Where Engineering Meets Earth

Geotechnical Desktop Assessment

In support of the proposed

Karoo Wind Energy Facility Cluster and Associated Infrastructure

Mulilo Karoo Wind Power Development 2

5 567 Ha

Beaufort West, Western Cape

Final Report TG24-001/b/3 July 2024

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environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

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

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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

THE PROPOSED DEVELOPMENT OF THE KAROO WIND ENERGY FACILITY CLUSTER LOCATED NEAR BEAUFORT WEST, WITHIN THE BEAUFORT WEST LOCAL MUNICIPALITY, CENTRAL KAROO DISTRICT MUNICIPALITY, WESTERN CAPE

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1. SPECIALIST INFORMATION

Specialist Company Name:	Terra Geotechnical			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	
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2. DECLARATION BY THE SPECIALIST

I, Eugene van der Walt, 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

Terra Geotechnical

Name of Company:

10/07/2024

Date

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;	Appendix A
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Yes
c) an indication of the scope of, and the purpose for which, the report was prepared; (cA) an indication of the quality and age of base data used for the (cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 6
d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	N/A
f) an identification of any areas to be avoided, including buffers;	N/A
g) 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;	N/A
h) a description of any assumptions made and any uncertainties or gaps in knowledge	Section 9
i) 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;	N/A
j) any mitigation measures for inclusion in the EMPr;	Section 6
k) any conditions for inclusion in the environmental authorisation	N/A
l) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	N/A
m) 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;	Section 5 & Section 8
n) a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
o) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
p) any other information requested by the competent authority.	N/A
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.	N/A

Table of Contents

1. Background

Terra Geotechnical have been appointed by Sharples Environmental Services (hereafter referred to as "SES") to conduct a baseline geotechnical desktop assessment in support of the proposed Karoo Wind Energy Facilities (WEF) Cluster, located near Beaufort West, Western Cape. The WEF Cluster consists of three separate WEF's (known as The Mulilo Karoo Wind Power (MKWP) development, The Mulilo Karoo Wind Power 2 (MKWP2) and The Mulilo Karoo Wind Power 3 (MKWP3)), and associated infrastructure. Additionally, the geotechnical desktop assessment for the proposed Droerivier – Karoo 132 kV Grid Corridor also forms part of the proposed scope of works.

The three (3) projects will typically comprise a multitude of wind turbines, battery storage facilities (only planned at phase 1), grid connection cables, internal roads and other ancillary structures.

MKWP and MKWP2 will potentially generate a combined 731 MW (MKWP = 348.5 MW and MKWP2 = 382.5 MW). MKWP3 will potentially generate up to 144.5 MW. Each phase will likely consist of (**Note: this is subject to change and will be confirmed in due course with the selected EAP):**

- MKWP will have up to 41 Wind Turbine Generators, MKWP2 will have up to 45 Wind Turbine Generators and MKWP3 will have up to 24 Wind Turbine Generators (WTG).
- Hub height up to Maximum 160m
- Rotor Diameter up to maximum 200m
- Blade length up to 82.5m
- Reinforced Concrete Foundations for each turbine (up to 0.08 ha per turbine)
- Crane platform and hardstand laydown area: approximately 0.8 ha for each turbine
- Up to 2 substations each of up to 2 ha. 33 kV to 132 kV collector substation to receive, convert and step-up electricity from the WEF to the 132 kV grid suitable supply. The substations maximum height will be Lightning Mast of 25m high. The facility will house control rooms and grid control yards for both Eskom and the Independent Power Producer (IPP).
- Operations and Maintenance (O&M) Buildings of approximately 2.0 ha.
- Construction yards and laydown areas (used during construction and rehabilitated thereafter): It is proposed that 1 construction/office yard be established with an area of 4 ha (this include bunded fuel areas, oil storage areas, general stores (containers) and skips) and 1 tower component laydown area with an area of 4 ha. There will also be a separate on-site concrete batching plant with an approximate area of (1.0 ha).
- Site access will, where possible, make use of existing farm roads that get upgraded and maintained for the life of the plant.

The proposed WEFs will each connect via a 132kV overhead transmission line, to the Eskom Grid. MKWP will connect to the existing Droërivier Substation, following a proposed corridor of approximately 70 km.

1.1. Sources of Information

The following sources of information were utilized:

- 1:250 000 Scale Geological Map 3122 Victoria West & 3222 Beaufort West
- A review of the 1:50 000 scale of Topocadastral Maps
- Aerial photographs (Google Earth imagery, current and historical)
- Various geotechnical investigation reports in the area. The consulted reports were conducted by both Terra Geotechnical and other consultants.
- Various hydrological and environmental studies conducted in the area by other consultants.
- An Environmental Impact Assessment matrix was used to quantify the impacts of the project on the receiving environment
- Remote Sensing Information:
- Elevation Heat Map; Online Resource
- Planet GIS

2. Study Area Assessment - Karoo WEF Cluster

2.1. Study Area Location

The proposed Karoo WEF Cluster and associated infrastructure is located approximately 30 km north of Beaufort West in the Western Cape Province and is within the Beaufort West Local Municipality, in the Central Karoo District Municipality.

The general location of each of the Wind Energy Facilities (MKWP, MKWP2 & MKWP3) along with the proposed Droërivier – Karoo 132 kV Grid Corridor is depicted in Figure 1.

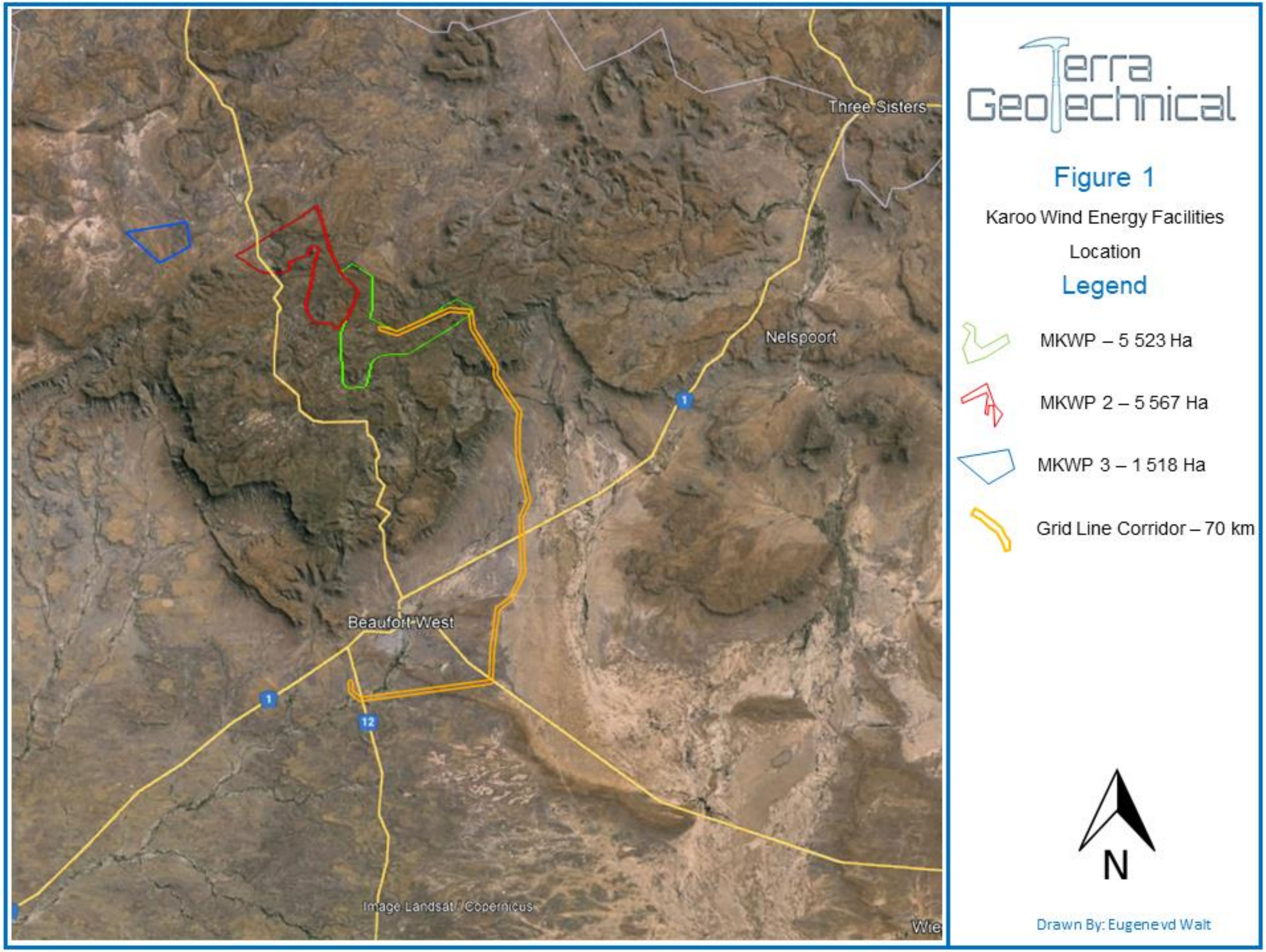
The table below lists the farms affected by each of the developmental regions of the Karoo Wind Energy Cluster.

Table 1: WEF Farm Portions

Project Number	Farm Name	Farm Portion & Number
Karoo WEF Mulilo Karoo Wind Power Development	Matjies Valie	103
	Matjies Kloof	110
	Scheurfontein	112
	Dundee	80
	Annex Waterval	102
	Scheurfontein	1/112
	Matjies Valie	4/103
	Matjies Valie	2/103
	Matjieskloof	2/110
Karoo WEF Mulilo Karoo Wind Power Development 2	Waterval	101
	Middle Kraal	98
	Waterval	1/101
	Waterval	3/101
Karoo WEF Mulilo Karoo Wind Power Development 3	Bastards Poort	94
	Quaggafontein	83
	Matjiesfontein	412
	Quaggafontein	1/83

Project Number	Farm Name	Farm Portion & Number
Droërivier-Karoo 132kV Line Grid Corridor	Matjies Valie	4/103
	Matjies Valie	103
	Matjieskloof	2/110
		425
		424
		408
		3/120
		156
	Speelmans Kuil	1/154
	Speelmans Kuil	154
		413
		423
	Blaauw Bosch Kuil	165
	Quagga Fontein	166
	Hans Rivier	4/169
	Steenrotsfontain	3/168
	Steenrotsfontain	1/168
	Weltevreden	170 (various portions)

This report and its findings are specifically related to MKWP 2.

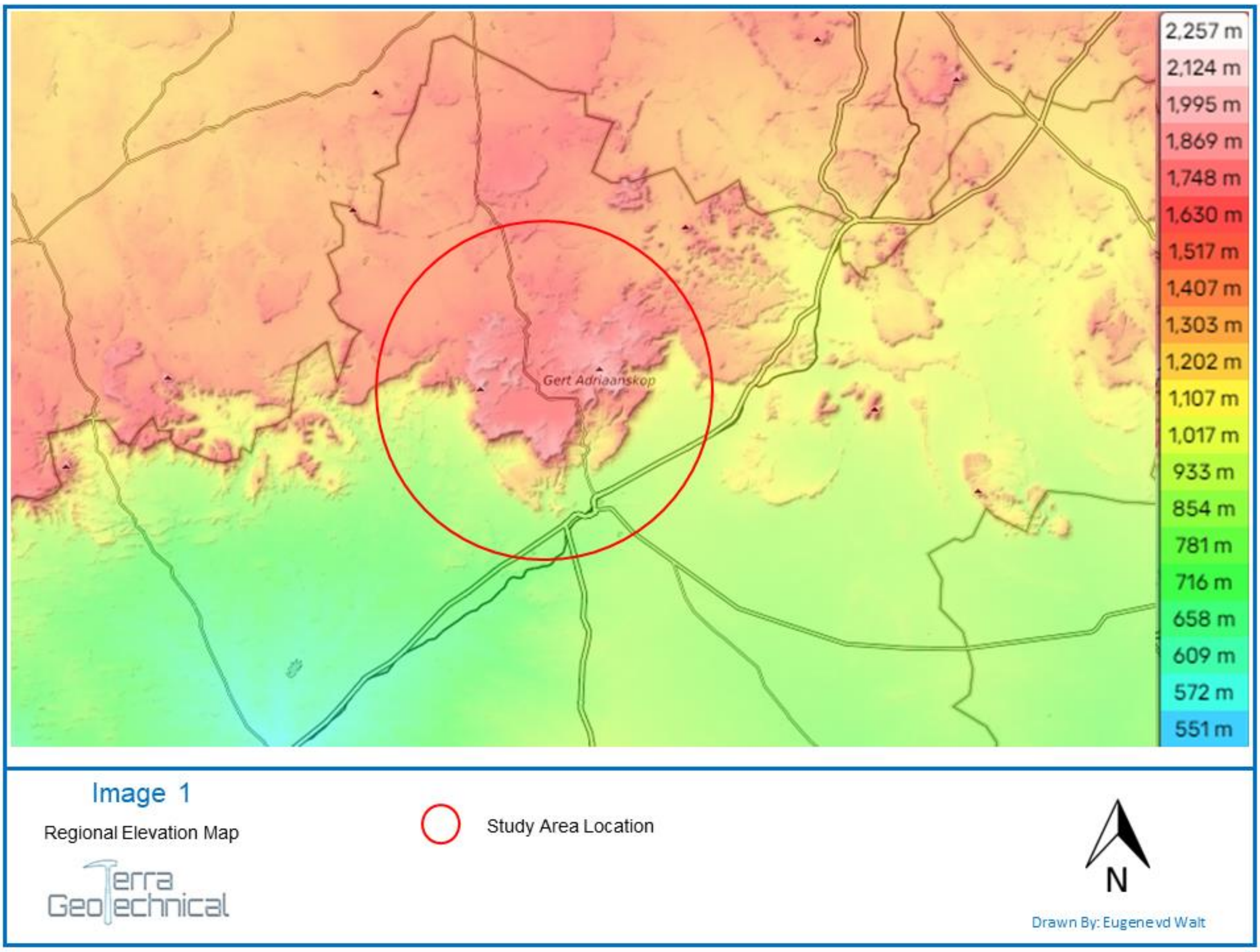

Three Sisters
Nelspoort
Beaufort West
1
1
1
12
Image Landsat / Copernicus
Wie
Terra
GeoTechnical
Figure 1
Karoo Wind Energy Facilities
Location
Legend
MKWP – 5 523 Ha
MKWP 2 – 5 567 Ha
MKWP 3 – 1 518 Ha
Grid Line Corridor – 70 km
N
Drawn By: Eugene vd Walt

2.1. Topography

2.1.1. Regional Topography

The study area is characterized by the presence of the topographically important Great Escarpment. It consists of steep slopes between the higher central South African plateau and the lower coastal areas that surround southern Africa. These steep slopes give rise to a rugged varied topography, forming steep rocky ridge structures with steeply dipping incised valleys. These valley structures host drainage features that cut through the weaker strata. The colour coded image below depicts the variable nature of the study area, with the higher lying Great Escarpment depicted by the red/white and the flat lying Lower Karoo depicted by the green/blue colours.

Image 1 Regional Elevation Map.



