Appendix H.13

GEOTECHNICAL ASSESSMENT

REPORT

Dalmanutha Wind Energy Facility Geotechnical Desktop Assessment

WSP Africa

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1.0 INTRODUCTION

WSP Golder Pty Ltd (Golder) was appointed by WSP Africa (WSP) to provide a geotechnical desktop assessment for the proposed Dalmanutha Wind Energy Facility (WEF). WSP was appointed by Dalmanutha Wind (Pty) Ltd to carry out an Environmental Impact Assessment (EIA) for the WEF development. The purpose of this desktop study is to provide preliminary geotechnical information regarding the feasibility for the proposed project and to indicate potential geotechnical constraints.

The services to be provided by WSP Golder are set out in our proposal entitled "CX21500154_PRO_WSP Africa Dalmanutha WEF_Rev0_20211026" and includes the provision of a geotechnical desktop impact assessment.

This report presents the results of the desktop study.

1.1 Project Description

Two alternatives are proposed for the Dalmanutha WEF. Alternative 1 is a full wind energy facility, with a capacity of up to 300MW, comprising up to 70 wind turbines; Alternative 2 is a hybrid facility, with a capacity of up to 300MW, comprising 44 turbines and two solar fields. The Dalmanutha WEF alternatives will comprise the following:

Table 1: Key technical details of the Dalmanutha WEF

Component	Description	
Development	Dalmanutha Wind Energy Facility Alternative 1	
Affected farms	▪ Berg-en-Dal 378 JT (Portions 1 and 9)	▪ Vogelstruispoort 384 JT (Portion 5 and 7)
	▪ Waaikraal 385 JT (Portions 6, 7, 8, 10, 12,13 and 24)	▪ Leeuwkloof 403 JT (Portions 3 and 4)
	▪ Leeuwkloof 404 JT (Portions 1 and 2)	▪ Geluk 405 JT (Portion 3)
	▪ Camelia 467 JT (Portion 0)	▪ Welgevonden 412 JT (Portion 1
Extent	approximately 9 197 ha.	
Buildable area	approximately 400ha (subject to finalisation based on technical and environmental requirements)	
Capacity	Up to 300MW	
Wind turbines	▪ Up to 70 turbines, each with a foundation of approximately 25m² in diameter (500m² area and requiring ~2 500m³ concrete each) and approximately 3m depth ▪ Turbine hub height of up to 200m ▪ Rotor diameter up to 200m ▪ Permanent hard standing area for each wind turbine (approximately 1ha).	
On-site IPP substation and Battery Energy Storage System (BESS)	▪ IPP portion onsite substation of up to 4ha. The substation will consist of a high voltage substation yard to allow for multiple up to 132kV feeder bays and transformers, control building, telecommunication infrastructure, access road, etc. ▪ The Battery Energy Storage System (BESS) storage capacity will be up to 300MW/1200 megawatt-hour (MWh) with up to four hours of storage. It is proposed that Lithium Battery	

Component	Description
	Technologies, such as Lithium Iron Phosphate, Lithium Nickel Manganese Cobalt oxides or Vanadium Redox flow technologies will be considered as the preferred battery technology; however, the specific technology will only be determined following Engineering, Procurement, and Construction (EPC) procurement. The main components of the BESS include the batteries, power conversion system and transformer which will all be stored in various rows of containers.
Operations and Maintenance (O&M) building footprint	Operations and maintenance (O&M) building infrastructure will be required to support the functioning of the WEF and for services required by operations and maintenance staff. The O&M building infrastructure will be near the onsite substation and will include: ■ Operations building of approximately 200m^2 ■ Workshop and stores area of approximately 150m^2 ■ Stores area of approximately 150m^2 ■ Refuse area for temporary waste and septic/conservancy tanks with portable toilets to service ablution facilities. ■ The total combined area of the buildings will not exceed 5 000m^2.
Construction Camp Laydown	■ Temporary laydown or staging area -Typical area 220m x 100m = 22000m^2. ■ Laydown area could increase to 30000m^2 for concrete towers, should they be required. ■ Sewage: septic and/or conservancy tanks and portable toilets. ■ Temporary cement batching plant, wind tower factory & yard of approximately 7ha, comprising amongst others, a concrete storage area, batching plant, electrical infrastructure and substation, generators and fuel stores, gantries and loading facilities, offices, material stores (rebar, concrete, aggregate and associated materials), mess rooms, workshops, laydown and storage areas, sewage and toilet facilities, offices and boardrooms, labour mess and changerooms, mixers, moulds and casting areas, water and settling tanks, pumps, silos and hoppers, a laboratory, parking areas, internal and access roads - Gravel and sand will be stored in separate heaps whilst the cement will be contained in a silo. The maximum height of the silo will be 20m
Access roads	■ The Project site can be accessed easily via either the tarred R33 or the N4 national road which run along the northern and western boundaries of the site. ■ There is an existing road that goes through the land parcels to allow for direct access to the project development area. ■ Internal and access roads with a width of between 8m and 10m, which can be increased to approximately 12m on bends. The roads will be positioned within a 20m wide corridor to accommodate cable trenches, stormwater channels and bypass /circles of up to 20m during construction. Length of the internal roads will be approximately 60km.

Component	Description		
Cables	Cables up to and including 33kV that run underground, except where a technical assessment suggest that overhead lines are required, within the facility connecting the turbines to the onsite substation. Over the fence 132kV cable to connect the onsite IPP substation to the Common Collector Switching Station.		
Associated infrastructure	▪ Fencing of up to 4m high around the construction camp and lighting	▪ Lightning protection	▪ Telecommunication infrastructure
	▪ Stormwater channels	▪ Water pipelines	▪ Offices
	▪ Operational control centre	▪ Operation and Maintenance Area / Warehouse/workshop	▪ Ablution facilities
	▪ A gatehouse	▪ Control centre, offices, warehouses	▪ Security building
	▪ A visitor's centre	▪ Substation building	
Development	**Dalmanutha Wind Energy Facility Alternative 2: Hybrid Energy Facility**		
Extent	Approximately 9 197ha		
Buildable area	Approximately 400ha		
Wind turbines	▪ Up to 44 turbines, each with a foundation of approximately 25m² in diameter (500m² area and requiring ~2 500m³ concrete each) and approximately 3m depth ▪ Turbine hub height of up to 200m ▪ Rotor diameter up to 200m ▪ Permanent hard standing area for each wind turbine (approximately 1ha per turbine)		
Solar Fields	▪ Solar PV array comprising PV modules (solar panels), which convert the solar radiation into direct current (DC) ▪ PV panels will be up to a height of 6m (when the panel is horizontal) and will be mounted on fixed tilt, single axis tracking or dual axis tracking mounting structures. Monofacial or bifacial Solar PV Modules are both considered ▪ Footprint: ~160 ha ▪ Inverters, transformers and other required associated electrical infrastructure and components		
Associated infrastructure	The associated infrastructure is the same as for Alternative 1		

1.2 Scope of Work

The geotechnical desktop study scope of work includes the following:

- A review of available published and unpublished information including, but not limited to, geological data, geological maps, topographical maps and aerial images of the study area
- A site reconnaissance to observe general site characteristics
- An assessment of relevant geotechnical and geological fatal flaws within the study area
- Recommendations regarding requirements for subsequent detailed geotechnical investigations

1.3 Specialist Credentials

The geotechnical desktop study was undertaken by an experienced professionally registered engineering geologist and the work was overseen by a professionally registered senior geotechnical engineer.

Khuthadzo Bulala is an engineering geologist with a Bachelor of Science Honors Degree from the University of Limpopo. She is registered as a Professional Scientist (Pr.Sci.Nat 116482). Khuthadzo has seven years of experience in engineering geology, geotechnical engineering, environmental geology, and soil surveys. She has extensive experience in conducting renewable energy geotechnical assessments and detailed geotechnical investigations.

The desktop studies will be reviewed and authorized by **Heather Davis**. Heather is a qualified Professional Engineer (Pr.Eng 960229) with 40 years of experience. She obtained a BSc Honours degree in Engineering Geology and Geotechnics from the University of Portsmouth (UK) in 1982. A post graduate diploma was obtained from the University of the Witwatersrand in 1993 which focused on geotechnical engineering and rock mechanics. She is currently the geotechnical team lead at WSP Golder. Her responsibilities include providing geotechnical inputs to various projects, quality assurance on all geotechnical work and provision of reports. She has accumulated extensive experience in Sub Saharan Africa which has included work on the Medupi and Kusile Power Plants and on renewable projects such as the Sere Wind Farm, for Eskom, in the Northern Cape.

The CV's for Khuthadzo Bulala and Heather Davis are included in APPENDIX A.

2.0 STUDY AREA INFORMATION

2.1 Site Location and Physical Description

The proposed Dalmanutha WEF is located approximately 7km southeast of the town of Belfast within the Emakhazeni Local Municipality, Mpumalanga Province.

A locality plan is presented as Figure 1. The site is accessed via the N4, which is approximately 220 meters north from the proposed development area. There is an existing gravel road that goes through the parcels of land from north to south to allow for direct access to the project development area. The majority of the farms are utilized for cattle and horse farming. Minor agricultural activities were also observed during the site reconnaissance. Most of the areas is characterized by short grass and sparse trees.

