GEOLOGICAL IMPACT ASSESSMENT REPORT

SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED HAPPY VALLEY WIND ENERGY FACILITY NEAR HUMANSDORP, EASTERN CAPE PROVINCE, SOUTH AFRICA

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List of abbreviations and definitions

AMSL:	Above mean sea level
ECO:	Environmental Control Officer
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
ER:	Engineer's representative
Ma:	Million years ago
NEMA:	National Environmental Management Act 107 of 1998
NGL:	Natural ground level
Study area:	The area delineated on Figure 1
WEF:	Wind Energy Facility

1. INTRODUCTION

1.1. Background

Renewable Energy Investments South Africa (Pty) Ltd is in the process of investigating the feasibility of the proposed Happy Valley Wind Energy Facility (WEF) on a site 9km northwest of Humansdorp in the Eastern Cape Province. The proposed activity is defined as the establishment of a Wind Energy Facility and associated infrastructure. The proposed facility includes:

- 13 wind turbines and foundations to support them;
- Electrical cabling between turbines;
- On-site substation to facilitate connection to the grid;
- Power lines linking to Eskom's existing Melkhout substation;
- Access roads;
- Maintenance and storage buildings.

The wind energy facility is proposed on Portion 1 and Remaining Extent of Farm 810 in the Humansdorp district and is indicated in **Figure 1**.

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 requires authorisation from the National Department of Environmental Affairs (DEA) for the undertaking of the proposed project.

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

1.3. Terms of reference

Savannah Environmental has been appointed by Renewable Energy Investments South Africa to carry out the EIA process for the proposed activity. Specialist input is required in order to assess the environmental impacts on the geological environment (natural soil, bedrock and geological features/landforms) associated with the proposed activity. Savannah Environmental has appointed Outeniqua Geotechnical Services cc to conduct a specialist geological impact assessment.

The following scope of work has been given:

- Conduct a site visit to collect data pertaining to the physical and geological nature of the study area.
- Describe the geological environment and discuss the potential environmental impacts on the geological environment that may be associated with the proposed activity.
- Quantitatively assess the potential negative and positive impacts and provide mitigating measures for inclusion in the EMP.

1.4. Limitations

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

1.5. Authors credentials & declaration of independence

The author of this report, Iain Paton of Outeniqua Geotechnical Services cc (OGS), is a professional engineering geologist registered with the South African Council for Natural and Scientific Professions (Pr Sci Nat # 400236/07) with 12 years experience in the mining, energy and construction industries. 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). 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 report.

2. SITE DESCRIPTION

2.1. Location

The study area is located near Humansdorp in the Eastern Cape, which is approximately 90km west of Port Elizabeth, which is the nearest major commercial centre. Access to the study area is via the N2 and then R102 between Humansdorp and Kareedouw (see **Figure 1**).

