PROPOSED CONSTRUCTION OF THE LEEUWBERG WIND ENERGY FARM NEAR LOERIESFONTEIN, NORTHERN CAPE

PRELIMINARY ENGINEERING SERVICES REPORT

JANUARY 2017

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Report Title:	Leeuwberg Farm Preliminary Engineering Services Report
Project Name:	Mainstream Preliminary Engineering Service Study
Project Number:	C1643
Report for:	Ms Mercia Grimbeek

REVISIONS

Revision #	Date	Change Overview	Prepared by	Reviewed by
1	Nov 2016	Draft Issue	Glen Randall	Cobus Hendriksz
2	Jan 2017	Final Issue	Glen Randall	Cobus Hendriksz
3	Oct 2017	Revised Issue	Shameez Papathanasiou	Cobus Hendriksz

ISSUE REGISTER

Distribution List	Date Issued	Number of Copies
SMEC staff:		
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Office Library (SMEC office location):		
SMEC Project File:		

EXECUTIVE SUMMARY

This report is an investigation into the engineering services, transportation and geotechnical conditions for Erf 217 (known as Georgs Vley Farm), Erf 216 (known as Hartebeest Leegte Farm) and Erf 176 (known as Graskoppies Farm). The erven are collectively known as the Leeuwberg Wind Energy Farm (LWEF) and is located close to Loeriesfontein in the Northern Cape. In particular, it reviews the state and capacity of the various engineering services that will form part of the proposed development.

The proposed LWEF development is essentially an extension to two nearby wind farm projects; namely “Loeriesfontein 2” and “Khobab”. The LWEF project comprises some 188 new wind turbines together with new substations and a network of new internal roads.

From a geotechnical perspective, the major findings suggest that the site is relatively flat with local ridges associated with dolerite intrusions. The only prominent hill is Groot Rooiberg, on the southern site boundary. The water table is 10m below the ground level during the winter months and consequently the site is dry throughout the year.

With regards to transport, an assessment was undertaken to determine the impact that the proposed wind farm will have on the operation of the existing road network, both during construction and post completion. It is anticipated that during construction up to 100 vehicles will travel to the site in the morning peak hour, the majority travelling from the proposed construction camp along the R358. In addition, other transportation aspects relating to the proposed project, including access, internal circulation and abnormal vehicle transportation were investigated and form part of this report. The report recommends the primary access to the site to be via the R358 which links directly to the N7. This route is appropriate for both legal vehicles as well as abnormal vehicles carrying the wind turbine components.

There is no underground municipal stormwater infrastructure in place to service the site. The run-off gravitates towards on-site ponds, which act as retention ponds that promote infiltration and assist in recharging of the underground water table. The difference between the pre & post-development runoff for the development is minimal and it is proposed that the largest existing pond be reshaped and enlarged to offset any additional run-off from the site.

There are existing boreholes which currently supply water to the farm owners of the affected erven. The groundwater quality in this area is unsuitable for human consumption without treatment. It is proposed that a mobile water purification plant be utilised to produce potable water on-site. This system is working successfully on the nearby wind farm construction sites. In emergencies when the purification plant is not working water will be trucked in from nearby towns and stored on-site. The untreated groundwater is to be used for all wind farm and road construction activities, although further water tests will need to be conducted to ascertain the exact water composition as this will affect the concrete mix. Untreated groundwater is to be stored in a reservoir located in an area which is flat and capable of providing the appropriate water head pressure.

No underground municipal sewer network is present within the vicinity of the property and local farmers generally make use of septic tanks. This project requires new sanitary toilets

together with a septic tank both in the construction camp as well as on-site during construction due to the large workforce anticipated.

Greening interventions are recommended during construction of the wind farm. These include water and energy related interventions, material re-use and solid waste management. The site, being vacant, currently generates no solid waste and it is proposed that onsite composting, sorting and recycling will reduce the overall volume of waste being collected and removed from the site.

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ACRONYMS

AL – Abnormal Loads

CSW – Continuous Surface Wave

DWA – Department of Water Affairs

Ha – Hectares

HGV's – Heavy Goods Vehicles

LWEF – Leeuwberg Wind Energy Farm

MW – Mega Watts

MI – Mega Litre

O&M – Operation and Maintenance Phase

OHLs – Overhead Lines

1. INTRODUCTION

1.1 Terms of Reference

SMEC (Pty) Ltd have been appointed by South Africa Mainstream Renewable Power Developments (Pty) Ltd to prepare a Preliminary Engineering Services Report for the proposed Leeuwberg Wind Energy Farm (hereafter known as the LWEF site or project) situated near Loeriesfontein in the Northern Cape Province, South Africa. The LWEF project comprises of four individual projects; known as Project 1, Project 2, Project 3 and Project 4. The phasing of these projects are yet to be determined and it is therefore possible that all four projects be constructed concurrently.

1.2 Background

The information used to prepare this report is based on documents supplied by Mainstream as well as other research reports. The supporting documents interrogated include:

1. Kmz files of the site layout, proposed internal roads, proposed substation, etc;
2. Stormwater Management Plan report;
3. Preliminary Engineering Report for the Kangnas Wind Farm; and
4. “Loeriesfontein 2” and “Khobab” Wind Farm Route Survey and Environmental Impact Assessment (EIA) reports.

The two abovementioned wind farms are relatively nearby to the LWEF site and are currently under construction. The Loeriesfontein 2 and Khobab wind farms are approximately 40 and 60km east of the LWEF site respectively. Loeriesfontein 2 and Khobab will each provide 47 turbines when completed. Technical studies undertaken for these projects reveal that the Hantam Municipal Area (area within which both projects are located in) is ideal due to favourable wind conditions, its proximity to national roads (i.e. access), the favourable construction conditions, positive municipal and local stakeholder support, as well as the relatively straightforward electrical connection into Eskom’s transmission grid.

1.3 Site Location

The LWEF site is located in an extremely rural area in the Northern Cape Province. The area is primarily farmland together with some mining activities. The LWEF site falls within the jurisdiction of the Hantam Local Municipality, which forms part of the overarching Namakwa District Municipality. **Figure 1.1** shows the site location within a regional context while **Figure 1.2** shows the municipal area spatially together with the LWEF site location.

Figure 1.1 - Regional Locality Plan

Figure 1.2 - Hantam Municipality Locality Plan

The towns within reasonable proximity of the LWEF site are shown **Figure 1.3**. These include:

1) Kliprand – 75km west;
2) Loeriesfontein – 80km south;
3) Brandvlei – 135km east; and
4) Bitterfontein – 150km southwest

Kliprand and Bitterfontein are small towns with population sizes of 205 and 986 people respectively. Loeriesfontein is the most well-known town within the area but is itself also a small town with a population of 2744 people. The town appears to have better amenities to those of its neighbours.

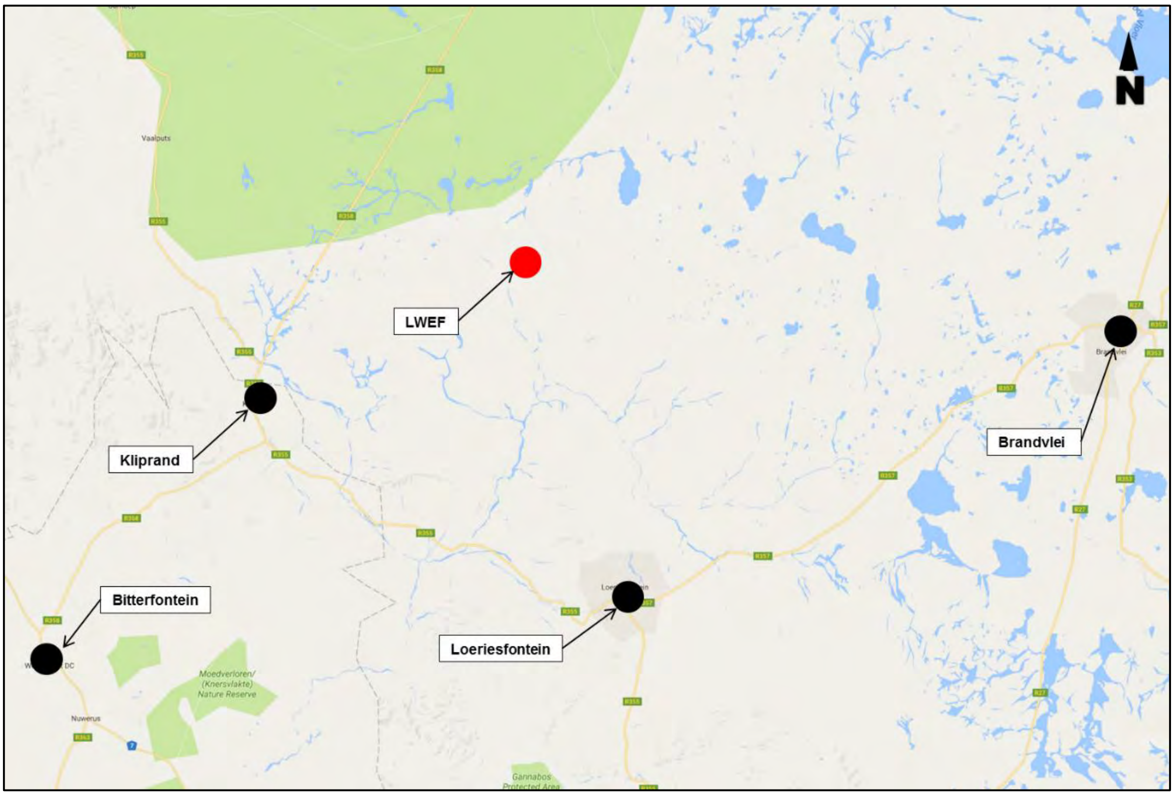


Figure 1.3 - Nearby Towns to LWEF Site

The area surrounding Loeriesfontein is within a geological basin surrounded by mountains, and assuming travel from Cape Town, is accessed via the N7 highway, turning off onto the R27 at Vanrhynsdorp to Nieuwoudtville, and then following the R357 to Loeriesfontein (a further 65km north). The surrounding road network is shown in **Figure 1.4**.