2.1.2. Site Specific Topography and Drainage – MKWP 2

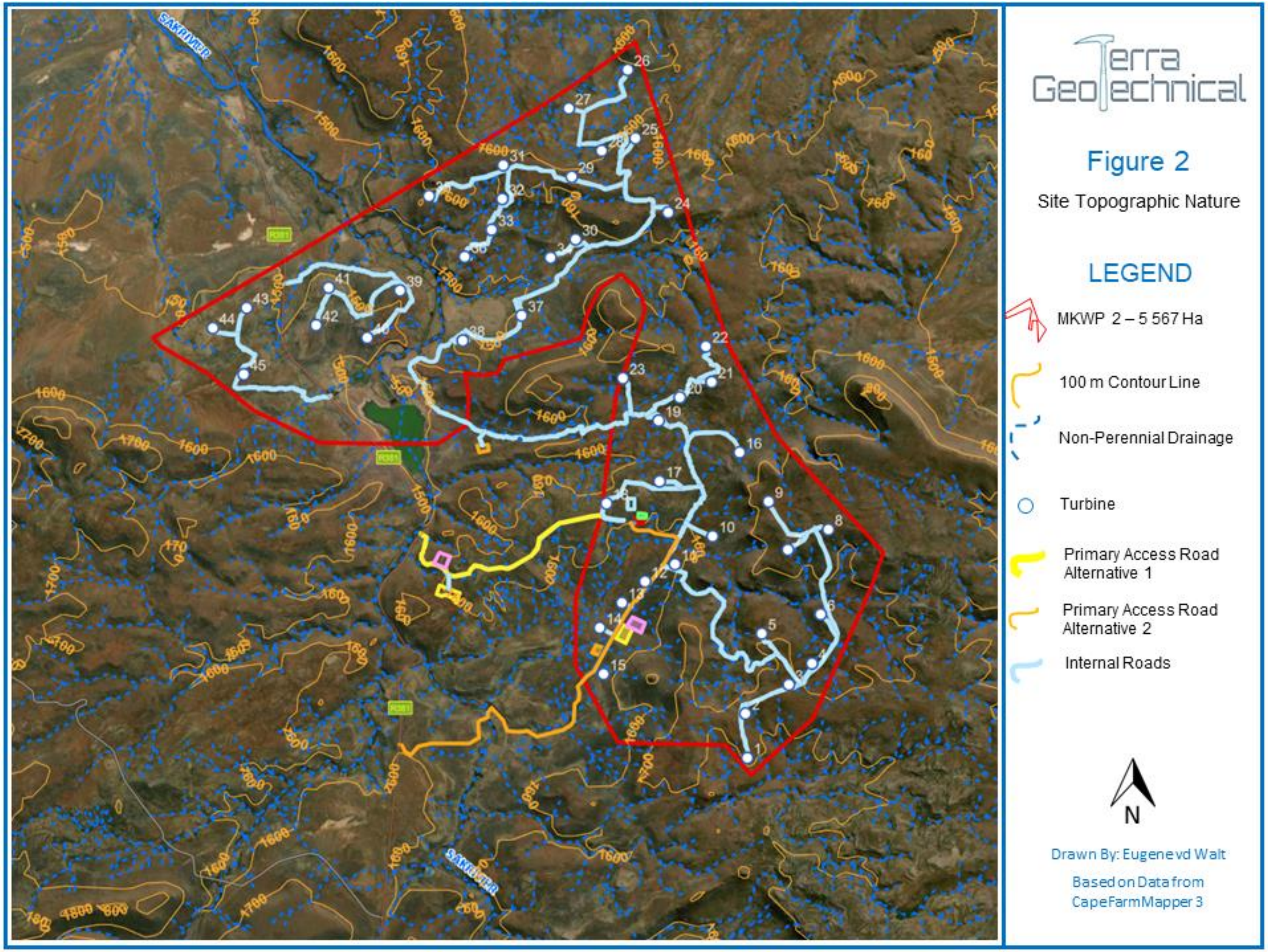
The site (MKWP 2) is located within the eastern portion of the Nuweveld Mountains, which forms part of the Great Escarpment. The landscape consists of rocky outcrops, gentle to steep slopes, dry river beds and deep valleys. The site hosts various pinnacles and deep valleys, with its highest elevation in the south eastern portion, reaching heights of 1740 mamsl, and its lowest elevation of 1480 mamsl within the northern western portion. This area of lowest elevation hosts the perennial Sak River. The Sak River traverses the site from south to north.

Figure 2 on the following page, depicts the topographical nature of the site with the overlay of the 20 m contour lines **(Please refer to the Maps section at the end of the report for Figures 2A to 2C, illustrating the topographical locations on the 5-meter contour map).** It depicts the area as having an irregular surface topography with numerous non-perennial drainage structures originating across the of the site. In general, the area is considered "mountainous" and it is anticipated that the majority of the turbines will be situated on elevated locations such that they will be exposed to maximum wind duration and velocity.

According to the available data, a regionally important watershed traverses the south eastern portion of the site. This watershed forms the boundary between the western Orange Water Management Area and the eastern Mzimbubu-Tsitsikamma Water Management Area.

During and after periods of heavy/prolonged rainfall, it is anticipated that stormwater will be in the form of sheet wash towards the non-perennial drainages within the valley structures.

The extent and detailed nature of the drainage features and slopes across the project area could not be conclusively confirmed through this desk study assessment.


Terra GeoTechnical
Figure 2
Site Topographic Nature
LEGEND
MKWP 2 – 5 567 Ha
100 m Contour Line
Non-Perennial Drainage
Turbine
Primary Access Road Alternative 1
Primary Access Road Alternative 2
Internal Roads
N
Drawn By: Eugene vd Walt
Based on Data from CapeFarmMapper 3

2.2. Site Slopes

Utilizing Cape Farm Mapper software, the site slopes are depicted in Figure 3 below. The site slopes can generally be separated into three ranges;

- Slopes less than 6°,
- Slopes between 6 and 16°,
- Slopes in excess of 16°

According to the proposed turbine layout, each of the turbines are located on in areas with slopes of less than 6°. The exact sloping nature of each turbine location will have to be determined during a detailed geotechnical investigation.

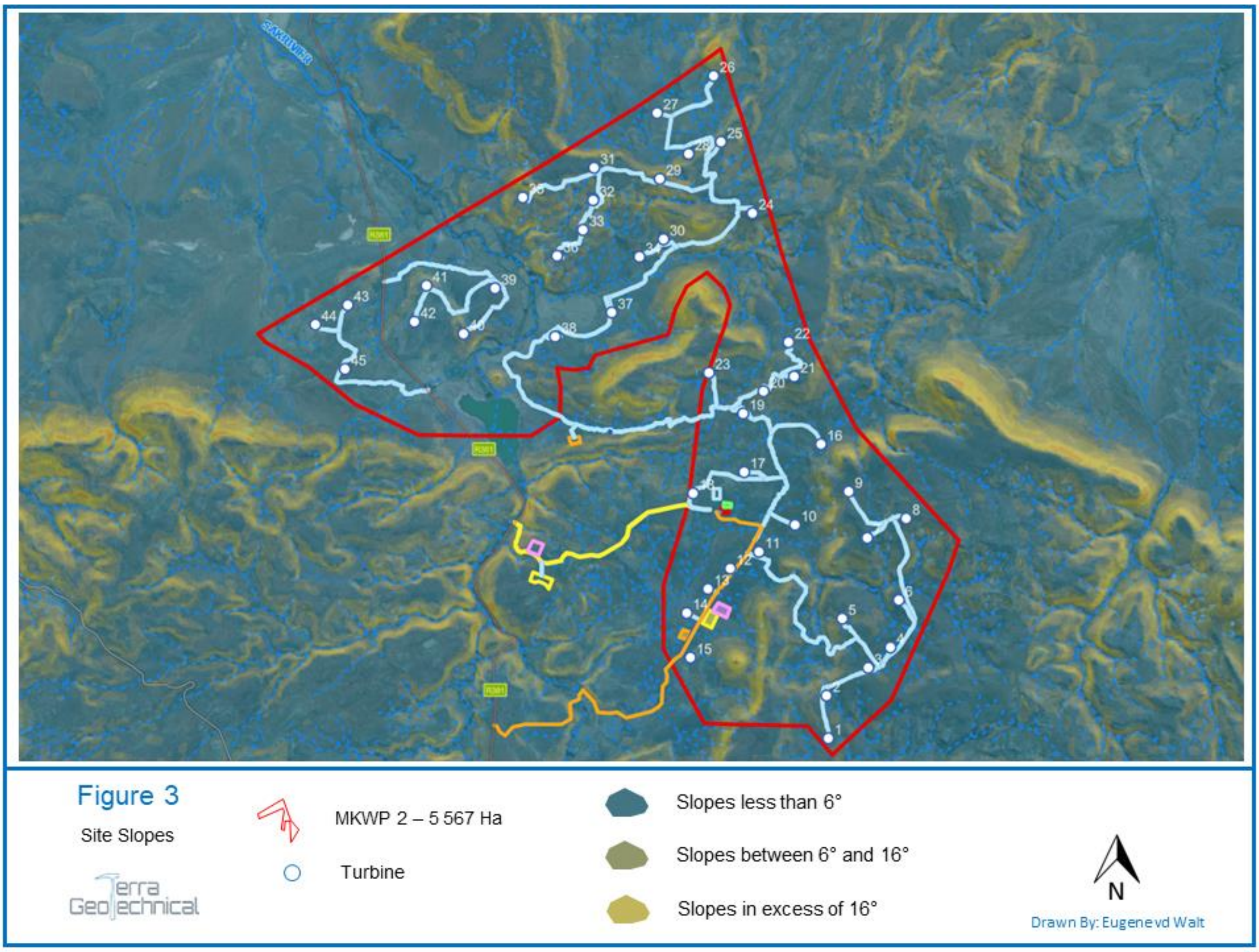


Figure 3
Site Slopes

Figure 3A to 3C at the end of the report visually presents a detailed view of the slopes at each turbine site.

2.3. Climate

The study area north of Beaufort West and in the Karoo is considered to have a desert climate with little rainfall all year long. The area can be classified as arid desert/steppe climate according to the Köppen-Geiger climate classification. The annual rainfall is between 200 and 250 mm with the average maximum and minimum temperatures of 23.2°C and 12.9°C, respectively.

Climate significantly influences both rock weathering and soil development. Weinert (1980) introduced the climatic N-value, which reveals how climate impacts weathering processes like soil formation. When the climatic N-value is 5 or less, indicating a water surplus, chemical decomposition is the primary weathering mode. These conditions foster the creation of deep residual soil profiles.

However, if the climatic N-value surpasses 5, mechanical disintegration becomes the main mode of rock weathering. In drier regions with higher N-values, residual soils tend to be shallow. When N-values exceed 10, indicating an arid climate, residual soil profiles are limited or absent. In such climates, physical disintegration prevails, resulting in thin, gravelly residual soils and shallow bedrock, unless transported soils cover it. These conditions are conducive to the formation of pedogenic calcrete.

For this study area, Weinert's climatic N-value exceeds 15, signalling a scarcity of water. Consequently, physical disintegration dominates, leading to a thin, gravelly residual soil and shallow bedrock, unless covered by transported soils. This arid climate favours the formation of pedogenic calcrete.

2.4. Seismic

The site area can generally be considered a region with a low seismic hazard (peak ground acceleration of 0 – 0.2 m/s^2). According to the Seismic Hazard Map of South Africa contained in SANS 10160-4 (2017) 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 0.10 m/s^2. The seismic hazard in the area is seemingly associated with natural seismic activity. This will indicate a low seismic hazard for the site for the proposed wind energy facility.

3. Geological Setting

According to the regional geology map, the study area is underlain by various sequences of geological strata, largely consisting of Teekloof Formation Mudstone, Sandstone and thin Chert Beds. This forms part of the Adelaide Subgroup, and Beaufort Group sediments, all forming part of the Karoo Supergroup.

The depositional and interbedded nature of the above-mentioned sedimentary units has led to the formation of horizontally and vertically uniform bedrock topographies, however this interbedded nature can lead to the formation of soils and fragmented rock material with adverse geotechnical properties.

The mudrock is typically prone to slaking. Slaking is a process of disintegration of the mudrock once exposed to the environmental factors (principally humidity), resulting in drastic decomposition of the rock into silt and clay sized particles

The Beaufort Group sediments in this area experienced significant intrusion and thermal alteration due to an extensive network of dolerite sills. These dolerite intrusions have predominantly occurred as widespread, flat sills, intruding mostly horizontally. These sills only had a limited effect on the surrounding sediments, with baking only occurring to a limited degree. Thermal metamorphic changes are most pronounced in the mudrocks which, in extreme cases, may have changed into the dark, glassy rock known as 'lydianite'. Some of these dolerite sills are quite substantial in volume. Dolerite outcrops are most prevalent in the central and northern sections of the site. These dolerite formations within the project area are typically identified by regions of rocky outcrops.

No mining activities have taken place in the project area.

The study area does not reflect any risk for the formation of sinkholes or subsidence caused by the presence of water-soluble rocks (dolomite or limestone), and as such is not deemed "dolomitic land

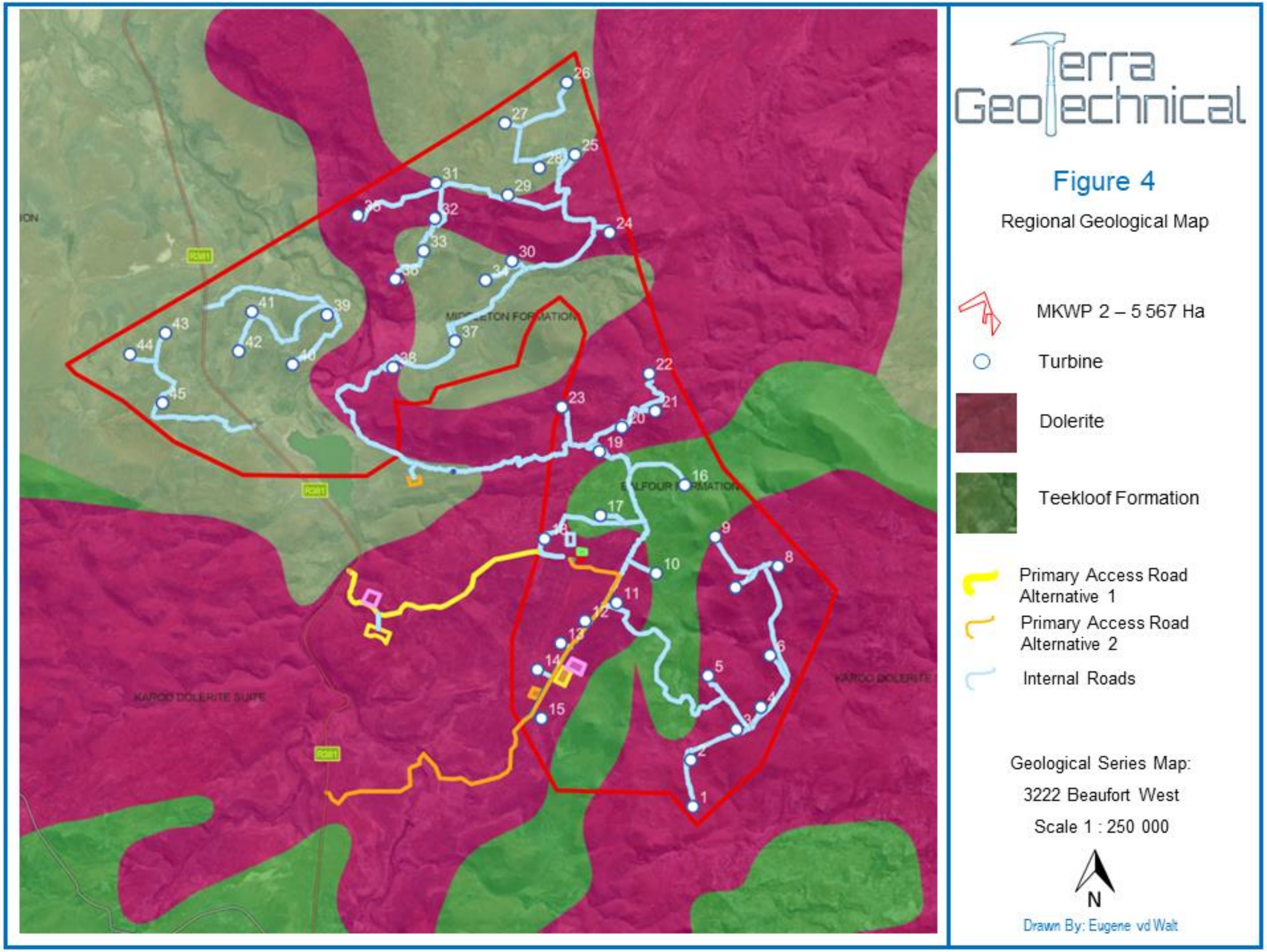


Figure 4

Regional Geological Map

4. Published Geotechnical data – Karoo Supergroup

4.1. Karoo Sandstone

4.1.1. Introduction

Sandstones are among the most common sedimentary rocks, with the Karoo Sandstones and quarzitic Sandstones covering extensive portions of the interior of South Africa. Quartz grains are the dominant constituents of sandstones but are frequently accompanied by varying amounts of feldspars, clays, rock fragments and other materials (Davis et al, 1978). These sedimentary rocks can be classified as pure or impure, depending on the amount of non-quartz constituents.