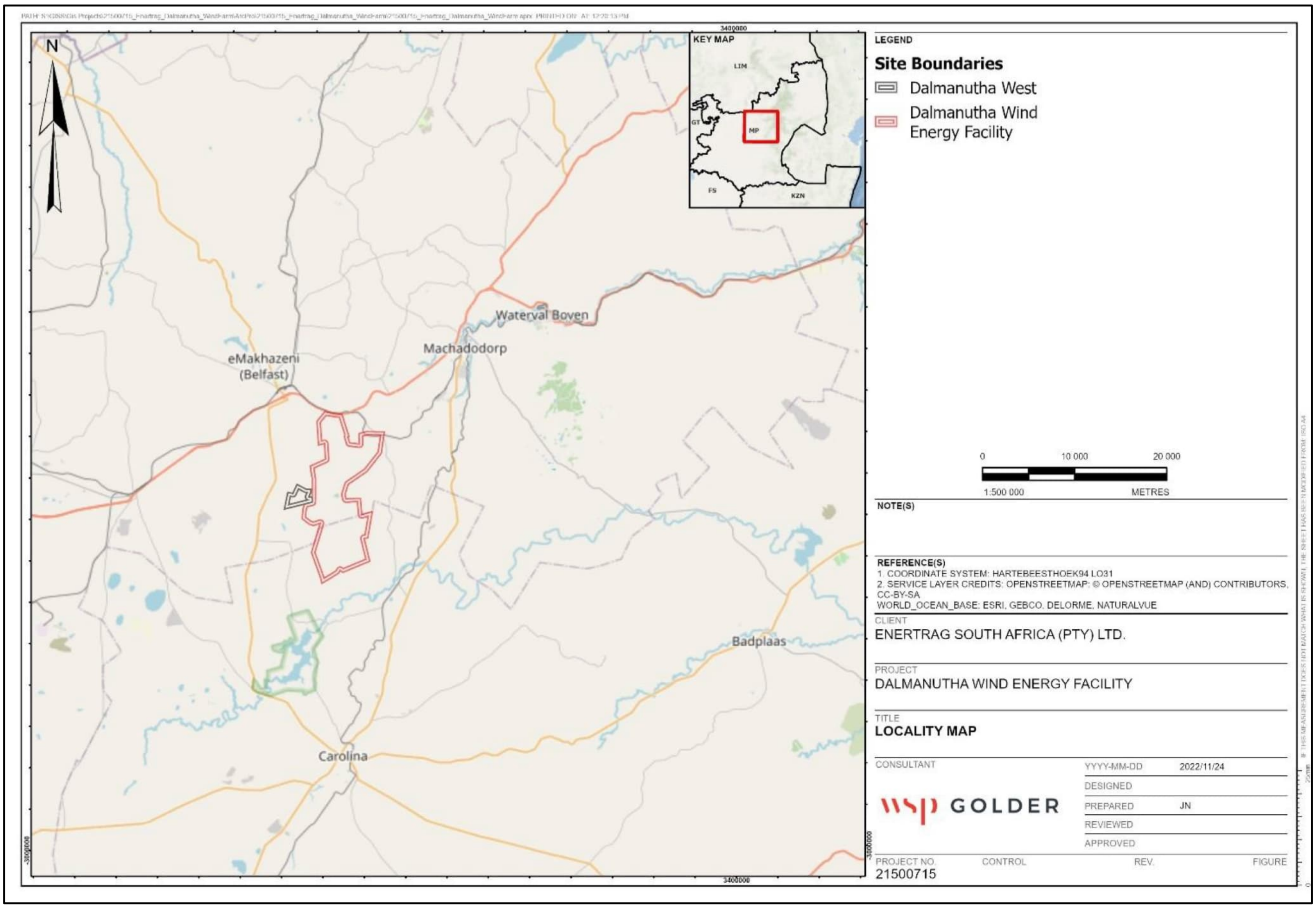

Figure 1: Locality of the Project Site

2.2 Drainage and Topography

The site lies within the Quaternary catchment X11D. This catchment receives 744mm rainfall per year and experiences 1413mm of evaporation annually. Numerous non-perennial rivers drain in an easterly direction into the perennial Waalkraalloop river and in a westerly and southerly direction into the perennial Klein Komati River.

Marsh/vlei features are indicated on Figure 2 to the north and south of the site.

The terrain consists of rolling hills with flat hill tops. The proposed WEF lies at an elevation of approximately 1630m in the northern section to 1888m in the southern section. Areas with a relatively high elevation are shown in green on Figure 2. whilst areas with a relatively low elevation are shown in pink.

The majority of the WEF has a slope of between 4.4º and 10.2º. The central part of the site is generally flat with a range in slope from 0.0º to 4.4º as shown in Figure 3. The southern portion is characterized by hills leading to steeper slopes of between 10.2º – 34.4º. However, all the turbines and the western solar field in this area are located on the flat hill tops. The eastern solar field is located across a valley and is characterized by steep slopes. A general view of the site is provided in Figure 4.

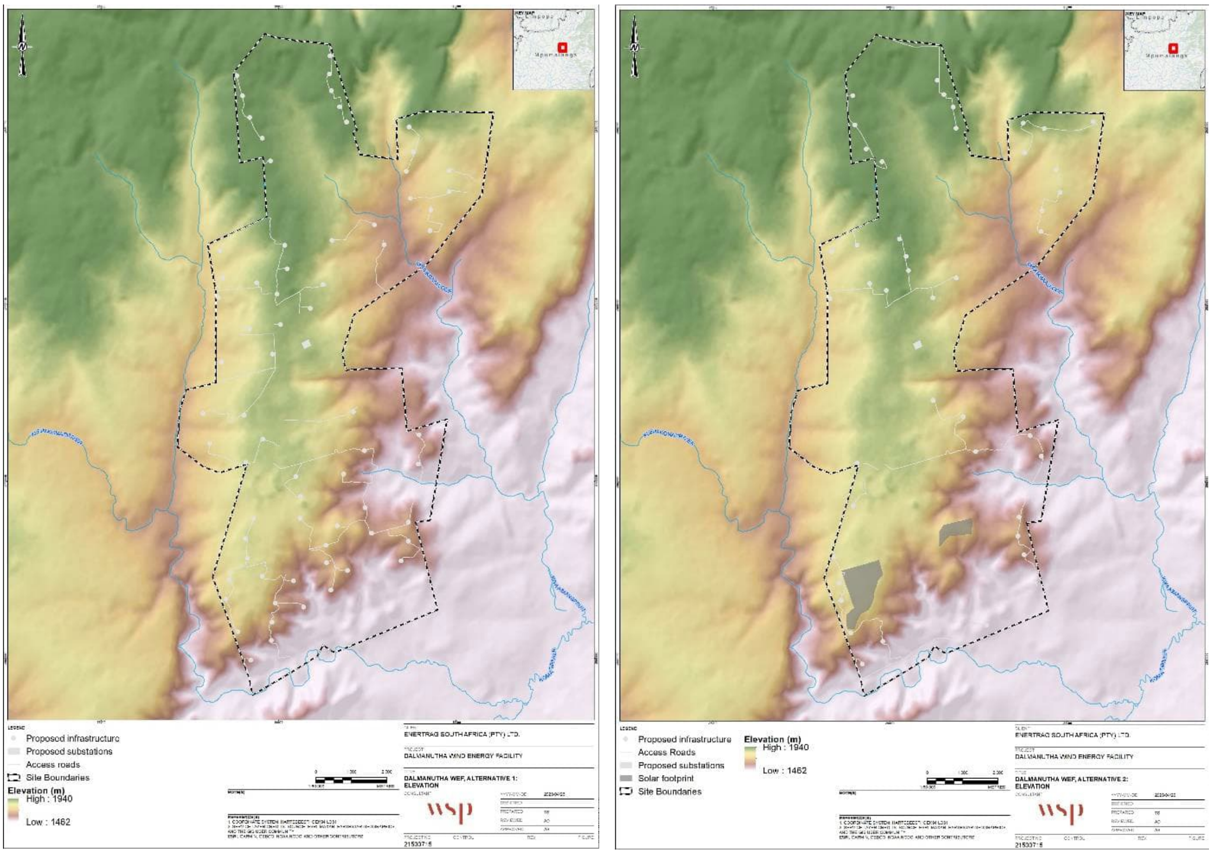

Figure 2: Elevation Map of the Project Site (Alternative 1 and Alternative 2)

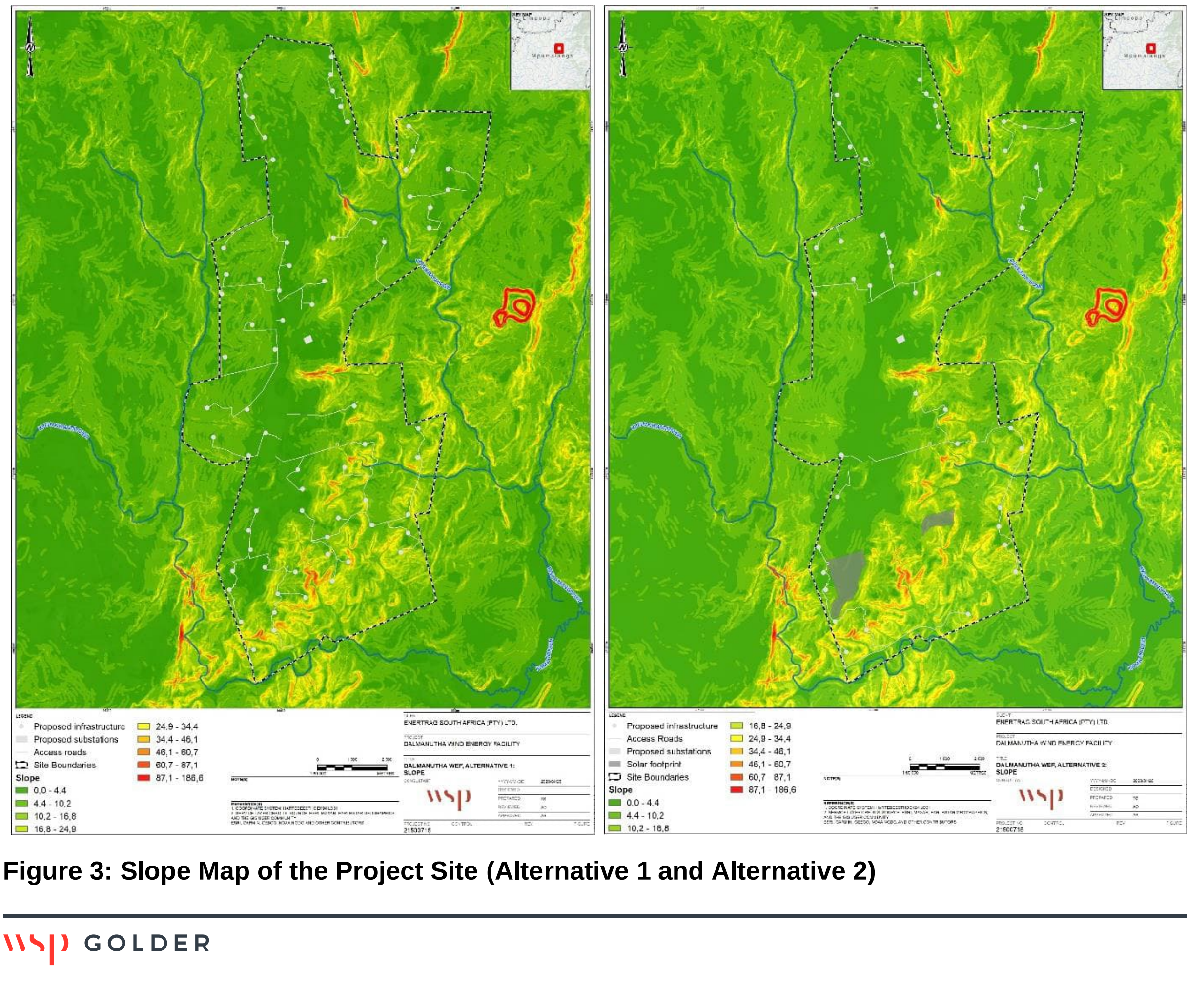

Figure 3: Slope Map of the Project Site (Alternative 1 and Alternative 2)

Figure 4: Proposed WEF Area Characterized by Hilly Terrain (Photos Taken from WTG7 Facing WTG63)

3.0 GEOLOGY

According to the published 1: 250 000 geological map (Sheet 2530 Barberton), the western and northeastern portions of the study area are underlain by the Vryheid Formation (Pv), Ecca Group, Karoo Supergroup. This comprises quartzitic, cross-bedded sandstone, pebbly near its base, gritty sandstone and shale.

A small portion of the western boundary is underlain by the Vermont Formation (Vv) comprising fine-grained hornfels, with sedimentary structures, near the top and base, layers of silt and sandstone and minor layers of carbonate and calc-silicate rocks, Hornfels was not observed on site during the reconnaissance. However, baked shale was encountered.

The central portion of the site is underlain by the Magaliesberg Formation (Vm) which comprises pure, coarse-grained, white quartzite containing sporadic impersistent shale layers in places, upper part comprising interlayered shale, siltstone and quartzite, and lower part shale.

The eastern portion is underlain by the Silverton Formation (Vsl) comprising greenish, fine-grained, laminated shale and subordinate mudstone, interlayered carbonate layers rare, hornfels in places.

The Vermont, Magaliesberg and Silverton Formations form part of the Pretoria Group, Transvaal Supergroup. These formations have been intruded by diabase (Vdi). Recent surficial deposits (Q), alluvium and scree blanket a small section of the study area.

Excerpt of the published geological map showing the two alternative project areas are presented as Figure 5 and Figure 6 respectively.