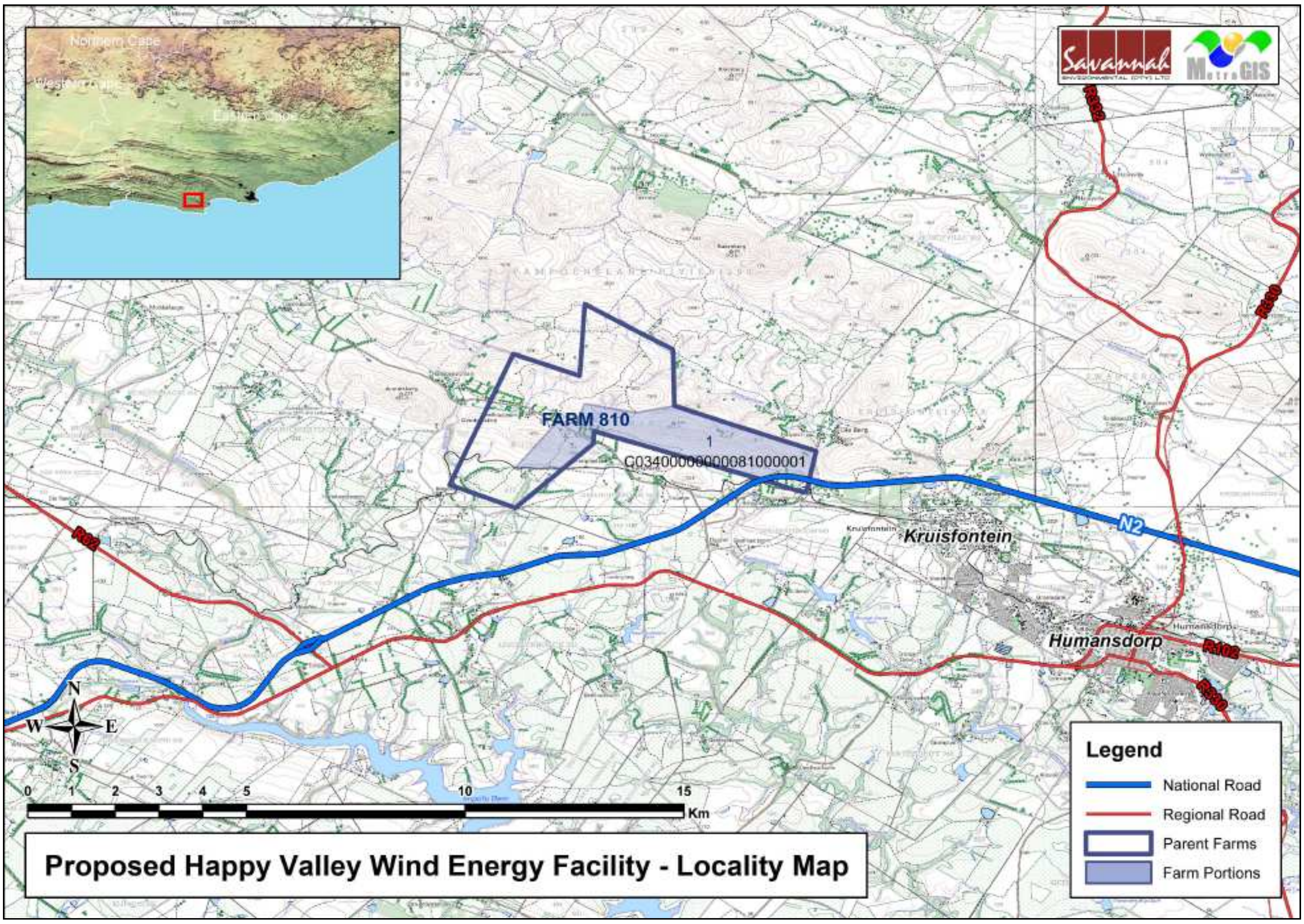

Figure 1: Locality map of the study area (dark blue polygon)

2.2. Topography, climate, & vegetation cover

The proposed development site is situated on the hills to the north of the main access gravel road (in red in **Figure 2**). The slope gradients increase sharply up towards the summits of the hills and the terrain is generally rough and inaccessible with normal vehicles. Access to the hilltops can be gained with a quad-bike via narrow farm tracks from the camps below. The highest peak within the boundary of the study area reaches an altitude of 565m AMSL.

The proposed site falls within the coastal temperate climatic region of South Africa which is characterised by frontal weather, leading to changeable, often overcast and moderate conditions. Seasonal variation in temperatures is generally mild, but snow can occur at high altitudes on Cape mountain ranges. Midday temperatures typically range between 15 and 25°C [2] and mean annual precipitation is 650-800mm.[4] The Weinert Climatic N-number[7] for the area, which is approximately 2, indicates that the climate is semi-humid and chemical weathering processes are dominant.

Vegetation on the slopes dominantly consists of Fynbos (False Macchia[12]) and the foothills below are significantly transformed pastures.