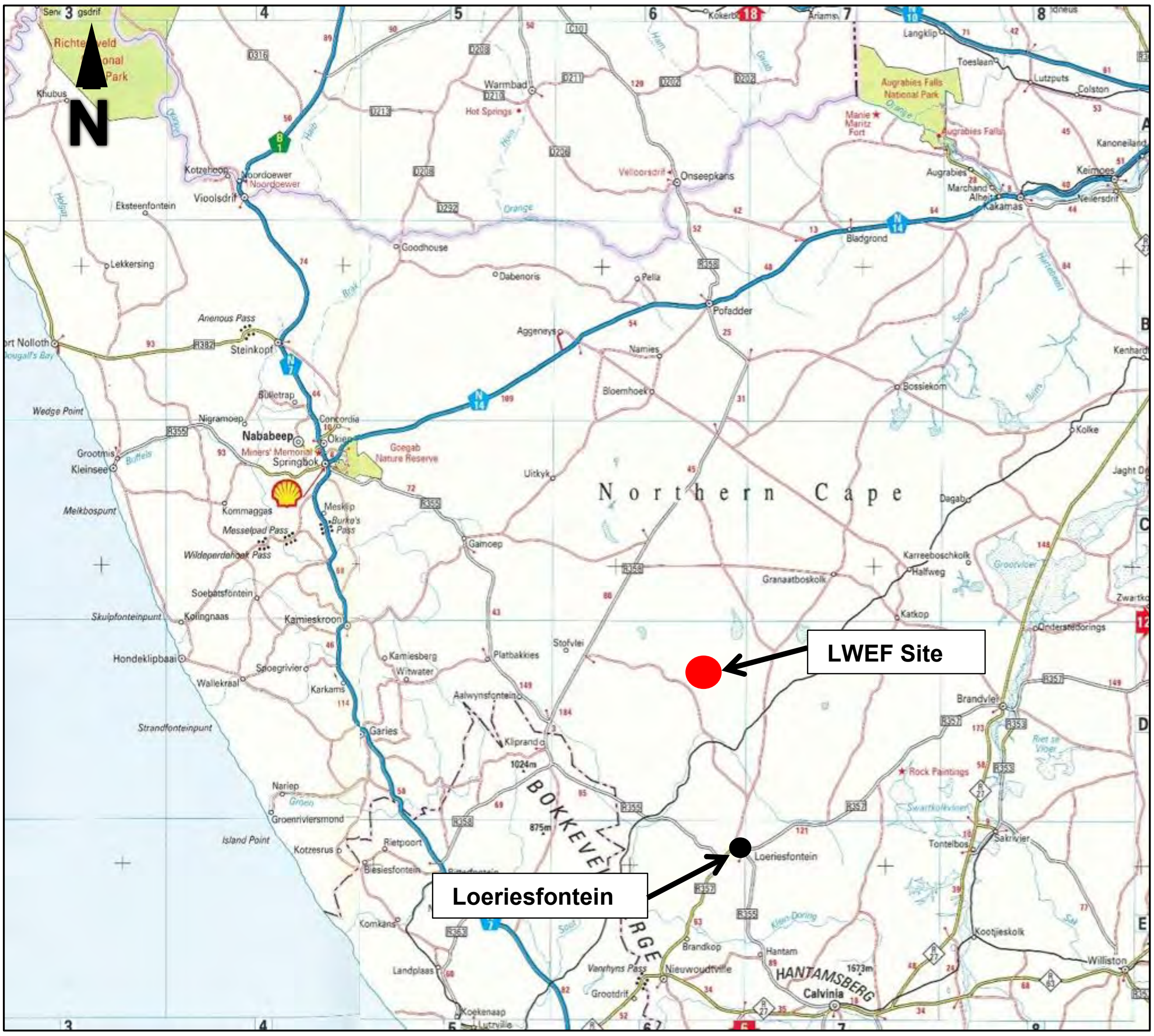


Figure 1.4 – Existing Road Network

1.4 Climate

No climatic information specific to the LWEF site is known, although climatic information for Loeriesfontein has been obtained and indicates that the area typically receives approximately 143mm of rain per year, with the highest rainfall occurring during winter. The climate for the region can best be described as “Mediterranean” in terms of the Koppen Climate Classification, i.e. dry summers.[1] The area receives the lowest rainfall in the month of January (1mm) and the highest in the month of June (28mm).

The average daily temperatures for Loeriesfontein range from 31.8°C in February to 17°C in July, although temperatures can drop to 2°C in the evenings.

The climatic conditions has a bearing on the soil and rock conditions; more specifically the rate at which the rocks weather to form soil. Geologically, the physical disintegration of the rock is the dominant form of weathering in the area, resulting in shallow granular and gravelly residual soil. Where significantly thick soil profiles occur on the site these would most likely be related to transported soils of Aeolian or Alluvial origin. **Chapter 6** provides a more detailed summary of the climatic conditions and soil profiles.

[1] (https://en.wikipedia.org/wiki/Mediterranean_climate).

1.5 Objectives

The purpose of an Engineering Services Report is to identify the engineering issues/risks that may have an impact on the potential feasibility and constructability of a project.

In identifying the risks associated with the LWEF project, a list of general objectives were established and are provided below:

1) Determine the most cost effective access to the site by both construction vehicles as well as abnormal vehicles;
2) Identify a local water supply for use during construction;
3) Establish the 1 in 100 flood line to demonstrate that the proposed LWEF does not lie within a floodplain;
4) Determine the volume of traffic during construction as well as for maintenance periods, ensuring that the impact of increased vehicular activity is mitigated; and
5) Establish how best to connect to ESKOM's grid.

In order to achieve these objectives the following tasks were undertaken:

- Preliminary route determination for the activities anticipated;
- Traffic management required to minimise damage to public roads and risk to other road users;
- Review most appropriate locations for the wind farm substations, operation and maintenance buildings, laydown area etc.;
- Estimate water use and to identify water sources to enable construction of the LWEF project;
- Undertake preliminary Geotechnical studies, with specific attention to Eskom requirements and appropriate locations for the Substations;
- List material sources and related issues;
- Develop a preliminary Stormwater Management Plan and identify measures to prevent flooding; and
- Review alternatives for the main electrical grid connection.

1.6 Assumptions and Limitations

The following assumptions and limitations are to be noted:

- This research report has been a desktop study and as such, surveys were limited to on-site observations together with a field trip of the two wind farm projects currently under construction. It is therefore recommended that the findings of this report be verified either through more detailed studies once the project moves into the preliminary and detail design stages of the engineering life cycle;

- This report assumes that Abnormal and some Heavy Goods Vehicles (HGV's) are unable to navigate the Vanrhynsdorp Pass or the Piketberg Pass due to sharp horizontal curves and steep slopes along particular sections;
- The wind turbine components could be either manufactured locally (i.e. Gestamp in Atlantis) or imported using one of the cargo ports available in South Africa. All planning therefore recognises that logistical plans must ensure a suitable corridor is available for both alternatives;
- This report only considered two possible ports for the importation of turbine components; namely Saldanha and Coega. The ports of Walvisbaai and Cape Town have been excluded on the basis that they are primarily container ports rather than ports servicing the oil and gas industry. As a consequence they appear ill equipped to deal with large items such as wind turbine cells and blades;
- It is assumed that each wind farm has a power export capacity of 235MW (total of 940MW for four projects);
- The grid connection shall not be N-1 compliant (export redundancy) as set out in the SA Network Code, due to economic considerations. As such, the cheapest connection costs is considered;
- The grid connection is based on the latest site development plans. Any changes to these plans would require a rework of this report;
- Any competing connections not mentioned in **Chapter 10** of this report should be made known to SMEC in order to update the report;
- The technical performance of the connection shall not be assessed, as this is a preliminary desktop assessment only;
- Technical studies (steady state, fault, contingency studies, etc.) are not included at this stage.

2. PROJECT DESCRIPTION

This chapter is largely based on information provided by Mainstream together with site investigations conducted on the 19th, 20th and 21st September 2016 by SMEC. Other relevant literature has also been utilised and referenced where appropriate. The approximate GPS co-ordinates of the centre of the site are 30.172221°S and 19.190297°E.

2.1 Project Description

The proposed LWEF Project comprises four Erf portions as listed below:

- Portion 2, Erf 217 – known as the Georg's Vley Farm;
- Portion 1, Erf 216 – known as the Hartebeest Leegte Farm;
- Remainder of Erf 216 – also part of the Hartebeest Leegte Farm; and
- Portion 2, Erf 176 – known as Graskoppies.

The four projects do not exactly conform to the cadastral boundaries. **Figure 2.1** shows the proposed project boundaries in relation to the farm boundaries.

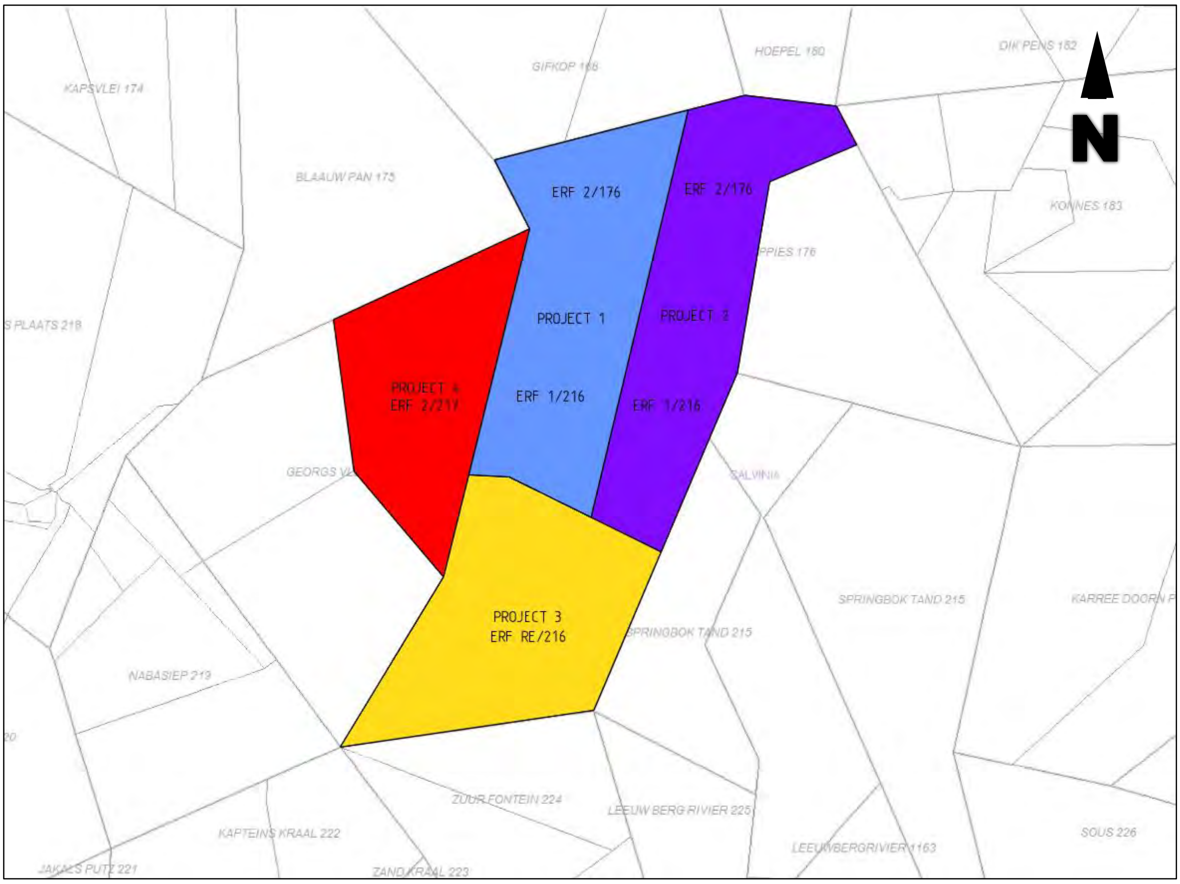


Figure 2.1 – LWEF Project Areas and Affected Erf Portions

Each project comprises of 47 wind turbines, each turbine generating between 5.0 MW to provide a combined generation capacity of 235MW per project (940MW in total). Each project will also have its own sub-station that will connect to an Eskom Transmission Substation known as Helios.

The extent of the farms occupying the development form an area of approximately 30900ha with a perimeter of 136km. However, the actual area of the LWEF is only 19220ha since not all farms will be fully occupied. Each project covers an area of approximately 4800ha.

Table 2.1 below shows the extent of the farms forming the LWEF project together with the development proposals.