The lithostratigraphy of the area is presented in Table 2.

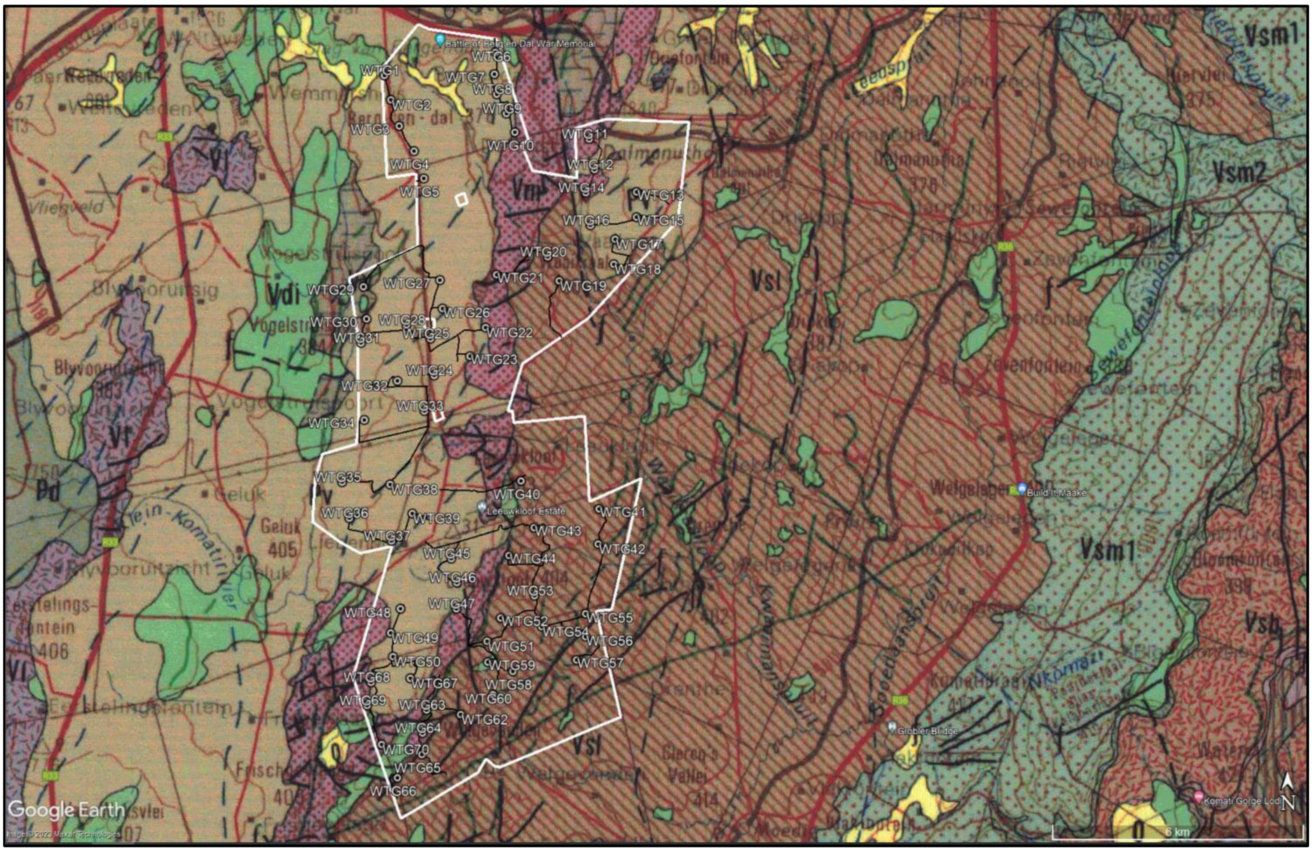

Figure 5: Geology Map of Alternative 1 Project Site

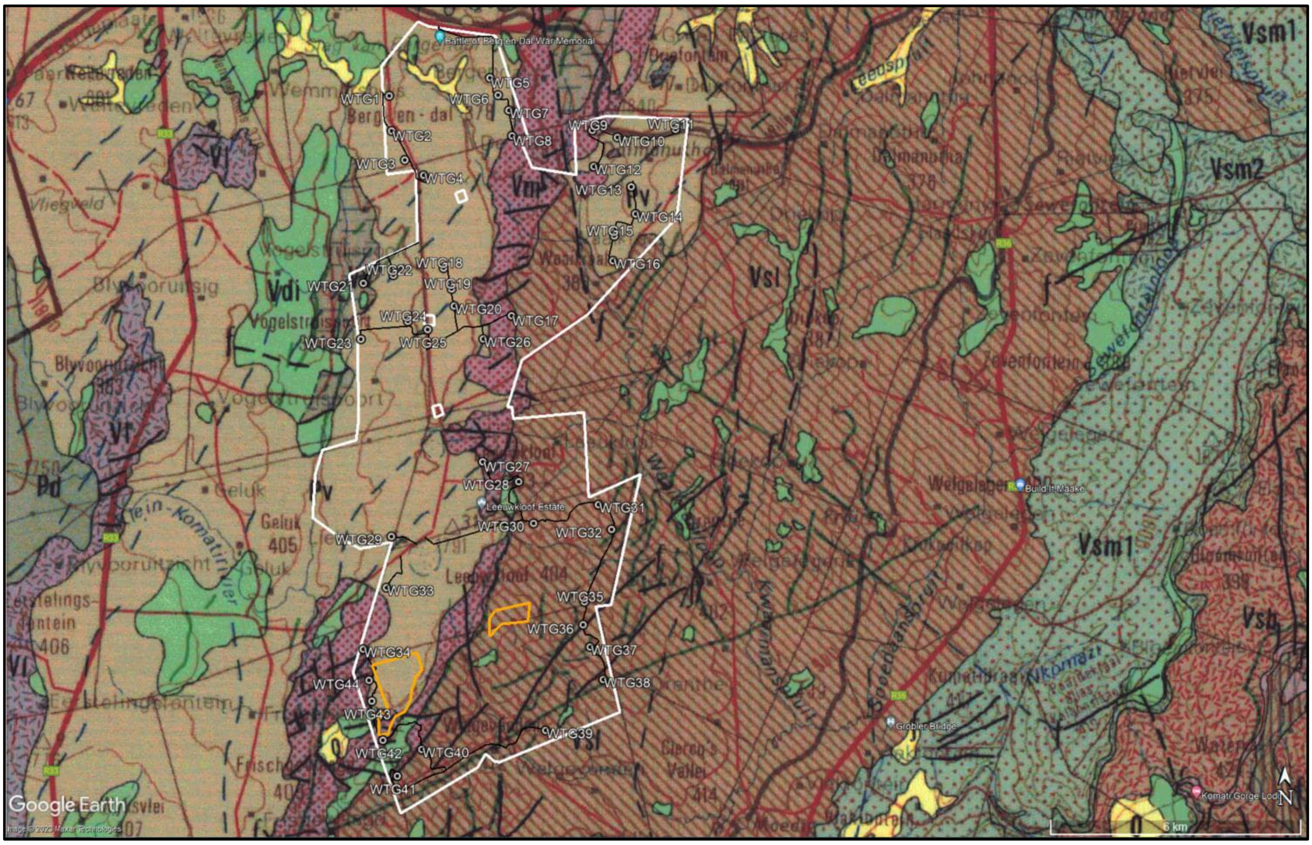

Figure 6: Geology Map of Alternative 2 Project Site

Table 2: Lithostratigraphy of the area

Super-group	Group	Formation	Member	Lithology	Map symbol
				Dolerite	Vdi
Karoo	Ecca	Vryheid		Quartzitic, cross bedded, sandstone, gritty sandstone & shale	Pv
Transvaal	Pretoria	Vermont		Fine grained hornfels. Layers of siltstone and sandstone. Minor layers of carbonate and calc-silicate rocks	Vv
		Magaliesberg		Pure, coarse-grained quartzite with some shale layers in places. Upper part comprises interlayered shale, siltstone and quartzite.	Vm
		Silverton	Lydenburg Shale	Greenish, fine grained, laminated shale and subordinate mudstone. Interlayered carbonate layers are rare. Hornfels in places	Vsl

4.0 RESULTS OF THE DESKTOP STUDY

A site reconnaissance of the study area was conducted by Golder personnel on Monday 14th March 2022.

A summary of the key findings from the desktop study and site reconnaissance is provided below.

Climate

The climatic regime of the present and of the relatively recent times plays a fundamental role in the development of the soil profile. The site falls within the sub-humid part of South Africa where Weinerts climatic N-value is less than 5 which promotes chemical weathering and results in thick deeply weathered residual soils. Pedocretes, where present, are likely to be in the form of ferricrete. However, during the site reconnaissance, surface and subsurface rock was observed. Thicker soil profiles are anticipated in the valleys.

Undermining

Subsidence at surface in undermined areas is caused by collapse and failure of the underground mining void relatively close to the surface (Heath and Engelbrecht, 2011). The Dalmanutha WEF site is located approximately 8km southeast of the North Block Complex Belfast Coal Mine and approximately 10km east of the Exxaro Belfast Mine. Both mines are operating as open cast mines and, hence, there is no undermining at the WEF site, and no mine related subsidence is expected.

Flooding

Flooding affects flat lying areas, areas confined to drained channels and flood plains. All the turbines are located on flat hill tops where water ponding is a possibility. Stormwater management is recommended at all flat areas to facilitate water run-off and to alleviate the possibility of standing water at the positions of foundations.

Erosion

The topography of the site and erosion are interrelated. The slope on site, as well as the soil structure will influence the amount of erosion. Land on steeper slopes will be more prone to erosion.

It must be noted that no significant erosion channels were encountered during the reconnaissance with the exception of erosion gullies along the farm road cuttings.

The proposed turbine locations and solar fields are covered with grass and sparse trees, and there is therefore a reduced risk of erodibility problems. The possibility of erosion must be mitigated, at each turbine position, by revegetation after construction.

Seismicity

According to the published seismic hazard map of South Africa (Kijko, et al., 2003), the probability of a seismic event occurring is low with a value for peak ground acceleration at the site being between 0.08 and 0.12m/s as illustrated in Figure 7.

A 10% probability exists that this value will be exceeded in a 50-year period.

