GEOLOGICAL IMPACT ASSESSMENT REPORT

SPECIALIST INPUT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED DE AAR SOLAR ENERGY FACILITY, NORTHERN CAPE PROVINCE, SOUTH AFRICA

11 October 2011 (Final Rev)

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Ref No: 2011\Savannah\De Aar\EIA Report\De Aar PVF Geological Impact Report 11.10.2011 Rev 0

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

African Clean Energy Developments (Pty) Ltd is in the process of investigating the feasibility of a proposed photovoltaic solar energy facility on a site near De Aar in the Northern Cape Province. The proposed activity is defined as the establishment of a solar energy facility and associated infrastructure, including the construction of photovoltaic (PV) panels, access roads, buried pipelines and ducting, overhead electrical power lines, a workshop, storeroom and maintenance/control building. The facility will have a maximum generating capacity of 400MW.

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 Northern Cape Provincial Department 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 African Clean Energy Developments (Pty) Ltd to carry out the EIA process for the proposed activity. Savannah Environmental has appointed Outeniqua Geotechnical Services cc to conduct a specialist geological study in order to assess the environmental impacts on the geological environment, with specific focus on soil erosion.

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 Environmental Management Programme (EMP).

1.4. Limitations

Information provided in this specialist report has been based on information provided by the developer, 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, 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 10km east of De Aar in the Northern Cape of South Africa. The study area is accessed via the Hydra Substation, located off the N10, southeast of De Aar (see **Figure 1**). The proposed facility is to be located on the following farm portions:

- Wagt En Bietjie 5
- Portion of Wagt En Bietjie Annexe C137
- Riet Fountain 6 Portion 1
- Carolus Poort 3 Portions 3 and 4