Table 2.1 - Leeuwberg Wind Farm Projects

Project	ERF No	Area (m^2)	No of Turbines	No of Substations
Project 1	Half of ERF No 1/216 and 2/176	5 245	47	1
Project 2	Half of ERF No 1/216 and 2/176	5 088	47	1
Project 3	ERF RE/216	5 088	47	1
Project 4	ERF 2/217	3 800	47	1
	TOTAL	**19 221**	**188**	**4**

2.2 Design Components for each Project

It is envisioned that each project will broadly follow the same design philosophy when executing the construction work. These tasks include:

1) Setting out of turbine base locations;
2) Construction of internal access roads
    a. Establish borrow pit;
    b. Import fill material for road sub-base, base and wearing course;
3) Construction of bases
    a. Excavation of foundations;
    b. Installation of shuttering;
    c. Steel fixing;
    d. Establish batching plant; and
    e. Concrete casting and curing;
4) Construction of substations;
    a. Interconnection of the turbine circuits to the substation;
    b. Fencing;
    c. Interconnection to the Eskom Grid; and
    d. Construction of OHL

5) Conveyance and installation of turbine towers, followed by the blades and finally the turbine cell.

A brief description of the main components are provided in the subsequent paragraphs for completeness.

2.2.1 Wind Turbines

Due to this report being a preliminary study, the exact turbine specifications are not known, although it is known that the rotor diameter and the hub height are both 160m. It is also anticipated that 188 turbines will have a combined installed generation capacity of up to 235 MW per project. The operational life span of the wind turbines is based on the turbine model and the turbine life span last longer through regular maintenance. The locations of the proposed wind turbines were determined by wind energy specialists/engineers employed by Mainstream.

2.2.2 Substations

Electricity generated from the individual turbines are to be routed to the substations through underground cables (or overhead lines in sections with difficult terrain). The substations are connected to main LWEF substation with overhead cables. The main substation will be connected through overhead power lines to the main Eskom grid. Mainstream provided alternative locations of the substations for the proposed development.

In additional to the wind turbine substations, a site substation will also be required within the site compound to general use.

2.2.3 Powerlines

Each wind turbine will be interconnected to the Eskom grid by way of an overhead line. In addition to the physical connection, each of the turbine circuits must also be interconnected to the substation.

2.2.4 Roads on Site

An existing road leading to site will need to be upgraded where necessary to serve as the primary access to site. Roads within the site will also provide internal access for main construction activities as well as to allow for the delivery of the wind turbine components. Once complete the roads will also supply on-going access for the operation and maintenance of the LWEF project. **Table 2.2** below illustrates the preferred access road to LWEF site and more details of the upgrades required will be discussed in **Chapter 3**.

Table 2.2 - Road Segment Co-ordinates and Lengths

Road Intersection	Co-ordinates (SE)	Distance (km)
N7/R358	31º00'07" S 18º15'37" E	R358 road segment = 105km
R358/P2948	30º18'38" S 18º51'18" E	
LWEF Boundary	30º17'29" S 19º14'01" E	P2948 road segment = 41km

3. TRANSPORTATION STUDY

This Chapter provides a summary of a separate report entitled "Leeuwberg Farm Preliminary Transportation Study" which attempts to address all transport related issues. Both the abnormal and legal vehicles were reviewed in terms of their type of activity; i.e. construction traffic, traffic associated with the transportation of the wind turbine components, or traffic associated with the transportation of materials, equipment and people. The key issues associated with the construction and operational phases of the project that will be assessed as part of the transport study are:

- Increase in traffic generation throughout the lifetime of the project;
- Increase in road maintenance required; and
- Ability to transport wind turbine components to site safely and efficiently.

3.1 Assumptions

The assessment has been based on the traffic information available at this stage of the project. Information was sourced from the Department of Transport for the Northern Cape. In order to predict the likely staffing requirements the nearby Loeriesfontein 2 and Khobab wind farms were used as a guidance, although it is accepted that these values could vary substantially and are project specific. Caution is therefore advised when quoting the staff numbers.

3.2 Existing Traffic Conditions

Table 3.1 below shows a summary of the roads and road segments affected by the LWEF project. The information has been sourced from the Western Cape and Northern Cape Department of Transport to establish the exact kilometre markers.

Table 3.1 – Road Segments Affected by LWEF

Road Segment	Segment Name	Chainage Start	Chainage End	Distance (km)
Atlantis to R358				
R304	Dr1134	Km1	Km0	1
N7	Segment 1	Km36 (Atlantis)	Km52 (Malmesbury)	16
	Segment 2	Km0 (Malmesbury)	Km34 (Moorreesburg)	34
	Segment 3	Km0 (Moorreesburg)	Km31 (Piketberg)	31
R366	MR023/MR531	Km0 (Piketberg)	Km38	38
R365	MR538	Km86	Km0	86
R364	TR5501	Km61	Km0	61
N7	Segment 5	Km0	Km75 (Vanrhynsdorp)	75
	Segment 6	Km0	Km83 (Bitterfontein)	83
	Segment 7	Km0	Km4 (R358 intersection)	4
			Total	429

SMEC

Road Segment	Segment Name	Chainage Start	Chainage End	Distance (km)
R358 to P2948				
R358	MR736	Km0	Km61 (R355 intersection)	61
	MR736	Km61	Km105 (P2948 intersection)	44
			Total	105
P2948 to LWEF Boundary				
P2948		Km0	Km29	29
Private Access Road		Km0	Km12 (LWEF Boundary)	12
			Total	41
Loerisfontein to R358				
	R355	Km0 (Loerisfontein)	Km84 (R358 intersection)	84

Table 3.2 shows that the Average Daily Traffic (ADT) for the N7 between Vanrhynsdorp and Nuwerus is in the order of 1100 vehicles of which the Average Daily Truck Traffic (ADTT) consist of 300 vehicles. The N7 is only one lane in each direction and is capable of carrying 2000vph. It is furthermore reasonable to assume that this portion of the N7 carries significantly lower volumes of traffic than elsewhere along its length. SMEC are still awaiting additional traffic data from the provincial DoT.

Table 3.2 – Existing Traffic Volumes (2013)

Historic Traffic Trip Generation of N7 (2013)	
Section	Between Vanrhynsdorp and Nuwerus
Average Daily Traffic (ADT)	1038 vehicles
Average Daily Truck Traffic (ADTT)	290 vehicles (27.9% of total)

3.3 Traffic Generation

The traffic generation estimates detailed below have been determined based on a single project.

3.3.1 Construction Phase

These vehicle trips occur during the construction phase and include the transport of materials, equipment and people to site. This phase also includes the civil works required for the construction of the internal roads themselves, the excavations of the footings, and trenching for electrical cables. The delivery of the wind turbine components and lifting cranes would require abnormal vehicles that require access to site via the public road network. The construction traffic typically generates the highest number of vehicular trips.

In order to calculate the amount of traffic generated for this element of works, certain assumptions were made regarding staff and staff travel behaviour. It is estimated that a total of 127 full time employees are required during the construction of the LWEF project. Not all personnel will be required at once since the project will be constructed in phases. It is also assumed that the majority of employees would reside in Loeriesfontein.

Based on this it can be assumed that approximately 40 vehicular trips will be generated during the peak hours of 07:00 – 08:00 and 16:00 – 17:00. The details used to calculate the total labour during the construction of the project is shown in **Table 3.3** below.

Table 3.3 - Assumed Labour Requirements

Construction Phase	Technical Staff	Skilled Labour	Unskilled Labour	TOTAL
Road Construction	3	8	5	16
Foundation Construction	3	15	20	38
Electrical System Construction	2	10	10	22
Substation Construction	2	10	5	17
Wind Turbine Assembly and Installation	4	10	15	34
TOTALS	**14**	**58**	**55**	**127**
Vehicle Trips/Day	**14**	**15**	**14**	**43**

Table 3.4 below shows an assumption made to envisage the number of daily traffic generated by the transportation of materials, equipment and people. It was also assumed that the material required for construction will be obtained from suppliers off-site.

Table 3.4 – Estimated Trip Generation

Activity		Assumptions	Trips/ day
People	Technical and Non-technical Staff	See Table 2.2 above	43
Foundation	Concrete	3675 Bags of 50kg cement required per concrete foundation. One truck capable of carrying 680 bags of cement. Equates to 5 trucks per foundation.	5
	Stone	239m^3 required per foundation. One truck capable of carrying 20tonnes of stone. Equates to 12 trucks per foundation.	12
	Sand	239m^3 required per foundation. One truck capable of carrying 20tonnes of sand. Equates to 12 trucks per foundation.	12
	Steel	306 tonnes of steel required per foundation based on the assumption that 130kg of concrete requires 100kg of steel to support it. Assuming one truck is capable of carrying 20tonnes per trip, this equates to 15 trucks per foundation construction.	15
Road	Internal Roads	It is assumed that 1.2km of natural gravel roads will be constructed every week in 150mm layers at 0.2km/day using tipper trucks at 10m^3/truck to import material.	10
Foundation and Road	Water	Based on preliminary water use calculation discussed further on in this report it is assumed that the following number of 32 000 litre water trucks will be required per day.	8
Electrical	Substations, cables, overhead cables and transmission poles	200 transmission poles (30 poles/week) using an interlink truck	1
		Trucks for carting electrical equipment using an interlink truck.	1

Total Light Motor Vehicles	43
Total Heavy Motor Vehicles	64
TOTAL DAILY TRAFFIC	**107**

Note: Excludes abnormal vehicle trips

From **Table 3.4** it can be seen that the total daily traffic generated by the transport of people, materials and equipment is estimated at approximately 107 vehicles per day (60% being HGV's). It is estimated that the number of heavy vehicles trips, per 235MW Project, during the construction phase would be between 3000 and 4000. These trips would be made over an estimated period of 9 to 12 months.

It has been assumed that the workforce (or a portion thereof) will be based at the construction camp, located some 40km from site. Construction is expected to take place during normal daily working hours (starting 07:00 - 08:00 and ending 17:00 – 18:00) and the workers are expected to arrive from the construction camp over a one hour period in the morning and depart over a one hour period in the afternoon. Assuming a traffic management plan is in place the HGV vehicles are likely to be distributed throughout the day. The HGV vehicle trips have also been excluded from the peak hours as these vehicles would not be allowed on-site prior to the workforce arriving.

Should a dedicated bus system be implemented, the 127 peak hour person trips can be converted to vehicle trips using the bus occupancy rate of 40, which equates to 3 bus round trips per hour. More specific requirements will be determined at the feasibility stage. From a land-use/transportation planning point of view, a bus system would be the preferred method.

The windfarm construction will also require the transportation of large volumes of construction material to site on an ongoing basis throughout the construction period as shown in **Table 3.4**. The approximate daily mass of the material to be transported onto site, as well as the type(s) of vehicle to be used for this purpose, will inform the type of road required to withstand the wear.

In addition to the normal daily demand for construction materials that can be transported using normal heavy construction vehicles, there will also be several abnormally large consignments to be transported by road to the LWEF site. In order to safely accommodate abnormally large vehicles and their loads, the future road intersections between the harbour and site should be designed accordingly.

If there are existing intersections that limit the size of construction vehicles, new routes should be planned or the consignments could be transported in smaller portions and assembled on-site.

As detailed information regarding the construction material and labour requirement becomes available, this transportation component will be analysed in sufficient detail at feasibility level to inform the infrastructure requirements.

In summary, the additional traffic generated during the construction phase will have a low negative impact.

Traffic Generation for the Delivery of the Wind Turbine Components

Table 3.2 below shows the estimated daily traffic that can occur during the delivery of the wind turbine components to site. The calculations are based on the delivery of six complete turbines per week.

