Report to SiVEST

Desktop Geotechnical Specialist Study for the:

PROPOSED CONSTRUCTION OF 132 KV POWERLINES BETWEEN THE AUTHORISED LOERIESFONTEIN 3 PV SOLAR ENERGY FACILITY (12/12/20/2321/2/AM4) AND THE AUTHORISED DWARSRUG WIND ENERGY FACILITY (14/12/16/3/3/2/690/AM4), AND FROM THE DWARSRUG WIND ENERGY FACILITY TO THE AUTHORISED NAROSIES SUBSTATION (12/12/20/2049/3), LOCATED NEAR LOERIESFONTEIN IN THE HANTAM LOCAL MUNICIPALITY, NAMAKWA DISTRICT IN THE NORTHERN CAPE PROVINCE OF SOUTH AFRICA

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Project name:	Powerline between Loeriefontein 3 PV Solar Energy Facility and Dwarsrug Wind Energy; and between Dwarsrug Wind Energy to Narosies substation
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Report by:	Approved by:
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PROPOSED CONSTRUCTION OF 132 KV POWERLINES BETWEEN THE AUTHORISED LOERIESFONTEIN 3 PV SOLAR ENERGY FACILITY (12/12/20/2321/2/AM4) AND THE AUTHORISED DWARSRUG WIND ENERGY FACILITY (14/12/16/3/3/2/690/AM4), AND FROM THE DWARSRUG WIND ENERGY FACILITY TO THE AUTHORISED NAROSIES SUBSTATION (12/12/20/2049/3), LOCATED NEAR LOERIESFONTEIN IN THE HANTAM LOCAL MUNICIPALITY, NAMAKWA DISTRICT IN THE NORTHERN CAPE PROVINCE OF SOUTH AFRICA

Executive Summary

This desktop geological and geotechnical specialist study assed the three (3No.) proposed grid connections, two alternative route corridors between the approved substation at the authorised 100 MW Loeriesfontein 3 PV SEF (12/12/20/2321/2/AM4) and approved substation at the authorised 140 MW Dwarsrug WEF (14/12/16/3/3/2/690/AM4); and one corridor between the Dwarsrug WEF and the proposed (and authorised) Narosies Substation (12/12/20/2049/3), all located near Loeriesfontein in the Hantam Local Municipality, Namakwa District in the Northern Cape Province of South Africa.

The majority of the corridors are located on flat to slightly inclined terrain sloping at a ratio less than 1:50 (less than 2%). Localised areas along the proposed grid connections intersect terrain that slopes between gradients 1:50 and 1:20 (2% to 5%). Drainage is expected to occur in various direction towards endoreic basins and rivers in the area. There are a few continuous and distinct drainage features on the site, although signs of concentrated overland surface flow and occasional rills are noted to exist throughout the study area. It is expected that localised undulations and erosional features occur. The nature of the drainage features could not be confirmed in the desk study. The site falls within a hot desert climate (BWk) according to the Köppen-Geiger climate classification.

The assessment corridor areas may be divided into four (4No.) Ground Units (GU), I, II, III and IIII where similar geotechnical conditions are anticipated. GU I is defined by shallow occurring bedrock covered by thin, loose transported material and varying degrees of cemented calcrete. GU II can be characterised by talus deposits on relatively steep slopes that is linked to GU III that defines the high lying outcropping bedrock of which is seemingly shale material. GU IIII is confined to low lying areas that are underlain by relativity thicker alluvial deposits, identifiable by erosion paths, rills, pans and continuous drainage features.

No faults, lineaments or other geological features are illustrated on the geological map or are visible from aerial photography.

The Permian-aged Whitehill Formation is known to contain plant, palaeoniscoid fish and anthropod fossils and remains of two species of the swimming reptile Mesosaurus (Johnson et al 2006). This rock unit may be classified as “High Sensitivity” for the palaeontology theme. The Prince Albert possesses marine fossils, as well as plant and palaeoniscoid fish remains and coprolites have been identified in this formation. The Tierberg Formation is known to contain fossils, mainly being sparse to locally concentrated assemblages of trace fossils (Johnson et al 2006). Body fossils are very rarely recorded. The intrusive rocks, namely dolerite, are not fossiliferous.

Based on the impact significance ratings, the development of the proposed powerlines within Corridor 1, Corridor 2 and Corridor 3, from a geological and geotechnical perspective, will be “Negative Low impact”, provided that the recommended mitigation measures are implemented. Corridor 1 is considered marginally more suitable for development from a geotechnical perspective than Corridor 2, due to the generally flatter topography, however other factors are likely to be more critical in determining the final layout. Therefore no preference between Corridor 1 and Corridor 2 is provided.

From a geotechnical and geological perspective, no fatal flaws, sensitivities, or areas to be avoided have been identified within or close to the assessment area. It is therefore recommended that the proposed activity be authorised.

NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT NO. 107 OF 1998) AND ENVIRONMENTAL IMPACT REGULATIONS, 2014 (AS AMENDED) - REQUIREMENTS FOR SPECIALIST REPORTS (APPENDIX 6

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	**Section of Report**
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	 1.3 Appendix B
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix A
c) an indication of the scope of, and the purpose for which, the report was prepared;	1.1, 1.2
(cA) an indication of the quality and age of base data used for the specialist report;	1.4, References
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	5, 6
d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Not applicable
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	1.4, Appendix C
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	3, 6, 7
g) an identification of any areas to be avoided, including buffers;	None identified
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	No sensitivities identified
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	2
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, (including identified alternatives on the environment) or activities;	5,6,7
k) any mitigation measures for inclusion in the EMPr;	6.1 Table 6-1
l) any conditions for inclusion in the environmental authorisation;	6.1 Table 6-1
m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	6.1 Table 6-1
n) a reasoned opinion- i. (as to) whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	6.1, 8 6.1 Table 6-1
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not applicable
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	None
q) any other information requested by the competent authority.	None
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Not applicable

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1. Introduction

GaGE Consulting (Pty) Ltd has been appointed by SiVEST (Pty) Ltd, on behalf of South Africa Mainstream Renewable Power Developments (Pty) Ltd, to undertake a Basic Assessment (BA) Process for the proposed construction of 132 kV overhead powerlines between the proposed (and authorised) 100 MW Loeriesfontein 3 Photovoltaic (PV) Solar Energy Facility (SEF) (12/12/20/2321/2/AM4) and proposed (and authorised) 140 MW Dwarsrug Wind Energy Facility (WEF) (14/12/16/3/3/2/690/AM4); and between the Dwarsrug WEF and the proposed (and authorised) Narosies Substation (12/12/20/2049/3) located near Loeriesfontein in the Northern Cape Province of South Africa.

In terms of the Environmental Impact Assessment (EIA) Regulations, which were published on 04 December 2014 [GNR 982, 983, 984 and 985) and amended on 07 April 2017 [promulgated in Government Gazette 40772 and Government Notice (GN) R326, R327, R325 and R324 on 7 April 2017], various aspects of the proposed development are considered listed activities under GNR 327 and GNR 324 which may have an impact on the environment and therefore require authorisation from the National Competent Authority (CA), namely the Department of Environment, Forestry and Fisheries (DEFF), prior to the commencement of such activities. Specialist studies have been commissioned to assess and verify the power line under the new Gazetted specialist protocols.

1.1. Scope and Objectives

Assess the impacts associated with the installation of a powerline between the Loeriesfontein 3 PV SEF (12/12/20/2321/2/AM4) and Dwarsrug WEF (14/12/16/3/3/2/690/AM4); and between the Dwarsrug WEF and the proposed (and authorised) Narosies Substation (12/12/20/2049/3), as well as including potential fatal flaws, if any.

The following key considerations were taken into account during the desktop study:

- The geological and geotechnical conditions (ground conditions) and the influence thereof on the competency of founding of civil infrastructure and structures
- Site topography and influence thereof on the site stability and suitability
- The presence of geological or geomorphological features such as faults, lineaments and unstable ground
- The presence of problem soils, geotechnical constraints, shallow groundwater conditions
- Geologically significant or sensitive features such as ridges, outcrops and exposures

1.2. Terms of Reference

The terms of reference were provided by SiVEST to allow a consistent approach to the various specialist studies and allow enable comparison of environmental impacts, efficient review, and collation of the specialist studies into their Basic Assessment report. This study is undertaken in accordance with the requirements provided in Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6.

A detained description of the infrastructure required for the powerline, including layouts of the proposed development, were provided by SiVEST.