The Karoo sediments are frequented with various amounts and types of clay minerals, which are believed by some to be the cause for excessive drying shrinkages observed in concretes made with Karoo sediments. This will be discussed further in the below Section

4.1.2. Utilisation as Concrete Aggregate

The use of Karoo Sandstones as coarse and/or fine aggregate for use in concrete is often not recommended as the material can result in serious deterioration of the final product. The deterioration of concrete made with these aggregates is manifested in four major ways (Brink, 1983): 1) deflection of reinforced members, 2) cracking of concrete coincident with reinforcing steel, 3) corrosion of the reinforcing steel and 4) surface crazing or pattern cracking

One of the main cause's deterioration can be attributed to the materials' excessive shrinkage upon drying out, which can be linked to the materials high colloidal content and low modulus of elasticity. Concretes made from these Sandstones have been shown to shrink as much as 10 times more than concretes created with normal aggregate materials. According to Brink (1983), sedimentary aggregates that respond normally in concrete display drying shrinkages in the order of 0.005, whereas the Karoo Sandstone aggregates display values in the order of between 0.04 and 0.84.

The table overleaf displays some values for drying shrinkages of Sandstone samples retrieved from the Beaufort Group.

Table 3: Drying Shrinkages of Sandstone Samples Retrieved from the Beaufort Group (Brink, 1983)

Subgroup	Locality	Drying Shrinkage (%)	
		Specimen cut parallel to bedding	Specimen cut perpendicular to bedding
Adelaide	Graaf-Reinet Quarry	0.038	0.058
	Adendorp Quarry	0.23	0.84
	Aberdeen	0.024	-
	Beaufort West	0.04	-

As seen from the results in Table 3, the drying shrinkages are excessively high and it can also be noted that the shrinkage is anisotropic; with values seen to vary depending on whether the specimen was cut parallel or at right angles (perpendicular) to the bedding planes.

4.1.3. Utilisation as Road Building Material

The Karoo Sandstones are often used in the lower layers in road construction, but it is crucial that strict adherence to specifications regarding grading, plasticity and strength be met; particularly when the material is to be used as subbase. Many of the Sandstones contain a clay-matrix, which makes them suitable for lime stabilisation. Sandstones with a 10% FACT value greater than 140kN and a soaked to dry ratio of 75% may be used as basecourse, provided testing has been done to ensure a low pyrite or muscovite content (prevalent in Vryheid Formation), as this may cause problems.

Only Sandstones containing silica as a binding agent can sometimes display sufficient strength to be used as a surfacing aggregate. Some Sandstones have been used as chips but requires an additional 1.25 bitumen due to the high bitumen absorption rate.

4.2. Karoo Mudrock

4.2.1. Introduction

One of the biggest issues with the Karoo Mudrocks is the tendency of rapid and spontaneous breakdown upon exposure, with the Mudrocks exhibiting three main responses to exposure; very little breakdown, disintegrating into hard fragments of various sizes and slaking Mudrock which breaks down into clay and silt sized particles (Brink, 1983).

The slaking process is not yet fully understood, but the dissolution of cementing material as well as air-breakage (process of building up internal pressure due to water absorption) play a definite role. The disintegration process is not significantly affected by the abovementioned processes; but is deemed to be controlled by moisture loss and/or stress relief which results in micro-cracks. When these micro-cracked Mudrocks encounter water, they expand and break along these planes of weakness. Previous experiments by Olivier (1979a) and Venter (1980) also concluded that the Karoo Mudrocks were seen to be very sensitive to changes in humidity.

Residual soils of the Karoo Mudrock have been known to exhibit expansive behaviour, but it is now known that fresh Karoo Mudrocks also display dimensional changes following changes in moisture content. Olivier (1976) documented free swells ranging from 0.01 to 7% for samples from the Beaufort Mudrocks of the Tarkastad Subgroup.

4.2.2. Utilisation as Coarse Concrete Aggregate

Owing to the previously mentioned deleterious properties of the Karoo Mudrocks, these materials are seldom, if ever used as concrete aggregate.

4.2.3. Utilisation as Road Building Material

The karoo Mudrocks are suitable for use as selected layers in roads and are often used in national routes as the subbase layer. The Mudrocks do however require stabilisation, with the most suitable stabilizer deemed to be Lime. Road builders often make use of these rocks in gravel roads as a wearing-course, provided that the plasticity and breakdown have been tested as not all types are suitable for this application (Brink, 1983).

Although these rocks are suitable for use in road construction, problems have been documented by numerous users (Brink, 1983):

The biggest factor is the spontaneous breakdown of the Mudrocks from certain sources.

Certain sources have alternating bands of hard and soft material which makes it difficult to evaluate the overall quality of the material. It is therefore recommended that sources be found that are more homogeneous.

During compaction insufficient fines may be produced, which will result in the need for a binder to improve the grading. The opposite may also hold, where the Mudrock slakes and becomes completely unusable.

A mixture of hard and soft material makes compaction ineffective as the compactor will tend to slide over the harder particles while failing to compact the softer material.

Effects of erosion are often not of concern, except for Mudrocks from the Elliot, Burgersdorp and upper Smithfield Formations.

In general, road construction materials need to meet three main durability criteria; namely resistance to crushing, resistance to decomposition and resistance to abrasion in moist environments. Previous research has shown that the 10% FACT, wet ball-mill and sand equivalent were seen to be the most suitable tests to provide indicative values for the above-mentioned properties. However, for design specific values these tests are insufficient and extensive testing needs to be conducted. The phenomenon of spontaneous breakdown requires additional testing as the above-mentioned tests do not fully evaluate these properties. The standard ISRM Slake Durability Test is most suitable for assessing slaking, while for disintegration, the most suitable test is the quantitative analysis of the behaviour in wire-mesh baskets of six rock samples graded between 36.5 and 26.5 mm during five wet-dry cycles in water.

4.3. Karoo Dolerites

4.3.1. Introduction

The Dolerites intruding the Karoo strata are popular among concrete manufacturers as these materials tend to be more dimensionally stable than the aggregates derived from the sedimentary and basaltic rocks of the Karoo (Davies et al., 1978).

4.3.1. Utilisation as Coarse Concrete Aggregate

The karoo Dolerites are often used for concrete aggregates due to their large extent and sound mechanical properties. Some precautionary measures however, are needed when considering the basalt-like phases of some dykes and sills. These phases can contain volcanic glass or Palagonite (its devitrification product) which can have a detrimental reaction with certain cement types which may result in shrinkage cracks within the final concrete.

When using unweathered Dolerite as a concrete aggregate, in conjunction with Dolerite crusher sand, harshness and segregation in fresh concrete may become a concern; in addition, the high relative density of the rock often leads to bleeding of fresh concrete. These issues however, can be overcome by giving attention to the following points (Brink, 1983):

- Well-shaped aggregate (cubical or ‘chunky’) reduces water demand and the chances of ‘bleeding’, while the correct particle shape of crusher sand also aids in reducing bleeding and improves the placeability of the mix.
- A high concentration of extreme fines of the Dolerite crusher sand is desired (8-10% of material passing 75µm screen); with this moving, up to 12% if the cement content is low.
- Suitable amounts of fine natural sand can significantly increase the workability of Dolerite mixes.
- If harshness of the concrete cannot be controlled by the above methods, then a suitable air entraining admixture may be used.

In contrast to unweathered Dolerite, Dolerite that has undergone some weathering and/or hydration is not suitable for use in concrete, as they contain damaging secondary minerals such as clays (namely smectite) which result in excessive water demand and drying shrinkage. Fines produced from weathered Dolerite may require washing, to ensure the removal of the detrimental secondary minerals. A petrographic analysis may assist in the identification of secondary minerals; with an increased H_2O+ content (above 0.5) also providing in indication of severe alteration to the material.

4.3.2. Utilisation as Road Building Material

Karoo Dolerites, both weathered and unweathered, are often used in road construction; with fresh dolerite often being satisfactory for use in bituminous surfaces as well as in the base and subbase layers with no major issues being observed. Due to these aggregates displaying a Mohs hardness of approximately 6, the Dolerites tend to polish under traffic which can become problematic.

It should be noted that when using these materials in road construction, the environmental conditions along with the stage of weathering need to receive careful attention:

- In areas with a climatic region of N > 5, weathered material that meets the design criteria will pose no significant problems
- In areas within a climatic region of N < 5, the material needs to adhere to a stricter selection process as the decomposition of the material does not cease once the aggregate is placed within the road layer. Decomposition of the dolerites may result in the formation of clay minerals of the smectite group (especially montmorillonite), which can negatively affect the road's integrity as these clay minerals have no bearing strength

5. Geotechnical Desktop Evaluation

5.1. Engineering Geological Conditions

The site’s geology and climate will result in thin sandy gravelly transported and residual soils overlying shallow bedrock. It is expected that the majority of the site will be underlain by shallow bedrock, with the exception of the various drainage channels which will be covered in a variable thickness transported material.

It is anticipated that the wind turbines will be located on ridges, where shallower soil cover is anticipated. Access roads will therefore need to be constructed up and along the ridges from existing access points. The anticipated bedrock to be encountered at shallow depths at the turbine locations, should provide an adequate founding medium to allow the use of shallow foundations for the turbines. Intermediate to hard excavation conditions are anticipated at shallow depths (<0.5m) and the use of pneumatic breakers or blasting will be required to excavate for gravity foundations. The bedrock's interlayered nature and past geological alterations might result in varied and complex geotechnical conditions, even within individual foundation footprints. Less stable mudrock might be found beneath more stable sandstone layers, and zones of weathering may occur within otherwise unweathered rock as depicted by Image 3 below (taken from another site in the region).

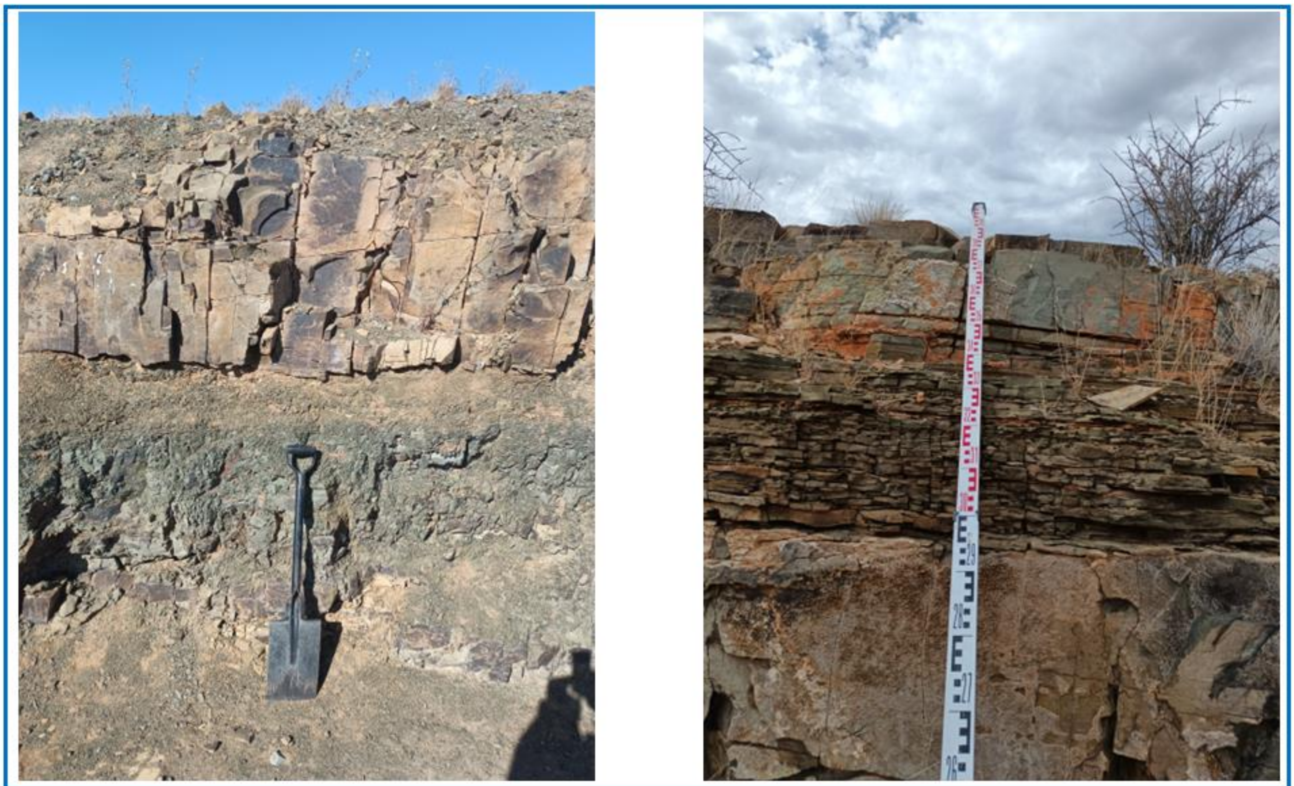


Image 3

Typical Profile in Karoo Supergroup

Drawn By: Eugene vd Walt

The assessment area hosts a variable sloping morphology, ranging from gentle slopes on the ridge crests to very steep on the side slopes of these ridge structures. This entails that terracing and additional earthworks for roads and platforms may be required for construction in the steeper sections of the site.

5.1.1. Generalised soil profile

Transported Soils

These soils, deemed to be hillwash or colluvium, could be expected within the lower lying areas as well as the valley structures. Its thickness in these areas is deemed to be variable and its composition can vary from fine, sandy gravelly soils to coarse cobbles and boulders. On the higher lying areas, where the turbines are likely to be placed, these soils would typically be of negligible thickness.

Residual Mudrock

This layer can be characterized as medium dense/firm (depending on moisture content), comprised of clayey silty sand. It's important to anticipate that this residuum might have the potential for activity, potentially showing moderate heave tendencies. Additionally, the residual soils might include fractured soft rock mudrock.

Residual Sandstone

The residual sandstone is likely to occur as dense to very dense, silty sand

Bedrock Mudrock

The Karoo mudrock in this area is likely to be intersected at shallow depths. The horizon would comprise a variably weathered, very fine grained, massive thick beds. The rock is typically is highly fractured and fissured which may lead to rapid decomposition (slaking) if exposed to water saturation and drying cycles. The hardness of this rock ranges from soft rock to very hard rock.

Bedrock Sandstone

The bedrock sandstone is likely to occur as a slightly to moderately weathered, fine-to medium-grained, massive with minor fractures, medium hard to very hard rock.

Dolerite

According to Brink et al., the Dolerite can be present as, Solid Dolerite, Fractures Dolerite, Boulder Dolerite, Gravel Dolerite, Granular Dolerite or Residual Dolerite (increasing in weathering). Across the WEF, the dolerite is expected to be present as Gravel to Boulder Dolerite, hosting a variable nature with boulders of between 0.5 and 3.0 m. Boulders typically have rounded corners and hosts a silty/sandy gravelly matrix.

5.2. Desktop Geotechnical Appraisal

5.2.1. Ground Units

Based on the desktop study, the area can be subdivided into two generalized ground or mapping units where similar ground conditions are expected. These units correspond to areas underlain by the sedimentary rocks of the Teekloof Formation and the dolerite. The boundaries of these units are illustrated on Figure 4. Both units are expected to be suitable for the development of the infrastructure for the WEF provided that standard engineering design and construction measures are adopted to mitigate identified geotechnical constraints.

The ground conditions in the sedimentary units are considered most suitable for the development due to their relatively uniform geotechnical condition, whereas variable boulder conditions might characterize the dolerite.

Additionally, within the valley floors, variably developed, unconsolidated and potentially loose transported soils encountered. This horizon will not be suitable for the placement of turbine bases. As such, it should either be founded on bedrock below the transported soils, provided that it is not thickly developed, or supplementary geotechnical measures such as dynamic compaction or construction of a soil raft must be considered to provide suitable foundations. The anticipated geotechnical constraints and mitigation measures are summarised in Table 2.