Table 3.2- Traffic Generation Rates for the Delivery of Wind Turbine Components

GENERATED TRAFFIC FOR THE DELIVERING OF THE WIND TURBINE COMPONENTS				
Activity	**Assumptions**	**Trips/ Week***	**No. Used**	**Trips /Day**
Turbine Components	3xTower sections per turbine =1 Tower/truck (AV)	18	3	3
	1xNacelle (hub) per turbine = 1 Nacelle/truck (AV)	6	1	1
	3xBlades per turbine= 1 Blade per truck (AV)	18	3	3
Estimated Abnormal Truck per day				**7**

From *Table 3.2* it can be seen that 7 Abnormal Vehicles (AV) will be required for the delivery of one complete wind turbine.

In addition to the construction vehicles, each wind turbine will require at least 9 abnormal loads to transport the individual components. These components consist of 3 Blades, 5 Towers and 1 Nacelle. Since each Project proposes 47 turbines the total number abnormal loads anticipated for LWEF project is estimated to be 423 abnormal vehicles per Project (1692 trips for all four projects). In addition to the wind turbines, some electrical equipment such as the Padmount transformers, Main Transformer and OHL pole segments will also generate abnormal loads**.** This equipment is estimated to generate approximately 50 additional abnormal loads.

3.3.2 Operational and Maintenance Phase:

This phase involves the operation and maintenance of the LWEF estimated over a 20 year period. Typically the replacement of one of the wind turbine components would require access for cranes and replacement parts delivered using abnormal vehicles, both of whom would arrive to site via the public road network. In terms of vehicle generation this phase generates the least traffic.

It is assumed that a maximum of 10 permanent employees' will be employed per phase to oversee the operation and maintenance of the wind farm. It is therefore assumed that a total of 40 persons will be employed once all the phases are operational.

Assuming the worst case where each worker drives to site, the increase in traffic is estimated at 10 vehicles per day which is negligible.

In addition to private vehicle trips, some additional trips can be expected in the form of water supply, refuse and sanitation collection vehicles. These services are anticipated to collectively generate an additional 3 HGV trips per week.

Some abnormal loads will be generated during this phase, when faulty components need replacing, although this will conducted on an ad-hoc basis and unlikely to have any impact on the overall traffic conditions on the surrounding public roads.

3.3.3 Decommissioning Phase:

It is estimated that the number of heavy vehicles trips, per 235MW Project, during the decommissioning phase would be between 2000 and 3000. The decommissioning phase is assumed to take 12 months.

The significance of the additional traffic generated during this phase would be low negative.

3.3.4 Proposed Mitigation

Even though the traffic generated would not be significant, the following requirements should still be met by the developer during the construction phase:

1. All abnormal loads must be transport under a permit;
2. A route study be undertaken to confirm the most appropriate route to site;
3. Dust suppression techniques should be utilised to reduce the impact on air quality for the surrounding area;
4. A Traffic Management Plan must be prepared once the Project advances to the preliminary phase. This plan should ensure that vehicles arrive in a dispersed manner throughout the day to reduce the impact to other road users. The plan should also promote the use of car sharing, especially from Loeriesfontein and the construction camp. Methods to improve driver safety should also be outlined, e.g. the use of speed cameras or Average Speed Over Distance (ASOD) cameras along particular sections such as the R358 to Loeriesfontein.

A Risk Assessment has been undertaken and included as **Appendix B.**

3.4 Recommended Routes to Site

This section provides a summary of the preferred routes. A more detailed description is provided in the Transportation Study report, also undertaken by SMEC.

3.4.1 Preferred Port

At this stage it is unsure whether the wind turbines will be manufactured locally or imported. It is possible that the wind turbine tower sections will be manufactured locally, ideally in Atlantis in the Western Cape were a dedicated manufacturing facility has been set up to service the wind farm industry and to stimulate economic growth. Items not manufactured locally will be imported from international suppliers. It has been assumed that the wind turbine components are of such size that they would arrive by ship at one of South Africa's ports. Two ports were considered, namely Coega and Saldhana Bay Harbour. Saldhana Bay Harbour is the preferred port due it being 410km closer to the LWEF site than Coega, and has previously accommodated wind turbine components for other wind farm projects.

3.4.2 Preferred Abnormal Vehicle Route

Having established that the wind turbines would enter the country via either the Saldanha Bay Harbour or be generated in Atlantis, a routing exercise was undertaken to determine the most appropriate route to site. The alternatives were either

- Alternative A - via the N1 to Loeriesfontein (1476km); or
- Alternative B - via the N7 towards Kliprand via R358 (630km).

Both alternatives are shown in **Figure 3.1**. Alternative A is required to travel via the N1 through Beauford West because abnormal loads cannot negotiate Vanrhynsdorp Pass due to vehicle traction problems on account of tight geometry and steep gradients.

Figure 3.1 - Abnormal Loads Main Alternatives

The recommended route for abnormal vehicles is via the N7 due to it being significantly shorter as well as carrying significantly less traffic which assists in reducing any safety concerns to other road users. The N7 route has also been discussed with the Western Cape Government Permitting office that supports the N7 route as the preferred option. One key concern was the ability for abnormal loads to pass under an existing railway bridge across the Sout River. SMEC's structural engineers have recently completed a bridge inspection of this structure and conform that the clearance is 5.94m. **Appendix C** provides an extract of the bridge inspection.

Other transport concerns associated with this route were:

1) Piekenierskloof Pass towards Citrusdal; and
2) N7 turn-off onto the R358 towards Kliprand

The Piekernierskloof Pass is an acceptable abnormal route for most loads. However, given that blade lengths could be in the order of up to 80m in length, a detailed route study will need to be conducted to accurately determine whether blades of this length can safely navigate the pass. It is imperative that this limit be established prior to exploring alternative routes as this will negate almost all the benefits of using the N7 corridor all together.

Figure 3.2 shows the existing N7/R358 intersection while **Figure 3.3** shows the swept path of a typical extendable trailer used for transporting blades. It clearly shows that despite rear steerable axles, some local widening at the intersection is required. The following upgrades are therefore proposed:

1) Extend N7 road shoulder of the northbound carriageway by approximately 5m or preferably up to the road reserve fenceline. This local widening should be from the intersection extending 100m south to provide hardstanding for the rear axle group when performing the turn;
2) Widen the southern splay at the N7/R358 intersection to provide additional space for turning;
3) Relocate existing road signs to be outside the turning envelope of the abnormal vehicle swept path;
4) Relocate the existing telephone poles to be outside the operational area of the intersection (see **Figure 3.2**). It is also proposed that the telephone line be buried under the N7 to avoid telkom height clearances being required for every load being transported.in the future.

Figure 3.2 - N7 / R358 Intersection

Figure 3.3 - Swept Path Analysis N7/R358

The transportation of materials, plant and people are envisaged to be transported from the nearest town, Loeriesfontein. Materials sourced from elsewhere will generally arrive via the N7 which further supports this route as the preferred route. Ultimately, the transportation of materials, plant and people will be user dependant.

3.4.3 Preferred Access to Site

Four alternative site accesses were reviewed and are evaluated below. These include

1) Access Option 1 – Northern access via DR2972;
2) Access Option 2 – Eastern access via DR2972;
3) Access Option 3 – Southern access via P2948;
4) Access Option 4 – Western access via P2948

The various access routes are shown in **Figure 3.2** below.

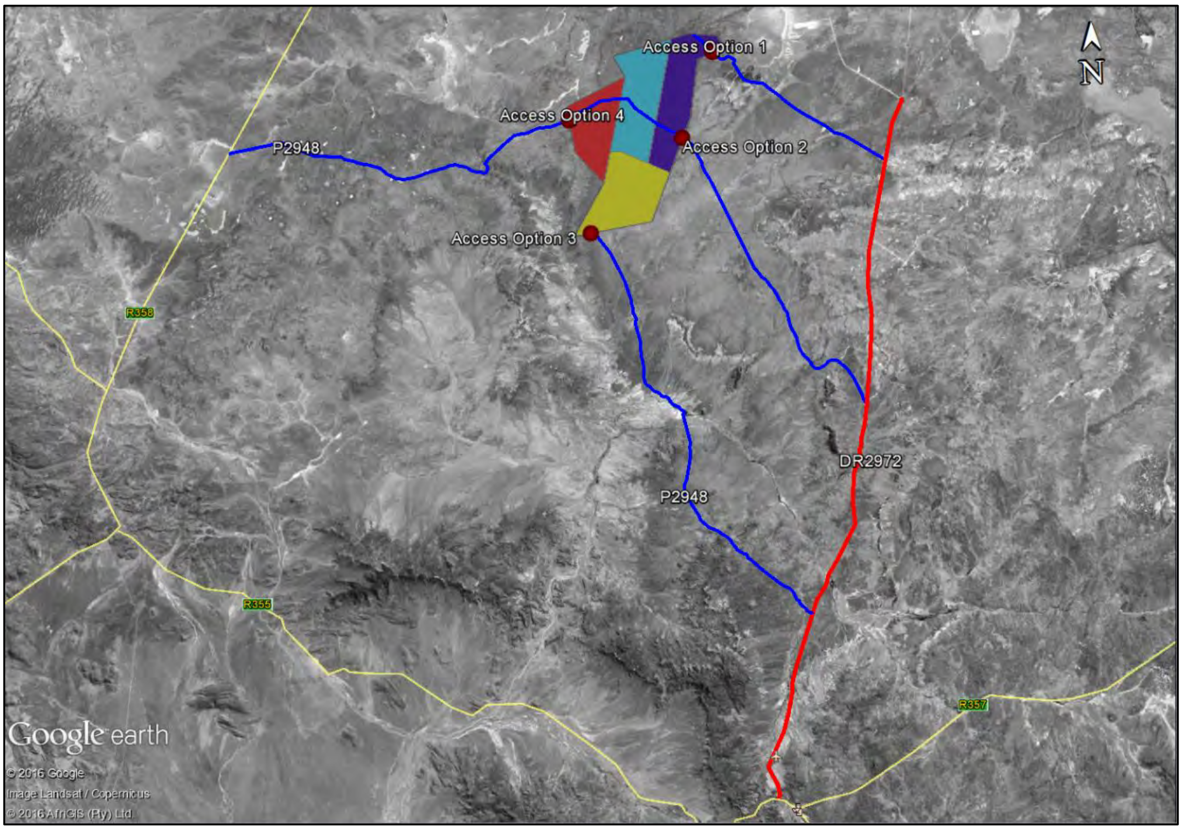


Figure 3.4 – Site Access Route Alternatives

The site observations assisted in evaluating the advantages and disadvantages of each access option and these are summarised in **Table 3.5** below.

Table 3.5 – Evaluation of Accesses

Route Criteria	Access Option 1	Access Option 2	Access Option 3	Access Option 4
Road Gradient	Flat	Steep	Steep	Flat
No of Farms Gates	Few	Numerous	Numerous	Few
No of Structures (bridges)	None	1 major bridge, 1 culvert	1 major bridge, 1 river crossing	None
No Farm Buildings Located Close to Road	Few	Numerous	Some	Few
Existing Traffic	High	Medium	Low	Low
Road Conditions	Fair	Fair	Bad	Fair
Likely Road Upgrade Cost	Medium	High	High	Medium
Drivability	Medium	Low	Low	Medium
Distance to Site from N7	Longest	Long	Short	Shortest
Preference Ranking	Unfeasible	Feasible	Least Feasible	Most Feasible
Preferred Access	**Option 4**			

Based on the above Access options 1 and 3 were deemed least unfavourable. The two feasible options were compared against one another and Access option 4 is our preferred option for the following reasons:

1) Access options 2 and 4 are almost equidistance if measured from Vanrhynsdorp, although option 4 route avoids Vanrhynsdorp Pass which is unsuitable for HGV's;
2) Access option 4 provides a single route from the N7 to the site, thereby reducing signage requirements and any confusion to drivers travelling to the site;
3) Having a single access route for all vehicle types reduces costs as only one route needs to be maintained during construction;
4) Access option 4 negates the need to travel through Loeriesfontein; and
5) Utilises the N7 corridor as far as possible, which has the most robust and resilient pavement layers capable of accommodating high HGV volumes.