1.3. Specialist Credentials

This study has been undertaken by Steven Bok, a Professional Natural Scientist registered by the South African National Council for Natural Scientific Professions (SACNASP) registration number 400279/07 (Geological Science). Mr Bok's CV is attached in Appendix B.

1.4. Assessment Methodology

The assessment involved a review of the following information:

i) 1:250 000 Scale Geological Map 3018 Loeriesfontein (Council for Geoscience, 2011)
ii) Aerial photographs (Google Earth imagery, current and historical)
iii) Technical report titled "Factual Report on Preliminary Geotechnical Investigation Loeriesfontein Wind & Solar PV Project" published by Vela VKE Consulting Engineers and produced by Mainstream Renewable Power dated July 2012
iv) Technical report titled "Factual Geotechnical Report for Loeriesfontein Wind Power Project" published by Vela VKE Consulting Engineers and produced by Mainstream Renewable Power dated July 2014
v) Technical report titled "Proposed Development of the Dwarsrug Wind Farm near Loeriesfontein, in the Northern Cape Province. Surface Water Impact Assessment Report" produced by Mainstream Renewable Power dated March 2015
vi) Technical report titled "Dwarsrug Wind Energy Facility. Heritage Impact Report" published by PGS Heritage and dated May 2015
vii) Screening Report for Environmental Authorisation (national web based environmental screening tool)
viii) General site photographs provided by SiVEST
ix) Literature as referenced within this report

The geotechnical investigation reports referenced in bullets iii to vi cover investigation footprints close to the area of interest with the closest test pits located within approximately 400 m to approximately 8.0 km from the proposed powerline assessment area. These investigated footprints are underlain by the similar stratigraphic units to those that underlie the proposed powerline routes.

An Environmental Impact Assessment matrix was used to quantify the impacts of the project on the receiving environment (provided by SiVEST and attached as Appendix C).

2. Assumptions and Limitations

The services performed by GaGE Consulting (Pty) Ltd were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession practising under similar conditions in the locality of the project. The interpretation of the site conditions is based on available information, experience in the general project area and professional judgement and is considered to provide sufficient confidence to meet the objectives of this specialist study. The nature of geotechnical engineering is such that conditions at variance with those described may be encountered on site. Engineering recommendations provided in this report are preliminary and must be confirmed through further intrusive investigations.

Third party information has been utilised in good faith.

A site visit was not undertaken.

3. Technical Description

3.1. Project Location

The three (3No.) proposed grid connections between the approved substation at the authorised 100 MW Loeriesfontein 3 PV SEF (12/12/20/2321/2/AM4) and approved substation at the authorised 140 MW Dwarsrug WEF (14/12/16/3/3/2/690/AM4); and between the Dwarsrug WEF and the proposed (and authorised) Narosies Substation (12/12/20/2049/3), is located near Loeriesfontein in the Hantam Local Municipality, Namakwa District in the Northern Cape Province of South Africa.

Two (2No.) powerline alternatives will be assessed to link the Loeriesfontein 3 PV SEF to the Dwarsrug WEF and a single powerline is proposed to link these two (2No.) facilities to the National grid from the Dwarsrug WEF. All three (3) powerline route alignments will be assessed within a 300 m wide assessment corridor (150 m on either side of powerline) to allow for the micrositing / specialist guidance regarding placement can be made. Corridor Alternative 1 is approximately 18.9 km, Corridor Alternative 2 is approximately 19.1 km and Corridor 3 is approximately 3.50 km in length. The location of the study area is presented in Figure 3-1.

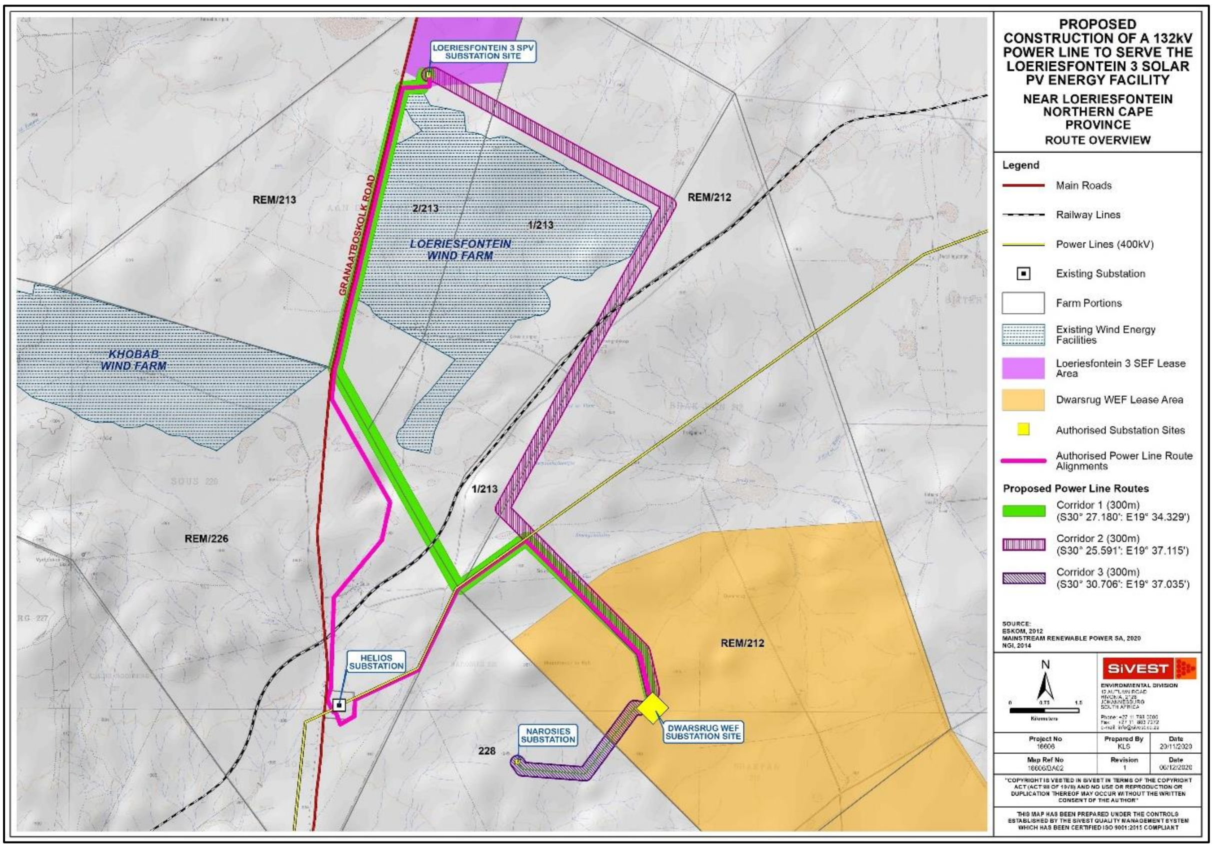

Figure 3-1 Powerline alternatives proposed to link Loeriesfontein 3 PV SEF to Dwarsrug WEF as well single power line proposed to link two (2) facilities to National grid from Dwarsrug WEF

3.2. Project Description

Mainstream are proposing the construction of 132 kV overhead powerlines between the proposed (and authorised) 100MW Loeriesfontein 3 PV SEF (12/12/20/2321/2/AM4) and proposed (and authorised) 140MW Dwarsrug WEF (14/12/16/3/3/2/690/AM4); and between the Dwarsrug WEF and the proposed (and authorised) Narosies Substation (12/12/20/2049/3) located near Loeriesfontein in the Northern Cape Province of South Africa.

The powerline from the Loeriesfontein 3 PV SEF to the Dwarsrug WEF is proposed to link the SEF to the WEF in order to create a hybrid renewable energy facility, which will ensure that electricity is constantly supplied to the national grid by at least one or both technologies (namely solar PV and wind), at any given time. The powerline from the Dwarsrug WEF is proposed to tie the above mentioned, hybrid renewable energy facility into the approved Narosies substation to feed the National grid.

3.2.1. Alternatives

Two (2No.) powerline alternatives will be assessed to link the Loeriesfontein 3 PV SEF to the Dwarsrug WEF and a single powerline is proposed to link these two (2No.) facilities to the National grid from the Dwarsrug WEF. The layout alternatives are being considered and assessed as part of the BA process and will be refined to avoid identified environmental sensitivities

The 'no-go' alternative is the option of not constructing the powerline project, which would prevent the realization of the hybrid facility and thus prevent electricity generated from renewable sources being fed into the national grid. This alternative would result in no additional environmental impact other than that assessed during the BA for the Renewable Energy (RE) facilities.