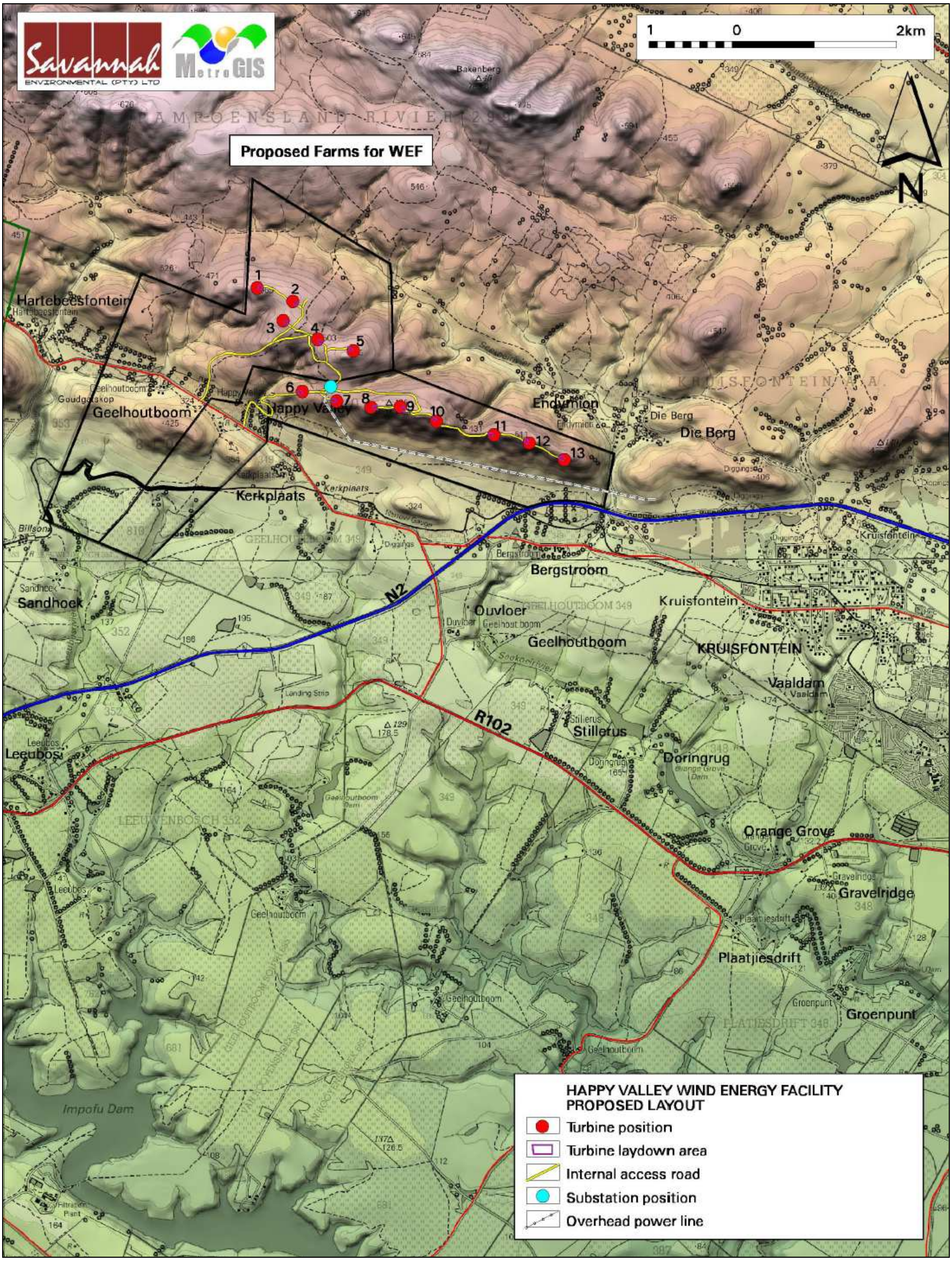

Figure 2: Topographical map of site showing the proposed infrastructure layout

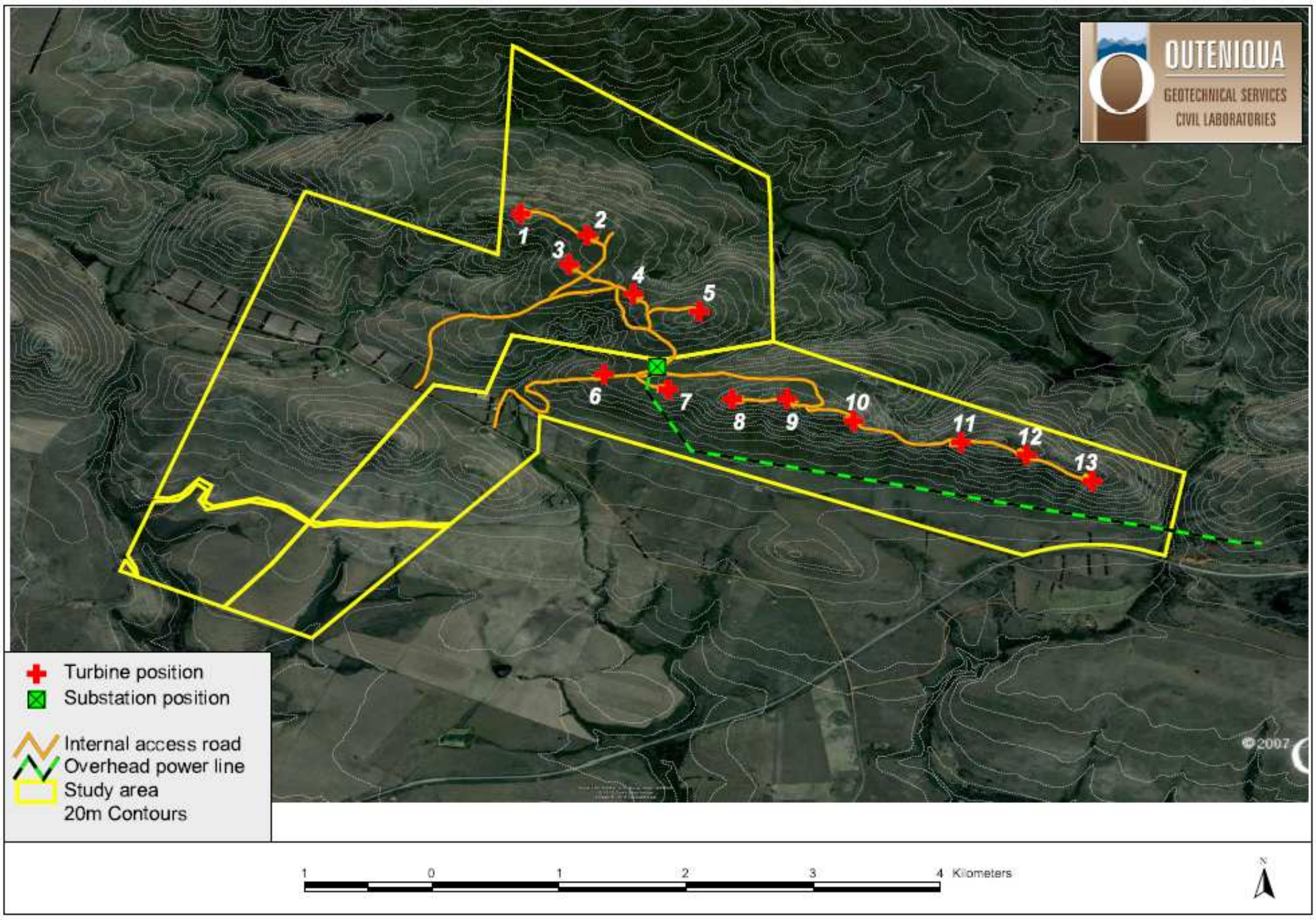

Figure 3: Aerial photo of study area showing contours and proposed infrastructure

2.3. Geology & soil types

The proposed turbines are positioned along the crest of the hills in the northern and eastern portions of the study area and these hills are underlain by hard, resistant quartzite of the Peninsula Formation. The southern foothills are underlain by softer feldspathic sandstone and siltstone and of the Goudini Formation.

The steep slopes are covered by thin veneer of talus gravel and boulders with localised organic-rich topsoil development between rock outcrops. The average grain size of the soil cover will tend to decrease downslope but gravelly soils remain dominant. The development of residual clay on Goudini Formation sandstone on the lower slopes is expected.

Shallow, hard quartzitic rock or outcrops are expected over 90% of the proposed development footprint area.