In summary, the access route (option 4) via the R358 in combination with the N7 is the preferred route both for abnormal vehicles as well as other legal vehicles. Legal vehicle have the added option to utilise the DR2972 (option 2) as an alternative, although allowing multiple site entrances adds additional security/operational complications which might not be desirable.

3.5 Internal Roads

Mainstream engineers provided SMEC with locations of the wind turbines as shown in **Figure 3.5**. Given the extent of land incorporated under the LWEF project several alternative layouts were possible for the internal road arrangements.

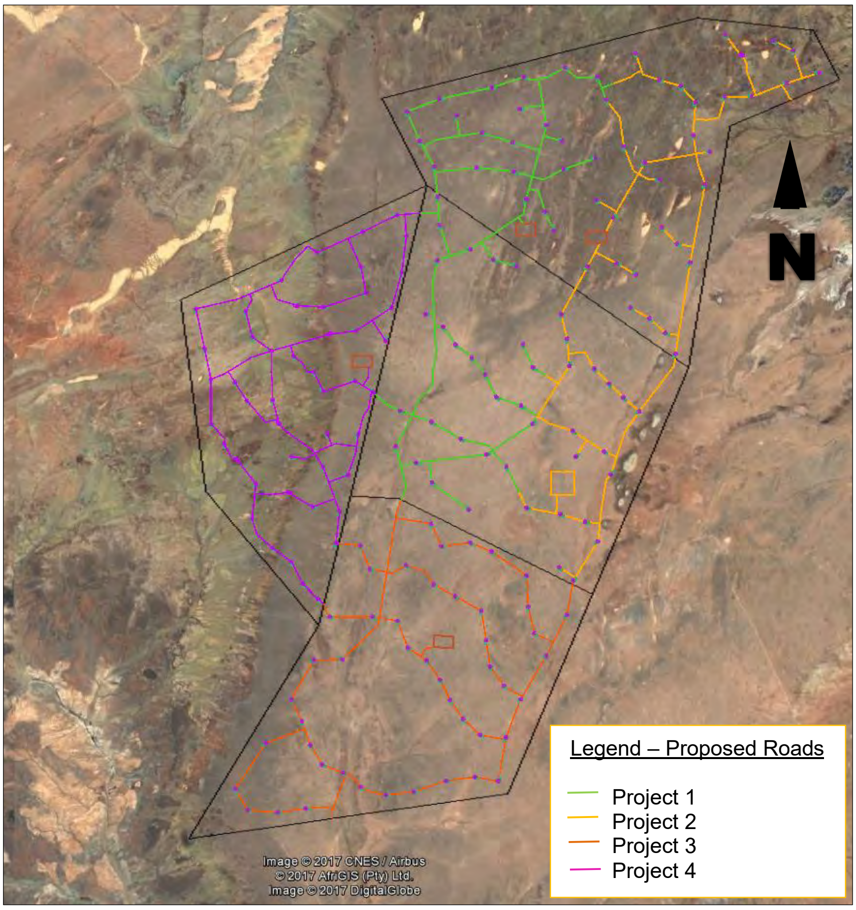


Figure 3.5 – Internal Roads

The following criteria were deemed appropriate for the internal roads.

- Roads to be widened to at least 8m wide together with 2m verges either side to accommodate battered slopes in areas where the road rises or falls below the natural ground level;
- Road surface to be gravel; and
- Local material to be used.

The LWEF project will require a total of 167.9km of road to be constructed of which 32.51km are existing track roads that need to be upgraded. The Internal roads must be constructed with material excavated from turbine foundations to minimise costs. Further details relating to the internal roads are discussed in **Section 8.1.1**.

4. CONSTRUCTION CAMP AND SUBSTATION LOCATION

This chapter describes the proposed locations of both the construction camp and substations.

4.1 Construction Camp

The construction camp will comprise of a site compound together with several laydown areas.

4.1.1 Site Compound

A site compound will be required during construction and it is proposed that it should be located close to the access point. The site compound consists of temporary buildings to provide secure storage, ablution facilities, site offices, welfare and first aid facilities, parking area, concrete batching plant and a generator with fuel storage. A site compound area of up 32 000 m^2 (400m x 80m) is considered appropriate for the scale and size of the project. **Figure 4.1** below shows a typical layout of a construction camp. In addition, a batching plant of approximately 10 000m^2 in area is deemed necessary and would need to be accommodated on site.

Figure 4.1 - Typical Site Compound Layout

4.1.2 Laydown Area

The laydown area is the reserved space where the turbine components, tools and material will be stored during the construction process.

The laydown area would need to be constructed alongside turbine points for easy access of the components. A large laydown area will be required to accommodate the turbine assembling crane as well as the assisting crawler crane, which will need to stand on a compacted hard standing. This area would be required to be compacted as shown in **Figure 13** below. An area of up to 4900m^2 (70m x 70m) would be ideal.

A laydowns area of up to 1600m^2 would be required alongside the site compound for tools and material. Partially

The laydown areas are to be rehabilitated and made good once construction is completed.

Figure 4.2 - Typical Laydown area for Turbine Components

4.1.3 Proposed Location of Construction Camp

The site compound should generally be located next to an access road to ensure accessibility and for health and safety reasons. **Appendix D** shows the location of the proposed site compound area in relation to the R358 and surrounding areas. The proposed location is some 40km from the LWEF site which is consistent with the setup at the Loeriesfontein 2 project. The route from the camp to the site is also along the preferred access route and would therefore benefit from the increased activity along this corridor.

No drainage problems are anticipated on account that the area is relatively dry throughout the year and that the local soil conditions indicate that the area is high permeable (refer to **Chapter 8** for more details).

4.2 Substations

Mainstream provided SMEC with the proposed substation locations and these are illustrated in **Figure 4.3** below.

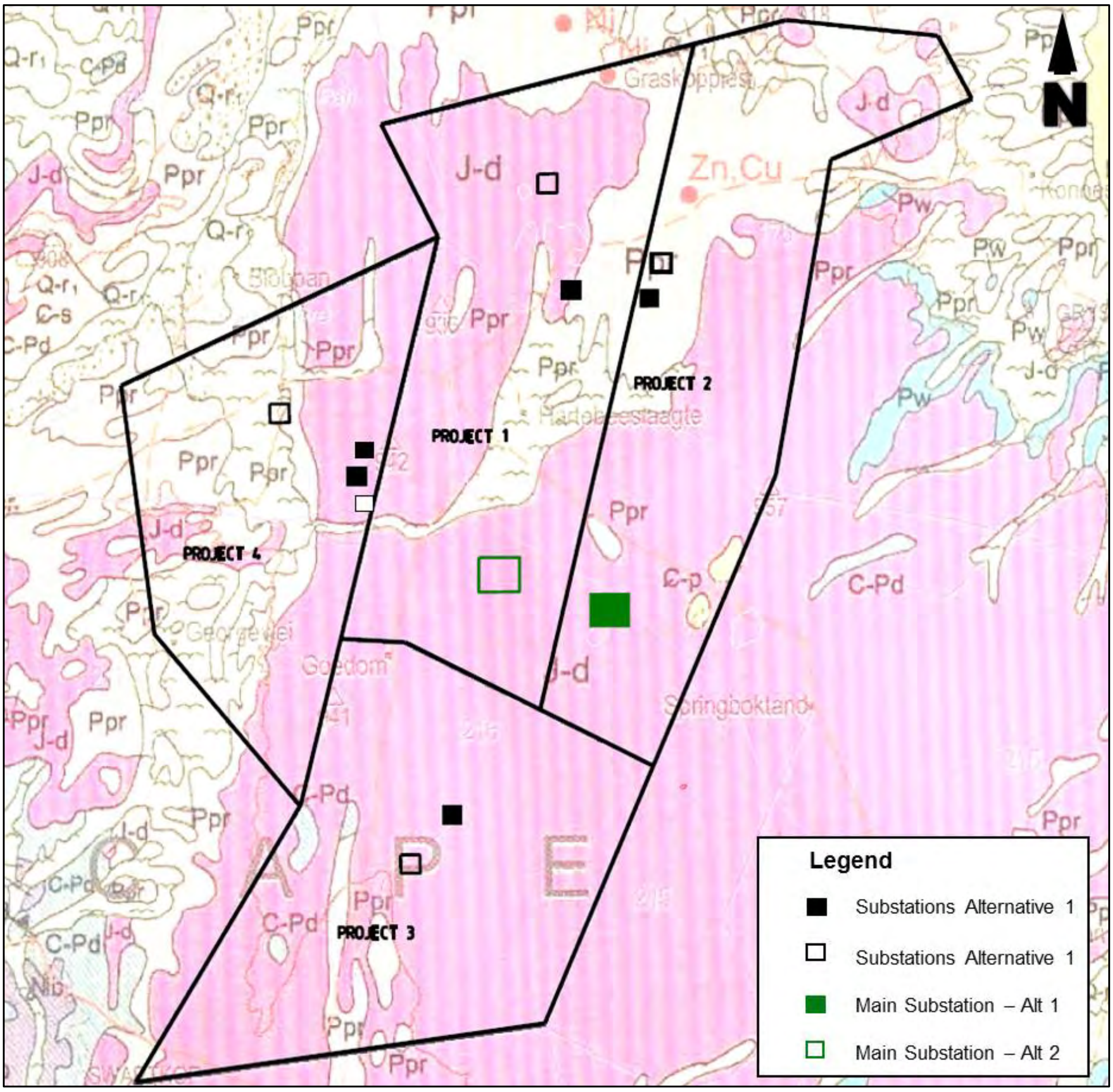


Figure 4.3 - Substation Alternatives

The figure includes the anticipated geological conditions which have been used to inform the constructability of each substation alternative. Table 4.1 below shows a summary of the suitability of the ground conditions for each of the substation alternatives presented.

Table 4.1 – Substation Location Evaluation

Substation Name	Alternative 1	Alternative 2	Preferred Alternative	Reason
Main Substation	Ok	Ok	Alternative 1	Closest to Eskom substation
Project 1 Substation	Problematic – Possible Dolerite shale area - highly fractured bedrock may be encountered	Ok	Alternative 2	Better ground conditions
Project 2 Substation	Ok	Ok	Alternative 1	Closest to main substation
Project 3 Substation	Ok	Ok	Alternative 1	Closest to main substation
Project 4 Substation	Ok	Problematic - alluvial deposits present	Alternative 1	Better ground conditions

It is recommended that environmental studies verify the above recommendations as it there is a possibility that the preferred substation location for Project 4 is within an environmentally sensitive area due to the presence of alluvial deposits. The preferred alternatives substation locations are presented in **Figure 4.4** below.