Table 2: Geotechnical Constraints

Ground Unit	Geology	Geotechnical Constraints	Impact on Engineering Design
Ground Unit A	Teekloof Formation Mudstone & Sandstone	Shallow Bedrock Rapid weathering of mudrocks on exposure Thin Soil Cover Intermediate to Hard Excavation from shallow depths Potentially unstable slopes in areas of moderate to steep slopes Bedrock outcrop	Favourable founding fonditions for structures on sandstone bedrock. Less favourable if bedrock is mudrock Rapid placement of blinding to protect excposed rock Conventional foundations suitable Conventional subgrade preparation for roads, platforms and laydown areas Difficult excavation conditions, requiring the use of blasting, heavy plant and/or pneumatic tools
Ground Unit B	Dolerite	Shallow Bedrock consiting of boulders Thin Soil Cover Irregular, Intermediate to Hard Excavation conditions Potentially unstable slopes in areas of moderate to steep slopes Bedrock outcrop	Moderately favourable founding fonditions for structures Care must be taken to avoid differential settlement Conventional foundations suitable Conventional subgrade preparation for roads, platforms and laydown areas Difficult excavation conditions, requiring the use of blasting, heavy plant and/or pneumatic tools

The site for this proposed WEF is likely to classify as $R^{Shallow\ Rock}/S^{compressible\ soils}$.

5.2.2. Roads & Potential Borrow Pits

Refer to Section 4 in the report for a detailed discussion on the typical reusability of the Karoo Sediments. Further testing needs to be conducted to establish the quality of the materials across the site.

5.2.3. Excavations for Underground Services

Critical to the development is the understanding of excavation conditions throughout the site, as these conditions will significantly influence foundation preparation, construction, and the excavation of trenches for buried services and access roads. Considering the geological characteristics of the area and the engineering geological implications discussed, the following excavation conditions are anticipated. However, it is essential to confirm these conditions through a detailed site investigation.

- Transported Soils – generally soft excavation.
- Residual Soils – soft to generally intermediate excavation.
- Weathered bedrock – generally intermediate to hard excavation.

Table 3: Summary of Excavation Conditions (SANS 1200, 1986).

Class of Excavation	Definition
Soft	Material that can be efficiently excavated, without prior ripping by the following equipment: Bulldozer with a mass of at least 22 tons and an engine developing approximately 145 kW at the flywheel. A tractor-scraper unit with a mass of at least 28 tons and an engine developing approximately 245 kW at the flywheel, pushed by a bulldozer during loading (35 tons, 220 kW). Track-type front end loader with a mass of at least 22 tons and an engine developing approximately 140 kW at the flywheel
Intermediate	Material that 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 220 kW at the flywheel.
Hard	Material that cannot be efficiently ripped by a bulldozer equivalent to that described for Intermediate Excavation and requires blasting.
Boulder Class A	Material containing in excess of 40% by volume of boulders between 0.03 m^3 and 20 m^3 in size, in a matrix of softer material or smaller boulders.
Boulder Class B	Materials containing 40% or less by volume of boulders ranging from 0.03 m^3 to 20 m^3 in size, in a matrix of soft material or smaller boulders

It is predicted that the majority of the WEF is likely to be underlain by shallow rock. As such, the use of large equipment or pneumatic tools may be required for excavation purposes.

5.2.4. Possible Foundation Solutions

Lightly loaded structures (e.g. substations) could typically be founded on either;

- conventional foundations
- reinforced concrete raft foundations
- engineered soil mattress

Large structures (e.g. turbines) could typically make use of reinforced mass concrete at depths to be confirmed during a follow up detailed investigation utilizing rotary core drilling. These foundations are suitable in areas where shallow bedrock is encountered.

It's crucial to emphasize that a detailed geotechnical investigation is necessary to refine and ultimately establish the most suitable foundation solution for all structures. This investigation will play a pivotal role in accurately determining the existing founding conditions throughout the proposed development area.

5.2.5. Suitability of Area for Development of WEF and Associated Infrastructure

From a geotechnical point of view, the WEF assessment area is considered suitable for the development of the proposed infrastructure, provided that standard engineering design and construction measures are implemented to mitigate the identified geotechnical constraints. The anticipated geotechnical constraints and mitigation measures are summarised in Table 2.

6. Project Impact on the Geological Environment

6.1. Geotechnical comparative assessment of alternatives

Design and layout alternatives were considered and assessed as part of this geotechnical report. These include alternatives for the temporary construction yards, laydown areas and batching plants, as well as access road alternatives.

The various alternatives, as shown in Figure 5 (on page 24), are described below.

The IPP & Eskom Substation, O&M building, Fuel Storage areas, (depicted by Figure 5A) will be located within the central portion of the eastern limb of the site. These are collectively known as Associated Structures. The proposed area can be described as follows;

- This area is underlain by Dolerites
- The site slope is less than 2 degrees
- Area is likely to be underlain by thin transported soils

Two alternative temporary construction laydown areas are also proposed. These two areas can be described as below.

Construction Laydown Area (Figure 5B)

- Alternative 1: is located roughly between the to the south of the site (within the eastern limb)
    - Alternative 1 is underlain by Dolerites
    - The site slope is less than 3 degrees
    - Area is likely to be underlain by thin transported soils
    - Alternative is close to an access road
    - Haulage distance to all construction locations could be a potential constraint
- Alternative 2: is located roughly between the two limbs of the site, in close proximity to the R381
    - Alternative 2 is underlain by mostly by Dolerites, with only the temporary batching plant underlain by Teekloof Formation mudstone and sandstones
    - This alternative is close to an access road.
    - The site slope is less than 6 degrees
    - Area is likely to be underlain by thin transported soils
    - Haulage distance to all construction locations could be a potential constraint

No geotechnical preference are given to any of these two alternatives.

Access Roads (Figure 5C)

Two primary access road alternatives were considered, namely:

- Alternative 1: this alternative provides access to the site from the R381.
    - This alternative is underlain by dolerite.

    - This option is seen to meander through the generally gentle sloping landscape, with only the start of the road (close to R381) hosting steep slopes of up to 15 degrees.
    - This road does not follow an existing road
- Alternative 2: this alternative provides access to the site from the south
    - This alternative is underlain by dolerite.
    - This option is seen to traverse various non-perennial drainage features as well as the large drainage channel hosting the Sak River.
    - This alternative follows a generally gentle sloping morphology (<6°), with the road traversing some minor steep ridges close to the Sak River.
    - The majority of this option follows existing roads (jeep track and gravel), thus providing easy access.

No geotechnical preference are given to any of these two alternatives.

Construction activities on steeply inclined slopes will require additional earthworks, longer access routes in comparison to lower topographic areas.

Slope stability issues can arise in steeply inclined terrain which will require retention structures and advanced foundations. Mountainous terrain will require earthworks to create level platforms for structures.

None of the alternatives are considered fatally flawed provided the recommendations presented in this report are adhered to.

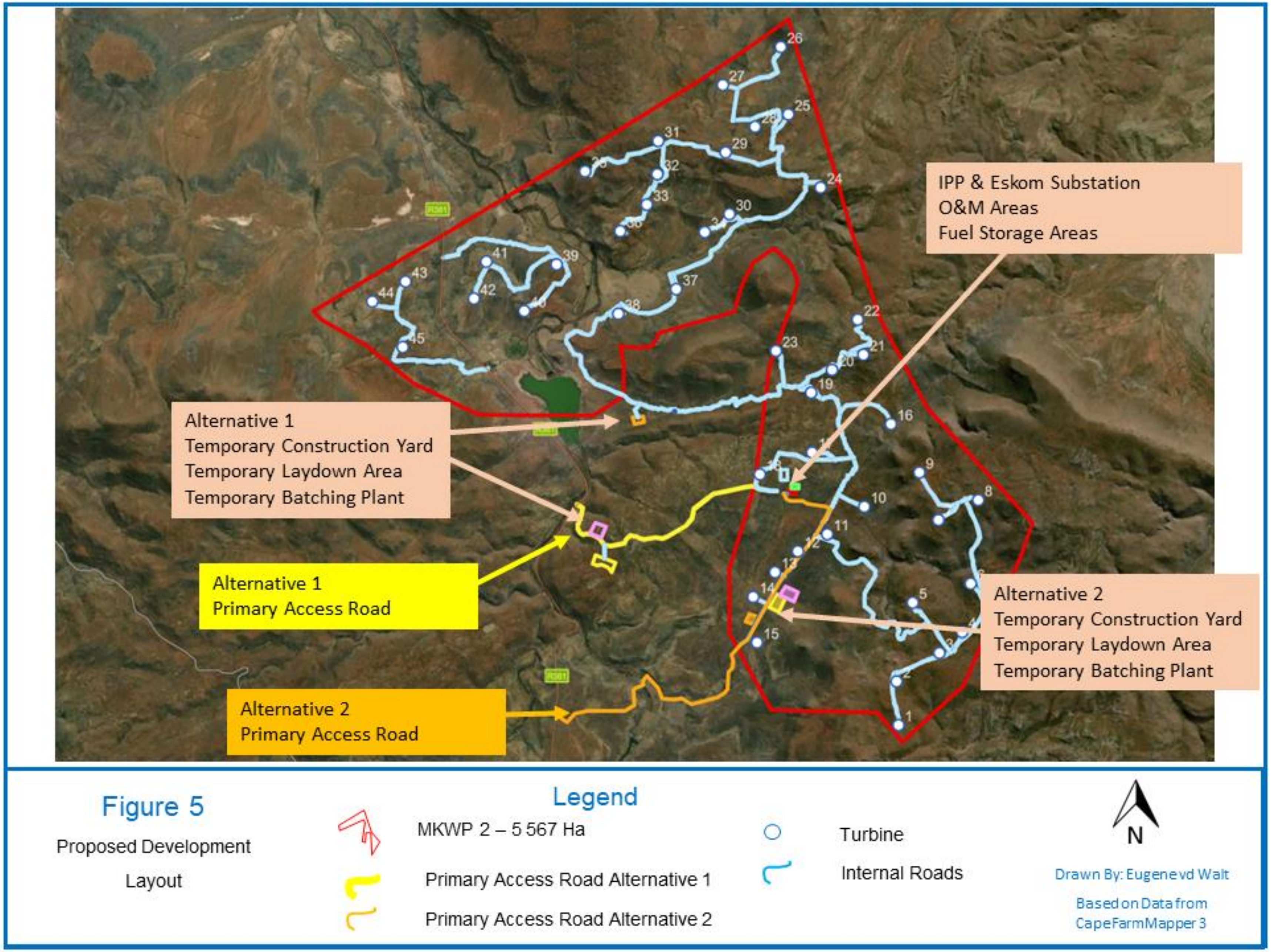


Figure 5

Proposed Development Layout

Based on the planned turbine layout, no geological or geotechnical fatal flaws or “no-go” areas have been identified which would render these areas unsuitable. No turbines are planned for the areas identified as drainage channels.

The geotechnical impacts related to the construction and operation of the WEF project would primarily be confined to activities such as topsoil stripping, excavations for turbine bases, excavations for switching stations and pylons, trenching for cables, as well as the construction of access roads and laydown areas.

The significance of the geotechnical related impacts associated with the proposed wind energy facilities is rated in the tables below (Section 6).

The extent of disturbance is contingent on the project site's topography and the characteristics of the proposed infrastructure. Steep slopes are less favourable as they necessitate substantial earthworks for creating working platforms and access roads, heightening the risk of soil movements or slope failure. Construction activities on such slopes, involving vegetation removal and potential disturbance to natural surface drainage, increase the risk of soil erosion. This may impede rainwater infiltration, elevate surface runoff, and concentrate surface water flow, potentially causing extended impacts beyond the infrastructure footprint over time.

While the majority of the site exhibits gentle to moderate topography requiring some bulk earthwork, localized areas feature moderately steep to very steep slopes, with talus present. To minimize impact, it is advisable to avoid the steepest slopes (greater than 1:15) when finalizing the infrastructure layout. Careful planning of access routes to circumvent these areas is recommended. Construction materials should preferably be sourced from cuttings and excavations instead of establishing borrow pits. A detailed geotechnical investigation should assess in-situ material suitability and the need for processing, such as crushing or stabilization.

Although the soils on the site are not highly susceptible to erosion, mitigation measures are essential, especially in lower-lying sections where concentrated surface flow is anticipated after heavy rainfall. The ridge crests are expected to feature outcropping or very shallow bedrock, providing a solid foundation for large structures but posing challenges for excavations needed for turbine foundations, services, and road construction.

6.2. Construction Phase Impacts

Table 4.1 Ground Disturbance During Construction

Issue	Ground Disturbance during construction
Description of Impact	
Ground disturbance during earthworks for turbine bases, access roads, platforms and laydown areas	
Determination of the Extent (Scale)	
Site specific	On site or within 100m of the site boundary, but not beyond the property boundary
Determination of Duration	
Permanent	This is the only class of impact that will be non-transitory. Such impacts are regarded to be irreversible, irrespective of what mitigation is applied.
Determination of Probability	
Definite	The impact will take place regardless of any prevention plans
Determination of Significance (without mitigation)	
Medium-High	The impact is of high importance and is therefore considered to have a negative impact. Mitigation is required to manage the negative impacts to acceptable levels.
Determination of Significance (with mitigation)	
Low	The impact will be mitigated to the point where it is of limited importance.
Determination of Reversibility	
Partly Reversible	The impact is partly reversible but more intensive mitigation measures
Determination of Degree to which an impact can be Mitigated	
Can be partly mitigated	The impact is partly reversible but more intense mitigation measures
Determination of Loss of Resources	
Marginal loss of resource	The impact will result in marginal loss of resources.
Determination of Cumulative Impact	
Negligible	The impact would result in negligible to no cumulative effects.
Medium	The impact would result in minor cumulative effects.
High	The impact would result in significant cumulative effects.
Determination of Consequence significance	
Negligible	The impact would result in negligible to no consequences.
Low	The impact would result in insignificant consequences.
Medium	The impact would result in minor consequences.
High	The impact would result in significant consequences.
Very High	The impact would result in detrimental consequences.

Table 4.2 Soil Erosion During Construction

Issue	Soil Erosion during construction
Description of Impact	
Erosion due to clearing of vegetation and alteration of natural drainage	
Determination of the Extent (Scale)	
Site specific	On site or within 100m of the site boundary, but not beyond the property boundary
Determination of Duration	
Long term	The impact will continue for the entire operational lifetime of the development, but will be mitigated by direct human action or by natural processes thereafter.
Determination of Probability	
Probable	There is a possibility that the impact will occur to the extent that provisions must therefore be made.
Determination of Significance (without mitigation)	
Medium	The impact is of sufficient importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impact to acceptable levels.
Determination of Significance (with mitigation)	
Low	The impact will be mitigated to the point where it is of limited importance.
Determination of Reversibility	
Partly Reversible	The impact is partly reversible but more intensive mitigation measures
Determination of Degree to which an impact can be Mitigated	
Can be mitigated	The impact is reversible with implementation of minor mitigation measures
Determination of Loss of Resources	
Marginal loss of resource	The impact will result in marginal loss of resources.
Determination of Cumulative Impact	
Negligible	The impact would result in negligible to no cumulative effects.
Low	The impact would result in insignificant cumulative effects.
Medium	The impact would result in minor cumulative effects.
High	The impact would result in significant cumulative effects.
Determination of Consequence significance	
Negligible	The impact would result in negligible to no consequences.
Low	The impact would result in insignificant consequences.
Medium	The impact would result in minor consequences.
High	The impact would result in significant consequences.
Very High	The impact would result in detrimental consequences.

6.3. Operational Phase Impacts

Table 4.3 Soil Erosion During Operational Phase

Issue	Soil Erosion during operational phase
Description of Impact	
Increased erosion due to alteration of natural drainage	
Determination of the Extent (Scale)	
Site specific	On site or within 100m of the site boundary, but not beyond the property boundary
Determination of Duration	
Permanent	This is the only class of impact that will be non-transitory. Such impacts are regarded to be irreversible, irrespective of what mitigation is applied.
Determination of Probability	
Probable	There is a possibility that the impact will occur to the extent that provisions must therefore be made.
Determination of Significance (without mitigation)	
Medium	The impact is of sufficient importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impact to acceptable levels.
Determination of Significance (with mitigation)	
Low	The impact will be mitigated to the point where it is of limited importance.
Determination of Reversibility	
Partly Reversible	The impact is partly reversible but more intensive mitigation measures
Determination of Degree to which an impact can be Mitigated	
Can be partly mitigated	The impact is partly reversible but more intense mitigation measures
Determination of Loss of Resources	
Marginal loss of resource	The impact will result in marginal loss of resources.
Determination of Cumulative Impact	
Negligible	The impact would result in negligible to no cumulative effects.
Low	The impact would result in insignificant cumulative effects.
Medium	The impact would result in minor cumulative effects.
High	The impact would result in significant cumulative effects.
Determination of Consequence significance	
Negligible	The impact would result in negligible to no consequences.
Low	The impact would result in insignificant consequences.
Medium	The impact would result in minor consequences.
High	The impact would result in significant consequences.
Very High	The impact would result in detrimental consequences.