The 'no-go' option is a feasible option; however, this would prevent the hybrid facility from contributing to the environmental, social and economic benefits associated with the development of the renewables sector.

4. Legal Requirement and Guidelines

The desktop study was undertaken according to the guidelines provided by The South African Institution of Civil Engineering Site Investigation (SAICE) Code of Practice published by The Geotechnical Division of SAICE, 2010.

This report has been prepared to meet the requirements for a specialist report as provided in Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6.

5. Description of the Receiving Environment

The following description of the receiving environment is relevant to assessing the geological and geotechnical impacts.

5.1. Climate

The area surrounding Loeriesfontein is considered to have a desert climate with little rainfall all year long. The area can be classified as hot desert climate (BWk) according to the Köppen-Geiger climate classification. The average annual rainfall is 224 mm with the average maximum and minimum temperatures of 22.8°C and 9.9°C, respectively.

Climate plays a fundamental role in rock weathering and soil development. The effect of climate on the weathering processes (i.e. soil formation) in a particular area can be determined from the climatic N-value, defined by Weinert (1980). A climatic N-Value of 5 or less implies a water surplus and the dominant mode of weathering is chemical decomposition. These climatic conditions are favourable for the development of a deep residual soil profile. Where the climatic N-value is greater than 5, mechanical disintegration is the predominant mode of rock weathering. In these drier areas residual soils are typically shallow.

Weinert's climatic N-value for the site is greater than 10, approximately 18 to 22, which indicates a scarcity of water. Physical disintegration will dominate resulting in a thin gravelly residual soil and a shallow bedrock (unless covered with transported soils). This climate is conducive to the formation of pedogenic calcrete.

5.2. Topography and Drainage

According to the chart provided by SiVEST, presented in Figure 5-1, the majority of the alternative corridors are located on flat to slightly inclined terrain sloping at a ratio less than 1:50 (less than 2%). Localised areas along the proposed grid connections intersect terrain that slopes between gradients 1:50 and 1:20 (2% to 5%). Although, the chart indicates no areas with gradients greater than 1:20 underlain the proposed grid areas, it is expected that some areas near the topographical highs, in the southern portion of the proposed three (3No.) grid connections (near Dwarsrug WEF), may exceed 1:20. This entails that terracing may be required for construction in the steeper sections of the site.

Based on topo-cadastral sheet 3019BC, the greater area of the site is scattered with non-perennial drainage features with no continuous and distinct drainage features, although Google Earth imagery indicates signs of overland surface flow and occasional rills throughout the study area. Concentrated overland flow is expected to occur between shale outcrops that define the highly lying areas in the southern to middle portions of the site.

The southern to eastern portions of Corridor 2 area is scattered with non-perennial drainage lines and features that lead an endoreic basin, named Brakpan. The most southern portion of the site seems to be located very closely to the watershed between two drainage basins that lead either to the Brakpan or towards the Rooiberg River located southwest of the site. The drainage of the northern portion of Corridor 2 is expected to occur predominately towards the north east direction, towards an endoreic basin, named Kareedoringpan. Localised areas in the northern portions will drain, following non-perennial streams, towards an endoreic basin named Bitterputspan located northeast of Corridor 2.

The middle to southern portions of the Corridor 1 is characterised by generally flat terrain with localised depression defining small pans and undulating terrain. Drainage in this area will occur in south westerly direction towards the Klein-Rooiberg River. The northern portion of Corridor 1 is underlain by very slightly sloping terrain dipping towards the north. Drainage is expected to occur in this direction towards Kareedoringpan. It is expected that localised undulations and erosional features occur throughout the northern portions of Corridor 1.

According to the topo-cadastral 3019DA, Corridor 3 is underlain by undulating low-lying terrain with well-defined non-perennial drainage features that flow towards the Rooiberg River. The terrain in the vicinity of Corridor 3 mainly slopes at a gradient less than 1:50 and lesser between 1:50 and 1:20 gradient. Some slopes within Corridor 3 assessment area may exceed gradients of 1:20.

The extent and detailed nature of the drainage features and slopes within the area of interest could not be confirmed in the desk study.

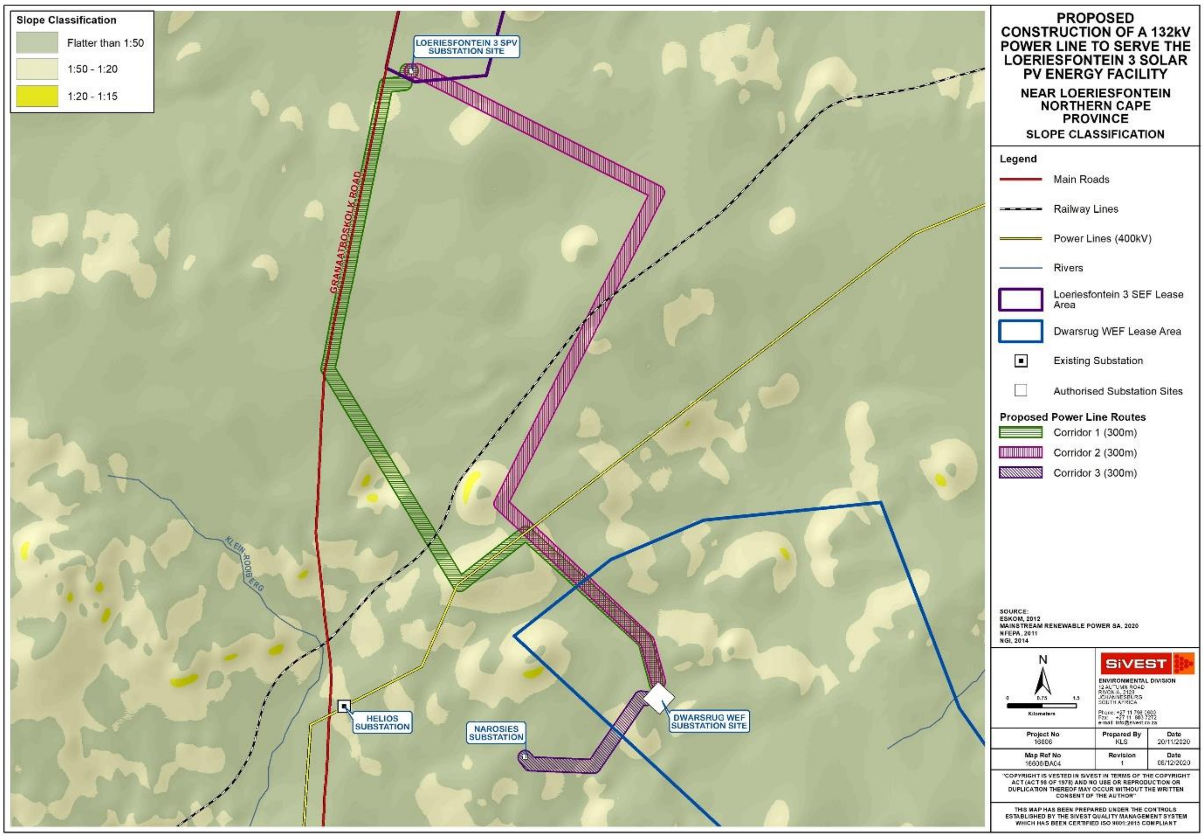

Figure 5-1 Slope classification chart of the site

5.3. Seismicity

The Northern Cape can generally be considered a region with a low hazard (peak ground acceleration of 0 – 0.2 m/s^2). According to the Seismic Hazard Map of South Africa contained in the new South African Loading Code - SANS 10160 the peak ground acceleration (g) with a 10% probability of being exceeded in a 50-year period for the site is in the order of 0.12 – 0.16 g.

5.4. Bedrock Geology

According to the 1:250 000 scale geological map 3018 Loeriesfontein (2011), the bedrock geology beneath the northern portion of the area of interest comprises black to light grey weathering, dark grey carbonaceous, pyrite bearing, shale of the Whitehill Formation (designated ***Pw***) found in the Ecca Group. The mudrocks weathered to white on surface making them easily identifiable (Johnson et al, 206). The shale is very thinly laminated and contain relatively high organic carbon (up to 17%). The local geological map shows bedrock over the northern sections of Corridor 1 and Corridor 2 are is overlain by extensive deposits of Quaternary-aged alluvium (designated by yellow shaded area) assumed to be associated with the drainage features in the area. A relativity small area is underlain by the Prince Albert Formation (designated ***Ppr***) that comprises dark grey to black carbonaceous shale and medium to fine- to medium-grained feldspathic arenite and wacke.