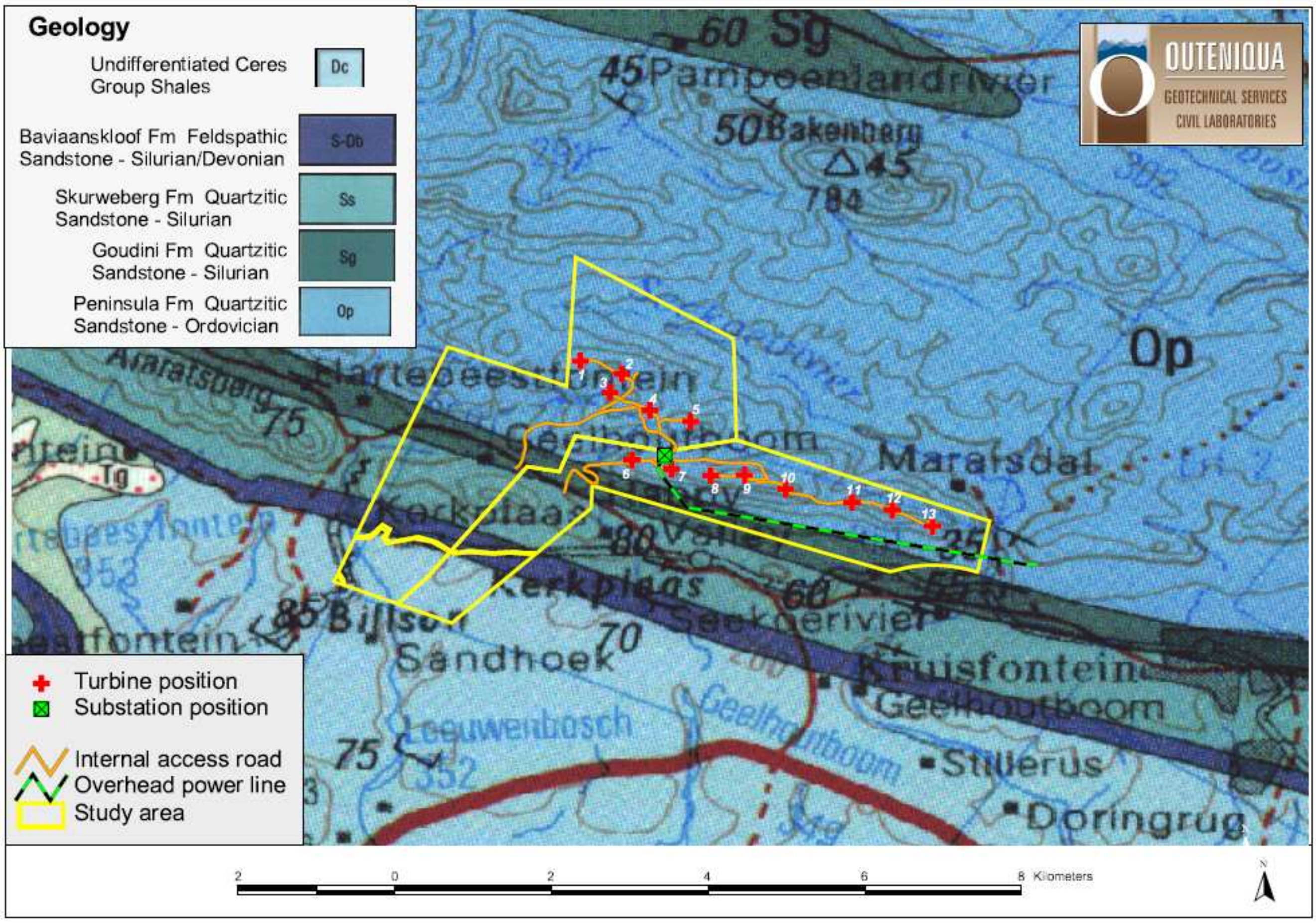

Figure 4: Geological map of the study area.

2.4. Hydrology

The site falls within the K90E and K90F quaternary catchment areas which drain into the Krom and Seekooi Rivers, respectively. Mean annual precipitation for the study area is 650-800mm and expected run-off is high in areas underlain by Peninsula Formation quartzite.

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 natural soil cover, bedrock geology and other geological landforms. Important or prominent geological features or landforms (geosites) that contribute to the aesthetic scenery or geological interest in the area also considered in the impact study. Geological features, such as middens, addits, etc. which are important from archaeological or heritage perspective are not covered in this report. The geohydrological environment is also not covered in this study.

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 due to construction activity will negatively affect soil formation, natural weathering processes, moisture levels and soil stability. This will, in turn, affect biological processes operating in the soil. Soil degradation includes erosion (i.e. due to water and wind), soil removal, mixing, wetting, compaction, pollution, salinisation, crusting, and acidification.

The proposed activity may potentially result in all or some of the above negative direct impacts. The proposed activity could also result in negative indirect impacts, such as increased siltation in waterways downstream from the site or dust pollution in the area surrounding the site. 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 insignificant 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 global agricultural potential. 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 more important due to the magnitude of the potential impact over a relatively short period of time which can be very difficult to control. 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 (e.g. construction sites). Erosion sensitivity can be broadly mapped according to the severity of the potential erosion if land disturbing activities occur and this is generally related to the geology, soil types and the topography. Generally speaking, unconsolidated or partly consolidated fine-grained soils of low plasticity along drainage lines and 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. These areas are typically called "highly sensitive" areas.

Specifically relating to the site in question, the geological map in **Figure 3** indicates that the vast majority of the proposed site is underlain by hard resistant quartzite rock of the Peninsula Formation. The soil cover in this geological terrain is typically thin and consists of coarse-grained granular soils (gravels) and boulders which are not easily eroded by normal volumes of run-off. In areas where run-off is concentrated, such as along natural drainage lines, hydraulic energy is higher and erosion is more common. **Table 2** summarises the site sensitivity in terms of water erosion.

Table 2: Water erosion sensitivity

Sensitivity Level	Area/Terrain	Comments/Recommendations
Moderate	Natural drainage lines	Natural erosion taking place at present. No-go areas.

Low	Remainder of site	Minor natural erosion taking place at present. Normal mitigating measures apply.

3.2. Degradation of bedrock and topography

Excavations for foundations, pipelines and access roads in areas where shallow bedrock occurs will have a negative impact on the bedrock. However, the excavations are likely to be restricted and to a depth of less than a few meters which will have minimal effect on the surroundings. Excavations for access roads in areas with steep and rugged terrain may involve significant road cuttings which may result in unsightly scars on the hillside. Road cuttings can also lead to slope instability if not engineered properly, resulting in further degradation of the landscape. Degradation of the natural topography can also lead to changes in the hydrology and groundwater regime of the surroundings.