6.4. Decommissioning Phase Impacts

Table 4.4 Ground Disturbance During Decommissioning

Issue	Ground disturbance during decommissioning
Description of Impact	
Ground disturbance during earthworks to remove platforms, turbine bases, road rehabilitation and removal of surface and sub surface structures	
Determination of the Extent (Scale)	
Site specific	On site or within 100m of the site boundary, but not beyond the property boundary
Determination of Duration	
Permanent	This is the only class of impact that will be non-transitory. Such impacts are regarded to be irreversible, irrespective of what mitigation is applied.
Determination of Probability	
Definite	The impact will take place regardless of any prevention plans
Determination of Significance (without mitigation)	
High	The impact is of great importance. Failure to mitigate with the objective of reducing the impact to acceptable levels could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.
Determination of Significance (with mitigation)	
Medium	Notwithstanding the successful implementation of the mitigation measures, the impact will remain of significance. However, taken within the overall context of the project, such a persistent impact does not constitute a fatal flaw.
Determination of Reversibility	
Partly Reversible	The impact is partly reversible but more intensive mitigation measures
Determination of Degree to which an impact can be Mitigated	
Can be partly mitigated	The impact is partly reversible but more intense mitigation measures
Determination of Loss of Resources	
Marginal loss of resource	The impact will result in marginal loss of resources.
Determination of Cumulative Impact	
Negligible	The impact would result in negligible to no cumulative effects.
Low	The impact would result in insignificant cumulative effects.
Medium	The impact would result in minor cumulative effects.
High	The impact would result in significant cumulative effects.
Determination of Consequence significance	
Negligible	The impact would result in negligible to no consequences.
Low	The impact would result in insignificant consequences.
Medium	The impact would result in minor consequences.
High	The impact would result in significant consequences.
Very High	The impact would result in detrimental consequences.

Table 4.5 Soil Erosion During Decommissioning

Issue	Soil Erosion during decommissioning
Description of Impact	
Increased erosion due to ground disturbance during rehabilitation activities	
Determination of the Extent (Scale)	
Site specific	On site or within 100m of the site boundary, but not beyond the property boundary
Determination of Duration	
Permanent	This is the only class of impact that will be non-transitory. Such impacts are regarded to be irreversible, irrespective of what mitigation is applied.
Determination of Probability	
Probable	There is a possibility that the impact will occur to the extent that provisions must therefore be made.
Determination of Significance (without mitigation)	
Medium	The impact is of sufficient importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impact to acceptable levels.
Determination of Significance (with mitigation)	
Low	The impact will be mitigated to the point where it is of limited importance.
Determination of Reversibility	
Partly Reversible	The impact is partly reversible but more intensive mitigation measures
Determination of Degree to which an impact can be Mitigated	
Can be partly mitigated	The impact is partly reversible but more intense mitigation measures
Determination of Loss of Resources	
Marginal loss of resource	The impact will result in marginal loss of resources.
Determination of Cumulative Impact	
Negligible	The impact would result in negligible to no cumulative effects.
Low	The impact would result in insignificant cumulative effects.
Medium	The impact would result in minor cumulative effects.
High	The impact would result in significant cumulative effects.
Determination of Consequence significance	
Negligible	The impact would result in negligible to no consequences.
Low	The impact would result in insignificant consequences.
Medium	The impact would result in minor consequences.
High	The impact would result in significant consequences.
Very High	The impact would result in detrimental consequences.

6.5. Cumulative Impacts

In relation to an activity, cumulative impact "means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may be significant when added to the existing and reasonably foreseeable impacts eventuating from similar or diverse activities" (NEMA EIA Reg GN R982 of 2014).

With respect to the Phase 2 Karoo WEF project, the assessments in Tables 4-1 to 4-5 indicate the ultimate cumulative impacts per issue are rated as **Medium without mitigation** measures and **Low with mitigation** measures.

6.5.1. Construction Phase

Ground disturbance during earthworks is expected during the construction of turbine bases, access roads, laydown areas and platforms.

The impact can be mitigated by removing surfacing in the laydown areas and rehabilitation of the ground.

Soil erosion during construction due to clearing of vegetation and alteration of drainage lines.

Berms and drainage channels to divert water. Design roads so site drainage is undertaken correctly. Use only designated roads for trafficking across the site.

Cumulative Impact rated as **Medium without mitigation** measures and **Low with mitigation** measures.

6.5.2. Operational Phase

Soil erosion during operation phase due to clearing of vegetation and alteration of drainage lines.

Routine monitoring during the operational phase.

Cumulative Impact rated as Medium **without mitigation** measures and **Low with mitigation** measures.

6.5.3. Decommissioning Phase

Ground disturbance during the removal of the various platforms, turbine bases and all related surface and sub surface structures.

The impact can be mitigated by landscaping and rehabilitation of the site to restore it to its previous topography.

Soil erosion during rehabilitation activities.

Berms and drainage channels to divert water. Use only designated roads for trafficking across the site. The natural site topography should be restored where possible.

Cumulative Impact rated as **Medium without mitigation** measures and **Low with mitigation** measures.

6.6. Mitigation & EMPR Requirements

The following mitigation measure on ground disturbance should be implemented:

- Proper site selection.
- The surfacing must be removed in the laydown areas and the ground rehabilitated
- Controlled excavation procedures supervised by a competent person.
- Weekly monitoring should be undertaken during the decommissioning stage and thereafter at four monthly intervals until final sign-off.

The following mitigation measure on soil erosion should be implemented:

- Temporary berms and drainage channels should be employed, as needed, to redirect water. It is crucial to ensure timely rehabilitation of disturbed areas. Additionally, the designs of road and site drainage should be executed accurately. Furthermore, only designated access routes should be utilized for trafficking around the site
- Routine monitoring of the construction of mitigating measures is required by the Resident Engineer and ESO/ECO on the site.
- Maintain drainage channels and other drainage structures such as culverts. Monitor for erosion and remediate and rehabilitate timeously.

6.7. “No-Go” Alternative

The proposed configurations for Phase 2 of the Karoo Wind Energy Facility Cluster will undergo evaluation, comparing them to the 'no-go' alternative. This alternative involves maintaining current agricultural activities on the site, without implementing the project. From a geological and geotechnical standpoint, this option is considered neutral, with no discernible changes expected.

Opting not to proceed with the development would mean avoiding additional impact on the receiving environment. However, this decision comes with the opportunity cost of forgoing potential socio-economic benefits that could have been realized by establishing wind energy facilities within the local community. It also means missing the chance to contribute renewable/clean energy to the national grid and play a role in meeting the country's energy demands.

Regarding the layout, the study area did not reveal any geologically or geotechnically sensitive zones. While areas underlain by sedimentary rocks are considered slightly more suitable for development compared to those underlain by dolerite and alluvium, other factors are expected to play a more crucial role in determining the final layout. Therefore, specific preferences for the ultimate layout within the area are not provided.

7. Further Geotechnical Investigations

Based on information presented within this desktop study, Terra Geotechnical recommend the following detailed geotechnical investigations as per guidelines:

- Site walkover survey and surface mapping of geological features
- Excavation of test pits across the site at each turbine location, access roads, borrow areas and other structures
- In situ density testing with heavy dynamic probes
- Detailed sampling of the soil and rock.
- Rotary Core Drilling of one borehole per turbine structure to a minimum depth of 25 m below ground level or at least 3m into competent bedrock (R3 or greater)
- Geophysical survey with thermal and electrical resistivity will be required across the project sites, in order to design the earthing cabling and backfill design for the installation. Multichannel Analysis of Surface Wave (MASW) should be considered at random turbine locations across the respective wind energy facility developments.

8. Conclusion

This report presents the findings of the geotechnical desktop assessment for the proposed Mulilo Karoo Wind Power Development 2 including associated infrastructure. It is our opinion that the geotechnical conditions below the project site will be suitable for the proposed wind energy facility developments, however, all founding conditions will need to be proven by conducting a detailed geotechnical investigation.

The respective wind energy facility developments, once completed, are unlikely to pose any major geological or geotechnical impact to the surrounding area and environment, so long as each respective development is designed, constructed and operated by competent practitioners.

The findings provided in this report are based on the information gained from the existing information from archives of Terra Geotechnical and other consultants. No site inspection or field mapping was conducted, as this was not deemed necessary at this stage.

Although the confidence in the information is high, some variations must be expected during the fieldwork.

Cumulative impact

A cumulative impact on the geotechnical environment will be minimal and acceptable for the development.

'No go' option

Should it be decided to not proceed with the development all associated negative impacts will therefore be removed, however, it should be noted that the opportunity cost of missed socio-economic benefits to the local community that would otherwise be realized from establishing the wind energy facilities. The option of not developing also entails that the bid to provide renewable / clean energy to the national grid and contribute to meeting the country's energy demands will be forfeited.

9. Limitations & Assumptions

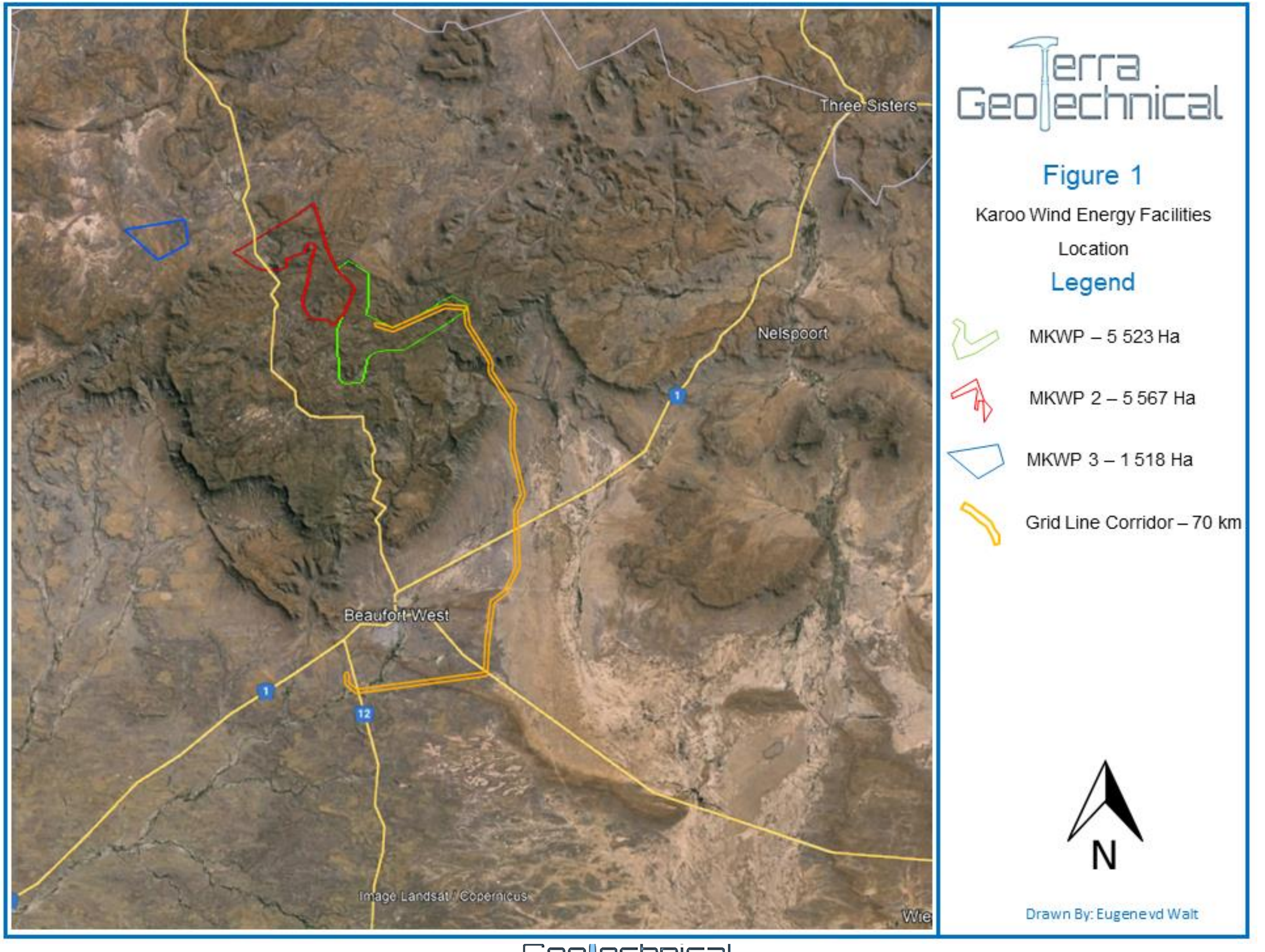
This report assumes relatively uniform geotechnical conditions across the site for the proposed wind energy facility. From previous investigations conducted for similar projects which tend to cover large areas, cognisance of the environment must be considered. Typically, a geotechnical investigation will incur a much smaller environmental impact compared to actual construction.

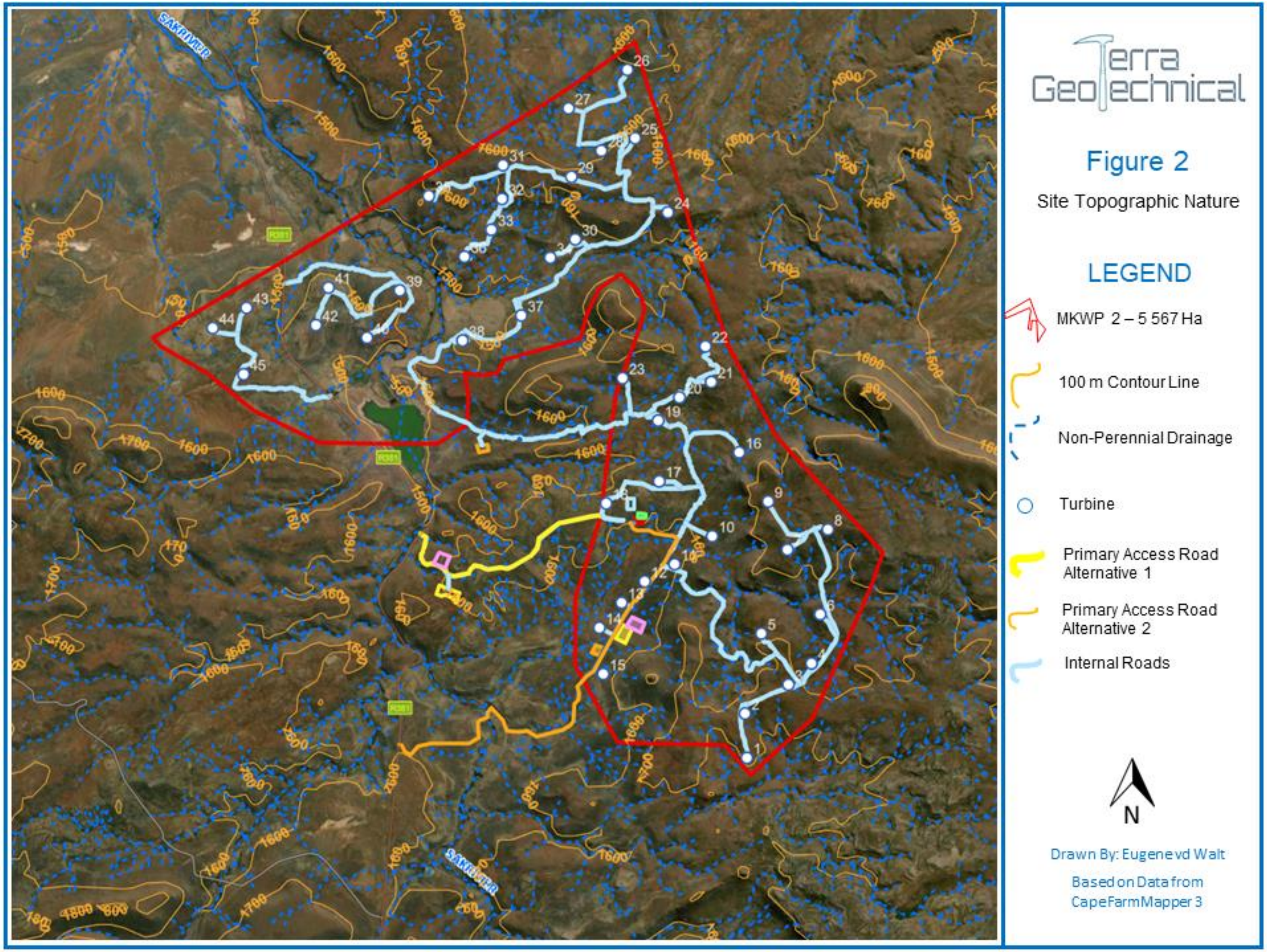
The extent of the investigations undertaken is deemed adequate, within the time and budget constraints, to present an overview of the geotechnical conditions across the investigation site.