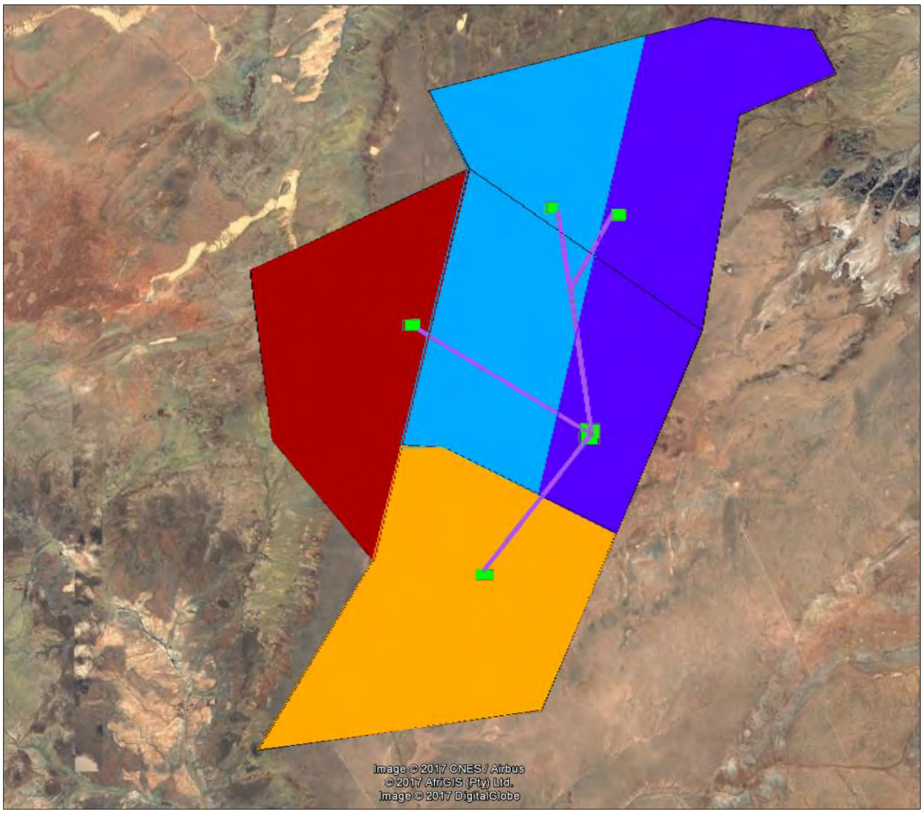


Figure 4.4 - Preferred Substation Network

Electricity generated by the individual turbines within LWEF would be routed to one of the project substations through 33kV underground electric cables. The substations will then be connected to the Eskom Helios Substation with overhead cables.

It was also proposed that each substation have the following:

1) An approximate area of 1600m^2;
2) An O&M building close to ensure ease of access and control;
3) Fencing around the substation compound together with access control to the HV Yard.

5. WATER USAGE AND WATER SOURCES

The purpose of this chapter is to identify potential water sources and to estimate the amount of water required during construction as well as during Operation & Maintenance (O&M). This chapter investigates available water requirements, water source, water transportation, and onsite storage including storage costs, piping, storage volumes and location.

5.1 Water Requirements

It has been estimated that the entire project would be completed over a period of 48 months. The following construction activities were identified for consideration when calculating water use requirements:

- Dust Suppressions;
- Earth works;
- Turbine foundation construction (Concrete);and
- Ablution facilities and Employees.

For dust suppression it is recommended to use a chemical / polymer mix as a suppressant to reduce the amount of water required.

5.1.1 Construction Phase

The assumptions made for the detailed calculations of water quantities required during the constructing phase of LWEF Project are illustrated in **Appendix E** of this report. The total estimated water requirements anticipated during the construction of LWEF Project will be approximately 252m^3/day (all 4 projects running concurrently). It should however be noted that the above estimations assumes that all the project construction activities occurs uniformly throughout the 48 month construction period, which is not realistic. Daily water usage can vary significantly depending on the type of construction activity being undertaken. To demonstrate this, the water usage for the Loeriesfontein 2 and Khobab wind farms was obtained from the contractor and is presented in Table 5.1 below.

Table 5.1 – Loeriesfontein 2 and Khobab Water Usage

Date	Total Monthly Use (m^3)	Water used for Wind Farm Construction (m^3)		Water used for Road Construction (m^3)	Average Daily Use (m^3)
Jan-16	3389	2843	84%	546	261
Feb-16	10763	9953	92%	810	473
Mar-16	6301	6085	97%	216	350
Apr-16	3285	3051	93%	234	164
May-16	1603	1311	82%	292	89
Jun-16	1776	1434	81%	342	134
Jul-16	2215	2071	93%	144	158
Aug-16	2215	2035	92%	180	180
Sep-16	7823	6761	86%	1062	376
Oct-16	5460	3426	63%	2034	248
Nov-16	8517	5655	66%	2862	405
Dec-16	3604	2866	80%	738	600
Yearly Total	**56.9 Ml (ave 182m³/day)**	**47.49 ML**		**9.46 Ml**	

Source: Murray and Roberts 2017

The table confirms that during 2016 the majority of water was utilised for wind farm construction purposes. This is most likely because the internal roads were constructed in 2015. Of key importance is the average daily usage which fluctuated between 89 and 600 m^3 per day for both wind farm projects, which collectively is 122 turbines (61 turbines each). Furthermore, the daily average for the year is only 182m^3/day (assuming a 6 day work week) which varies vastly from the monthly averages.

This table therefore highlights the inaccuracy of calculating water usage over the project period. Instead, it is recommended that a peak factor or 3 is recommended to compensate for periods when water intense activities are programmed (i.e. average daily usage would increase from 252m^3/day to 756m^3/day). This peak value provides some confidence sufficient water will be available at all times.

5.1.2 O&M Phase

The average water requirement during the O&M phase is estimated to be approximately 4.0 m^3 per day assuming 10 employees per project.

5.1.3 Water Usage Summary

It is concluded that the total water requirement for the construction of the proposed development is approximately 259Ml over an estimated period of 48 months (assuming 252m^3/day, 6 days a week, 12 months a year). It is also estimated that a further 5Ml of water will be required for O&M purposes.

It is however recommended that a conservative value of 756m^3/day be used when applying for the water license to compensate for peak periods.

5.2 Water Sources

According to the Olifants-Doorn Water Management report completed in October 2016[2], the entire Hantam Municipal area relies almost entirely on groundwater for its water supply. The water quality is generally poor, and the groundwater table is subject to large variations, especially during periods of drought, refer to **APPENDIX F** for the status of groundwater borehole levels in this area. SMEC is still waiting for borehole historical depth from Hantam Municipality water department. The Hantam area lies within the E31 and E32 catchment areas as defined by the Department of Water Affairs (DWA). The LWEF site lies predominately within the catchment area E31C (a subset of the larger E31 zone) together with a small portion within the D53F catchment area. According to new regulations from DWA, no general authorisation for taking water from a ground water resource is allowed within E31C and D53F.

5.2.1 Water from the Site

According to the DWA, water users may take up to 45m^3 per ha per annum. Given that the LWEF site covers approximately 30 900ha, it has been assumed that up to 1391Ml of water per annum can be abstracted from local groundwater sources.

The water requirement during the construction phase is equivalent to 72Ml per annum which is well below the maximum amount that may be obtained from a groundwater source. Boreholes have been identified on the proposed site and it was revealed that groundwater static levels within the LWEF boundaries are generally deeper than 20m, with occasional occurrences of a shallower water table within the fractured aquifer (generally 9.5m below surface) in the vicinity of preferred drainage paths.

Available records on the groundwater chemistry within the site showed that the water is generally unsuitable for human consumption, being slightly - mildly aggressive to concrete and highly aggressive towards steel. This water can still be used for civil work, however it does require changes to the concrete mix. The results are summarised in **Table 5.2** below.

Table 5.2 - General Groundwater Quality

Water Characteristics	Max	Min	Average
pH	8.1	6.8	7.5
Conductivity (mS/m)	1313	132	496.9
Alkalinity (mg/L as CaCO3)	245	143	192.1
Total disolved solids (mg/L)	8799	626	2504.1
Cl (mg/L)	3586	173	1259.7
SO4 (mg/L)	1897	337	933.3
F (mg/L)	2.01	0.784	1.4
Ca (mg/L)	777	100	356.6
Mg (mg/L)	420	56.1	187.1
Na (mg/L)	1805	164	1076.4

[2] https://www.dwa.gov.za/io/Catchment%20Management/ODCMA/OD_CMA_Last_Proof.doc

K (mg/L)	38.1	13	23.8

It is therefore recommended that a water purification plant be constructed on site in order to treat the water before use. It can also be noted that with thorough treatment this water can be used for human consumption and concrete works.

5.2.2 Water from Commercial Source

The commercial water supply source used by the neighbouring town of Loeriesfontein or Bitterfontein was identified as a possible water source, due to its relatively close proximity to the LWEF site. The water from this source can be used for human consumption purposes as well as concrete production. Water can be transported by water truck to onsite reservoirs as a temporary option when on-site water treatment purification is not working. This will need to be discussed in more details with water authorities.

5.3 Water Storage

It is recommended that water should be stored on site so that it can be readily available for use. The water required for earthworks will be stored in a temporary reservoir capable of storing 400m^3 of water. It should be noted that a safety factor has been included to determine the capacity of the temporary storage tank. At this stage, two circular temporary steel storage tanks with a diameter of 12.28m and a height of 3.45m and one circular steel tank (14.58D X 1.20H)[3] is envisaged for the project. Due to the size of the storage tank it may be located adjacent to the construction camp on R358 Road. Mitigation measures should be in place to protect the water from contamination and wastage.

Figure 5.1 - Typical Steel Reservoir

The water during the operation and maintenance phase will be stored in a permanent reservoir on site. Experience from other wind farm projects indicates that a minimum of at

[3] http://www.rainbowtanks.co.za

least one week water requirement should be available at any time. It is been calculated that a 40m^3 reservoir would be sufficient. At this stage, one vertical, circular temporary plastic storage tank with a diameter of 6.95m and a height of 1.2m is envisaged for the project. Due to the small size of the storage tank compared to the wind farm facilities the storage tank may be placed adjacent to the operation and maintenance building. Mitigation measures should be in place to protect the storage water.

6. PRELIMINARY GEOTECHNICAL STUDY

6.1 Introduction

This chapter discusses the geotechnical conditions present over the area in which the site is situated. An evaluation of the impact of the expected geotechnical characteristics on the development are discussed below.

The objectives of the geotechnical investigation are:

- Identification of relevant ground-related features and their influence on the proposed development;
- To analyse common geotechnical conditions present, assess the general suitability of the site and to make recommendations for site works for the proposed development;
- To provide generalised foundation recommendations for the proposed development and to comment on possible geotechnical factors that would have an impact on the development of the site to enable the creation of an economic design and the construction of the proposed development;
- To identify possible locations of stone/gravel quarries onsite.

The following geological sources have been consulted and/or made available:

- Previous reports in the vicinity of the site.
- Geological Map Sheet 3018 Loeriesfontein at a scale of 1:250 000
- Topographical Map Sheet 3019AB Uitspankolk at a scale of 1:50 000
- Topographical Map Sheet 3019AC Lospersplaas at a scale of 1:50 000
- Topographical Map Sheet 3019AD Springboktand at a scale of 1:50 000
- Topographical Map Sheet 3019CB Brakfontein at a scale of 1:50 000
- Google Earth kmz file showing proposed farm boundaries
- Published technical references (see **Chapter 13**)

6.2 Existing Conditions

Topographical maps show the site to be relatively flat with local ridges associated with dolerite intrusions. The only prominent hill is Groot Rooiberg, on the southern site boundary.