3.3. Degradation of geo-sites

Geo-sites are interesting or scientifically important geological features or landforms 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. At this stage, there are no known geo-sites on the site.

3.4. Assessment of impacts

The environmental impact assessment aimed to evaluate the impact that the proposed activity will have on the geological environment and attempted to provide mitigating measures to minimise the impact.

The most important geological issues are the direct negative impacts of soil and rock degradation during the bulk earthworks phase for the construction roads, pipelines, and structures. Indirect negative impacts could include increased siltation in watercourses downstream caused by an increase in erosion from the site or increased dust pollution away from the site. There are no positive impacts envisaged. 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).

3.4.1. Direct impacts

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

Table 2: Assessment of potential direct impacts

Nature: Soil degradation – Excavation and removal of soil for roads, pipelines and structures.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Long term (4)	Medium term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Definite (5)	Definite (5)
Significance	**Moderate (55)**	**Moderate (40)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible

Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to a certain extent.	
Mitigation:	» Use existing roads where possible. » Design platforms, lay-down areas and roads according to contours to minimise cut and fill operations. » Restrict activity outside of authorised construction areas. » Rehabilitate soil after construction.	
Cumulative impacts:	» The cumulative impact of soil removal in the area is considered low due to undeveloped nature of the area.	
Residual impacts:	» Minor negative – slow regeneration of topsoil.	

Nature: Soil degradation – Loosening, mixing, wetting & compacting of in situ soil during earthworks.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Short term (2)
Magnitude	Moderate (6)	Low (4)
Probability	Definite (5)	Definite (5)
Significance	**Moderate (50)**	**Moderate (35)**
Status	Negative	Negative
Reversibility	Irreversible	Reversible
Irreplaceable loss of resources?	Yes	Minor
Can impacts be mitigated?	Yes, to a certain extent	
Mitigation:	» Use existing roads where possible. » Design platforms and roads according to contours to minimise cut and fill operations. » Restrict activity outside of construction areas. » Rehabilitate soil after construction.	
Cumulative impacts:	» The cumulative impact of earthworks in the area is considered low due to the undeveloped nature of the area	
Residual impacts:	» Minor negative – slow regeneration of vegetation & soil.	

Nature: Soil degradation – Pollution of soil by contaminants (e.g. fuel, oil, chemicals, cement).		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (2)	Very short term (1)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Low (21)**	**Low (12)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible

Irreplaceable loss of resources?	Yes	Minor
Can impacts be mitigated?	Yes, to a certain extent	
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 due to the undeveloped nature of the study area.	
Residual impacts:	» Minor negative – slow regeneration of soil processes in and under topsoil	

Nature: Soil degradation – Soil erosion by wind and water.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Very short term (1)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (24)**	**Low (18)**
Status	Negative	Negative
Reversibility	Irreversible	Practically irreversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation:	» Minimise construction footprint area. » Restrict activity outside of construction area. » Implement effective erosion control measures. » Carry out earthworks in phases across site to reduce the area of exposed ground at any one time. » Keep to existing roads, where practical, to minimise loosening of natural ground. » Protect and maintain denuded areas and material stockpiles to minimise erosion and instability	
Cumulative impacts:	» The cumulative impact of soil erosion in the area is considered low due to the undeveloped nature of the area.	
Residual impacts:	» Minor – Localised movement of sediment. Slow regeneration of soil processes	

3.4.2. Indirect impacts

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

Table 3: Assessment of potential indirect impacts

Nature: Increased siltation of drainage lines and watersources downstream from site.		
	Without mitigation	***With mitigation***

Extent	Regional (3)	Local (1)
Duration	Long term (4)	Long term (4)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**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. » No development in or near water courses/natural drainage lines as sediment transport is higher in these areas.	
Cumulative impacts:	» The cumulative impact of siltation in the area is considered low.	
Residual impacts:	» Minor localised movement of soil across site	

Nature: Dust pollution from construction site affecting areas surrounding site.		
	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, low	Yes, minor
Can impacts be mitigated?	Yes	
Mitigation:	» Place dust covers on stockpiles » Use suitable gravel wearing course on access roads » Apply straw bales or dampen dusty denuded areas.	
Cumulative impacts:	» The cumulative impact of dust in the area is considered low.	
Residual impacts:	» Minor localised movement of soil across site	

3.4.3. Impact statement

The potential impacts on the geological environment are considered to have a low to moderate significance. With effective implementation of mitigating measures the impacts identified above can be reduced to an acceptable level.