Intrusive dolerite in the form of a large sill we intruded into the abovementioned sedimentary rock units during the Jurassic age (designated ***Jd***). Alternative Corridor 1 traverses a short section of dolerite while a larger portion of Corridor 2 traverses dolerite.

The bedrock geology in the middle to southern portions of both Corridor 1 and Corridor 2 comprises well-laminated, dark, brown and grey shale of the Tierberg Formation (designated ***Pt***), which is the upper-most formation of the Ecca Group. The planar lamination of these shales suggests settling suspension in a low-energy environment. The Tierberg Formation also supports a number of upward coarsening sequences of 2 m to 10 m thick comprising mudstone, siltstone and very fine-grained sandstone. Calcareous formations are common in the towards the top of the formation. Aerial photography indicates that the bedrock outcrops sporadically in along the corridor alternatives.

The bedrock, when not outcropping, is overlain by extensive deposits of Quaternary-aged dolerite rubble (designated ***Q-g₁***), assumed to originate from dolerite sills that intruded into the shale during the Jurassic age. The local geological map indicates that sections of all routes are underlain by the transported dolerite rubble.

No faults, lineaments or other geological features are illustrated on the geological map or are visible from aerial photography.

The Permian-aged Whitehill Formation is known to contain plant, palaeoniscoid fish and anthropod fossils and remains of two species of the swimming reptile Mesosaurus (Johnson et al 2006). This rock unit may be classified as "High Sensitivity" for the palaeontology theme. The Prince Albert possesses marine fossils, as well as plant and palaeoniscoid fish remains and coprolites have been identified in this formation. The Tierberg Formation is known to contain fossils, mainly being sparse to locally concentrated assemblages of trace fossils (Johnson et al 2006). Body fossils are very rarely recorded. The intrusive rocks, namely dolerite, are not fossiliferous.

The geological map indicates that a gypsum source is located near northern end of Corridor 1 (designated ***Gy***). Gypsum is an evaporite deposit and usually occurs on surface. No large-scale or underground mining activities have taken place on or close to the assessment areas.

An extract from the 1:250 000 scale geological map 3018 Loeriesfontein is provided in Figure 5-2.

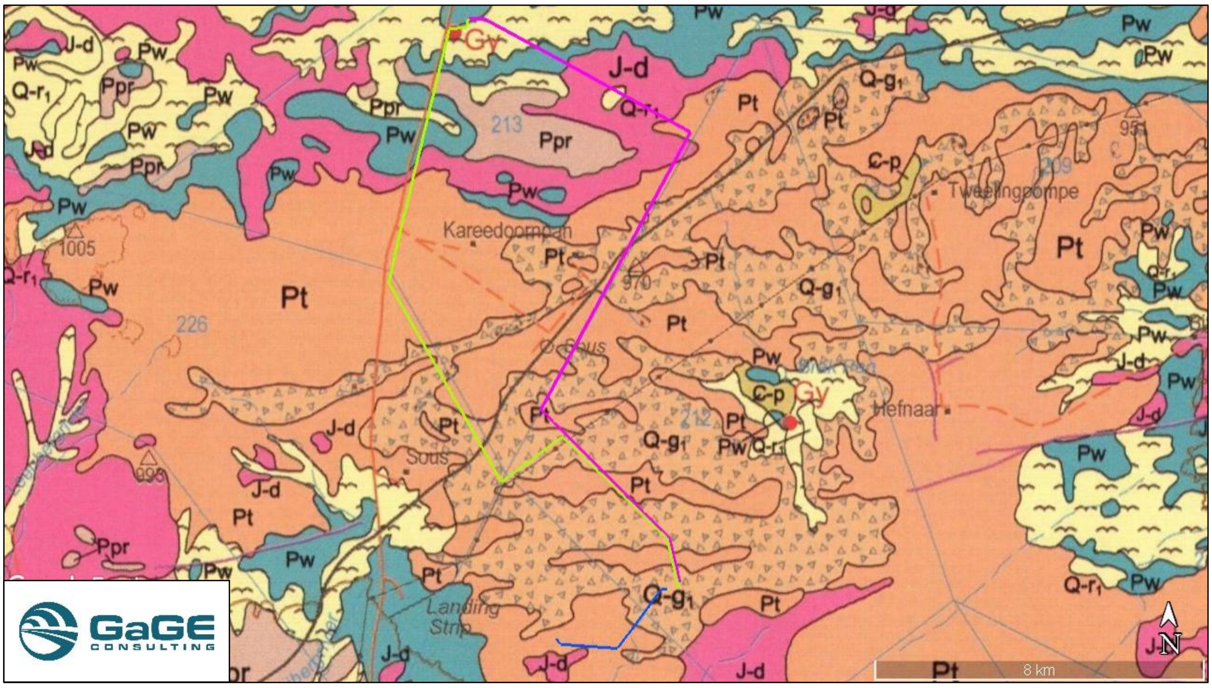

Figure 5-2 Extract of 1:250 000 scale Geological Map 3018 Loeriesfontein (Google Earth, 2020)

5.5. Engineering Geology

Within the northern portion of the assessment area, the shale and sandstone bedrock are expected to occur from a very shallow depth below ground level (BGL). Review of the pervious geotechnical investigation in this vicinity indicates that shale and sandstone bedrock was encountered from an average depth of approximately 0.35 m and 0.40 m BGL, respectively. Majority of the test pits refused in the sandstone bedrock at an average of 0.97 m BGL and in shale bedrock at an average depth of 1.90 m BGL. The shale material is thinly laminated and highly fractured, allowing the TLB to rip the material and excavate to great depths even in competent bedrock.

The bedrock in the northern portion is covered by a relatively thin transported horizon, mainly alluvium, existing from surface to an average depth of 0.38 m BGL and to a maximum depth of 1.20 m BGL, that comprises a loose, silty gravelly sand, being sandier within local drainage features and within the vicinity of pans, and occasionally underlain by a very weakly to weakly cemented calcrete horizon. The formation of duripan (in the form of a variable calcrete horizon ranging from nodules to hardpan calcrete) is expected to occur locally in parts of the site, which is characteristic of the Namaqualand soils. Very few of the trial pits refused on hardpan calcrete at an average depth of 0.90m BGL.

According to pervious investigations, the central portion of the investigation area is defined by generally shallow occurring shale bedrock existing from 0.51 m BGL and causing the TLB to refuse at an average depth of 1.00 m BGL. One test pit in this portion of the site refused on hardpan calcrete at 0.60 m BGL.

No test pits from the previous investigation were excavated within the southern portion of the site. It is expected that similar ground conditions will persist in this area with shallow occurring bedrock when covered by transport horizons comprising silty sand to gravelly sand material. It can be expected that the alluvial material may thicken in portions between high lying shale outcrops as indicated by Google earth imagery, especially in rills and erosion features seemingly present on site.

The alluvial material in this area exhibits collapsible fabric according to pervious geotechnical investigations. Soils with a collapsible structure have an open-voided texture with individual grains being separated or weakly bonded by bridging material such as clay, iron oxides, calcium, or other bridges (Brink, 1985). While these soils have a high to moderate strength and can withstand fairly large loads under low soil moisture conditions, an increasing moisture content can weaken the bridging materials. Increasing the soil moisture content under load can cause a decrease in the soil volume, resulting in large settlements with no increase in the applied stress. This can lead to sudden settlements beneath foundations and structures.

The charts provided by ~~SiVest~~ SiVEST indicate that no slopes exceed gradients of 1:20 within any of the corridors, however it is expected that very small, localised areas against the shale outcropping ridges, in the southern portion of the site, will exceed slope gradients of 1:20. This entails that terracing may be required for construction in the steeper sections of the site.

5.6. Desktop Geotechnical Appraisal

Based on the desktop study, the assessment corridor areas may be divided into four (4No.) Ground Units (GU), **I**, **II**, **III** and **IIII** as presented in Figure 5-3 and Figure 5-4, where similar geotechnical conditions are anticipated. **GU I** is defined by shallow occurring bedrock covered by thin, loose transported material and varying degrees of cemented calcrete. **GU II** can be characterised by talus deposits on relatively steep slopes that is linked to **GU III** that defines the high lying outcropping bedrock of which is seemingly shale material. **GU IIII** is confined to low lying areas that are underlain by relativity thicker alluvial deposits, identifiable by erosion paths, rills, pans and continuous drainage features. The boundaries between of the zones are approximate only and will need to be confirmed on site through intrusive investigations. The boundaries of Ground Units were drawn with the assistance of the satellite imagery and other available data.