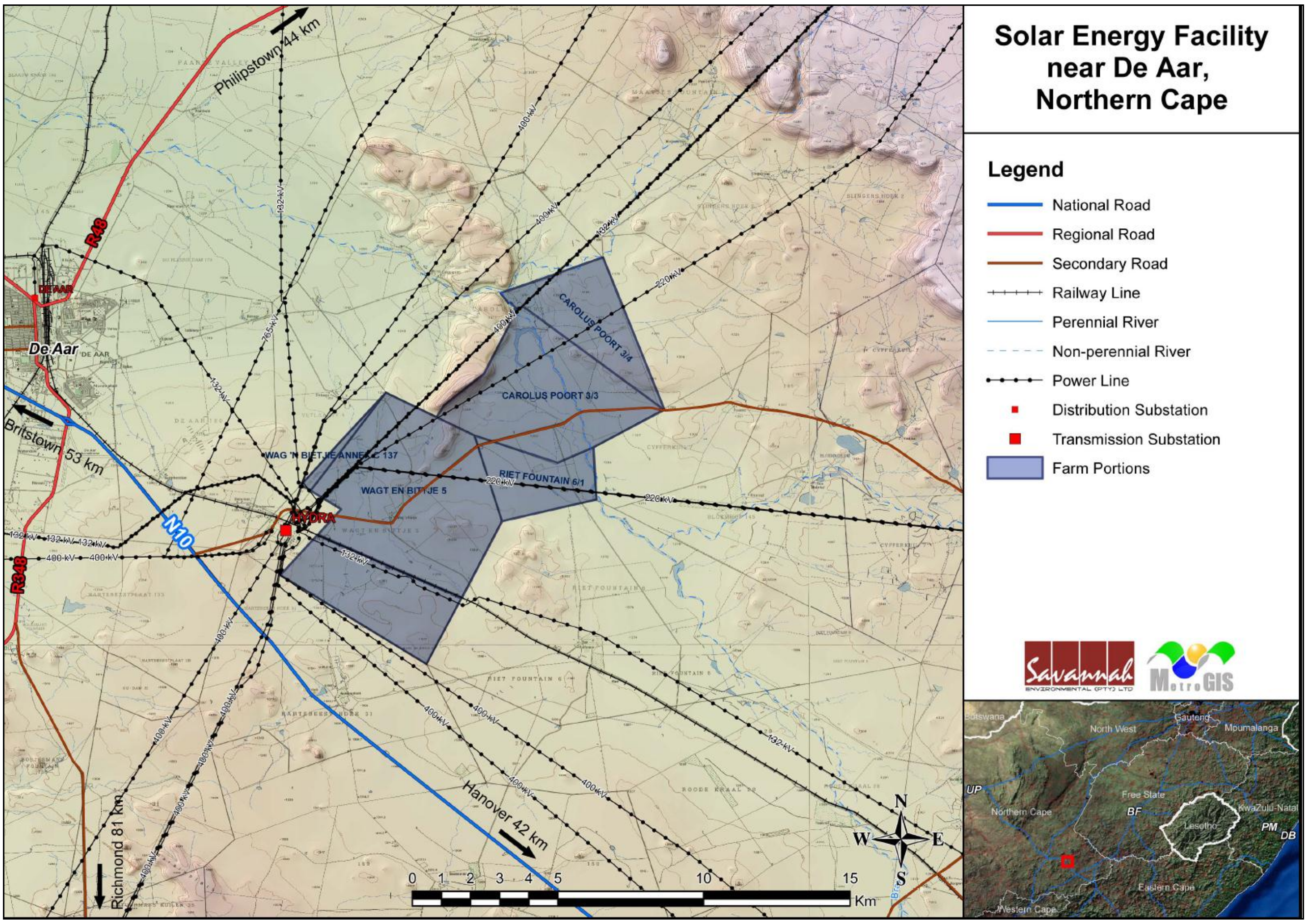

Figure 1: Locality map of the site.

2.2. Topography, climate, & vegetation cover

The majority of the study area is characterised by gentle slopes which drain into small ephemeral tributaries of the Brakrivier which flows in a north-westerly direction across the site. Several small hills are dotted around the study area and there is a prominent ridge on the northwestern boundary which attains a maximum altitude of 1466m AMSL (see **Figure 2**).

The Weinert Climatic N-number[7] for the area, which is 13, indicates that the climate is semi-arid and mechanical weathering processes are dominant. Mean annual precipitation for this region is less than 350mm and the mean annual potential evaporation (S-Pan) is between 2000mm and 2200mm.[2]