The cumulative impact on the geological environment is considered low due to the localised and scattered nature of the proposed activity and the scarcity of development in the vicinity of the site.

3.4.4. Alternatives

There are no site alternatives under consideration. The no-go alternative will have no impact on the geological environment. The proposed development alternative will have a moderate to low impact which can be mitigated to an overall low impact significance.

3.5. Environmental Management Plan (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 shall be undertaken as per the requirements set out in the EMP.
2. All earthworks shall be undertaken in such a manner so as 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 detailed in a method statement for approval by the Site Manager.
4. No equipment associated with the activity shall be allowed outside of these areas unless expressly permitted by the Site Manager.
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. Blasting (If required)

1. A current and valid authorisation shall be obtained from the relevant authorities and copied to the ER prior to any blasting activity.
2. A method statement shall be required for any blasting related activities.
3. All laws and regulations applicable to blasting activities shall be adhered to at all times.
4. A qualified and registered blaster shall supervise all blasting and rock splitting operations at all times.
5. The contractor shall ensure that appropriate pre-blast monitoring records are in place (i.e. photographic and inspection records of structures in close proximity to the blast area).
6. The contractor shall allow for good quality vibration monitoring equipment and record keeping on site at all times during blasting operations.
7. The contractor shall ensure that emergency services are notified, in writing, a minimum of 24 hours prior to any blasting activities commencing on site.
8. The contractor shall take necessary precautions to prevent damage to special features and the general environment, which includes the removal of fly-rock. Environmental damage

caused by blasting / drilling shall be repaired at the contractor's expense to the satisfaction of the ER.

9. The contractor shall ensure that adequate warning is provided immediately prior to all blasting. All signals shall also be clearly given.
10. The contractor shall use blast mats for cover material during blasting. Topsoil may not be used as blast cover.
11. During demolition the contractor shall ensure, where possible that trees in the area are not damaged.
12. Appropriate blast shaping techniques shall be employed to aid in the landscaping of blast areas, and a method statement to be approved by the ER, shall be required in this regard.
13. At least one week prior to blasting, the relevant occupants/owners of surrounding land shall be notified by the contractor and any concerns addressed. Buildings within the potential damaging zone of the blast shall be surveyed preferably with the owner present and any cracks or latent defects pointed out and recorded either using photographs or video. Failing to do so shall render the contractor fully liable for any claim of whatsoever nature, which may arise. The contractor shall indemnify the employer in this regard.

3.5.5. Borrow pits and quarries (If required)

1. All borrow pit sites shall be clearly indicated on plan.
2. Prior to the onset of any quarrying or borrow pit activities the contractor shall establish from the ER whether authorisation has been obtained, both in terms of the Minerals and Petroleum Resources Development Act 28 of 2002 (via the compilation of an Environmental Management Programme Report) and in terms of the National Environmental Management Act (via the Environmental Impact Assessment process). No excavation or blasting activities shall commerce before the necessary authorizations are in place.
3. Borrow pits to be used must be approved by the ER and shall at all times be operated according to the regulations promulgated in terms of the Occupational Health & Safety Act (No 85 of 1993) and Noise Regulations of the Environment Conservation Act (No 73 of 1989).
4. Only a single lane access for construction vehicles shall be provided at borrow pit and quarry sites. New access roads require approval by the Engineer.
5. Stormwater and groundwater controls shall be implemented.
6. Machinery, fuels and hazardous materials vulnerable to flooding shall be stored out of flood risk areas.
7. Vehicles leaving borrow pits shall not deposit/shed mud, sand and debris onto any public road.
8. All loads shall be covered with a tarpaulin or similar to prevent dangers and nuisance to other road users.
9. Borrow pits shall be fenced to prevent unauthorized persons and vehicles from entering the area. Fences shall also be stock and game proof.
10. Rehabilitation and re-vegetation of borrow pits sites shall be according to a method statement to be approved by the ECO.
11. The contractor shall ensure that blasted faces of the pit shall be shape-blasted to the approval of the site manager.
12. Where required, dust and fly-rock prevention methods shall be detailed in a Method Statement to be approved by the site manager.

13. During the rehabilitation of borrow bits, the slope or the borrow pit shall be graded to blend with the natural terrain and be stabilized to prevent erosion.

3.5.6. 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.

3.5.7. Trenching

1. Trenching shall be kept to a minimum through the use of 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.

3.5.8. 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.

3.5.9. 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.

3.5.10. Summary of objectives and performance monitoring

A summary of the project components, potential impacts, mitigating measures and performance monitoring is outlined in **Table 4.**

Table 4: Summary of objectives of the EMP

OBJECTIVE: Soil and rock degradation and erosion control

The natural geological environment must be preserved as far as possible to minimise unforeseen impacts on the surrounding environment.