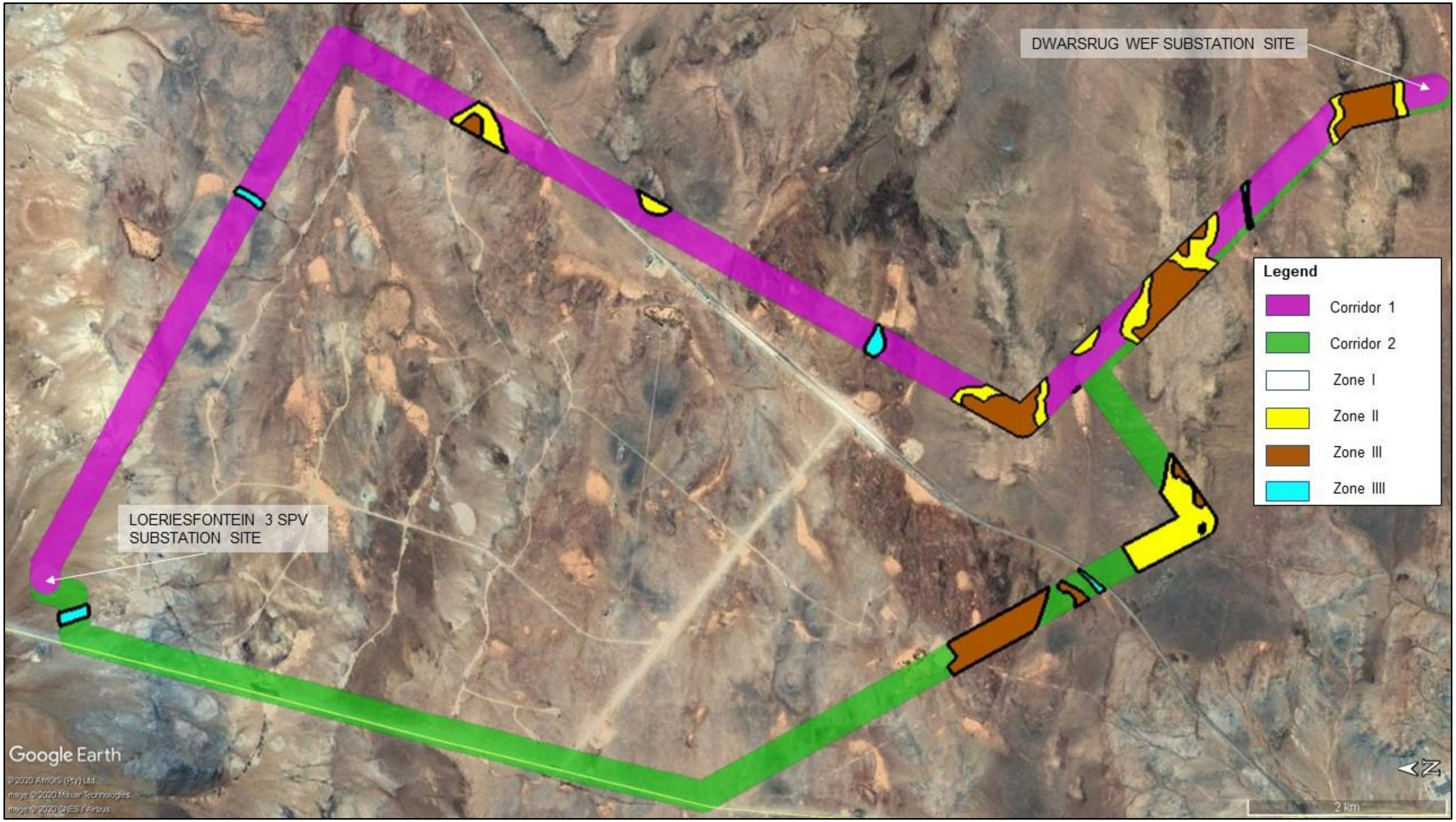

Figure 5-3 Inferred Ground Units for Corridor 1 and 2 (Google Earth, 2020)

Figure 5-4 Inferred Ground Units for Corridor 3 (Google Earth, 2020)

All of the Ground Units are considered suitable for the development of the powerline infrastructure, from a geotechnical viewpoint, provided that standard engineering design and construction measures are implemented to mitigate the identified geotechnical constraints. While **GU I**, compared to **GU II**, **III** and **IIII**, is considered marginally more suitable for development from a geotechnical perspective, other factors are likely to be more critical in determining the final layout.

The anticipated geotechnical constraints and mitigation measures are summarised in Table 5-1.

Table 5-1 Summary of Geotechnical Conditions

Ground Unit	Geology	Geotechnical Conditions / Constraints	Impacts on Engineering Design and Construction
I	Fairly shallow shale bedrock covered by transported and calcrete material	• Shallow bedrock • Thin soil cover • Intermediate to hard excavation conditions with depth • Overlain by alluvial soils of variable thickness in some areas	• Good founding conditions for structures at shallow depths • Conventional shallow foundations suitable • Conventional subgrade preparation for roads • Intermediate to hard excavation conditions for pole planting / trenching / earthworks
II	Talus on steep slopes	• Boulder excavation conditions • Potentially unstable talus slopes	• Terracing and slope stabilisation required
III	Outcropping bedrock	• Hard excavation conditions	• Heavy plant machinery / pneumatic methods / required for excavations (pole planting earthworks / trenching/foundations) • Good founding conditions for structures
IIII	Alluvium	• Loose sandy soils • Potentially collapsible soils • Moderate soil cover • Moderate bedrock depth • Increased erosion potential	• Deeper spread footings (found below alluvial sands) • Soft excavation conditions becoming intermediate with depth • Unstable trench sidewalls – shoring/battering required • Surface drainage measures required

6. Identification and Assessment of Impacts

No fatal flaws have been identified that would render the two alternative corridors, proposed to link Loeriesfontein 3 PV SEF to Dwarsrug WEF, as well as the single power line proposed to link two (2No.) facilities to national grid from Dwarsrug WEF, unsuitable from a geological and geotechnical perspective.

The impact of the activity on the geological environment is limited to topsoil stripping and excavations for support structures and the construction of access roads along the routes. Bulk earthworks, where required for the construction of access roads and working platforms on the steeper sections of the routes, may be a more significant impact.

6.1. Impact of the Project on the Geological Environment

The main impact of the development from a geological perspective is the displacement and possible removal of soil and rock materials and soil erosion linked to these activities. These activities will predominantly take place during the construction phase. The degree of disturbance is largely dependent on the topography of the project site and the nature of the proposed infrastructure. Steep slopes are unfavourable as these require bulk earthworks to create working platforms and access roads. Earthworks on steep slopes increases the risk of soil movements or slope failure.

The risk of soil erosion is also increased during construction activities, by the removal of vegetation and by possible disturbance to the natural surface drainage environment. These activities may prevent infiltration of rainwater, increase surface runoff and cause concentration of surface water flow. Erosion will increase the disturbance and displacement of soils and the impact may extend beyond the infrastructure footprint/s over time.

The effects of the development on the geological environment were evaluated using an Environmental Impact Assessment (EIA) Methodology, provided by SiVEST, which aids in determining the significance of an environmental impact on an environmental parameter through a systematic analysis. The EIA methodology is attached as Appendix C.

Based on the impact significance ratings presented in Table 6-1, the development of the proposed powerlines within Corridor 1, Corridor 2 and Corridor 3, from a geological and geotechnical perspective, will be “Negative Low impact”, provided that the recommended mitigation measures are implemented.

The soils do not render the site particularly susceptible to soil erosion, though mitigation measures need to be implemented, particularly within the steeper sections of the site and lower-lying sections of the site where concentrated surface flow is anticipated after heavy rainfall events.

Appropriate engineering design of access roads, particularly drainage and erosion control measures, are critical to limit the impact of the development on the geological and geotechnical environment.

The soils and topography render the site moderately susceptible to soil erosion. No ridges or rock outcrops which may be of geological importance were identified.

