of an appropriate and effective EMP.

The objectives, impacts, risks and mitigating measures that are required for inclusion in the EMP are outlined in **Table 4** below:

OBJECTIVE: Soil and rock degradation and erosion control

The soil resource on the site needs to be conserved as far as possible to minimise the cumulative impact on the local environment.

A set of strictly adhered mitigation measures are required to effectively limit the impact on the environment. The disturbance areas where human impact is likely are the focus of the mitigation measures laid out below.

Project components and areas of activity	Wind turbines
	Access roads
	Substations
	Workshops
	Underground cables
	Overhead powerlines
Potential Impact	Degradation of soil
	Degradation of local geology
	Soil erosion
	Siltation of drainage lines
Activities/risk sources	Rainfall and wind
	Excavation, mixing, dumping, stockpiling and compaction of soil
	Concentrated discharge of water from construction activity
Mitigation:	To minimise degradation of rock and soil by construction activity

Target/Objective	To conserve topsoil by stockpiling and re-using in disturbance areas
	To minimise erosion of soil from site during construction
	To minimise deposition of soil into drainage lines

Mitigation: Action/control	Responsibility	Timeframe
Identify disturbance areas and restrict construction activity to these areas.	ECO/Contractor	Before and during construction
Access roads to be carefully planned and constructed to minimise the impacted area and prevent unnecessary excavation, placement and compaction of soil.	Engineer/ECO/ Contractor	Before and during construction
Dust control on construction site: Wetting/covering of denuded areas.	Contractor	During construction
Rehabilitate disturbance areas as soon as an area is vacated.	Contractor	During and after construction
Strictly control vibration pollution from compaction plant or excavation plant.	Contractor	During construction
Soil conservation: Stockpile topsoil for re-use in rehabilitation phase. Maintain stockpile shape and size and protect from erosion.	Contractor	Before and during construction
Erosion control measures: Run-off attenuation on slopes (sand bags, logs), silt fences, stormwater catch-pits, shade nets or temporary mulching over denuded 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	Engineer/ECO/ Contractor	Before construction and maintenance over duration of contract
Control depth of excavations and stability of cut faces/sidewalls	Engineer/ECO/ Contractor	Before construction and maintenance over duration of contract

Performance Indicator	• Acceptable level of soil erosion around site • Acceptable level of increased siltation in drainage lines • Acceptable level of soil degradation • Acceptable state of excavations • No activity in restricted areas
Monitoring	• Regular inspections of the site by ECO

	• Fortnightly inspections of sediment control devices • Fortnightly inspections of surroundings, including drainage lines • Immediate reporting of ineffective sediment control systems • An incident reporting system will record non-conformances

Table 4: EMP guidelines

4. GEOTECHNICAL CONSTRAINTS

A basic preliminary assessment of the geotechnical nature of the study area affords the opportunity to identify any potential fatal flaws with the proposed site, in terms of the suitability of the site for development. A basic assessment of the main geotechnical constraints that may impact on the civil engineering design is given in **Table 5**.

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
Collapsible & compressible soil	Soil horizons with a potentially collapsible or compressible fabric unsuitable for foundations.	Low-medium	Unconsolidated transported soils are potentially compressible and collapsible under load. Dynamic compaction of soil will be necessary or found on rock.
Differential settlement (DS)	Foundations placed across different soil types or rock may settle differentially.	Medium-High	Depth to bedrock or very dense soil horizons (residual) will vary across the site. Recommend found individual structures on very dense residual soil or preferably rock.
Bearing capacity	Soils with low in situ bearing capacity resulting in high settlements of structures if not compacted or engineered properly	Low-Medium	Transported sands: 50-80kPa, depending on level of consolidation. Not favourable. Residual soils: 50-250kPa, depending on moisture, structure and consistency. Not favourable. Rock: >250kPa, depending on lithology, structure and state of weathering. Favourable rock will be found at relatively shallow depths over most of the turbine sites.
Saturated soils, groundwater problems, perched or permanent water tables	Seepage from sidewalls of excavations affecting stability or dewatering of trenches necessary.	Low	Groundwater problems are unlikely to affect shallow excavations on upland areas. Perched water tables may exist on residual soils or underlying rock in depressions or low-lying areas.
Active soil	Heaving clays affecting foundation stability	Low-Medium	Active clay anticipated in residual weathered mudstones or dolerite. Found all turbines below clay on rock or very dense gravelly soil.
Excavations	Boulders or rock affecting excavations	Medium-high	Difficult excavations expected below 1m in most upland areas. Access roads may involve rock cuttings.