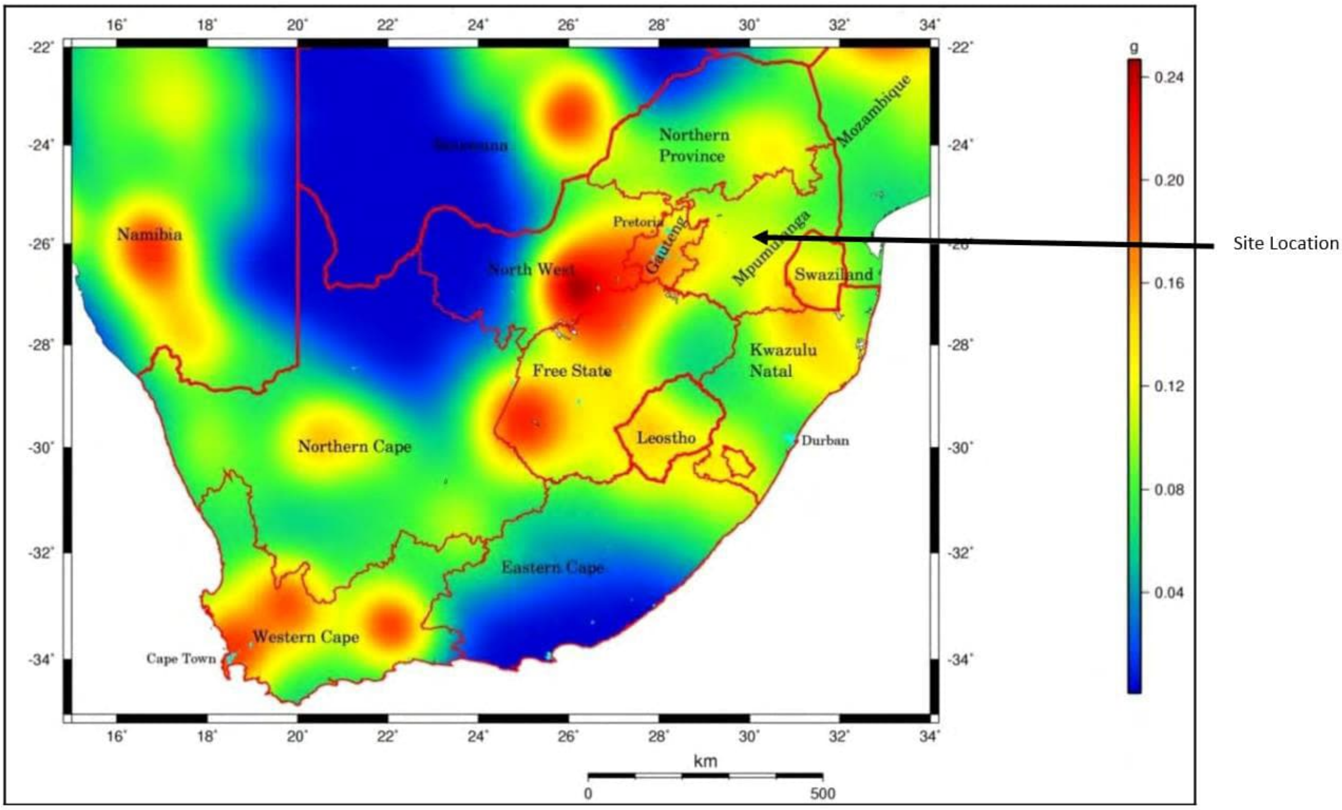

Figure 7: Seismic Hazard Map of South Africa

4.1 Engineering Geology of Encountered Formations

The turbine and solar fields positions are underlain by four different geological formations as listed in Table 3 below.

Plans indicating the layout of the proposed positions of the turbines and solar fields in Dalmanutha WEF alternative 1 and Dalmanutha WEF alternative 2 are presented as Figure 8.

Table 3: Geological Formations Underlying the Alternative 1 Layout

Geology	Turbines		Associated Infrastructure
Diabase	WTG59		
Vryheid Formation	WTG01 to WTG9 WTG13 WTG15 to WTG18 WTG23 to WTG28	WTG30 to WTG39 WTG45 – WTG50 WTG67	On-site IPP Substation and BESS Laydown and construction camp Batching plant and wind tower factory
Vermont Formation	WTG29		
Magaliesberg Formation	WTG12 to WTG12 WTG14 WTG21 to WTG22	WTG63 to WTG64 WTG68 to WTG70	
Silverton Formation	WTG19 to WTG20 WTG51 WTG40 to WTG44	WTG51 to WTG58 WTG60 to WTG62 WTG65 to WTG66	

Table 4: Geological Formations Underlying the Alternative 2 Layout

Geology	Turbines		Associated Infrastructure
Diabase	No turbines, solar or associated structure		
Vryheid Formation	WTG01 to WTG7 WTG10 to WTG11 WTG13 to WTG16 WTG18 to WTG20	WTG22 to WTG26 WTG29 WTG33 WTG43	On-site IPP Substation and BESS Laydown and construction camp 1 & 2 Batching plant and wind tower factory 1 & 2 Majority of solar 1
Vermont Formation	WTG21		
Magaliesberg Formation	WTG8 to WTG9 WTG12 WTG17	WTG27 WTG34 WTG42 WTG44	Southern section of solar 1
Silverton Formation	WTG28 WTG30 to WTG32 WTG35 to WTG41		Solar 2

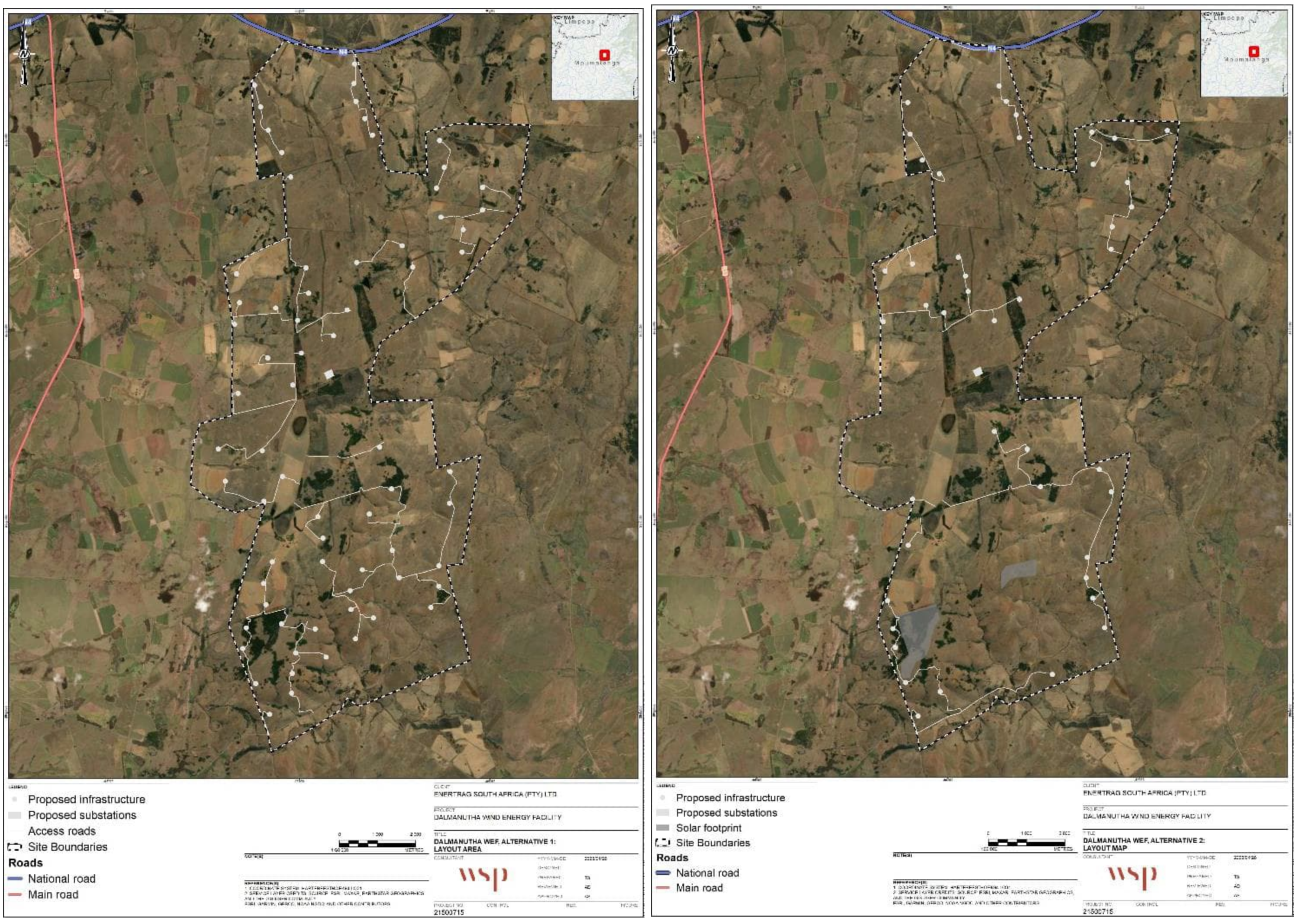

Figure 8: Position of Turbines in the Dalmanutha WEF Alternative 1 and Alternative 2

Vryheid Formation

On site, shale of the Vryheid Formation was observed in a small borrow pit situated close to WTG37. The profile in the pit comprised a thin layer of transported and residual soil underlain by shale as illustrated in Figure 9.

Figure 9: Small Vryheid Shale Borrow Pit Observed on Site Close to WTG37 on the Northern Portion

Vryheid shale generally weathers to a clayey residual soil which is often compressible and potentially expansive. Expansive soils are those materials that exhibit volume change with a change in moisture content. These materials “shrink” when the moisture content decreases and “heave” or “expand” when the moisture content increases. Where the residual shale profile is thinly developed, it is recommended that the material should be stripped. Where thickly developed, the structural design needs to take cognizance of the potential expansiveness.

Some shale breaks down rapidly after exposure to the elements with micro-cracks developing as a result of moisture loss or stress relief. Mudrocks such as shale, are generally not considered suitable for use as construction materials. This is due to their potential expansiveness, excessive absorption of water, poor engineering performance and lack of durability. However, some shale material is considered suitable for use as selected layers in road construction (wearing coarse for gravel roads). However, the durability and potential expansiveness should be ascertained beforehand.

Diabase (Dolerite)

Diabase was not observed in outcrop across the site during the site reconnaissance. A hill with diabase boulders was observed approximately 0.35m south-west of WTG49, Figure 10. According to the published geological map, WTG54 is underlain by diabase. According to the Google Earth image, diabase boulders may be present in the area of WTG54.

Generally, the residual soil is relatively thickly developed above diabase rock with the profile becoming coarser with depth. Cobbles and boulders are often present above the rock grading into gravel, sand and finally residual clay. Cobbles and boulders of diabase, however, are often present throughout the residual profile.

Residual clay is generally compressible and potentially expansive in the “medium to high” range. Where a structure straddle residual diabase and a different soil type, the structure should be moved to avoid differential settlement or designed accordingly.

Diabase rock, cobbles, boulders, gravel and sand a generally durable and are suitable for a variety of purposes. It is commonly quarried and used as a construction material such as for concrete aggregate and road construction material.

Figure 10: Diabase Hill with Boulders, Located Close to WTG49, Side Profile (Left) and Top (Right)

Magaliesberg Formation

Quartzite outcrop was observed on surface across the center of the WEF on the flat hilltop. The sides of the slopes are characterized by quartzite boulders as shown in Figure 11 and Figure 12. The quartzite encountered is cream white, moderately weathered, medium to coarse grained, medium hard to hard rock. Where present, residual soils are likely to be thinly developed.

Figure 11: Quartzite on Surface, Photo Taken Facing WTG45 (Left) and Facing WTG16 (Right)

Although not observed on site, the residual soil tends to comprise loose silty sand or clayey sand with a thickness of less than 2m. The residual quartzitic clayey/silty sand may be potentially collapsible.

Soils with a collapsible structure experience additional settlement when subjected to an inundation of some kind. This occurs without an increase in loading and may occur many years after construction. Soil improvement, by means of compaction with the addition of water to -1% to +2% of optimum moisture content might be required where the residual soil is thickly developed. This is, however, not expected as rock is expected to be encountered within the 3m excavation required for the turbine bases.

Quartzite is often quarried and used as concrete aggregate and in road pavement layers.

Figure 12: Quartzite on Surface

Silverton Formation (Shale)

Silverton shale underlies the majority of the eastern side of the site. Shale outcrop was encountered on a road near to WTG25 (Figure 13). The rock is light grey, moderately weathered, fine grained, thinly laminated, with light yellow silty sand infill along the bedding planes, soft rock shale. The rock was overlain by a thin (0.30m) layer of residual shale profiled as slightly moist, light brown to beige, soft, intact, sandy silt. A slightly moist, light greyish brown, loose, silty sand topsoil blanketed the area.