It must be borne in mind that the overall interpretation of geotechnical conditions is based upon available information which have been inferred by interpolation, extrapolation and professional judgement.

The findings given on this report are limited to the sources available to Terra Geotechnical and no field mapping or site inspection has been conducted.

MAPS


Three Sisters
Nelspoort
Beaufort West
Image Landsat / Copernicus
Terra GeoTechnical
Figure 1
Karoo Wind Energy Facilities
Location
Legend
MKWP – 5 523 Ha
MKWP 2 – 5 567 Ha
MKWP 3 – 1 518 Ha
Grid Line Corridor – 70 km
N
Drawn By: Eugene vd Walt


Terra GeoTechnical
Figure 2
Site Topographic Nature
LEGEND
MKWP 2 – 5 567 Ha
100 m Contour Line
Non-Perennial Drainage
Turbine
Primary Access Road Alternative 1
Primary Access Road Alternative 2
Internal Roads
N
Drawn By: Eugene vd Walt
Based on Data from CapeFarmMapper 3

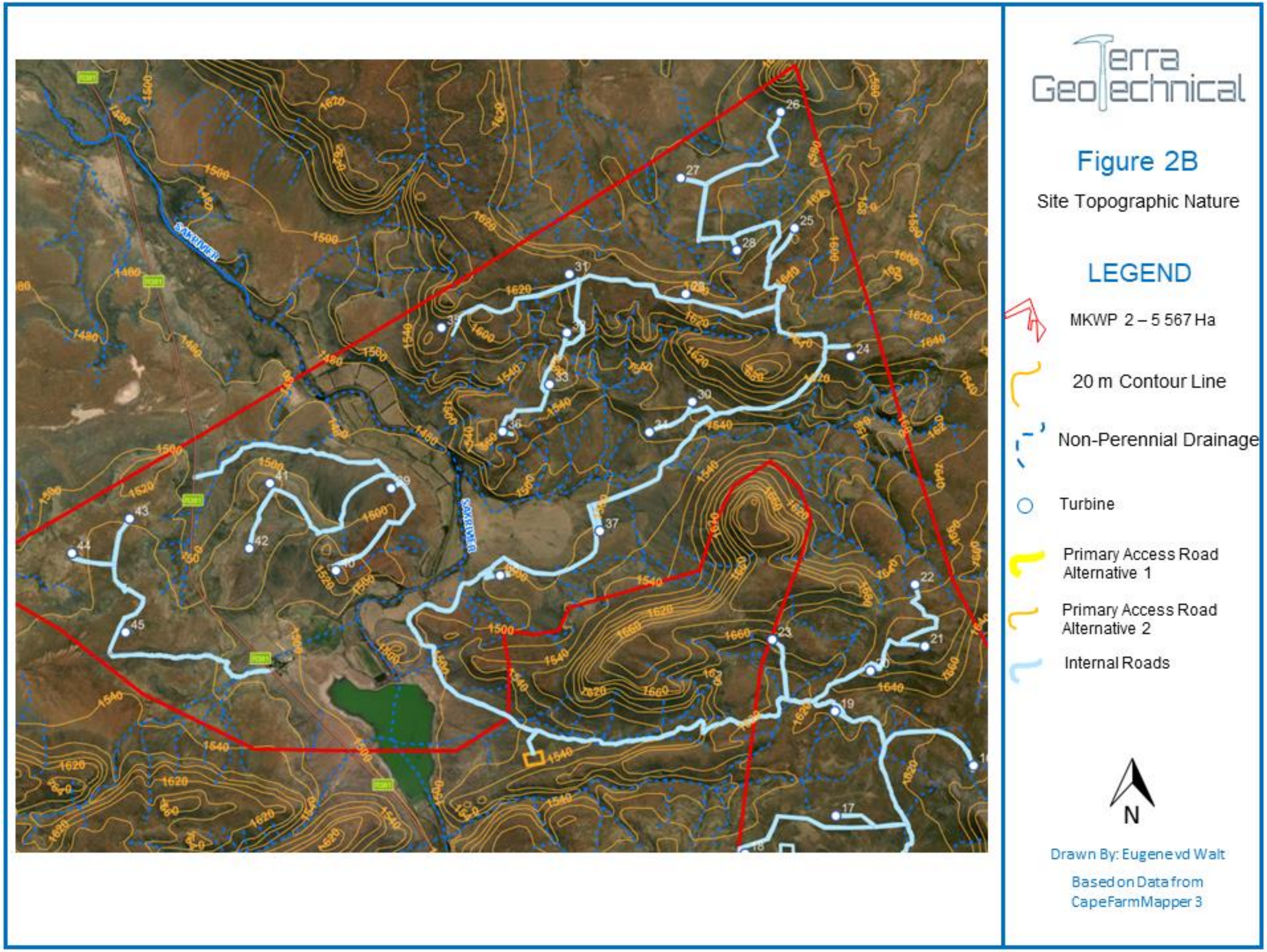
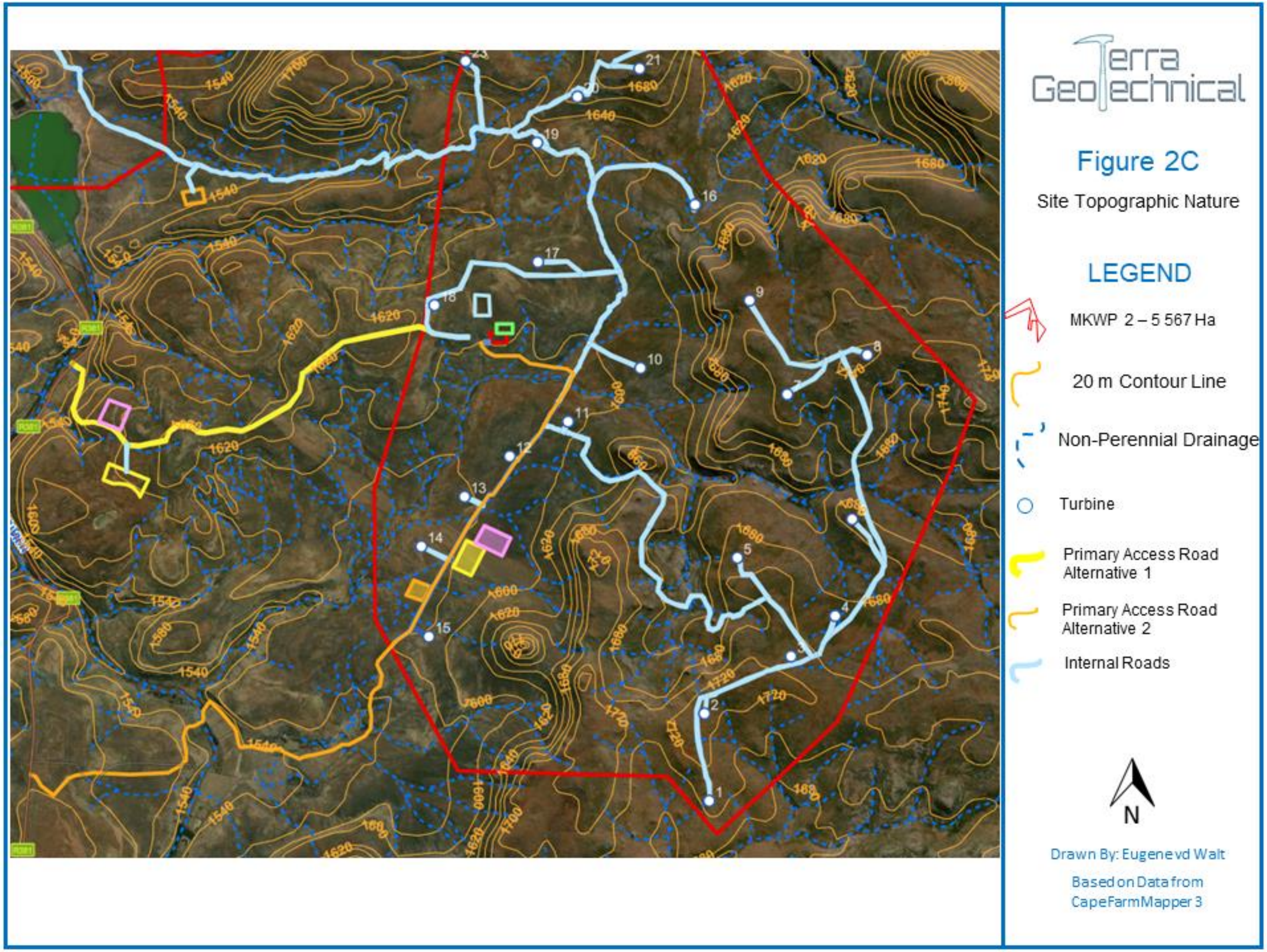


Figure 2B
Site Topographic Nature
LEGEND
MKWP 2 – 5 567 Ha
20 m Contour Line
Non-Perennial Drainage
Turbine
Primary Access Road Alternative 1
Primary Access Road Alternative 2
Internal Roads
N
Drawn By: Eugene vd Walt
Based on Data from CapeFarmMapper 3


Terra Geotechnical
Figure 2C
Site Topographic Nature
LEGEND
MKWP 2 – 5 567 Ha
20 m Contour Line
Non-Perennial Drainage
Turbine
Primary Access Road Alternative 1
Primary Access Road Alternative 2
Internal Roads
N
Drawn By: Eugene vd Walt
Based on Data from CapeFarmMapper 3

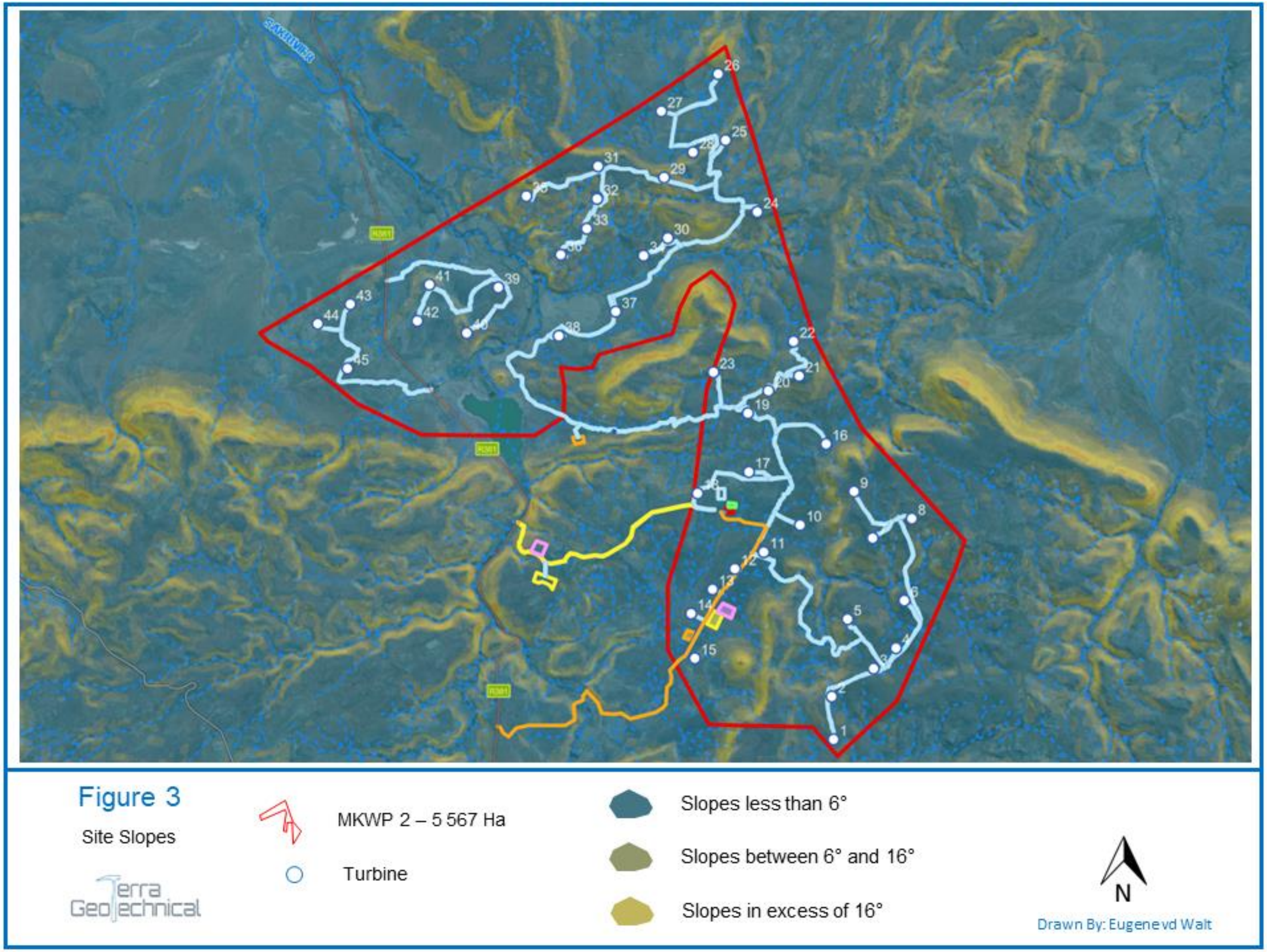
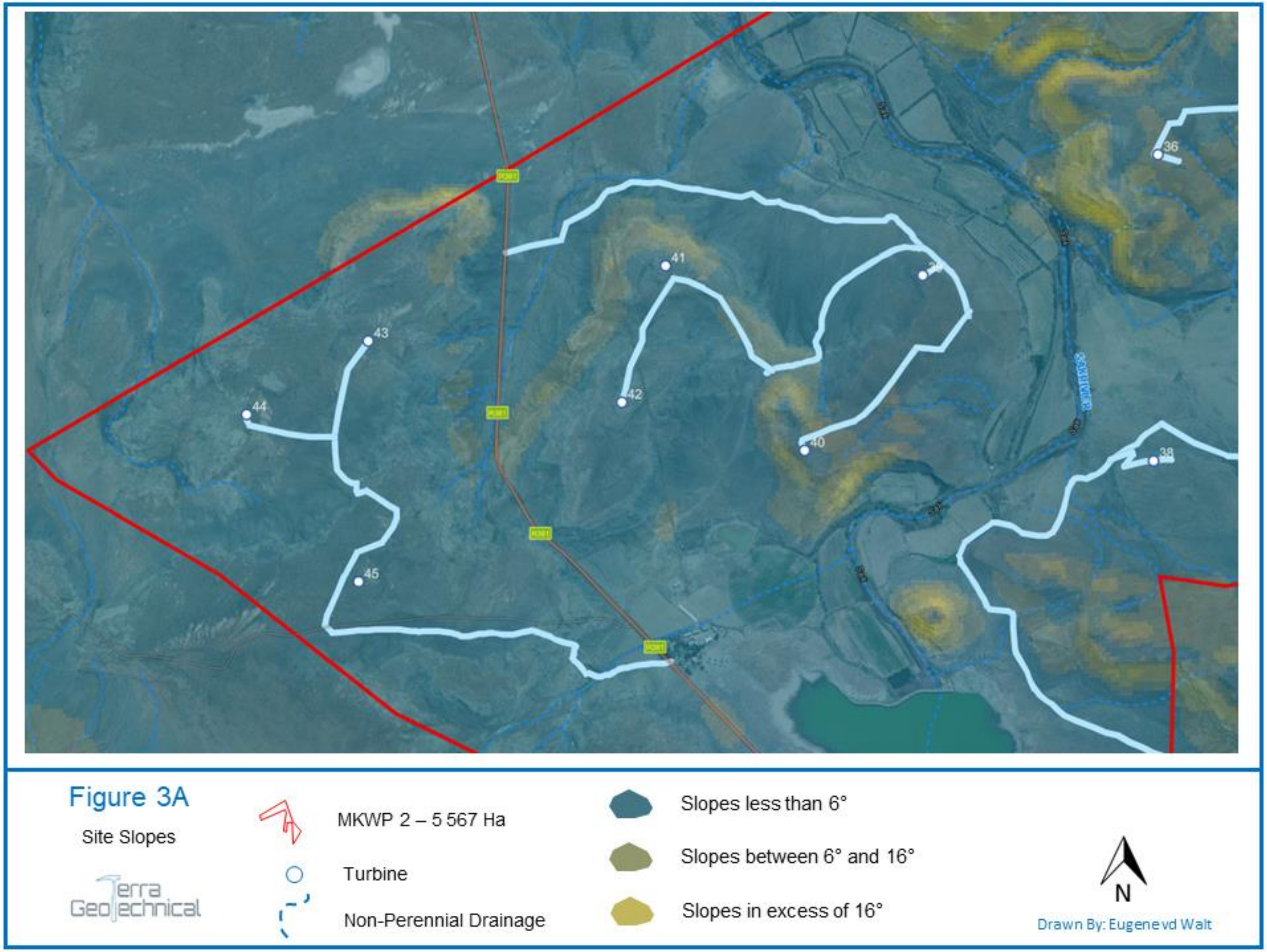
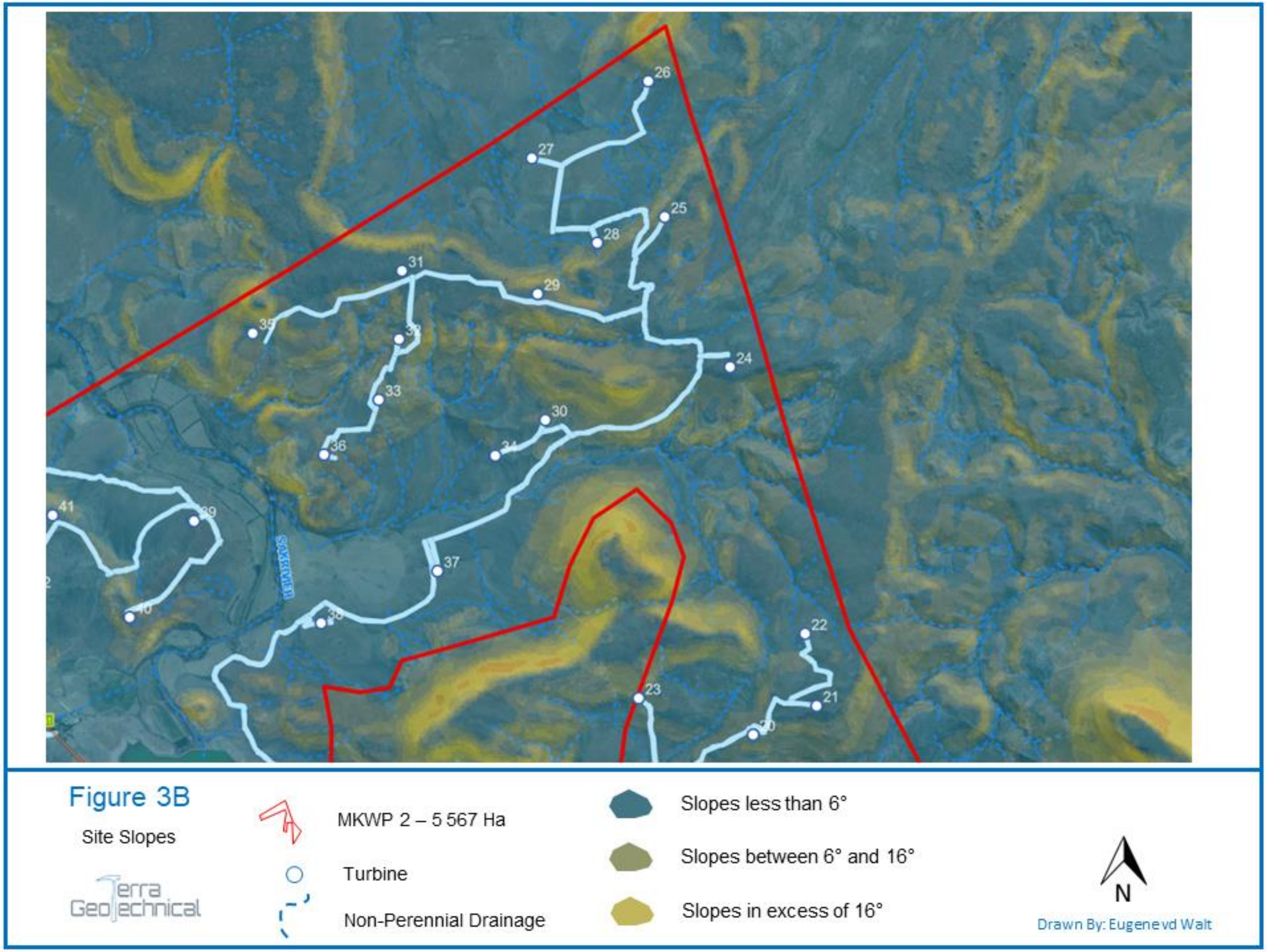