Farms within the region are generally undeveloped and used for grazing. The surface of the region is generally characterised by a gravelly crust that becomes sandier in the vicinity of the stream floodplains and pans. The southern part of the site is drained by generally south west flowing, non-perennial Klein Sandkraal River tributaries. Within the northern part of the site, water typically flows in the form of sheet wash, with some small stream tributaries draining towards Konnes se Pan in the far north.

According to Acock's field types of South Africa, the area is located within the western Mountain Karoo that has a desert appearance with its sparsely populated succulent dwarf shrub species, particularly of the Vygie Family, with Bushmanland grass.

The general appearance of the area, in which the site is situated, is shown on the photographs below.

	
General aerial view (During dry season)	*General surface cover (During rainy season)*

Figure 6.1 - Existing Ground Conditions

6.3 Seismicity

The Northern Cape can generally be considered a region with a low hazard (peak ground acceleration of 0 – 0.2m/s^2). According to the Seismic Hazard Map of South Africa contained in the new South African Loading Code - SANS 10160 the peak ground acceleration (g) with a 10% probability of being exceeded in a 50 year period for the site is in the order of 0.08 – 0.12g. An extract of this map indicating the position of the site is as **Figure 6.2** below.

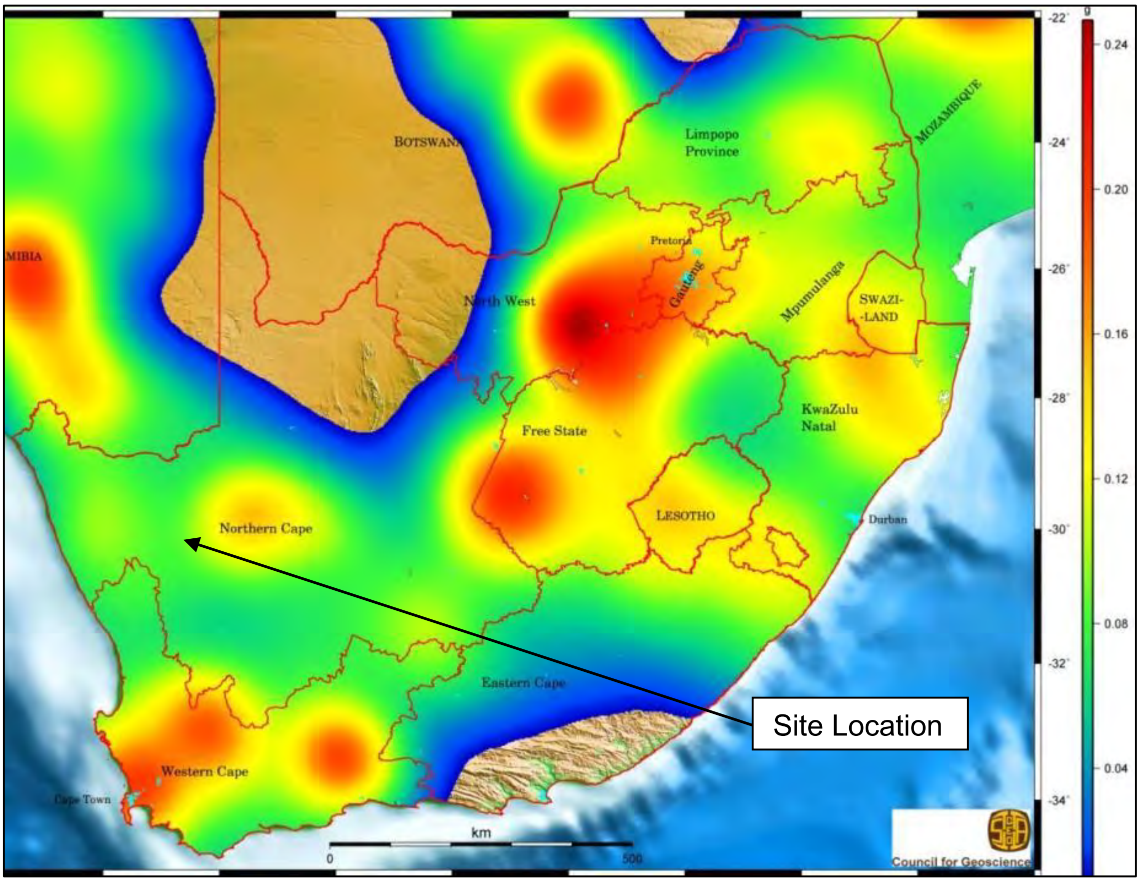


Figure 6.2 - Seismic Hazard Map of South Africa

6.4 Geology

According to the Geological Map of Loeriesfontein 3018 (scale 1:250 000, 2011) the site is mainly underlain by dolerite, which intruded into and crystallised as a sill within the brown and grey shale of the Prince Albert and Whitehill Formation. Significant alluvial sand deposits, associated with the local streams, partly cover the southern part of the site as shown on **Figure 6.3** below:

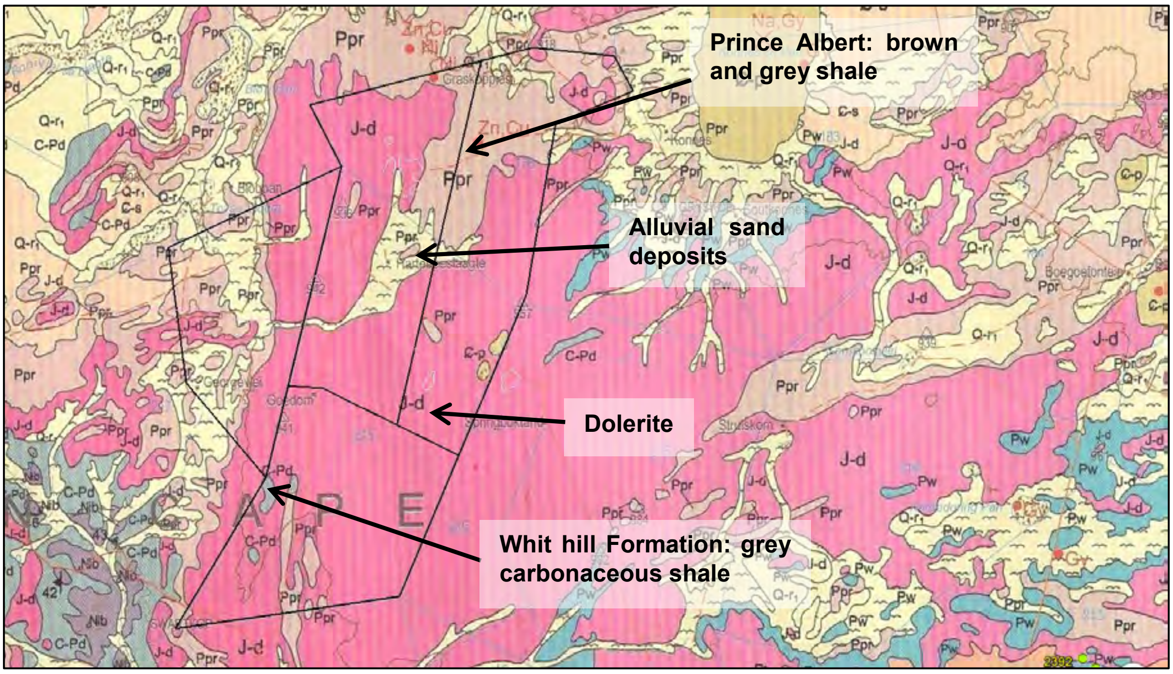


Figure 6.3 - Extract from Loerisfontein 3018 Geological Map

Breccia Pipes, associated with hydrothermal activity, caused by the dolerite intrusions, are found within the area, especially within the southern portion of the site. These pipes comprise baked and dislocated shale and mudstone, locally with breccia (shattered re-cemented blocks). Gas vugs and fractures are often filled with minerals like calcite, chlorite, fluorite, apophyllite, barite and quartz.

Economical zink and copper deposits are found on Erf 176 (Graskoppies) in the north, but with the exception of a couple of borrow pits within the dolerite sill, no mining has occurred on site.

6.5 General Ground Conditions

Previous investigations on neighbouring farms show the area is generally underlain by shallow bedrock found between 0 – 1.9m below surface. General profiles for the geological units mapped in **Figure 6.3** above, are summarised in **Table 6.1** below:

Table 6.1 - General Subsurface Profiles

UNIT	GEOLOGY	APPROXIMATE PROPORTION OF SITE (%)	GENERAL PROFILE DESCRIPTION
	Alluvial Sand	8	The surface is generally covered by silty sand with gravel & calcrete nodules. The soil cover is generally thin (0.2-2m thick) and underlain by shale or dolerite described below. Note: Excavations within existing floodplains tend to be deeper, with refusal of an excavator between 2-5m.
	Whitehill Formation Shale	2	The area is underlain by shale, covered by silty sand with gravel and calcrete nodules (generally between 0.1-2.0m thick), occasionally with weakly cemented to cemented calcrete towards the base. The shale tends to be fractured within the upper 2m below surface and within the vicinity of dolerite sills.

			Weathered dolerite sills (up to 1.5m thick), may be occasionally encountered within the upper 5m below surface, with thick hard to very hard rock dolerite sills at depth. Refusal of the excavator is generally expected between 0.3-1.5m below surface.
J-d	Dolerite	75	This area comprises a dolerite sill covered by silty sand with gravel and calcrete nodules (generally between 0.1-1.2m thick), occasionally with cemented calcrete towards the base. Sill thickness varies, generally between 5 - >10m, but may be locally absent. Here the subsurface is characterised by fractured shale. Weathering of the sill is also variable, with completely weathered dolerite grading into hard rock from 1.5- >10m below surface, with hard rock generally within 6m. Refusal of the excavator is generally expected between 0.3-3.5m below surface.
Pt	Prince Albert Shale	15	The area is underlain by shale, locally with surface outcrops and covered by silty sand with gravel and calcrete nodules (generally between 0.1-2m thick), occasionally with weakly cemented to cemented calcrete towards the base. The shale tends to be fractured within the upper 2m below surface and within the vicinity of dolerite sills. Weathered dolerite sills (up to 1.5m thick), may be occasionally encountered within the upper 5m below surface, with thick hard to very hard rock dolerite sills at depth. Refusal of the excavator is generally expected between 0.3-1.5m below surface.

6.6 Geotechnical Evaluation

From the available site information, conditions on the site are generally seen as favourable for the proposed development. An evaluation of the impact of the expected geotechnical characteristics on the development are discussed below.

6.6.1 Geotechnical Constraints to Development

Unfavourable geotechnical conditions on the site include:

1) Medium hard excavatability of hardpan (cemented) calcrete and soft rock shale. Hard excavatability through soft rock dolerite and hard rock shale.
2) Instability of excavation side walls within fractured bedrock.
3) Rocky risk for both turbines and roads.

Precautionary measures for foundations as detailed below will have to be incorporated in the design and construction of the proposed development.

6.6.2 Construction Material

Generally the natural gravel, calcrete, fractured shale, weathered dolerite and sand are expected to be suitable for road building material. All of the material in LWEF is expected to be suitable for general fill, but the weathered dolerite may also be suitable for a wearing course, however this material should first be tested to verify its quality before use.