Figure 13: Silverton Shale

The residual profile is generally thinly developed above the Silverton shale, less than 2m thick, and is expected to comprise a clay/silt material. The residual clay is generally potentially expansive and compressible.

Areas of subsurface or surface shale are present throughout the site and give rise to restricted drainage. Where a shallow water table is proven during the detailed investigation or the flat areas on top of the slopes, water ponding must be prevented to avoid the oversaturation of the residual soils. Residual shale soils are impermeable, which will lead to water ponding in and around the foundation. This can lead to differential settlement of the foundations, hence, stormwater management in the area is imperative.

Silverton shale can be used as sub-base and even base-course material, but usually the material will require mixing with granular material to improve the grading or blending to decrease the plasticity.

5.0 GEOTECHNICAL EVALUATION

It is anticipated that areas of outcrop, shallow rock and relatively thinly developed soil will be present across much of the Dalmanutha site.

5.1 Excavatibility

The excavation characteristics of the soil horizons has been evaluated according to the South African Bureau of Standards standardized excavation classification for earthworks (SABS – 1200D). The definition of the excavation classes is indicated in Table 5 and the assessment of the in-situ profile in Table 6.

Table 5: Excavation Classes

Class of Excavation	General Definition
Soft	Excavation in material which can be efficiently removed or loaded by any of the following plant without prior ripping: - A bulldozer with a mass of at least 22 tons (which includes the mass of the ripper, if fitted) and an engine developing approximately 145kW at the flywheel. Or A tractor-scraper unit with a mass of at least 28 tons and an engine developing approximately 245kW at the flywheel, pushed during loading by a bulldozer as specified for intermediate excavation. Or A track type front end loader with a mass of at least 22 tons and an engine developing approximately 140kW at the flywheel
Intermediate	Excavation (excluding soft excavation) in material which can be efficiently ripped by a bulldozer with a mass of at least 35 tons when fitted with a single tine ripper and an engine developing approximately 220kW at the flywheel.
Hard	Excavation (excluding boulder excavation) in material which cannot be efficiently ripped by a bulldozer with properties equivalent to those described for intermediate excavation. This type of excavation generally includes excavation in material such as formations of unweathered rock, which can be removed only after blasting.
Boulder Class A	a) Excavation in material containing in excess of 40% by volume of boulders between $0.03m^3$ and $20m^3$ in size, in a matrix of softer material or smaller boulders. b) Excavation of fissured or fractured rock shall not be classed as boulder excavation but as hard or intermediate excavation according to the nature of the material.
Boulder Class B	Where material contains 40% or less by volume of boulders in a matrix or soft material or smaller boulders.

The ease of excavation is a critical financial factor for any development. As evidenced during site reconnaissance, surface and subsurface rock characterizes majority of the area.

Table 6: Excavatibility

Material	Excavation Class
Quartzite Shale Diabase	
Transported material	Soft excavation.
Diabase	Soft excavation in residual clay, sand and gravel. Boulder Class A and Boulder Class B where boulders are encountered. Hard excavation in diabase rock
Vryheid shale and residual soil	Soft excavation in residual shale and very soft to soft rock. Intermediate to hard excavation in medium hard and harder rock
Vermont Formation	Soft excavation in residual hornfels and very soft to soft rock. Intermediate to hard excavation in medium hard and harder rock
Magaliesberg quartzite and residual soil	Soft excavation where residual quartzite is present. Intermediate to hard excavation from surface where outcrop is present and from a shallow depth where rock is encountered.
Silverton shale and residual soil	Soft excavation in residual shale and very soft to soft rock. Intermediate to hard excavation in medium hard and harder rock

Up to a depth of 3m, all excavations should be excavated at a batter of 1:1 in soil where no water or seepage is evident and to 1:2, or flatter, where water is encountered. Rock can be excavated at a batter of 1:0.5 or vertically in the temporary case up to a depth of 3m.

According to the published geological map the regional dip of the shale and quartzite is approximately 8° to the northwest. Instability is, therefore, not expected in rock slopes as the regional dip is less than the expected shear strength parameters of the rock.

Depending on the embedment depth, blasting may be required for cable trenches. Alternatively, surface conduits or pole mounted cables may be considered to alleviate the costs of blasting.

5.2 Foundations for Wind Turbines and Solar Pylons

Turbines

The proposed foundation bases are 25m^2 in area and the concrete base is 3m deep. The structures exert a static load. However, it is loading as a result of the high wind shear that drives the selection of founding medium. A high strength material is required for founding to provide sufficient bearing capacity and strength

Rock is expected across much of the site at a depth of less than 3m and, therefore founding in rock is recommended. It is recommended that test pits be excavated at each turbine position during the geotechnical site investigation to determine the depth to rock and the strength characteristics thereof. Some rotary cored boreholes would be required to determine the rock strength with depth in, particularly, the shales. The quartzite is expected to be medium hard to hard from surface or from a shallow depth.

Solar Pylons

The structures exert a static load. However, it is loading as a result of the high wind shear that drives the selection of founding medium. A high strength material is required for founding to provide sufficient bearing capacity and strength.

Due to the variation in the geotechnical conditions across the site, the foundation recommendations will vary depending on the geotechnical ground conditions.

In the areas underlain by quartzite, rock is expected on surface or in depth shallower than approximately 1.50m, and conventional founding in rock is recommended. The depth to rock in the areas underlain by mudrock (shales and siltstones) is expected to be >3m.

Proposed foundation types recommended are driven piles (areas with boulders and shallow bedrock excluded) and cast in-situ concrete piles (an appropriate piling method that can pierce through boulders and shallow soft to very soft rock).

6.0 GEOTECHNICAL IMPACT ASSESSMENT

Geotechnical impacts need to be taken into account as part of the WEF development. The identified risks can typically be mitigated by the implementation of an appropriate and effective plan. Mitigation measures must be implemented to avoid or reduce negative impacts during the construction, operation and decommissioning phases.

The geotechnical impact assessment applies for the two alternative WEF sites: Dalmanutha WEF and Dalmanutha Hybrid Energy Facility. The associated infrastructure falls within the same geology and slope characteristics and the either option is recommended for construction.

Based on the impact assessment matrix undertaken for this project, from a geotechnical perspective the impact of the Dalmanutha WEF was found to be *"Negative moderate to high impact - The anticipated impact will have negative effects and will require mitigation."* The assessment impact assessment matrix is presented as APPENDIX B.

The WEF application site is considered suitable for the proposed development provided that the recommendations presented in this report are adhered too and which need to be verified by more detailed geotechnical investigations during detailed design.

7.0 FURTHER GEOTECHNICAL RECOMMENDATIONS

A detailed intrusive site investigation is recommended to further characterize site conditions, to better understand the key geotechnical risks characteristics in order to refine the development of the WEF. Based on the current lack of previous geotechnical investigation data, the primary objectives of the proposed intrusive investigation must include:

- Determination of the founding conditions for all structures. The scope of the intrusive investigation should comprise test pitting, the drilling of a representative number of boreholes and laboratory testing.
- Investigation of subgrade conditions for service roads.
- Investigation for materials to be used during construction.
- Non-intrusive investigation techniques, such as geophysical (seismic refraction) surveys, thermal and electrical resistivity for ground earthing requirement.

8.0 CONCLUSIONS

Based on WSP Golder's overall desktop study, the proposed Dalmanutha site is suitable for the operation of a WEF.

A "n*egative moderate to very high"* impact was assessed, from a geotechnical perspective, for the pre-mitigation situation for the Dalmanutha WEF. Post-mitigation, the assessed impact decreases significantly to *"very low to low."*

A geotechnical site investigation must be undertaken to provide detailed geotechnical information for the design of the proposed structures and roads.

9.0 ASSUMPTIONS AND LIMITATIONS

Your attention is drawn to APPENDIX C "Document Limitations". The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimize the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by WSP Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

10.0 REFERENCES

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- Brink. A.B.A (1979). Engineering Geology of Southern Africa: The first 2000 million years of geological time. Volume 1. Building Publications: Pretoria.
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- South African National Standards 1200D: Earthworks, (1998).

Signature Page

WSP Group Africa (Pty) Ltd.

Khuthadzo Bulala (Pr. Sci. Nat)
Engineering Geologist

Heather Davis (Pr. Eng)
Geotechnical Team Lead

KB/HD/mk

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APPENDIX A

Specialist CVs

Heather Davis

Senior Geotechnical Engineer

Education

BSc (Honours) Engineering Geology and Geotechnics Portsmouth University, England,1982

Graduate Diploma in Engineering in the field of Geotechnical Engineering, University of the Witwatersrand SA,1993

Professional Registration

Professionally registered Engineer with the Engineering Council of South Africa (PrEng 960229).

Professional Affiliation

Fellow of the South African Institution of Civil Engineering.

PROFESSIONAL SUMMARY

Forty years of experience within the fields of geotechnical engineering and engineering geology. Much of the work has been gained in Sub Saharan Africa including Swaziland, Botswana, Malawi, and Angola. A wide range of projects have been handled ranging from investigations for large projects such as coal fired power stations, hydroelectric power schemes, major freeways and major pipelines to smaller scale projects for commercial developments and residential buildings. Forensic investigations have, also, been completed for failed tailings facilities, structures and slopes.

Responsibility has been taken for all facets of the geotechnical investigation including the site investigation planning, procurement, drilling supervision, fieldwork, in situ testing, analysis, reporting and supervision during construction. Contract documentation and administration for geotechnical investigations has, also, been handled. Extensive experience in dolomitic terrain and was involved in the re-drafting of SANS 1936 Parts 1 and 2 and subsequent revisions to the standard. Dolomite assessments for large facilities such as the Telkom site in Centurion, the Mispah tailings facility as well as for residential complexes and individual units have been carried out. Linear dolomitic assessments for roads, including the N1, and pipelines have been completed,

I am a fellow of the South African Institution of Civil Engineers Geotechnical Division and acted as Treasurer from 2006 to 2020.

EMPLOYMENT HISTORY

Golder/WSP (Pty) Ltd
Senior Geotechnical Engineer – (April 2022 to present)

Jones & Wagener (Pty) Ltd following the merger with Verdi Consulting
Technical Director (Jan 2018 to April 2021)
Consulting Geotechnical Engineer (May 2021 to March 2022)

Verdi Consulting Engineers (Pty) Ltd
Senior Geotechnical Engineer (March 2014 to Dec 2017)

AECOM SA (Pty) Ltd formerly BKS (Pty) Ltd
Technical Director and then Geotechnical Department Head (Feb 2007 to February 2014)

ARQ (Pty) Ltd
Geotechnical Engineer & Associate (Jan 2003 to Jan 2007)

Knight Hall Hendry (Pty) Ltd
Associate (Jan 2001 to Dec 2002)

VKE Engineers (Pty) Ltd
Principal Engineer (Nov 1987 to Dec 2000)

National Building Research Institute CSIR
Research Engineering Geologist (Nov 1985 to Oct 1987)

Geological Survey of South Africa
*Engineering Geologist (*Nov 1982 to Oct 1985)

RELEVANT EXPERIENCE

N1 Sections 20 and 21 Geotechnical Investigation
Brakfontein

Lead geotechnical Engineer for the upgrade, extensions and additions to the N1 Ben Schoeman Freeway, Sections 20 and 21, between the Brakfontein and Allandale Interchanges as part of the Gauteng Freeway Improvement Project (GFIP) carried out for South African National Roads Agency SOC Ltd (SANRAL). Contract documentation for the subsurface investigation was drafted and all components of the project management of the SANRAL contract were handled including payment certificates. The ensuing site investigation included extensive rotary core drilling, percussion drilling and test pitting. Work included the analysis, assessment and provision of founding recommendations for the 22km of dual carriageway. Design components included bridges founded on ancient granite, sedimentary rocks of the Pretoria Group along with dolomite and deeply developed dolomitic residuum of the Chuniespoort Group. Both conventional and piled foundations were used for the various bridge structures and elements. Foundation recommendations were, also provided for culverts, retaining walls, cut slopes and embankments. Site inspections took place during construction to ensure non variance in sub surface conditions from that indicated by the investigation.