Geotechnical Constraint	Effect on the proposed development	Severity	Comment & recommendations
	Unstable excavations requiring shoring	Low-medium	Sidewalls of excavations exceeding 1m in unconsolidated sandy soils will be unstable. Temporary slopes to be battered to 1:2. Excavations into rock will be marginally stable.
Slope stability	Geological instability causing damage to structures founded on slopes	Low	No unstable slopes in development footprint.
Seismic activity	Structures at risk of damage due to seismicity	Low-Medium	Eastern Cape is a potentially active seismic area. Seismic intensity of VI (MMS) and peak ground acceleration of less than $50cm/s^2$ with a 90% chance of not being exceeded within 50 years.
Flood potential or storm water damage	Low lying areas affected by poor drainage.	Low	Most of the upland areas are well drained.
	Steep slopes affected by uncontrolled run-off	Low	Turbine are not sited on steep slopes which could be unstable.
Unconsolidated fill	Unconsolidated fill material affecting foundations	Low	Minor fill associated with existing farm buildings and dams
Availability of local construction material	Large distances to nearest quarry for sources of suitable construction material negatively affect construction costs	High	Nearest major centre is Port Elizabeth (200km). Potential local sources of construction material (on site) are restricted to selected fill (weathered or ripped shale/sandstone).
Mining Activity	Past, present or future mining activity which may affect development of the site	Low	No known mining activity (developer should confirm this with land owner)

Table 5: Geotechnical constraints on the proposed development

The above classification highlights some basic potential constraints, none of which are considered insurmountable. A detailed geotechnical investigation should be undertaken before the engineering design phase to provide more information. Geotechnical supervision or input is recommended during construction.

5. CONCLUSIONS

The proposed development will have a low to moderate impact on the geological environment and these impacts can be largely mitigated with a resultant low overall significance due to the scattered nature of the proposed activity and the limited extent of the proposed earthworks. The anticipated geology also appears to be generally favourable in terms of erodibility potential. The proposed layout of turbines has been designed to avoid areas of the site with unfavourable topography and this bodes well for erosion. The proposed layout is deemed acceptable in terms of this impact study.

A basic assessment of the potential geotechnical constraints on the project indicates no insurmountable problems or "fatal flaws" which have may have an impact on the design and construction processes.

6. REFERENCES AND BIBLIOGRAPHY

1. South African National Biodiversity website (www.sanbi.org).
2. South African Weather Service website (www.weathersa.co.za).
3. Department of Water Affairs website (www.dwaf.gov.za).
4. Department of Environmental Affairs website (www.environment.gov.za)
5. Brink, A.B.A. (1979) Engineering Geology of South Africa (Series 1-4). Building Publications, Pretoria.
6. Identification of Problematic Soils in Southern Africa (2007). Technical notes for civil and structural engineers. Published by the Department of Public Works.
7. Mucina, L., Rutherford, M.C. & Powrie, L.W. (eds) 2005. Vegetation map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. South African National Biodiversity Institute, Pretoria.
8. Garland, G., Hoffman, T. And Todd, S. Soil degradation (in Hoffman, T., Todd, S., Ntshona, Z. And Turner, S. (eds) (1999). Land degradation in SA, Chapter 6, NBRI, Kistenbosch.