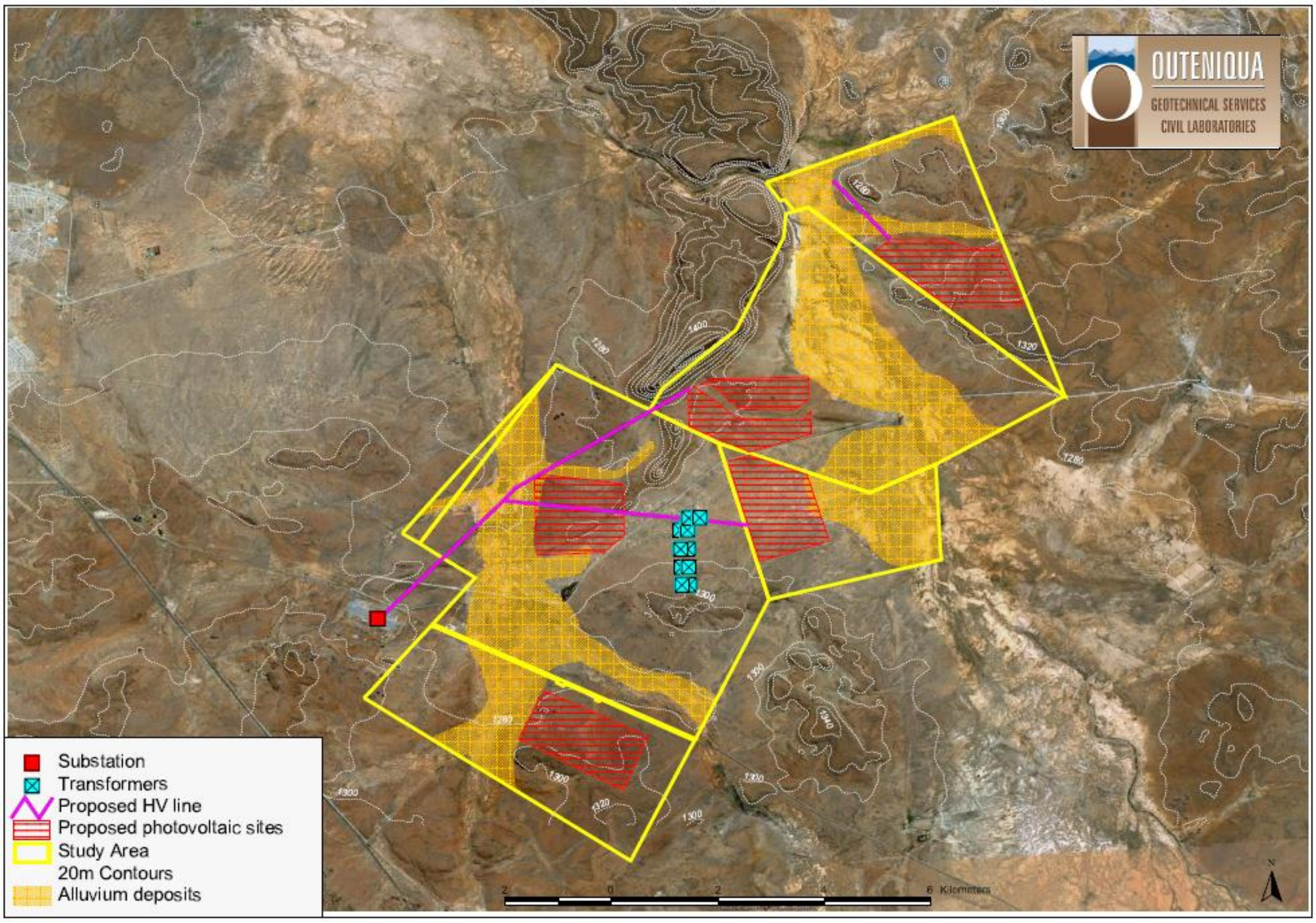

Figure 2: Aerial photo of site showing proposed infrastructure

2.3. Geology & soil types

The study area is underlain by mudstone and sandstone of the Adelaide Subgroup (Karoo Supergroup), intrusive dolerite of Jurassic age and Quaternary alluvium.[9] the sedimentary Karoo rocks were deposited during the Permian era in an inland basin before the breakup of Pangea. Subsequently, during the breakup of Pangea, tectonic instability lead to the injection of molten doleritic magma into fissures in the sedimentary rocks, forming dykes (vertical, sub-vertical intrusions) and sills (horizontal and sub-horizontal intrusions) which typify of the modern Karoo landscape. The dolerite is significantly harder and more resistant to weathering and erosion than the softer sedimentary rocks and thus the geology is a controlling factor in the development of the landscape and topography. Dolerite dykes and sills generally form areas of higher relief and the lower relief areas are generally underlain by sedimentary rocks and alluvium, which accumulates in low-lying areas and along natural drainage lines (see **Figure 3**). The alluvium is the product of the natural process of erosion of surrounding rocks and consists of varying proportions of clay, silt, sand and gravel-sized particles.