Figure 3
Site Slopes


41
43
44
42
40
39
36
38
45
Figure 3A
Site Slopes
Terra GeoTechnical
MKWP 2 – 5 567 Ha
Turbine
Non-Perennial Drainage
Slopes less than 6°
Slopes between 6° and 16°
Slopes in excess of 16°
N
Drawn By: Eugene vd Walt



GeoTechnical

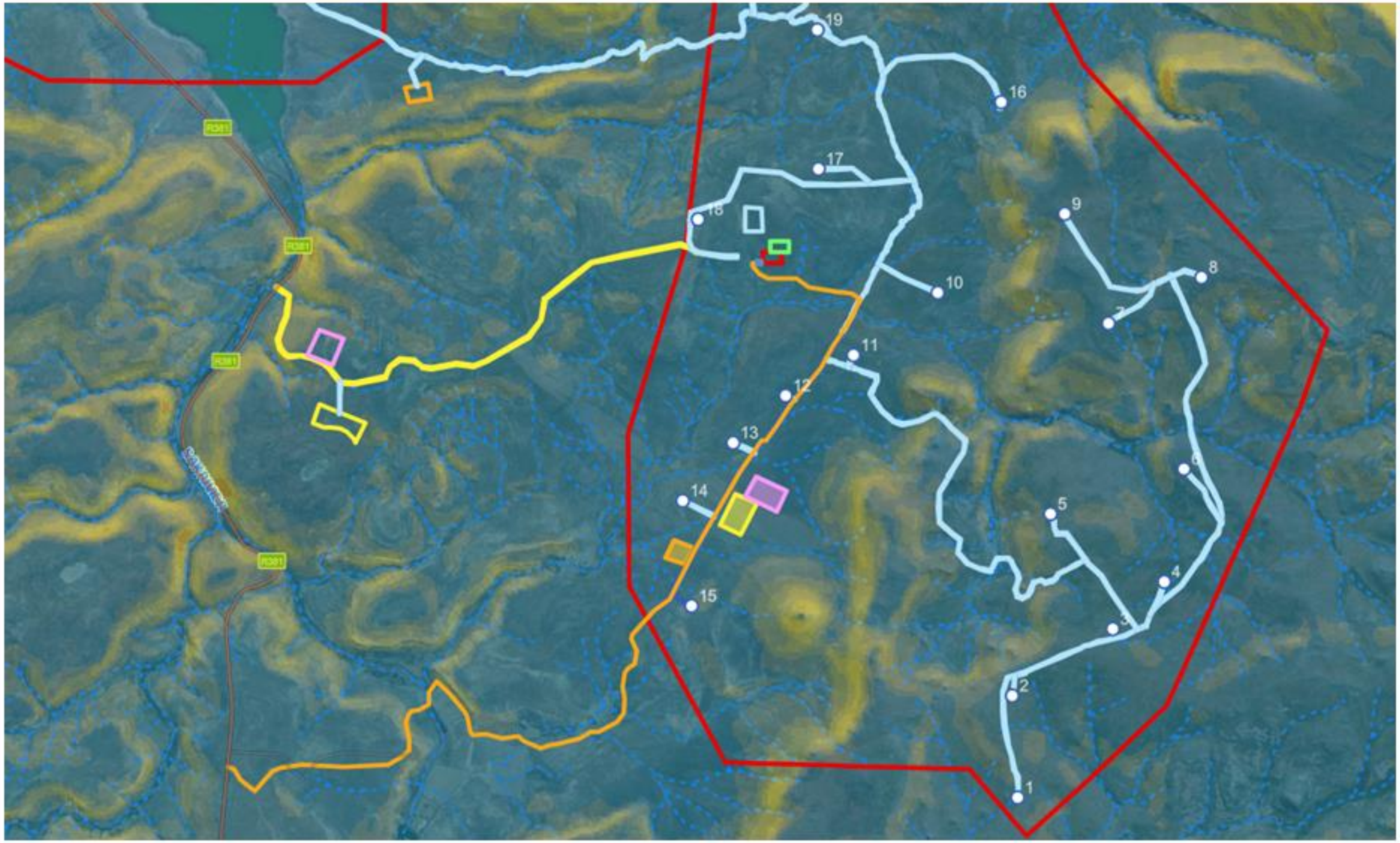
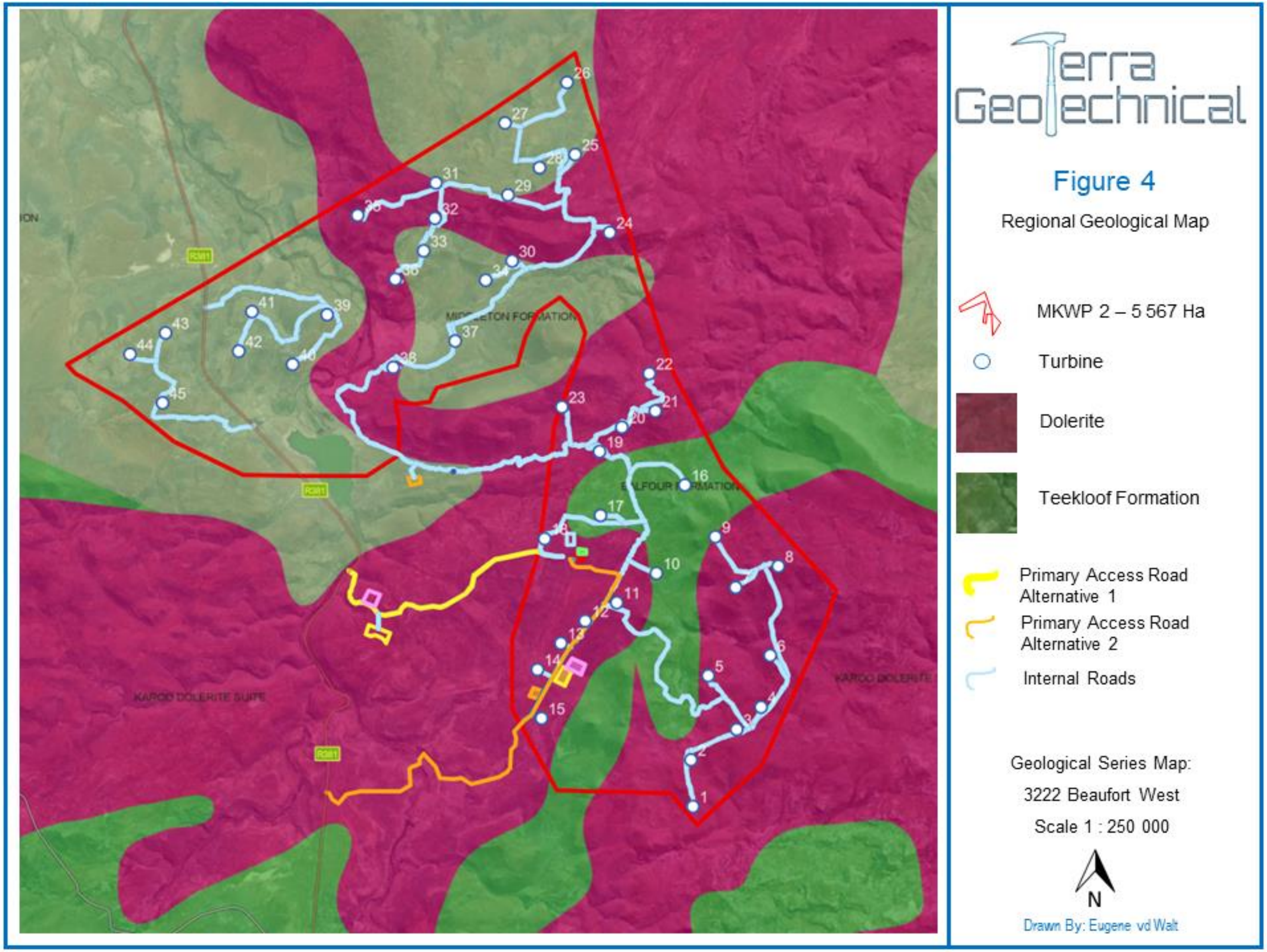


Figure 3C

Site Slopes


Terra Geotechnical
Figure 4
Regional Geological Map
MKWP 2 – 5 567 Ha
Turbine
Dolerite
Teekloof Formation
Primary Access Road Alternative 1
Primary Access Road Alternative 2
Internal Roads
Geological Series Map:
3222 Beaufort West
Scale 1 : 250 000
N
Drawn By: Eugene vd Walt
KAROO DOLERITE SUITE
KAROO DOLERITE
R381