Project component/s	• Wind turbines • Access roads • Substation linking the facility to the electricity grid • Underground pipelines and cabling • Overhead power lines

Potential Impact	• Soil and rock removal • Soil mixing, wetting, stockpiling, compaction • Soil pollution • Accelerated soil erosion • Increased siltation of drainage systems • Dust pollution
Activity/risk source	• Construction activity – earthworks & transportation across site • Chemical pollutants • Rainfall - water erosion of disturbed areas • Wind - erosion of disturbed areas
Mitigation: Target/Objective	• To minimise destructive activity within construction areas & prevent unnecessary activity outside of construction areas • To minimise soil degradation (removal, excavation, mixing, wetting, compaction, pollution, erosion, etc.) • To minimise siltation of drainage lines • To minimise dust pollution

Mitigation: Action/control	**Responsibility**	**Timeframe**
Identify areas of high erosion risk (drainage lines/watercourses). Only special works to be undertaken in these areas to be authorised by ECO and Engineer's representative (ER)	ECO/ER/Contractor	Before and during construction
Identify construction areas for general construction work and restrict construction activity to these areas.	ECO/ER/Contractor	Before and during construction
Prevent unnecessary destructive activity within construction areas (prevent over-excavations and double handling)	ECO/ER/Contractor	Before and 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 that cross drainage lines and roads on steep slopes (to prevent unnecessary cutting and filling operations).	ECO/ER/Contractor	Before and during construction
Dust control on construction site: Wetting or covering of cleared areas.	Contractor	During construction
Minimise removal of vegetation which aids soil stability.	ECO/Contractor	During construction
Rehabilitate disturbance areas as soon as an area is vacated.	Contractor	During and after construction
Soil conservation: Stockpile topsoil for re-use in rehabilitation phase. Protect stockpile from erosion.	Contractor	Before and 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

Mitigation: Action/control	Responsibility	Timeframe
		maintenance over duration of contract

Performance Indicator	» Only authorised activity outside disturbance areas » No activity in no-go areas » Acceptable level of activity within disturbance areas, as determined by ECO » Acceptable level of soil erosion around site, as determined by ECO » Acceptable level of increased siltation in 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	» Fortnightly inspections of the site » 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

4. GEOTECHNICAL ASPECTS

4.1 Foundations for wind turbines

The design of foundations for wind turbines primarily concerns the resistance to overturning forces induced by wind loading and the foundation type is largely dependent on geotechnical conditions.

The simplest form of foundation is the spread footing on competent rock or engineered fill. This is essentially a gravity foundation that relies upon the weight of the soil overburden and concrete to provide sufficient vertical force to counteract horizontal forces during extreme wind loading. These footings are typically suited to a relatively shallow founding medium of a few meters and a trench is excavated to reach this level. The typical geometry of a spread footing for a wind turbine is 15-20m in diameter/width and 2-3m thick, resulting in an excavation of some 600m3 of material.

Rock socketed piers are used where a competent rock layer exists at relatively shallow depths and rely primarily upon end bearing and secondarily upon side wall friction and sufficient lateral earth pressures.

Piled foundations are used in areas where competent founding mediums are found at greater depths.

Rock anchored footings are used where hard competent rock is found at surface or at very shallow depths and the footing is attached to the rock with steel anchors.

The site under consideration is underlain by shallow quartzitic sandstone but a comprehensive geotechnical investigation will have to be undertaken by the developer in order to determine the geotechnical characteristics of the rock in order to allow the engineer to design the foundations.

4.2. Internal access roads and crane platforms

Access roads are required onto site and between turbines for the transportation of components. The access roads are typically surfaced with a gravel wearing course and the roads need to be wide enough to accommodate trucks with restricted turning capabilities. Maximum road curvatures, camber and gradients are strictly adhered to in the design process. The natural gradients of the site are moderate to steep and significant cut and fill operations may be required for the construction of internal access roads. Steep inclines may require surfacing to aid vehicle traction.

Stable platforms are required at each turbine site for the operation of cranes to be used in the construction process. The footprint of the platform is typically 1000m^2. This crane pad is typically constructed on a cut and/or filled levelled platform upon which imported gravel layers are placed and compacted.

4.3. Underground services

Excavations for underground services are likely to encounter shallow hard rock in most areas. Blasting may be required to excavate through hard rock.

5. CONCLUSIONS

The proposed development has a low to moderate potential impact on the geological environment but these impacts can be mitigated to an acceptable level if appropriate mitigating measures are diligently applied.

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