Table 6-1 Impact Assessment Methodology Matrix

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase (Corridor 1)																				
Disturbance/ displacement/ removal of soil and rock	Ground disturbance during access road construction, foundation earthworks, platform earthworks	1	4	2	2	3	1	12	-	Low	1) Design access roads and pylon locations to minimise earthworks and levelling based on high resolution ground contour information 2) Correct topsoil and spoil management	1	4	2	1	3	1	11	-	Low
Soil Erosion	Increased erosion due to vegetation clearing, alteration of natural drainage	1	4	2	2	2	1	11	-	Low	1) Avoid development in preferential drainage paths 2) Appropriate engineering design of road drainage and watercourse crossings 3) Temporary berms and drainage channels to divert surface runoff where needed	1	2	1	1	2	1	7	-	Low

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
											4) Landscape and rehabilitate disturbed areas timeously (e.g. regressing) 5) Use designated access and laydown areas only to minimise disturbance to surrounding areas									
Construction Phase (Corridor 2)																				
Disturbance/ displacement/ removal of soil and rock	Ground disturbance during access road construction, foundation earthworks, platform earthworks	2	4	2	2	3	1	13	-	Low	1) Design access roads and pylon locations to minimise earthworks and levelling based on high resolution ground contour information 2) Correct topsoil and spoil management	2	4	2	1	3	1	12	-	Low
Soil Erosion	Increased erosion due to vegetation clearing, alteration of natural drainage	1	4	2	2	2	2	22	-	Low	1) Avoid development in preferential drainage paths	1	2	1	1	2	1	7	-	Low

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
	for powerline construction and access roads										2) Appropriate engineering design of road drainage and watercourse crossings 3) Temporary berms and drainage channels to divert surface runoff where needed 4) Landscape and rehabilitate disturbed areas timeously (e.g. regressing) 5) Use designated access and laydown areas only to minimise disturbance to surrounding areas									
Construction Phase (Corridor 3)																				
Disturbance/ displacement/ removal of soil and rock	Ground disturbance during access road construction, foundation earthworks, platform earthworks	1	4	2	2	3	1	12	-	Low	1) Design access roads and pylon locations to minimise earthworks and levelling based on high resolution ground contour information	1	4	2	1	3	1	11	-	Low

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
											Correct topsoil and spoil management									
Soil Erosion	Increased erosion due to vegetation clearing, alteration of natural drainage	1	4	2	2	2	1	11	-	Low	1) Avoid development in preferential drainage paths 2) Appropriate engineering design of road drainage and watercourse crossings 3) Temporary berms and drainage channels to divert surface runoff where needed 4) Landscape and rehabilitate disturbed areas timeously (e.g. regressing) Use designated access and laydown areas only to minimise disturbance to surrounding areas	1	2	1	1	2	1	7	-	Low
Operational Phase (Corridor 1)																				

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Soil Erosion	Increased erosion due to alteration of natural drainage	1	2	1	1	2	1	7	-	Low	1) Maintain access roads including drainage features 2) Monitor for erosion and remediate and rehabilitate timeously	1	1	1	1	2	1	6	-	Low
Operational Phase (Corridor 2)																				
Soil Erosion	Increased erosion due to alteration of natural drainage	1	2	1	1	2	1	7	-	Low	1) Maintain access roads including drainage features 2) Monitor for erosion and remediate and rehabilitate timeously	1	2	1	1	2	1	7	-	Low
Operational Phase (Corridor 3)																				
Soil Erosion	Increased erosion due to alteration of natural drainage	1	2	1	1	2	1	7	-	Low	1) Maintain access roads including drainage features 2) Monitor for erosion and remediate and rehabilitate timeously	1	1	1	1	2	1	6	-	Low
Decommissioning Phase (Corridor 1)																				

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Disturbance/ displacement/ removal of soil and rock	Ground disturbance during platform earthworks, road rehabilitation, removal of subsurface infrastructure	1	4	2	2	2	1	11	-	Low	1) Restore natural site topography 2) Landscape and rehabilitate access roads and disturbed areas timeously (e.g. regressing)	1	4	2	1	2	1	10	-	Low
Soil Erosion	Increased erosion due to ground disturbance during rehabilitation activities	1	2	2	2	2	1	9	-	Low	1) Temporary berms and drainage channels to divert surface runoff where needed 2) Restore natural site topography 3) Use designated access and laydown areas only to minimise disturbance to surrounding areas	1	1	1	1	2	1	6	-	Low
Decommissioning Phase (Corridor 2)																				

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Disturbance/ displacement/ removal of soil and rock	Ground disturbance during platform earthworks, road rehabilitation, removal of subsurface infrastructure	1	4	2	2	2	1	11	-	Low	1) Restore natural site topography 2) Landscape and rehabilitate access roads and disturbed areas timeously (e.g. regressing)	1	4	2	1	2	1	10	-	Low
Soil Erosion	Increased erosion due to ground disturbance during rehabilitation activities	1	2	2	2	2	1	9	-	Low	1) Temporary berms and drainage channels to divert surface runoff where needed 2) Restore natural site topography 3) Use designated access and laydown areas only to minimise disturbance to surrounding areas	1	1	1	1	2	1	6	-	Low
Decommissioning Phase (Corridor 3)																				

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Disturbance/ displacement/ removal of soil and rock	Ground disturbance during platform earthworks, road rehabilitation, removal of subsurface infrastructure	1	4	2	2	2	1	11	-	Low	1) Restore natural site topography 2) Landscape and rehabilitate access roads and disturbed areas timeously (e.g. regressing)	1	4	2	1	2	1	10	-	Low
Soil Erosion	Increased erosion due to ground disturbance during rehabilitation activities	1	2	2	2	2	1	9	-	Low	1) Temporary berms and drainage channels to divert surface runoff where needed 2) Restore natural site topography 3) Use designated access and laydown areas only to minimise disturbance to surrounding areas	1	1	1	1	2	1	6	-	Low
Cumulative (Corridor 1, Corridor 2 and Corridor 3)																				

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Disturbance/ displacement/ removal of soil and rock Soil Erosion	No cumulative effect																			

7. Comparative Assessment of Alternatives

No geologically or geotechnically sensitive areas were identified within Corridor 1 or Corridor 2. While Corridor 1 is considered marginally more suitable, as can be seen in Table 6-1, for development from a geotechnical perspective than Corridor 2, due to the generally flatter topography, other factors are likely to be more critical in determining the preferred corridor. No preferences for Corridor 1 and Corridor 2 are therefore provided.

No geologically or geotechnically sensitive areas were identified that would render the proposed Corridor 1, Corridor 2 and Corridor 3 unsuitable for development, provided that standard engineering design and construction measures are implemented to mitigate the identified geotechnical constraints.

8. Conclusion and Summary

8.1. Summary of Findings

This desktop geotechnical specialist study was undertaken for the three (3No.) proposed grid connections; two corridor alternatives between the approved substation at the authorised 100 MW Loeriesfontein 3 PV SEF (12/12/20/2321/2/AM4) and approved substation at the authorised 140 MW Dwarsrug WEF (14/12/16/3/3/2/690/AM4); and one corridor between the Dwarsrug WEF and the proposed (and authorised) Narosies Substation (12/12/20/2049/3).

The assessment corridor areas may be divided into four (4No.) Ground Units (GU), **I**, **II**, **III** and **IIII** where similar geotechnical conditions are anticipated. **GU I** is defined by shallow occurring bedrock covered by thin, loose transported material and varying degrees of cemented calcrete. **GU II** can be characterised by talus deposits on relatively steep slopes that is linked to **GU III** that defines the high lying outcropping bedrock of which is seemingly shale material. **GU IIII** is confined to low lying areas that are underlain by relativity thicker alluvial deposits, identifiable by erosion paths, rills, pans and continuous drainage features.

Some geotechnical constraints have been identified, including the presence of shallow bedrock and loose/collapsible sands. These constraints may be mitigated via standard engineering design and construction measures. Shallow spread footings or drilled foundations are considered suitable to support the structures.

No fatal flaws have been identified that would render the proposed powerlines unsuitable from a geological and geotechnical perspective.

The proposed Corridor 1, Corridor 2 and Corridor 3 are assessed to have a “Negative Low impact - the anticipated impact will have negligible negative effects and will require little to no mitigation”.

Further intrusive geotechnical investigations should be undertaken to confirm the engineering recommendations provided in this report.

8.2. Impact Statement and Conclusion

Based on the impact significance ratings presented in Table 6-1, the development of the proposed powerlines within Corridor 1, Corridor 2 and Corridor 3, from a geological and geotechnical perspective, will be “Negative Low impact”, provided that the recommended mitigation measures are implemented.