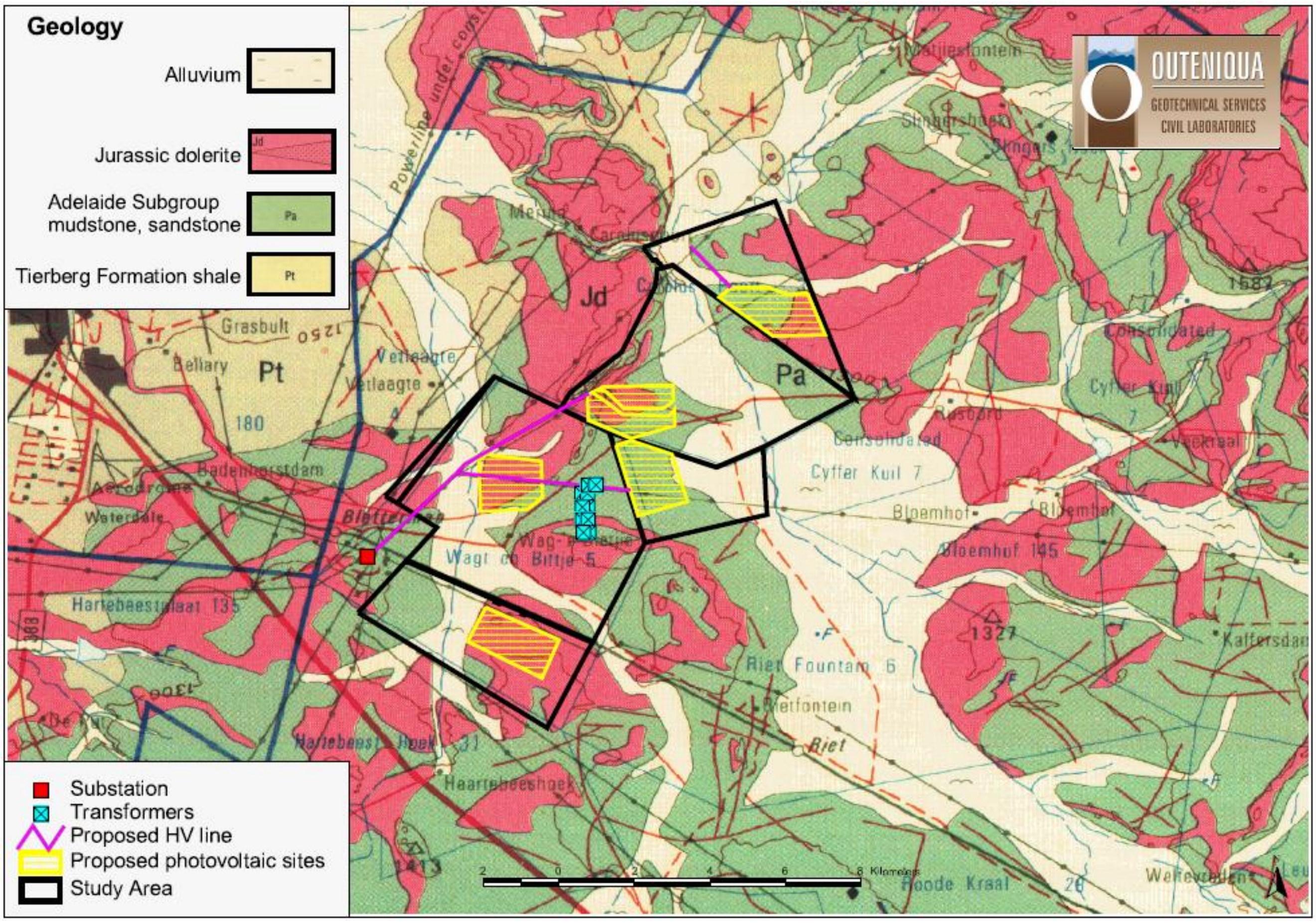

Figure 3: Geological map of the site showing proposed infrastructure and power line options.

Figure 4: Photos of the general terrain on the site.

Figure 5: Minor surficial erosion exposing underlying Adelaide sandstone.

2.4. Hydrology

The study area falls within the catchment area of the Brak River, which flows in a north-westerly direction into the Orange River near Prieska. The Brak River crosses the north-eastern portion of the site and a tributary of the Brak River crosses the south-western portion of the study area.

Although the region has a typically dry climate, flash-floods do occur infrequently and it is important not to underestimate this in the assessment of water erosion potential. Water erosion potential is directly related to the hydrology of the site which is, in turn largely affected by the geology. Infiltration of rainfall into the ground is largely determined by the thickness and permeability of the soil cover. Infiltration is likely to be higher where the soil cover is thicker and relatively low in areas where the bedrock is near or at surface. Infiltration is inversely proportional to run-off, 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.

3. GEOLOGICAL IMPACT ASSESSMENT

The geological impact assessment aims to assess the impact that the proposed development may have on the geological environment which includes the natural soil cover and the underlying bedrock. Important or prominent geological landforms that contribute to the aesthetic scenery or geological interest in the area are also considered in the impact study. Features such as fossil sites, middens, addits, etc. which are important from a scientific or heritage perspective are not covered in this report. The impact on the geohydrology of the area is also not assessed in this study.

The proposed activity may potentially cause a negative direct impact on degradation of soil, rock, and/or geological landforms. 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.

Potential direct positive impacts could include a reduction in soil erosion along poorly constructed and poorly maintained existing roads which could be improved to accommodate run-off in a more controlled manner (i.e. better drainage). The negative impacts are dominantly related to the construction phase with insignificant additional impacts in the post construction and decommissioning phases.

Potential indirect positive impacts relating to the geological environment could include a reduction in the demand for non-renewable energy sources on a national scale (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 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.