N11 Section 9
Hendrina

Lead geotechnical engineer for the upgrade of National route N11 Section 9 between Hendrina and Hendrina Power Station. Planning and supervision of the linear investigation, by means of rotary drilling and test pitting, of 18.56km of roadway including two river bridges, cuts, fills and culverts. Full report complied including recommendations for all facets of the project. All work carried out as per the current SANRAL requirements and all contract administration for the drilling investigation handled.

National Route N5, between Harrismith and Kestell: Geotechnical Investigation
Harrismith and Kestell

Lead geotechnical engineer for the project, carried out for SANRAL, which included drafting the contract documentation for the subsurface investigation which included extensive rotary core drilling and test pitting. The project includes the rehabilitation of the National Route 5 involving extending existing bridges, design and construction of new bridges and design of significant culvert structures. The bridge structures included river bridges, road over rail and road over road structures. Work carried out included supervision of the site investigation, analysis and provision of founding recommendations for all structures, contract administration and arbitration of claims.

Mogalakwena Platinum Mine: New Northern Concentrator
Limpopo

Lead geotechnical engineer for the pre-feasibility and feasibility level investigations for the New Northern Concentrator. Supervision of all field work and provision of recommendations for all the structural elements. Additional design level investigation carried out for the M3C BOS Low Grade Stockpile.

Multi Products Pipeline Project: Geotechnical Investigation
Johannesburg

Project carried out for NMPP/ Transnet. Project manager for the geotechnical input for pipeline section running from Kendal to Waltloo and Jameson Park to Langlaagte in Johannesburg. Investigations have included test pitting; in situ testing and borehole have included test pitting, in situ testing and borehole drilling. The assessment of the route underlain by dolomite and dolomitic residuum was, also undertaken.

Vaal River Eastern Sub-System Augmentation Project (VRESAP): Geotechnical Investigation
Vaal

Geotechnical investigation for TCTA for a pipeline to carry water from the Vaal Dam to Secunda for use by SASOL and ESKOM. Planning and preparation of contract documentation for drilling, trenching programmes, laboratory and in situ testing. Extensive field work was completed and recommendations provided for trench sidewall stability, excavatability, construction through problem areas and recommendations for design and construction of the surge tanks, pipe bridges, abstraction works, de-silting works and access roads.

Marikana Mine Processing Plant: Geotechnical Investigation
Rustenburg

Site investigation of several candidate sites and the detailed investigation of the final site for the processing plant for new platinum mine. Foundation recommendations for all plant elements were provided including those for silos, mills, crushers and conveyor trestles. Foundation design for large vibratory plant elements. Ongoing foundation inspections and providing geotechnical advice and recommendations to the client throughout construction.

Medupi and Kusile Power Stations: Investigations and Foundation Assessments
Limpopo

Assessment carried out for Hitachi/Eskom of existing information regarding the founding conditions. Provision of structure specific foundation recommendations which included settlement analysis, assessment of bearing capacity and determination of parameters for dynamic design. Site inspections and assessment of ground conditions during construction for both Kusile and Medupi. Also, project manager for an additional geotechnical investigation carried out at Medupi Power Station due to unforeseen ground conditions. Investigation included percussion drilling with the Jean Lutz computerised system along with triple tube rotary drilling. Analysis of data allowing optimisation of the power station design.

Medupi Flue Gas De-sulphurisation Project
Limpopo

Lead geotechnical engineer for the project which was carried out following the construction of Units 1 to 6. The investigation comprises test pitting, geophysical surveys and drilling. Foundation recommendations for all facets of the project were provided.

Mispah Tailings Storage Facility
Far West Rand

Extensive investigation and analysis following failure of a section of the Mispah Tailings Storage Facility (TSF) which is underlain by dolomite, dolomitic residuum and rocks of the Karoo Supergroup. The initial assessment lead to the entire facility being re-assessed and candidate sites for new facilities being investigated. Of specific note was the liaison with several other geotechnical/engineering geological consulting firms regarding the failure.

Irene Village Mall Extensions
Centurion

In depth assessment of existing information applicable to the Irene Village Mall retail development in Irene. Dolomite stability assessments for extensions to the existing shopping mall including the addition of a multi-level parkade and additional retail space. Provision of founding recommendations for all facets of the development including earthworks, roadways and foundations.

Gautrain
Centurion

BKS were the Client representatives on the Gautrain project. Input and comment on aspects of the route underlain by dolomite including the Centurion Gautrain Station were provided. Assessment of the efficacy of the remedial measures utilised at the station including an extensive programme of grouting. Also, investigation of dolomite related subsidence and a sinkhole adjacent to the Gautrain route and below a raised section of the train line in the Centurion area. Subsequent design of the remedial measures for the sinkhole, drainage measures and long-term monitoring of the area.

Serengeti Golf and Wildlife Estate
Kempton Park

Dolomite stability assessments, coupled with near surface investigations, of parcels of land throughout the Serengeti Golf and Wildlife Estate. Developments have included single, double and triple storey residential units, Hotel, Club House and artificial lake. All reports have been submitted to the Council for Geoscience (CGS) and have included IHC to IHC7 conditions with Dolomite Area Designations of D2 to D4 being represented. NHBRC applications have been made for all the residential developments.

Aerosud Facility, in Pierre van Ryneveld Park
Centurion

Various dolomite stability investigations and reviews have been undertaken for warehouses, ablution blocks, workshops, parking areas and other infrastructure elements across the Aerosud manufacturing facility. All work has, and is, being carried out according to SANS 1936 Parts 1 to 4 of 2012. A Dolomite Risk Management Plan was drafted for the Aerosud Facility and is updated on a regular basis. The site manly classifies as IHC4 to IHC7 with Dolomite Area Designation D2 and D3 being applicable to most of the site.

Erasmuspark/ Castlegate Multi Use Development
Erasmuspark

Re-assessment of existing information in line with SANS 1936 on a site underlain by dolomite and dolomitic residuum and non-dolomitic formations. Programme of drilling and near surface investigation, to feasibility level, to de-lineate those areas underlain by dolomite and provision of recommendations for a mixed-use development which will include retail and residential components. Subsequent design level investigations have been completed for various large structures across the site and further de-lineation of developable and non-developable areas.

Khuthadzo Bulala

Engineering Geologist

Education

BSc. (Honours) in Geological Sciences, University of Limpopo, South Africa, 2013

BSc. Degree in Geological Sciences, University of Johannesburg (Auckland Park Campus), South Africa, 2011

Certifications

South African Council for Natural Professions (SACNASP) - Pr. Sci. Nat (116482)

PROFESSIONAL SUMMARY

Khuthadzo Bulala, Pr.Sci.Nat. - is an engineering geologist with 6 years' experience in geotechnical investigations. Her experience and technical skills include:

- Compilation of geotechnical investigation reports
- Geotechnical core logging
- Core orientation for inclines boreholes
- Planning, managing, and executing in-situ testing (test-pitting, geotechnical drilling operations, DCP testing and piezometer installations) for geotechnical investigations
- Laboratory testing selection and liaison with laboratories
- Analysis and interpretation of laboratory and in-situ test data
- Geological mapping and sourcing of construction materials and aggregates
- Sourcing, testing and specification of construction materials and aggregates
- Health and safety documentation for fieldwork projects
- Project management including resource management and client liaison

EMPLOYMENT HISTORY

Golder Associates Africa (Pty) Ltd – Midrand, Gauteng

Engineering Geologist (Oct 2021 to Present)

- Geotechnical investigations for renewable energy
- Geotechnical desktop studies for railway lines
- Geotechnical investigations for infrastructure

JG Afrika (Pty) Ltd – Pietermaritzburg, Kwa-Zulu Natal

Junior Engineering Geologist (Sept 2016 to Sept 2021)

- Geotechnical investigations (Phase-1 & 2) and report reviews for housing development as per NHBRC requirements.
- Geotechnical investigation for renewable energy projects (wind energy facilities, solar farms, and their associated structures)
- Geotechnical investigations for roads and bridge structures.
- Evaluation of sites for cemetery and landfill developments or extensions.
- Geotechnical investigation for dams, pipelines, water treatment works, and waste-water treatment works projects.
- Geotechnical investigation for buildings (refurbishments, damaged, new structures).
- Material source investigation for construction projects.
- Site supervision for rotary and percussion drilling projects.
- Agricultural soil survey to assessment site potential.

Lesotho Highlands Development Agency (LHDA) – Polihali, Lesotho

Engineering Geology Intern (March 2016 to August 2016)

- Geotechnical investigation for the Polihali Dam investigation – based on site full time

RELEVANT EXPERIENCE

Geotechnical Investigation for the ArcelorMittal Mine Extensions
Tokadeh, Liberia
Geotechnical report writing for the ArcelorMittal facilities; Tokadeh pit, Tokadeh infrastructure, Gangra Pit, Water Storage Dam, Tailings Management Facility, and Bucanan Port.

Geotechnical Investigation for Polihali Dam, the Diversion Tunnel and the Transfer Tunnel
Tlokeng, Lesotho
Site supervision (drilling, water pressure tests, installation of piezometers), rotary core logging for the dam site, the saddle dam, the coffer dam, the diversion tunnel, the Katse Dam transfer tunnel and the proposed borrow pits.

Geotechnical Investigation for Rietfontein Dam
Eastern Cape, South Africa
Project management, trial pitting for the dam foundation, spillway construction and the construction material at the site. Evaluation of engineering properties of subsurface material. Geotechnical reporting for dam design purposes. Geotechnical investigation and reporting for construction material borrow pits.

Geotechnical Investigation for Darvil Dam
Pietermaritzburg, Kwa-Zulu Natal, South Africa
In-situ investigation including test pitting for geotechnical soil profiles of the proposed dam site to determine the dam foundation depth. Project management and selection of laboratory tests for study objectives subsequent to the fieldwork. Compilation of a geotechnical report for the dam design and fr the construction material.

Geotechnical Investigation for Gluckstadt Water Supply Scheme
Gluckstaadt, Kwa-Zulu Natal, South Africa
Site engineer responsible for augering and logging. Collation of data and report writing including recommendations for the installation of the proposed pipeline. Project manager ensuring the quality and client satisfaction.

Geotechnical Investigation for Nkobongweni Water Supply
Tugela Ferry, Kwa-Zulu Natal, South Africa
Project management and field geologist for the evaluation along the proposed water supply pipeline, at the proposed borehole structures and at the proposed reservoir. Assessment of geotechnical properties of potential bedding material for construction. Ntabamhlophe Tank – Project manager responsible for the field investigation and the report writing for the proposed tank.