From a geotechnical and geological perspective, no fatal flaws, sensitivities, or areas to be avoided have been identified within or close to the assessment area. It is therefore recommended that the proposed activity be authorised.

References

Brink, A.B.A. Engineering Geology of Southern Africa, Karoo Sequence, Volume 3. Building Publications, 1983

Johnson, M.R. Anhaeusser, C.R. Thomas, R.J. The Geology of South Africa. Council for Geoscience, 2006.

Appendix A. Specialist Declaration of Interest and Undertaking Under Oath

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

PROPOSED CONSTRUCTION OF 132 KV POWERLINES BETWEEN THE AUTHORISED LOERIESFONTEIN 3 PV SOLAR ENERGY FACILITY (12/12/20/2321/2/AM4) AND THE AUTHORISED DWARSRUG WIND ENERGY FACILITY (14/12/16/3/3/2/690/AM4), AND FROM THE DWARSRUG WIND ENERGY FACILITY TO THE AUTHORISED NAROSIES SUBSTATION (12/12/20/2049/3), LOCATED NEAR LOERIESFONTEIN IN THE HANTAM LOCAL MUNICIPALITY, NAMAKWA DISTRICT IN THE NORTHERN CAPE PROVINCE OF SOUTH AFRICA

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:	GaGE Consulting (PTY) LTD			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	2	Percentage Procurement recognition	125 %
Specialist name:	Steven Nicholas Bok			
Specialist Qualifications:	BSc Hons (Geology)			
Professional affiliation/registration:	Professional Natural Scientist SACNASP Reg. 400279/07			
Physical address:	17 Cowley Road, Bryanston, Johannesburg			
Postal address:	PO Box 71572 BRYANSTON			
Postal code:	2021	Cell:	082 875 8344	
Telephone:	010 823 1621	Fax:		
E-mail:	steven@gageconsulting.co.za			

2. DECLARATION BY THE SPECIALIST

I, STEVEN NICHOLAS BOK, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

GAGE CONSULTING (PTY) LTD
Name of Company:

11th DECEMBER 2020
Date

3. **UNDERTAKING UNDER OATH/ AFFIRMATION**

I, S.N. BOK, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

GAGE CONSULTING (PTY) LTD

Name of Company

11th DECEMBER 2020

Date

Signature of the Commissioner of Oaths

2020-12-11

Date

SOUTH AFRICAN POLICE SERVICE
CLAREMONT K.P/G.P
STATION COMMISSIONER
11 DEC 2020
STASIEKOMMISSARIS
SUID-AFRIKAANSE POLISIEDIENS

Appendix B. Specialist CV

DATE OF BIRTH
30 May 1979

NATIONALITY
South African

LANGUAGES
English
Afrikaans

QUALIFICATIONS
Professionally registered SACNASP 400279/07 (Geological Science), Bachelor of Science (Geology, Geography), Bachelor of Science (Honours) (Geology)

KEY SKILLS
Geotechnical site investigations
Desktop & feasibility studies
Materials investigations
Technical report writing
Project Management

INTERNATIONAL EXPERIENCE
Botswana, Democratic Republic of the Congo, Lesotho, Madagascar, Mozambique, Sierra Leone, South Africa, Zambia,

STEVEN BOK
Principal Engineering Geologist
PrSciNat BSc (Hons.)

SUMMARY OF CREDENTIALS

Steven is a registered professional natural scientist with 18 years of experience in the field of engineering geology and geotechnical engineering. He has broad exposure to infrastructure developments and is adept at undertaking and managing geotechnical site investigations, materials investigations and geotechnical report writing. He also has experience in geotechnical verification and monitoring during construction projects.

Steven has worked throughout South Africa and in Africa providing services to private-sector clients in the mining, consulting and construction industries as well as to government and parastatals.

His technical strengths are the planning and undertaking of site investigations for roads, railways, residential and commercial buildings, township development, large infrastructure (e.g. dams, reservoirs, pipelines, bridges, tailings facilities) and lateral support. Materials investigations (borrow pit and quarry identification and assessment) are an area of particular interest.

Many of the projects on which he has worked represent, complex, multi-disciplinary infrastructure developments. He has been responsible for undertaking and managing the geotechnical component of a major coal mine development in Mpumalanga as well as the new Sol Plaatjie University project in Kimberly. He was the Project Leader and undertook the detailed geotechnical investigation for the Kazungula Bridge over the Zambezi River.

He has also been involved with renewable energy projects from feasibility to preliminary and detailed design investigations.

He has undertaken geophysical investigations for quarries and borrow pits, groundwater identification and bridge and dam site investigation. Geophysical methods used are seismic refraction surveys, 2D resistivity and EM-34 electromagnetic surveys.

Steven has mentored young engineering geologists as a technical manager at a large South African consulting engineering firm.

He ensures that geotechnical investigations are undertaken in accordance with the Occupational Health and Safety Act and the Mine Health and Safety Act. He has experience in Risk Assessment and the preparation of Health & Safety files in terms of current regulations and client requirements.

STEVEN BOK: EXPERIENCE - KEY PROJECTS

Mafube Life Extension Project, Middleburg, Mpumalanga, SOUTH AFRICA, (2013-2019)
Client: Mafube Coal (Anglo Coal/Exxaro JV)
Lead Engineering Geologist – the project involved design and construction of mine infrastructure required to utilise the Nooitgedacht coal reserve, located 7km from the existing colliery. This included 7km of overland conveyor, 5km of haul roads, dams, a new ROM tip, road over rail bridge, major culverts, HMV workshops and associated infrastructure. Steven was responsible for undertaking or overseeing all site investigation work, from preliminary design commencing in 2013 to detailed design and geotechnical construction supervision during 2018/2019. Services included location and monitoring of rockfill and borrow materials. Effective use of mine overburden and borrow materials during construction resulted in a significant cost saving for the Client.
Project Value: US$200million.

N4 Upgrades, Rustenburg, SOUTH AFRICA (various phases, 2010 - 2019)
Client: Bakwena
Lead Engineering Geologist – Various upgrade and duelling projects along the N4 between Brits and Swartruggens. Steven was responsible for undertaking and overseeing road prism, materials and bridge investigations required for the detailed design of upgrades between Rustenburg and Swartruggens and duelling along Sections 9, 10 and 13 (approximately 60 km of new carriageway between Brits and Rustenburg). Work included mitigation of highly expansive "black turf" subgrades and sourcing of construction materials. Drilling investigations were undertaken for approximately 12 bridges, including a new bridge over the Crocodile River. Construction supervision and verification of founding conditions.

New Sol Plaatjie University, Kimberly, South Africa (2015-2017)
Client: WITS / Sol Plaatjie University
Project Leader for Geotechnical Consultant – the project involved the construction of a new university in Kimberly. Steven was the Project Leader for the geotechnical consultant responsible detailed site investigations and geotechnical construction supervision. The university complex is constructed on variably weathered dolerite bedrock, which posed a challenge for foundation design. The use of geophysics, detailed rock mass characterisation and targeted drilling, coupled with monitoring of the founding conditions during construction, allowed the design engineers to triple the foundation loads determined during the preliminary design phase.

Camden Power Station new ash dam, water return dam, Ermelo, SOUTH AFRICA (2016)
Client: Eskom 2016

Project Engineering Geologist – the project involved the detailed design and subsequent construction of a new Ash Dam Facility, water return dam and associated slurry pipelines and access roads. Steven was responsible for undertaking the geotechnical site investigations as part of the design team. The investigation involved a detailed materials investigation, specialised laboratory and in-situ testing and included extensive interaction with the design and Eskom's technical teams. The presence of nearby undermining necessitated the use of various geophysical methods to delineate the extent of tunnels, which could have lead to instability of the ADF.

Various Eskom Substations, SOUTH AFRICA (2013-2015)
Client: Eskom SOC Limited
Project Leader for Geotechnical Consultant – detailed geotechnical investigations for 5 major new substations across South Africa, namely the Northrand Substation (Johannesburg), Nieuwehoop Substation (Northern Cape), Dwaalboom Substation (Limpopo), Upington Substation and Firgrove Substations (Somerset West). Steven undertook the site investigations which included assessment of construction materials and geophysical surveys. Engineering geological models were produced for each site, which assisted Eskom's civil design team to optimise the platform layout and earthworks design. The appointment included conceptual platform and subsoil drainage design. The completed Firgrove Substation is illustrated.