Soil erosion is a natural process whereby the ground level is lowered by wind or water action and may occur because 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 or rehabilitate. 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). Removal of vegetation (ground cover) from dryland areas can 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 severity of the potential erosion if land disturbing activities occur and this is generally affected by to the geology, soil types, and the topography of the terrain. Generally speaking, thick deposits of unconsolidated or partly consolidated fine-grained soils of low plasticity occurring along drainage lines, 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 in **Figure 3** indicates that the proposed infrastructure has been carefully positioned to avoid areas where thick deposits of unconsolidated alluvium occur. Rather, the proposed infrastructure has been located in areas where the Karoo bedrock is very near surface and this bodes well for erosion potential of the proposed site. However, in the event of heavy rainfall, surface run-off will still cause minor erosion of topsoil and this may be accelerated in areas that have been cleared of vegetation, although 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). The majority of the proposed site has a gentle topography which also bodes well for erosion potential. **Table 2** summarises the sensitivity in terms of water erosion.

Table 2: Water erosion sensitivity

Sensitivity Level	Geological Formation/Terrain Units	Comments/Recommendations
High	Natural drainage lines/watercourses	No-go areas without special mitigating measures. Erosion presently taking place.
Moderate	Other areas underlain by Quaternary alluvium*	Moderate levels of erosion will occur if land-disturbing activities take place (construction). Mitigating measures to be applied to minimise impact.
Low	Areas underlain by Karoo rocks*	Minor erosion will naturally occur. Normal mitigating measures apply.

*See Figure 3 for spatial distribution

3.2. Degradation of bedrock, topography, and landforms

Earthworks for the proposed structures and access roads are likely to be minimal due to the gentle terrain and typically shallow and simple foundation systems utilised for the proposed infrastructure.

3.3. Assessment of impacts

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

Direct, indirect, and cumulative negative impacts are assessed in terms of the following criteria (as specified by Savannah Environmental):

- 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 PV park sites

There are no site alternatives under consideration. The do-nothing alternative will have no negative impact on the local geological environment.

The proposed photovoltaic (PV) 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). This method employs minimal earthworks for the foundations and the frames can be erected on moderate slopes without resorting to cut and fill operations.

An assessment of the individual potential direct impacts on the geological environment associated with the proposed PV facility is tabulated in **Table 3**.

Table 3: Potential direct impacts

Nature: Soil and rock degradation (soil/rock removal, mixing, compaction, etc) due to the construction of foundations for infrastructure.		
	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?	Yes	Yes
Can impacts be mitigated?	Yes, to a certain extent.	
Mitigation:	» Rehabilitate topsoil 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 at present. Further development of the area may have increasing impact on the natural soil.	
Residual impacts:	» Minor negative – slow regeneration of topsoil.	

Nature: Soil and rock degradation (soil/rock removal, mixing, compaction, etc) due to the construction of new access roads (cut and fill).		
	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?	Yes	Minor
Can impacts be mitigated?	Yes, to a certain extent.	
Mitigation:	» Use existing roads if possible/practical. » Minimise the length and width of new access roads. » Minimise access roads in steep terrain in order to minimise cut and fill operations.	

	» 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 at present. Further development of the area may have an increasing impact on the natural soil.
Residual impacts:	» Minor negative – slow regeneration of vegetation & topsoil along roadside.

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?	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 at present due to the undeveloped nature of the study area but further development may have an increasing impact.	
Residual impacts:	» Minor negative – slow regeneration of soil processes in and under topsoil.	

Nature: Soil degradation due to increased soil erosion by wind and/or water in denuded construction areas.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Very short term (1)
Magnitude	Low (4)	Minor (2)
Probability	Very probable (4)	Probable (3)
Significance	**Moderate (32)**	**Low (12)**
Status	Negative	Negative
Reversibility	Irreversible	Practically irreversible
Irreplaceable loss of resources?	Yes, minor	Yes, minor
Can impacts be mitigated?	Yes.	
Mitigation:	» Minimise size of construction camp areas around the proposed infrastructure. » Restrict activity outside of construction camp areas. » Implement effective erosion control measures. » 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 in the area 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.

An assessment of the potential indirect impacts associated with the proposed study site is tabulated in **Table 4**.

Table 4: Potential indirect impacts

Nature: Soil degradation due to increased siltation along drainage lines 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. » 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	Yes	

mitigated?	
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	N/A	
Irreplaceable loss of resources?	N/A	
Can impacts be mitigated?	N/A	
Mitigation:	N/A	
Cumulative impacts:	» The cumulative positive impact on a national scale is considered very high.	
Residual impacts:	N/A	

3.3.2. Potential impacts along the proposed new power line routes

Three of the proposed new PV parks are to be linked to the Hydra Substation via proposed new overhead high voltage (HV) power lines and two proposed new PV parks are to be linked via existing power lines to this same substation (see **Figure 2**).