Geotechnical Investigation for Ntabamhlophe Tank
Wembezi, Kwa-Zulu Natal, South Africa
Project manager and client liaison. Field investigation including test pitting and sampling. Report writing and foundation recommendation. Foundation assessment during construction.

Geotechnical Investigation for Kenhardt Solar Farm

Kenhardt, Northern Cape, South Africa

Project and subcontract management. Drilling supervision, in-situ investigation for site characterization. Management and selection of laboratory tests for study objectives. Client liaison and geotechnical report for pylon foundations, substation foundation and access road construction.

Geotechnical Desktop Assessment for the Dalmanutha Wind Energy Facility

Belfast, Mpumalanga, South Africa

Project management and client liaison. Geotechnical desktop study for three wind energy facilities and their associated structures to supplement a project Environmental Impact Assessment.

Geotechnical Investigation for the Oya and Yemaya Solar and Wind Energy Facility

Maitjiesfontein, Western Cape, South Africa

Geotechnical desktop study reports for the two sites for the two solar sites. Test pitting and sample selection for required tests for the Oya site. Analysing and interpreting fieldwork data and laboratory results.

Geotechnical Desktop Assessment for the Koup 1 and Koup 2 Wind Energy Facility

Leeu Gamka, Western Cape, South Africa

Project management and client liaison. Geotechnical desktop study for two wind energy facilities and their associated structures to supplement a project Environmental Impact Assessment.

Geotechnical Desktop Assessment for three Wind Energy Facilities

Northern and Western Cape, South Africa

Project management and client liaison. Geotechnical desktop studies for the proposed Brandvalley, Karreebosch and Rietkloof wind farm energy facilities and three 33kV powerlines and their associated structures.

Geotechnical Desktop Assessment for Uvuvuselela Railway Line Extensions

South Africa

Project management and client liaison. Geotechnical desktop studies for the proposed Transnet Railway Loop extensions, Port Elizabeth Port extensions and loading yards in Gauteng.

Geotechnical Gap Analysis for the Debswana Mine Facilities

Central District, Botswana

Geotechnical desktop study, gap analysis and additional investigation executions plans for Damtshaa, Orapa and Letlhakane mine facilities.

Geotechnical Investigation for the N2 Pongola to Kangela

Kwa-Zulu Natal, South Africa

Field geologist responsible for trial pitting, logging, and sample collection for laboratory analysis for the N2 construction borrow pits. Collation of field data and laboratory data.

Geotechnical Investigation for the N3 Borrow Pits

Kwa-Zulu Natal, South Africa

Rotary core logging and percussion chips logging for the proposed borrow pits located between Durban and Pietermaritzburg for the N3 construction.

Geotechnical Investigation for the Mfulamuni Access Road and Aggregates

Pomeroy, Kwa-Zulu Natal, South Africa

Project management and client liaison. Fieldwork for the realignment and the re-gravelling of the Mfulamuni access road. Ensuring adequate laboratory testing for the road and the potential borrow pits. Report compilation for the road and the material investigation.

Geotechnical Investigation for the P77 Culverts

Dududu, Kwa-Zulu Natal, South Africa

Field engineering geologist responsible for trial pitting, logging and DPL testing to determine the subsurface characteristics for the proposed seven culverts. Compilation of an interpretive geotechnical report highlighting the foundation depths for each culvert and the geotechnical constraints thereof.

Geotechnical Investigation for Kikwood to Addo Borrow Pit and Retaining Walls

Kirkwood, Eastern Cape, South Africa

Soil profiling and interpretation of the field profiles and laboratory results for the borrow pit and retaining walls. Material volume calculations for the borrow pits. Dynamic cone penetration and interpretation for the competent foundations for the retaining walls. Data assimilation and assessment for report writing

Geotechnical Investigation for Eastwood Pedestrian Bridge

Pietermaritzburg, Kwa-Zulu Natal, South Africa

Project management and client liaison for the construction of a pedestrian bridge. Fieldwork including test pitting and DPL testing. Analysing and interpreting the field data to recommend foundation levels.

Geotechnical Study for the Refurbishment of 9 Eskom Towers

Eastern Cape, South Africa

Test pitting for geotechnical ground profiles of each site. Management and selection of laboratory tests for study objectives. Foundation recommendations for each site. Geotechnical report for design purposes.

Geotechnical Investigation for Nkweletsheni Primary School

Richmond, Kwa-Zulu Natal, South Africa

Project management and client liaison school refurbishment. Test pitting, percolation testing and DPL testing for geotechnical ground profiles of the site. Management and selection of laboratory tests for study objectives. Geotechnical report for foundations, recommendations for the soak-away and for the multi purpose sports ground.

Geotechnical Investigation for Zwelisha Moyeni Water Treatment Works

Bergville, Kwa-Zulu Natal, South Africa

Project management and client liaison. Test pitting and DPL testing for geotechnical ground profiles of the site. Management and selection of laboratory tests for study objectives. Geotechnical report for foundations of treatment works structure founded at depth of 4-5m below NGL.

Geotechnical Investigation for Hammersdale Waste-Water Treatment Works

Hammersdale, Kwa-Zulu Natal, South Africa

Client liaison and project management. Subsurface profiling and DPL testing for the extensions to the existing Hammersdale WWTW. Analysis of the profiles and selection of laboratory tests for study objectives. Data analysis and report compilation for structure foundations.

Geotechnical Investigation for the Proposed Giba Industrial Development

Pinetown, Kwa-Zulu Natal, South Africa

Test pitting for soil profiling, disturbed and undisturbed sampling, delineation of groudndwater seepage areas. Management and selection of laboratory tests. Analysing and interpretation of laboratory test results. Compilation of geotechnical report for foundations and groundwater management recommendations.

Geotechnical Investigation for the Cornubia Fills

Cornubia, Kwa-Zulu Natal, South Africa

Project management and client liaison. In-situ testing for geotechnical soil profiles of the site and general site characterization for fills for the proposed housing development. Engineering geological report for the study for the fills. Reviewing the rotary drilling report for the client.

Geotechnical Investigation for Ward 7 Community Hall

Taylors Halt, Kwa-Zulu Natal, South Africa

Project management and liaising with Client. Conducting the geotechnical investigation that included trial pitting, laboratory testing and percolation testing. Fieldwork and laboratory data processing for geotechnical report compilation.

Geotechnical Investigation for Mandalathi Community Hall

Kwa-Zulu Natal, South Africa

Project management and liaising with Client. Conducting the geotechnical investigation that included trial pitting, laboratory testing and percolation testing. Fieldwork and laboratory data processing for geotechnical report compilation.

Geotechnical Investigation for Austerville Sites

Durban, Kwa-Zulu Natal, South Africa

Project management and client liaison. In situ soil profiling and interpretation of the profiles. Consistency tests (DPL) and interpretation of the results evaluate the EASPB. Data compilation and report writing to determine the site's suitability for temporary housing development and recommending relevant foundation measures.

Geotechnical Investigation for five ADA Rabbitry Sites

Kwa-Zulu Natal, South Africa

Project management and client liaison. In situ soil profiling and interpretation of the profiles. Consistency tests (DPL) and interpretation of the results evaluate the EASPB and sample collection for laboratory analysis. Report compilation with foundation recommendations.

Geotechnical Investigation for Several Intaba Ridge Estate Houses

Pietermaritzburg, Kwa-Zulu Natal, South Africa

Project management and client liaison with several property developers. In situ soil profiling, conducting in-situ consistency tests (DPL) and sampling for laboratory analysis. Report writing to determine the site's suitability for the house developments and recommending foundation depths and types as per NHBRC guidelines.

Geotechnical Investigation for a Proposed Student Accommodation

Pietermaritzburg, Kwa-Zulu Natal, South Africa

Project management and client liaison for the proposed three storey student accommodation development. In situ soil profiling, conducting in-situ consistency tests (DPL) and sampling for laboratory analysis. Report writing to determine the site's suitability for the housing development and recommending foundation depths and type as per NHBRC guidelines.

Geotechnical Investigation for the 220 Murray Road Development

Pietermaritzburg, Kwa-Zulu Natal, South Africa

Project management and client liaison. Report writing and field data analysis for the infill geotechnical investigation report for a multi-story development in Hayfields. The development includes a school, a shopping complex, a drive through, a petrol filling station and a residential area.

Geotechnical Investigation for the Heidelberg Cemetery Extension

Heidelberg, Gauteng, South Africa

Project management and client liaison for the extension of the existing Heidelberg cemetery. Subsurface profiling and interpretation of the profiles. Field sampling for laboratory analysis. Geotechnical report writing and evaluating the site as per the South African Council for Geoscience Guidelines for Cemeteries.

Geotechnical Investigation for Three Proposed Umhlathuze Cemeteries

Empangeni, Kwa-Zulu Natal, South Africa

Project management and client liaison for the development of three cemetery sites. Subsurface profiling, percolation testing and field sampling for laboratory analysis. Geotechnical report writing, evaluating nd rating the sites as per the South African Council for Geoscience Guidelines for Cemetery Development.

Geotechnical Investigation for the Proposed Alfred Duma Cemeteries

Ladysmith, Kwa-Zulu Natal, South Africa

Project management and client liaison for the development of cemetery sites I the municipality. Geotechnical desktop studies to evaluate and rate the proposed sites in Colenso, Ladysmith and Ezakheni. The desktop study reports were written as per the South African Council for Geoscience Guidelines for Cemeteries.

Geotechnical Investigation for the Closure of Acaciavale Landfill Site

Ladysmith, Kwa-Zulu Natal, South Africa

Fieldwork including test pit profiling and interpretation from test pitting and sampling for study objectives. Data analysis and report compilation for the closure of the landfill site and recommendations on closure material.

Geotechnical Investigation for the Proposed Danskraal Landfill Site

Ladysmith, Kwa-Zulu Natal, South Africa

Geotechnical desktop study report including GIS work to identify and shortlist potential landfill sites. Fieldwork including test pit profiling and interpretation from test pitting for landfill site development investigation. Data analysis and report compilation.

Site Supervision for the Proposed UMgungundlovu Landfill Site

Pietermaritzburg, Kwa-Zulu Natal, South Africa

Supervision for the percussion drilling contract for the proposed new landfill site. Subcontractor management and client liaison. Percussion chip logging. Borehole water level and yield measurements. Hydrocensus and sampling existing boreholes in a 1km radius.

Agricultural Soil Survey for the Harry Gwala District Municipality

Umzimkhulu, Kwa-Zulu Natal, South Africa

Project management and client liaison. Agricultural soil survey and sampling. Data analysis and report compilation for the agricultural potential and the irrigation potential of 7500ha land in the district municipality. Presentation of the final findings to the client.

TRAINING

ArcGIS1, Introduction to Geographic Information System, JG Afrika, 2018

Civil Engineering and Renewable Energy, Geopile Africa, 2020

Geotubes and Dewatering, Kaytech, 2019

Site Monitoring Workshop, JG Afrika, 2019

APPENDIX B

Geotechnical Impact Assessment

IMPACT ASSESSMENT METHODOLOGY

SCOPING PHASE

REPORTING REQUIREMENTS

- Project Description
- Legislative Context (as applicable)
- Assumptions and limitations
- Description of Baseline Environment – including sensitivity mapping
- Identification and high-level screening of impacts
- Plan of Study for EIA

HIGH-LEVEL SCREENING OF IMPACTS AND MITIGATION

Appendix 2 of GNR 982, as amended, requires the identification of the significance of potential impacts during scoping. To this end, an impact screening tool has been used in the scoping phase. The screening tool is based on two criteria, namely probability; and, consequence (**Table 0-3**), where the latter is based on general consideration to the intensity, extent, and duration.