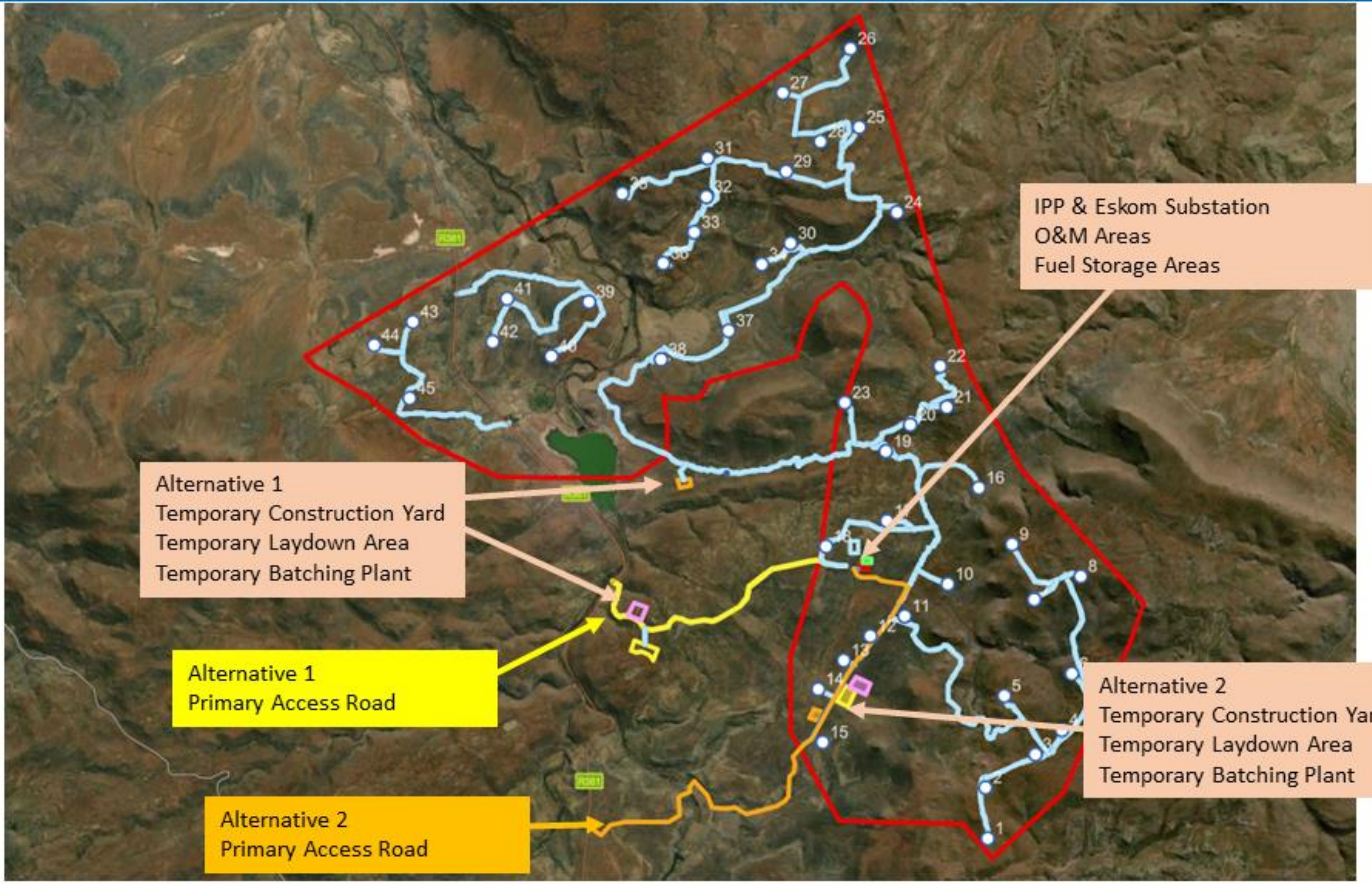


Figure 5

Proposed Development Layout

Legend

MKWP 2 – 5 567 Ha

Primary Access Road Alternative 1

Primary Access Road Alternative 2

Turbine

Internal Roads

N

Drawn By: Eugene vd Walt

Based on Data from CapeFarmMapper 3

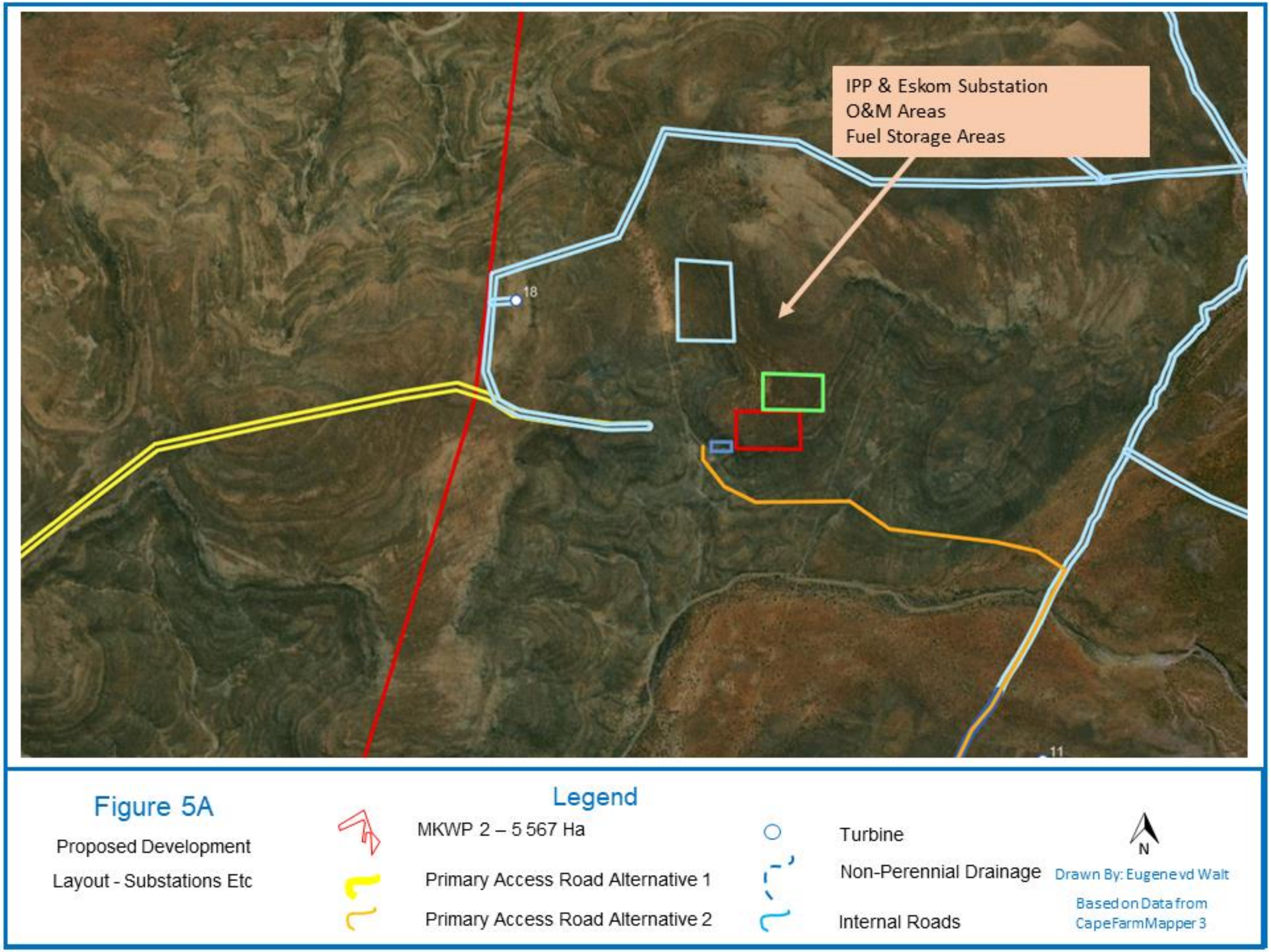


Figure 5A

Proposed Development Layout - Substations Etc

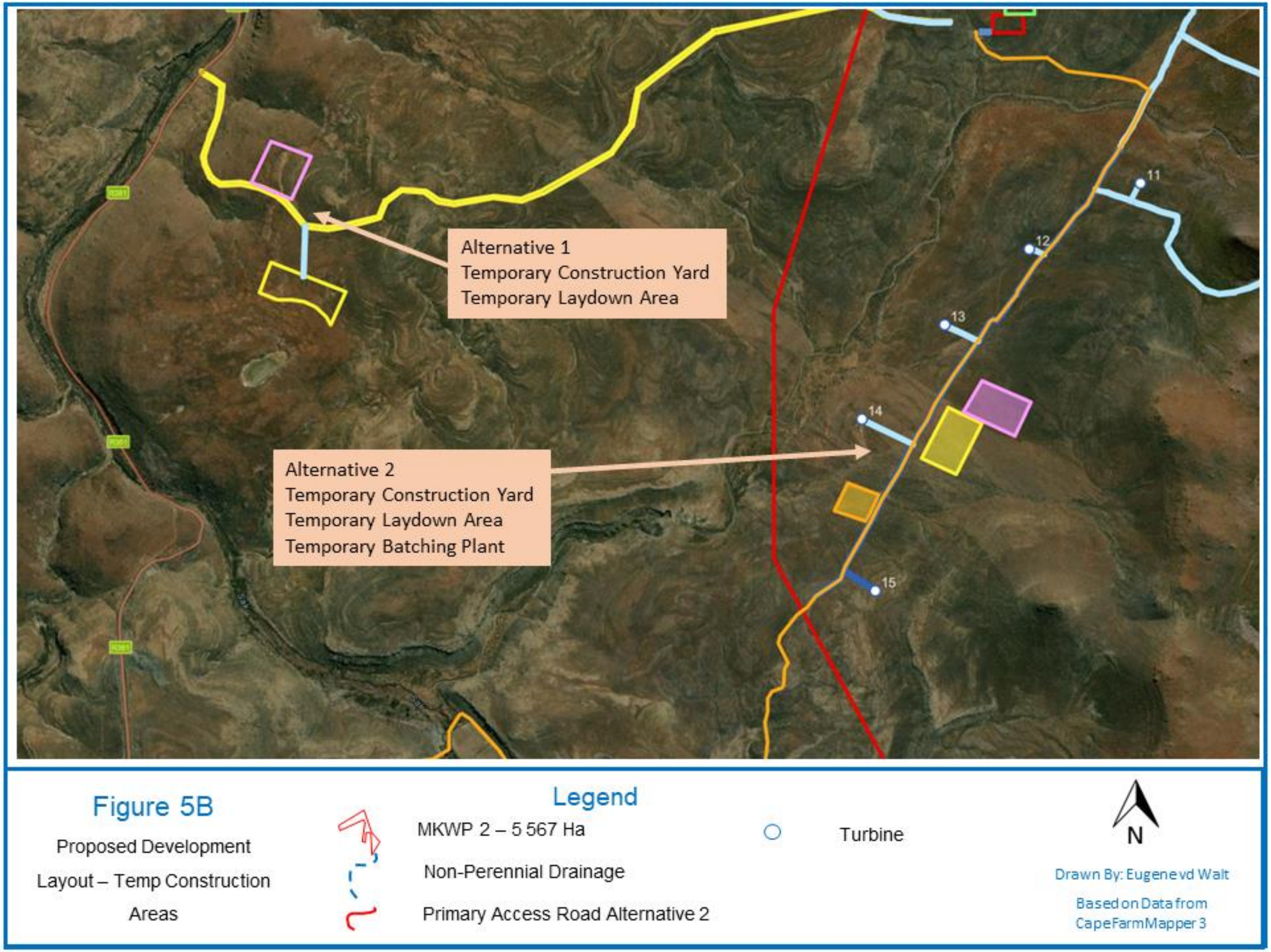


Figure 5B

Proposed Development Layout – Temp Construction Areas

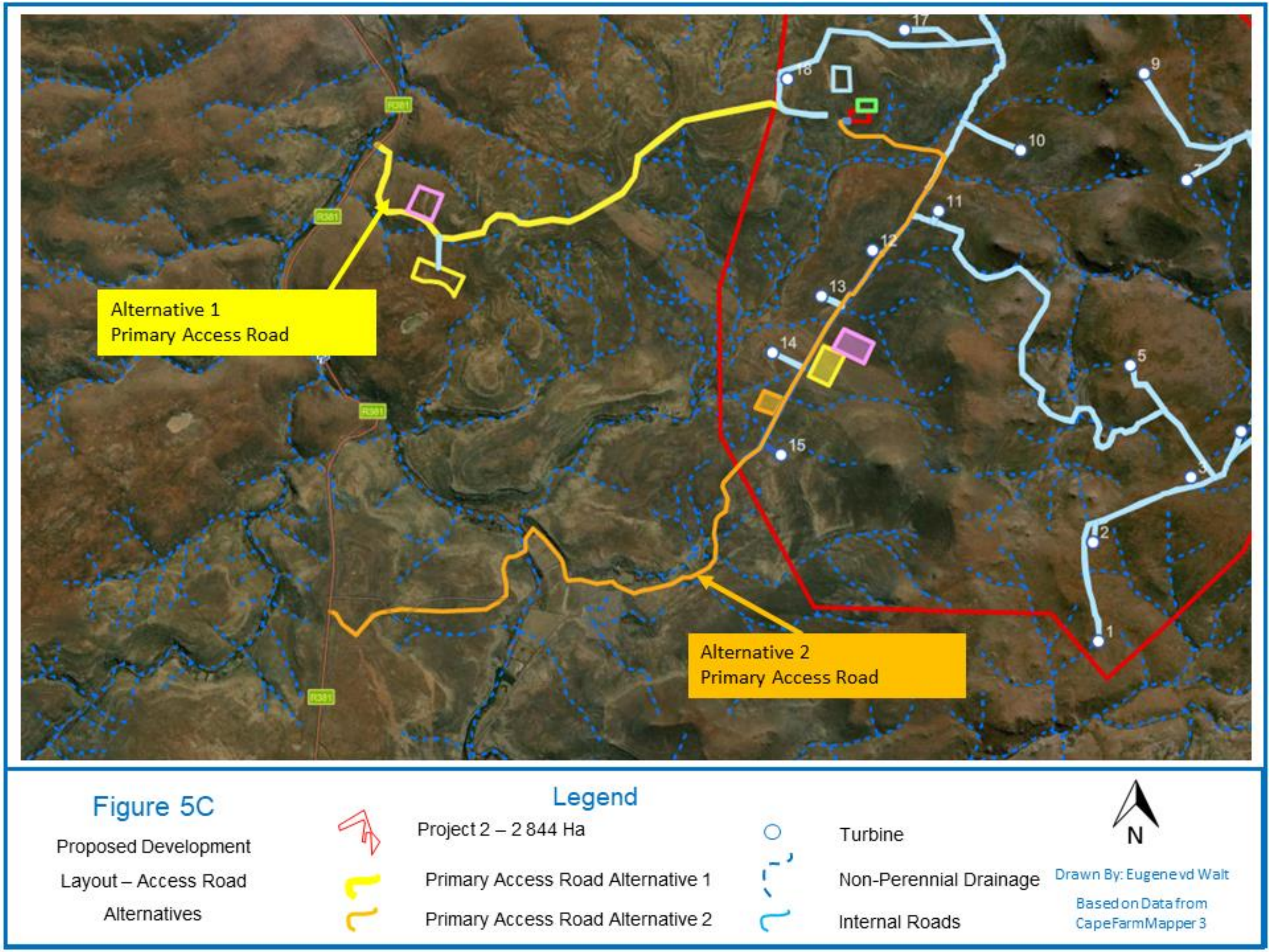


Figure 5C

Proposed Development Layout – Access Road Alternatives

Figure 5D

Proposed Development Layout -BESS

Legend

MKWP 2 – 5 567 Ha

Primary Access Road Alternative 1

Turbine

Non-Perennial Drainage

Internal Roads

N

Drawn By: Eugene vd Walt

Based on Data from CapeFarmMapper 3

APPENDIX A

A.1 Specialist Credentials

CURRICULUM VITAE

EUGENE DAVID VAN DER WALT

PERSONAL DATA	
SURNAME	Van Der Walt
FIRST NAMES	Eugene David
IDENTITY NUMBER	8305105220086
DRIVERS LICENCE	Code 14
NATIONALITY	South African
FIRST LANGUAGE	Afrikaans
SECOND LANGUAGE	English
TELEPHONE NUMBERS	+27 82 073 8566

TERTIARY EDUCATION	
INSTITUTION	University of Pretoria
DEGREE OBTAINED (2006)	Bachelor of Science in Geology
DEGREE OBTAINED (2008)	B.Sc. Honours in Engineering Geology

PROFESSIONAL AFFILIATION
Member of the South African Council for Natural Scientific Professions (SACNASP) Member of the South African Institute for Engineering and Environmental Geologists (MSAIEG) National Home Builders Registration Council (NHBRC)

Summary of Experience:

Eugene boasts over 15 years of extensive experience in the engineering geological/geotechnical field. He has conducted geotechnical investigations across Southern Africa and various African nations, including the Democratic Republic of Congo, Zimbabwe, Mozambique, and Zanzibar. Eugene's expertise spans diverse projects, encompassing mines, power stations, hydro-electric plants, solar farms, wind farms, substations, and other large-scale structures.

His work has involved geotechnical investigations for a range of purposes, such as assessing slope stabilities, examining reservoir/dam structures, evaluating bridges, and conducting studies for solar farms, townships, golf estates, shopping centres, lodges, cemeteries, landfill sites, as well as proving the suitability of borrow pits. Additionally, Eugene has contributed to materials and centreline investigations for roads and pipelines.

Throughout his career, Eugene has been responsible for all project phases. This includes preparing initial proposals and cost estimates, overseeing review and investigation stages, and compiling comprehensive completion reports. His role extends to providing crucial technical input during the construction phase of projects.

Previous project involvement in Southern Africa:

- Geotechnical investigation for the expansion of the Kriel Power Station. (ESKOM-Kriel FFP Project)
- Geotechnical Investigations for temporary crane pads at Kendal Power Station
- New Regional Garden Route Landfill Site
- Multiple large scale bulk water infrastructure upgrades/developments
- Geotechnical investigations for large scale Solar and Wind Farm Developments.
- Hydro-geological and Geotechnical investigations for golf estate developments.
- Geo-environmental and geo-hydrological Investigations for tailings dams for large industrial production plants.
- Slope stability assessments
- Geo-environmental and geo-hydrological Investigations for Filling Stations
- Geo-environmental and geo-hydrological Investigations for cemeteries
- Geotechnical investigations for Township developments.
- Geotechnical investigations for Waste Water Treatment Plants and associated structures.
- Geotechnical investigations for major industrial sized Silo structures.
- Geotechnical investigations for reservoirs and elevated water tanks.
- Geotechnical centreline and materials investigations for major and minor road structures (upgrading as well as rehabilitation), pipe-line structures and railway developments.
- Borrow pit exploration with both quantitative and qualitative data.
- Geotechnical investigations for bridge structures spanning across drainage channels or man-made infrastructure.
- Geotechnical investigations for development potential analysis of small-scale developments.