Various Bulk Water Supply pipelines, Gauteng, SOUTH AFRICA, (2009-2013)
Client: Rand Water SOC Ltd
Project Engineering Geologist / Project Leader – Steven managed or undertook detailed geotechnical investigations for a major proportion of Rand Water's pipeline construction projects between 2009 and 2013. Work included investigations for sections of the F5, H35, R5, H37, G37, B19, O5, O6 and C25 pipelines. In total, approximately 80 km of route was investigated, for pipelines ranging from 800 mm to 2500 mm diameter, including detained investigations at numerous pipe jacking positions. The investigation outputs included the compiling detailed geotechnical long sections of the pipeline routes highlighting excavation conditions and geotechnical risks. Most of the projects have been successfully constructed.

Various Rand Water Reservoirs & Pumping Stations, Gauteng, SOUTH AFRICA, (2010-2016)
Client: Rand Water SOC Ltd
Project Engineering Geologist / Project Leader – Detailed site investigations (typically drilling investigations) were undertaken for an additional reservoir a the Palmiet Pumping Station (100 Ml) the Amanzimtoti Reservoir (20 Ml), Bronberg Reservoir (100 Ml), extensions to the Palmiet Pumping Station and sections of the Zuikerbosch and Vereeniging WTW extension projects. Steven was involved with geotechnical site supervision during construction on many of the projects. Palmiet Pumping Station is illustrated.

Kazangula Bridge over the Zambezi River, BOTSWANA, (2011),
Client: EGIS BECOM International
Project Engineering Geologist for detailed geotechnical investigations – the 923-metre-long Kazangula Bridge, currently nearing completion, crosses the Zambezi River at Kasane, Botswana. The bridge provides a road and rail crossing between Botswana and Zambia and passes through Namibia, where the country's borders meet. Steven was the project Engineering Geologist for the contractor who undertook the site investigation and was responsible for ensuring that the investigations were undertaken in accordance with European standards and technical reporting. He undertook full-time supervision of the drilling and in-situ testing works, which were undertaken from a jack-up barge. The reporting included rock mass characterisation beneath the bridge piers, settlement estimates and provision of foundation recommendations.

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EXPERIENCE: OTHER PROJECTS

Khwezela Life Extension Project (2019)
Client: Anglo Coal
Project Leader (PL) & Senior Engineering Geologist - haul road materials investigation and pavement design project, including construction supervision as part of a coal mine expansion project.

Kriel Ash Dam Stability Analysis (2017-2018)
Client: Eskom
Senior Engineering Geologist - responsible for geotechnical investigations to characterise an existing wet ash dam facility.

Matjhabeng Solar Park (Sunelex Energy) 2015
Client: Sunelex Energy
Project Leader – detailed ground investigation for a proposed 500 MW Solar Park on 2000 ha site for the Matjhabeng Local Municipality, Odendaalsrus.

75 MW Nokukhanya Solar PV Plant (2015)
Client: Nokukhanya Energy
Project Leader – foundation investigations for a proposed solar project in near Groblersdal

Leeuwpan OI BFS External Roads Package (2015)
Client: Exxaro
Project Leader – a road prism and materials investigation for the realignment of the R50 provincial road around the Leeuwpan Colliery, Ogies, Mpumalanga.

Three story office building at Camden Power Station (2012/13)
Client: Eskom
Project Leader - site investigations, pilling supervision & pile integrity verification

Belfast Mine Leachate Dams (2011)
Client: Exxaro
Senior Engineering Geologist - GI for preliminary design of two lined earthfill return water dams

Foundation investigations for approx. 80 Eskom Telecommunication Towers (2010-2014)
Client: Eskom
Project Leader - term appointment for undertaking site investigations for foundation design of new Eskom telecommunication towers throughout South Africa

Sierra Leone centre line & materials investigation (2010)
client: African Minerals
Senior Engineering Geologist - road prism and materials investigation for 50km of new haul road / railway line in Sierra Leone, including foundation investigations for bridges.

Dumbe Coal Line Stability Analysis (2009-2010)
Client: Transnet
Project Leader & Senior Engineering Geologist - GI for slope stability analysis for widening of 6 km of cuttings on the Coal Line near Paulpietersburg.

Lesotho Lowlands Geotech Zone 4&5 (2007)
Client: Lesotho Ministry of Natural Resources
Engineering Geologist – Detailed GI for 350 km bulk supply pipeline, 46 Reservoirs & pump stations

Thuni Dam, in Eastern Botswana (2005)
Client: DWA Botswana
Engineering Geologist: Detailed geotechnical investigations and materials investigation for a large earthfill dam

PROFESSIONAL HISTORY

2019 – date:	GaGE Consulting (Pty) Ltd, Cape Town – Principal Engineering Geologist.
2002 – 2019:	JG Afrika (Pty) Ltd Engineering & Environmental Consulting. Engineering Geologist (Pietermaritzburg, 2002 to 2007), Senior Engineering Geologist (Pietermaritzburg, 2007 to 2009), Senior Engineering Geologist (Johannesburg, 2009 – 2013), Associate (Johannesburg, 2013 – 2019).

TECHNICAL QUALIFICATIONS

2000	Bachelor of Science (Geology, Geography)	Nelson Mandela Metropolitan University
2001	Bachelor of Science (Honours) (Geology)	Nelson Mandela Metropolitan University

TECHNICAL COURSES AND CONFERENCES ATTENDED

2014	Attendee, SAICE Young Geotechnical Engineers Conference, Stellenbosch.
2008	Attendee, SAICE Young Geotechnical Engineers Conference, Durban.
2005	Attendee, SAICE Young Geotechnical Engineers Conference, Swadini.

Appendix C. Environmental Impact Assessment (EIA) Methodology

1 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) METHODOLOGY

The Environmental Impact Assessment (EIA) Methodology assists in evaluating the overall effect of a proposed activity on the environment. Determining of the significance of an environmental impact on an environmental parameter is determined through a systematic analysis.

1.1 Determination of Significance of Impacts

Significance is determined through a synthesis of impact characteristics which include context and intensity of an impact. Context refers to the geographical scale (i.e. site, local, national or global), whereas intensity is defined by the severity of the impact e.g. the magnitude of deviation from background conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence. Significance is calculated as shown in **Table 1**.

Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

1.2 Impact Rating System

The impact assessment must take account of the nature, scale and duration of effects on the environment and whether such effects are positive (beneficial) or negative (detrimental). Each issue / impact is also assessed according to the various project stages, as follows:

- Planning;
- Construction;
- Operation; and
- Decommissioning.

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance has also been included.

The significance of Cumulative Impacts should also be rated (As per the Excel Spreadsheet Template).

1.2.1 Rating System Used to Classify Impacts

The rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the possible mitigation of the impact. Impacts have been consolidated into one (1) rating. In assessing the significance of each issue the following criteria (including an allocated point system) is used:

Table 1: Rating of impacts criteria

ENVIRONMENTAL PARAMETER		
A brief description of the environmental aspect likely to be affected by the proposed activity (e.g. Surface Water).		
ISSUE / IMPACT / ENVIRONMENTAL EFFECT / NATURE		
Include a brief description of the impact of environmental parameter being assessed in the context of the project. This criterion includes a brief written statement of the environmental aspect being impacted upon by a particular action or activity (e.g. oil spill in surface water).		
EXTENT (E)		
This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment of a project in terms of further defining the determined.		
1	Site	The impact will only affect the site
2	Local/district	Will affect the local area or district
3	Province/region	Will affect the entire province or region
4	International and National	Will affect the entire country
PROBABILITY (P)		
This describes the chance of occurrence of an impact		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
REVERSIBILITY (R)		
This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES (L)		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource.	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.

DURATION (D)		
This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity.		
1	Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).
INTENSITY / MAGNITUDE (I / M)		
Describes the severity of an impact (i.e. whether the impact has the ability to alter the functionality or quality of a system permanently or temporarily).		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
SIGNIFICANCE (S)		

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula:

Significance = (Extent + probability + reversibility + irreplaceability + duration) x magnitude/intensity.

The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.

Points	Impact Significance Rating	Description
5 to 23	Negative Low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
5 to 23	Positive Low impact	The anticipated impact will have minor positive effects.
24 to 42	Negative Medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
24 to 42	Positive Medium impact	The anticipated impact will have moderate positive effects.
43 to 61	Negative High impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
43 to 61	Positive High impact	The anticipated impact will have significant positive effects.
62 to 80	Negative Very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
62 to 80	Positive Very high impact	The anticipated impact will have highly significant positive effects.

The table below is to be represented in the Impact Assessment section of the report. The excel spreadsheet template can be used to complete the Impact Assessment.