The proposed new power line routes are likely to be underlain by shallow rock (dolerite or sandstone) or thick unconsolidated alluvium deposits which typically occur along the main drainage lines (see **Figure 3**). The earthworks associated with the proposed new power lines is generally limited to the construction of foundations for towers and minor work involved in creating minor gravel access tracks along the routes for construction and maintenance purposes. As mentioned in Table 2, the areas where unconsolidated alluvium deposits occur are likely to be sensitive to severe erosion if land-disturbing activities occur, and therefore any development within these areas must be treated with caution.

An assessment of the individual potential direct impacts associated with this proposed new power line routes is tabulated in **Table 5**.

Table 5: Potential direct impacts

Nature: Soil degradation due to removal, loosening, mixing, wetting, and compacting of soil for structures (towers) and access roads.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Long term (4)	Short term (2)

Magnitude	Minor (2)	Minor (2)
Probability	Definite (5)	Definite (5)
Significance	**Moderate (35)**	**Low (25)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to a certain extent.	
Mitigation:	» Restrict activity over virgin ground (off-road). » Rehabilitate soil around pylon foundations after construction.	
Cumulative impacts:	» The cumulative impact of soil degradation in the area is considered low at present due to undeveloped nature of the area but further development of may have an increasing impact on soil degradation.	
Residual impacts:	» Minor negative – slow regeneration of topsoil.	

Nature: Soil degradation due to pollution of soil by contaminants spilled on site during construction (e.g. fuel, oil, chemicals, cement).		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (2)	Very short term (1)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Low (15)**	**Low (12)**
Status	Negative	Negative
Reversibility	Partially reversible	Partially reversible
Irreplaceable loss of resources?	Yes, minor	Yes, negligible
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 degradation is considered low at present due to the undeveloped nature of the study area but further development of may have an increasing impact on soil degradation.	
Residual impacts:	» Minor negative – slow regeneration of soil processes in and under topsoil	

Nature: Soil degradation due to increased soil erosion by wind and water in denuded construction areas.		
	Without mitigation	***With mitigation***
Extent	Local (1)	Local (1)
Duration	Medium term (3)	Very short term (1)
Magnitude	Minor (2)	Minor (2)
Probability	Very probable (4)	Probable (3)
Significance	**Low (24)**	**Low (12)**
Status	Negative	Negative
Reversibility	Irreversible	Practically irreversible
Irreplaceable loss of resources?	Yes, minor	Yes, minor

Can impacts be mitigated?	Yes.
Mitigation:	» Keep to existing roads, where practical, to minimise loosening of natural ground. Restrict activity in virgin areas (off road). » Implement effective erosion control measures. » 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. » Rehabilitate ground with suitable vegetation after construction.
Cumulative impacts:	» The cumulative impact of soil erosion in the area is considered low at present due to the undeveloped nature of the area but further development may have an increasing impact on soil degradation.
Residual impacts:	» Minor localised erosion.

3.4. Impact Statement

The most significant potential negative impacts on the geological environment are soil degradation issues as a result of construction activity and its effect on soil stability and soil-forming processes. However, with effective implementation of mitigating measures, these impacts are considered to have a low to moderate localised significance, requiring diligent attention from the engineers, environmental officers and contractors, but not posing a significant threat to the environmental status-quo or the feasibility of the development.

The potential positive impacts on the geological environment are considered to have a moderate significance on a local scale but the cumulative impact of a reduction in demand and extraction/mining of non-renewable energy sources on a national scale is very significant.

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 soil degradation and erosion

» 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 ecosystems. Degradation of parent rock is considered low as there are no deep excavations planned.

Project Component/s	• PV arrays. • Access roads. • Underground cabling.

	• Foundations for storage and maintenance facilities. • 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). Only special works to be undertaken in these areas to be authorised by the 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 that cross drainage lines and roads on steep slopes (to prevent unnecessary cutting and filling operations).	ECO/ER/Contractor	At design stage and during construction
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

Mitigation: Action/Control	Responsibility	Timeframe
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 development will have a low to moderate potential *negative* impact on the geological environment. 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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