The scales and descriptors used for scoring probability and consequence are detailed in **Table 0-1** and **Table 0-2** respectively.

Table 0-1: Significance Screening Tool

		CONSEQUENCE SCALE			
PROBABILITY SCALE		**1**	**2**	**3**	**4**
	1	**Very Low**	**Very Low**	**Low**	**Medium**
	2	**Very Low**	**Low**	**Medium**	**Medium**
	3	**Low**	**Medium**	**Medium**	**High**
	4	**Medium**	**Medium**	**High**	**High**

Table 0-2: Probability Scores and Descriptors

SCORE	DESCRIPTOR
4	**Definite**: The impact will occur regardless of any prevention measures
3	**Highly Probable**: It is most likely that the impact will occur
2	**Probable**: There is a good possibility that the impact will occur

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1	**Improbable:** The possibility of the impact occurring is very low

Table 0-3: Consequence Score Descriptions

SCORE	NEGATIVE	POSITIVE
4	Very severe: An irreversible and permanent change to the affected system(s) or party(ies) which cannot be mitigated.	Very beneficial: A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit.
3	Severe: A long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these.	Beneficial: A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these.
2	Moderately severe: A medium to long term impacts on the affected system(s) or party (ies) that could be mitigated.	Moderately beneficial: A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way.
1	Negligible: A short to medium term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary.	Negligible: A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.

The nature of the impact must be characterised as to whether the impact is deemed to be positive (+ve) (i.e. beneficial) or negative (-ve) (i.e. harmful) to the receiving environment/receptor. For ease of reference, a colour reference system (**Table 0-4**) has been applied according to the nature and significance of the identified impacts.

Table 0-4: Impact Significance Colour Reference System to Indicate the Nature of the Impact

Negative Impacts (-ve)	Positive Impacts (+ve)
Negligible	**Negligible**
Very Low	**Very Low**
Low	**Low**
Medium	**Medium**
High	**High**

EIA PHASE

REPORTING REQUIREMENTS

- Project Description
- Legislative Context (as applicable)
- Assumptions and limitations
- Description of methodology (as required)
- Update and/or confirmation of Baseline Environment – including update and / or confirmation of sensitivity mapping
- Identification and description of Impacts
- Full impact assessment (including Cumulative)
- Mitigation measures
- Impact Statement

ASSESSMENT OF IMPACTS AND MITIGATION

The assessment of impacts and mitigation evaluates the likely extent and significance of the potential impacts on identified receptors and resources against defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise or compensate for any adverse environmental impacts, to enhance positive impacts, and to report the significance of residual impacts that occur following mitigation.

The key objectives of the risk assessment methodology are to identify any additional potential environmental issues and associated impacts likely to arise from the proposed project, and to propose a significance ranking. Issues / aspects will be reviewed and ranked against a series of significance criteria to identify and record interactions between activities and aspects, and resources and receptors to provide a detailed discussion of impacts. The assessment considers direct[1], indirect[2], secondary[3] as well as cumulative[4] impacts.

A standard risk assessment methodology is used for the ranking of the identified environmental impacts pre-and post-mitigation (i.e. residual impact). The significance of environmental aspects is determined and ranked by considering the criteria[5] presented in **Table 0-5**.

Table 0-5: Impact Assessment Criteria and Scoring System

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes

[1] Impacts that arise directly from activities that form an integral part of the Project.
[2] Impacts that arise indirectly from activities not explicitly forming part of the Project.
[3] Secondary or induced impacts caused by a change in the Project environment.
[4] Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.
[5] The definitions given are for guidance only, and not all the definitions will apply to all the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries
Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite
Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
IMPACT SIGNIFICANCE RATING					
Total Score	**4 to 15**	**16 to 30**	**31 to 60**	**61 to 80**	**81 to 100**
Environmental Significance Rating (Negative (-))	**Very low**	**Low**	**Moderate**	**High**	**Very High**
Environmental Significance Rating (Positive (+))	**Very low**	**Low**	**Moderate**	**High**	**Very High**

IMPACT MITIGATION

The impact significance without mitigation measures will be assessed with the design controls in place. Impacts without mitigation measures in place are not representative of the proposed development's actual extent of impact and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the application of mitigation and management measures and is thus the final level of impact associated with the development. Residual impacts also serve as the focus of management and monitoring activities during Project implementation to verify that actual impacts are the same as those predicted in this report.

The mitigation measures chosen are based on the mitigation sequence/hierarchy which allows for consideration of five (5) different levels, which include avoid/prevent, minimise, rehabilitate/restore, offset and no-go in that order. The idea is that when project impacts are considered, the first option should be to avoid or prevent the impacts from occurring in the first place if possible, however, this is not always feasible. If this is not attainable, the impacts can be allowed, however they must be minimised as far as possible by considering reducing the footprint of the development for example so that little damage is encountered. If impacts are unavoidable, the next goal is to rehabilitate or restore the areas impacted back to their original form after project completion. Offsets are then considered if all the other measures described above fail to remedy high/significant residual negative impacts. If no offsets can be achieved on a potential impact, which results in full destruction of any ecosystem for example, the no-go option is considered so that another activity or location is considered in place of the original plan.

The mitigation sequence/hierarchy is shown in **Figure 1** below.

Avoidance / Prevention	Refers to considering options in project location, nature, scale, layout, technology and phasing to **avoid** environmental and social impacts. Although this is the best option, it will not always be feasible, and then the next steps become critical.
Mitigation / Reduction	Refers to considering alternatives in the project location, scale, layout, technology and phasing that would **minimise** environmental and social impacts. Every effort should be made to minimise impacts where there are environmental and social constraints.
Rehabilitation / Restoration	Refers to the **restoration or rehabilitation** of areas where impacts were unavoidable and measure are taken to return impacted areas to an agreed land use after the activity / project. Restoration, or even rehabilitation, might not be achievable, or the risk of achieving it might be very high. Additionally it might fall short of replicating the diversity and complexity of the natural system. Residual negative impacts will invariably still need to be compensated or offset.
Compensation / Offset	Refers to measures over and above restoration to remedy the residual (remaining and unavoidable) negative environmental and social impacts. When every effort has been made to avoid, minimise, and rehabilitate remaining impacts to a degree of no net loss, **compensation / offsets** provide a mechanism to remedy significant negative impacts.
No-Go	Refers to 'fatal flaw' in the proposed project, or specifically a proposed project in and area that cannot be offset, because the development will impact on strategically important ecosystem services, or jeopardise the ability to meet biodiversity targets. This is a **fatal flaw** and should result in the project being rejected.

Figure 1: Mitigation Sequence/Hierarchy

Project Name Dalmanutha Wind Energy Facility and Dalmanutha Hybrid Energy Facility Geotechnical Impact Assessment

Impact Assessment

CONSTRUCTION

Impact number	Aspect	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation (M+	E+	R+	D)x	P=	S	Rating	Post-Mitigation (M+	E+	R+	D)x	P=	S	Rating	Mitigation Measures
Impact 1:	Soil Erosion	The displacement of natural earth material and overlying vegetation leading to: • Exposure of upper soil layer by removal of vegetation. • Increase in stormwater velocity. • Soil will be washed downslope, as well as into surrounding drainage channels leading to sedimentaton. •The erosion of these slopes will be exacerbated during periods of heavy rainfall.	Construction	Negative		4	3	3	3	5	65	N4	2	1	1	2	2	12	N1	• Rehabilitation of affected areas (such as revegetation, mechanical stabilization). • Selection of non-erodible and non-dispersive topsoil for general fill to avoid erosion. • Correct engineering design and construction of gravel roads and water crossings. • Use existing road network and access tracks. •Construction of temporary berms and drainage channels to divert surface water.
					Significance	N4 - High							N1 - Very Low							
Impact 2:	Oil Spillages	Contamination of ground and surface water resources from heavy plant leading to quality deterioration of the water resources.	Construction	Negative		5	3	5	5	5	90	N5	2	2	3	1	2	16	N2	• Vehicle and construction machinery repairs to be undertaken in designated areas with propoer soil protection. • Frequent checks and conditional monitoring
					Significance	N5 - Very High							N2 - Low							

OPERATIONAL

Impact number	Receptor	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation (M+	E+	R+	D)x	P=	S		Post-Mitigation (M+	E+	R+	D)x	P=	S		
Impact 1:	Soil Erosion	Displacement of natural earth material during maintenance	Operational	Negative		2	1	3	2	2	16	N2	1	1	1	1	1	4	N1	• Use of existing service roads and tracks to avoid damaging vegetation. • Rehabilitation of affected areas (such as erosion control mats). • Maintenance of stormwater system.
					Significance	N2 - Low							#N/A							
Impact 2:	Potential Oil Spillages	Potential oil spillages from service vehicles and heavy plant.	Operational	Negative		3	2	5	5	3	45	N3	2	1	3	2	2	16	N2	• Vehicle repairs to be undertaken in designated areas.
					Significance	N3 - Moderate							N2 - Low							

DECOMISSIONING

Impact number	Receptor	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation (M+	E+	R+	D)x	P=	S		Post-Mitigation (M+	E+	R+	D)x	P=	S		
Impact 1:	Erosion	• Increase in soil and wind erosion due to clearance of structures. •Displacement of soil and damage to vegettion by vehicles	Decommissioning	Negative		4	2	3	3	4	48	N3	2	1	1	2	2	12	N1	• Use existing road network and access tracks. • Use of temporary berms and drainage channels to divert surface water. • Minimize earthworks and demolish footprints. • Rehabilitation of affected areas (such as revegetation). • Develop a chemical spill response plan. • Reinstate channelized drainage features.
					Significance	N3 - Moderate							N1 - Very Low							
Impact 2:	Potential oil spillages	• Potential oil spillages due to clearance of structures.	Decommissioning	Negative		4	3	5	5	4	68	N4	3	1	3	1	2	16	N2	• Vehicle and construction machinery repairs to be undertaken in designated areas with propoer soil protection. • Frequent checks and conditional monitoring
					Significance	N4 - High							N2 - Low							

CUMULATIVE

Impact number	Receptor	Description	Stage	Character	Ease of Mitigation	Pre-Mitigation (M+	E+	R+	D)x	P=	S		Post-Mitigation (M+	E+	R+	D)x	P=	S		
Impact 1:	Erosion	The displacement of natural earth material and overlying vegetation leading to: • Exposure of upper soil layer. • Increase in stormwater velocity. • Soil washed downslope intodrainage channels leading to sedimentaton. •The erosion of these slopes will be exacerbated during periods of heavy rainfall.	Cumulative	Negative		3	2	3	3	4	44	N3	2	1	1	2	2	12	N1	• Use existing road network and access tracks. • Use of temporary berms and drainage channels to divert surface water. • Minimize earthworks and demolish footprints. • Rehabilitation of affected areas (such as revegetation). • Develop a chemical spill response plan. • Reinstate channelized drainage features.
					Significance	N3 - Moderate							N1 - Very Low							
Impact 2:	Potential Oil Spillages	Contamination of ground and surface water resources from heavy plant leading to quality deterioration of the water resources.	Cumulative	Negative		4	3	5	5	4	68	N4	2	1	3	1	2	14	N1	• Vehicle and construction machinery repairs to be undertaken in designated areas with propoer soil protection. • Frequent checks and conditional monitoring
					Significance	N4 - High							N1 - Very Low							

APPENDIX C

Document Limitations

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