Possible quarry sources for concrete aggregate include the hard rock dolerite sill which covers most of the site. Loeriesfontein 2 and Khobab both utilise the existing quarry located on the Loeriesfontein site. The quarry was reopened for these projects and as such the mining licence was easier to obtain. There is therefore an opportunity to utilise this quarry for the LWEF project. However, given that the quarry is some 80km away, the tipper trucks required to transport the material makes this option unfavourable. Instead, it is recommended that a new mining licence be applied for the LWEF project, utilising in-situ material as far as possible. The location of the mine site can only be determined once material suitability has been confirmed through further testing (see **Section 6.7**)

The dolerite within the northern portion of the site seems most promising, as this area is characterised with less preferential drainage channels and associated deeper weathered conditions. Generally significant overburden (up to 5m below surface) is expected. Overburden at the base of existing borrow pits may be thinner and the vegetation over these areas is already disturbed. The source should however be drilled to assess quantities, with additional laboratory testing to confirm the durability of the material. A map, indicating existing borrow pots recorded on the 1:50 000 map and the most promising area for a potential quarry is provided in **Appendix G**.

6.6.3 Foundations

Founding conditions are seen as relatively favourable on the site, with excavatability seen as the main concern.

It is likely that all the foundations would be placed on spread footings at shallow depth.

Estimated safe bearing capacities for these foundations include:

- Hardpan calcrete 200 - 500kPa.
- Fractured shale 500 -1,000kPa
- Soft to medium hard rock dolerite and hard rock shale >1,000kPa.

6.6.4 Geotechnical Evaluation

1) *Mining activity and undermining*. No mining has occurred on site, thus no undermined areas occur on site. There is, however occurrences of economic mineral deposits on the northern portion of the site.
2) *Dolomite*. The site is not situated on dolomitic land.
3) *Contaminated soils (including tailings).* No contaminated soils were noted. The site is also not on or near a tailings dam.

6.7 Further Geotechnical Investigations

The assessment of ground conditions on the site is based on limited information obtained during previous investigations on neighbouring farms. Although geotechnical conditions is expected to be favourable over the site, it is recommended that further, more detailed investigations are undertaken to confirm the assumed ground conditions given in this report. These additional investigations would also be aimed at optimising design assumptions so as to ultimately result in a reduced project cost.

Aspects which should specifically be addressed during these investigations include:

- Foundation conditions for turbine structures - Detailed investigations comprising rotary core drilling covering approximately 30% of the site, with percussion drilling and / or Continuous Surface Wave (CSW) test on the remainder of the positions. This investigation should extend to a minimum depth of 10m at each of the final turbine positions. Piezometers are also recommended to locate the permanent groundwater levels for the site.
- Excavatability - Rock excavation trials and/or either CSW or geophysical testing where excavations deeper than 1m are required.
- Mass haul and materials - Investigation of the suitability of materials from excavations for engineered layerworks and the identification and investigation of potential borrow areas.
- Electrical & thermal resistivity - Investigation of ground resistivity for the design of earthing for substations, and grading of buried cables.

6.8 Conclusion

From the available site information, conditions on the site are generally seen as favourable for the proposed development. However this report should be supplemented with a detailed geotechnical investigation.

7. CONSTRUCTION MATERIAL REQUIREMENT AND SOURCES

This chapter discusses the material requirements for the construction of the internal roads, hardstand areas, turbine foundations as well as the construction camp. Generally the natural gravel, rock, sand and water will be required during construction. The natural gravel from site will be used for the construction of the internal roads, hardstand areas and construction camp. Material for the construction of concrete turbine foundations will have to be sourced externally.

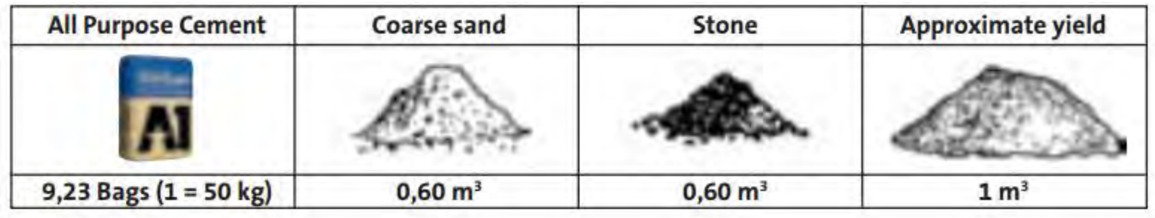
7.1 Material Requirements

The materials required to construct a typical foundation involve cement, sand, stone and water to mix concrete, together with steel reinforcing. Each foundation is assumed to have the following dimensions:

- Foundation Radius = 10m
- Foundation Depth = 4m
- Foundation Volume = 398m^3

Table 7.1 provides a summary of the estimated quantity of material required to produce 1m^3 of concrete, while **Table 7.2** provides an estimate of the material required.

Table 7.1 - Quantities per m^3 of Concrete



All Purpose Cement	Coarse sand	Stone	Approximate yield
9,23 Bags (1 = 50 kg)	0,60 m^3	0,60 m^3	1 m^3

Table 7.2 - Material Requirements per Foundation

Material	Volume per Foundation	Description
Concrete	3675 bags of 50kg	• One truck is capable of carrying 680 bags of cement. • Equates to 5 trucks per foundation.
Stone	239 m^3	• One truck is capable of carrying 20tonnes of stone. • Equates to 12 trucks per foundation.
Sand	239 m^3	• One truck is capable of carrying 20tonnes of stone. • Equates to 12 trucks per foundation, although the sand is to be sourced locally.
Steel	398 tonnes	• Assume 130kg of concrete requires 100kg of steel to support it. • Assume one truck is capable of carrying 20tonnes of steel per trip. • Equates to 15 trucks per foundation.

Based on the information above it can be seen that each project is expected to generate almost 30 HGV trips per foundation (1363 per project).

In addition to the foundations, an estimation of the material required to construct the internal roads is shown in **Table 7.3**.

Table 7.3 - Internal Road Material Requirements

Material	Volume	Description
Natural Gravel	180m^3 per km	• It is assumed that 1.2km of natural gravel roads will be constructed every week in 150mm layers at 0.2km/day using tipper trucks at 10m^3/truck to import material.

The general suitability of subgrade materials is usually based on laboratory tests results. The geotechnical investigation has confirmed the need for further testing. At this preliminary stage, however an example of the typical characteristics is given in **Table 7.4** below.

Table 7.4 – General Soil Material Assessment

Subsurface Layer	General Classification	Recommended Use
Sand	PI = 8-10 A -2-4 (0) Low expansive	Variable, but generally fair to good subgrade material that can be used for general fill, subject to screening and removal of any roots & rock fragments greater than 2/3 of individual layer thickness.
Gravel	PI = 9-12 A- 2- 6(0) / A -2-4 (0) Low expansive	
Weakly cemented Calcrete	PI = 12-18 A- 2- 6(0) / A -2-7 (0) Low-Medium expansive	
Fractured shale	PI = 0-15 A- 2- 6(0) / A -2-4 (0) Low expansive G7-G8	
Completely weathered dolerite	PI = 0-16 A- 2- 7(0) / A -2-4 (0) Low expansive G6-G7	

Typical rock tests on shale and dolerite samples within 5m below surface show general rock strength as follows:

- Hard rock Shale: 30 – 140 MPa
- Soft to medium hard rock dolerite: 7 – 30 MPa

It is unlikely that the soil properties will vary significantly from example provided above, although caution must be administered when using these results. A detailed soil test is recommended to confirm these assumptions.

7.2 Material Sources

As mentioned in the preliminary geotechnical study, it is possible to use the in-situ material (natural gravel, rocks (weathered dolerite), sand, calcrete and fractured shale) for road construction.

The Investigation did however confirm the following two important aspects:

- Possible quarry sources for concrete aggregate include the hard rock dolerite sill, covering most of the site;
- The surface soil deposit is estimated to be up to 5.0m below surface.

Other materials such as cement, sand for cable back filling, steel, etc will be sourced commercially in both the Northern and Western Cape Provinces. Although cement is generally available nationally, cement used for customised mixes could be harder to source due to the general demand being lower. Consideration must be given to the travel distances required when specifying higher grade cement or cement adapted for special use.

7.3 Conclusion

Based on geotechnical findings, it can be concluded that the site has the potential to supply a large portions of the material required for construction. This will reduce the amount of material imported from outside as well as significantly decrease the costs of construction.

8. PRELIMINARY STORMWATER MANAGEMENT PLANS

A desktop study was performed to prepare a preliminary stormwater management plan that aims to limit the risks of flooding and erosion associated with any additional stormwater runoff created by the proposed development.

The following objectives are outlined in this preliminary study:

- Stormwater considerations;
- Stormwater drainage features; and
- A stormwater management plan

8.1 Stormwater Considerations

8.1.1 Construction of the Internal Roads

The construction of the internal roads will involve earthworks where undisturbed soils would be exposed which may lead to erosion. These exposed areas tend to form channels and collect rain water. It is therefore important that all stormwater runoff be directed to the lower edge of the gravel road. Thereafter the water is to be collected in side drains and disposed of in designated places by means of suitable outlet structures and berms. All roads must therefore consider the management of stormwater during design.

8.1.2 Existing Drainage Features

A topographical map and *Google Earth* was used to identify existing drainage features within the area such as non-perennial rivers and jeep tracks.

It is recommended that all rivers and drainage channels should be kept untouched so that the existing hydrology is not disturbed. No rivers are to be diverted due to the construction of any internal roads. The natural drainage channels that collect water from the existing jeep tracks and secondary roads will be upgraded and should be used as drainage channels as far as possible. It is proposed that the drainage channels for the new internal roads should follow natural drainage lines. These drainage channels should then ultimately link up with the existing drainage routes on site.

8.1.3 Construction of Wind Turbine Foundations

The wind turbine foundations will be constructed on hard rock below surface and therefore deep excavations will be required. The images below show the typical layout of the construction envisaged for the turbine foundations.

Typical Wind Turbine Foundation

Steel Rebar and Concrete Foundation

Figure 8.1 – Concrete Foundations

Considering the flat nature of the site it is the recommendation that cut-off drains be constructed on the top side of the excavations. The cut-off drains would prevent surface water run-off from entering the excavation. The fresh excavations have a high risk for erosion and all water channels need to be kept away from the construction of the foundations. Water pumps should be available on standby to remove any water from the bottom of the foundations and the site agent should inspect excavations daily, or more frequently during periods of rain.

8.1.4 Construction Camp

The laydown area, operation and maintenance building, site compound and concrete batch plant area will be founded on levelled compacted and sloped natural gravel. Cut-off drains must be constructed around the construction camp which would then be channelled to existing drainage channels.

8.2 Stormwater drainage structures

8.2.1 Drainage Channels

Drainage channels should be constructed adjacent to the internal roads when constructed. The drainage channels should follow the natural flow of the ground with a constant depth to ditch invert. The objective is to allow stormwater from the roads to be discharged into natural drainage structures and then discharge it into the veld at suitable drainage locations.

The depth and type of trench can be established at the design stage. The drainage channel must be left in place permanently upon completion of the works or removed and the area reinstated as natural vegetation.

8.2.2 Intermediate Cross-Drains

If required, intermediate cross-drains should be built under the internal roads to make water crossings possible. Long gradient profiles should be avoided as this has the risk of surface water accumulating at the lowest point.

Large volumes of water flows on the internal roads can lead to scouring of the road surface, causing erosion. The image below shows the envisaged intermediate cross drain to be constructed under the internal roads.

8.3 Stormwater Management Plan

Based on the stormwater considerations the following requirements should be considered for the development of a detailed Stormwater Management Plan.

- Stormwater must be diverted from construction works and roads to prevent concentration;
- Increased run-off due to vegetation clearing must not lead to bank instability;
- The natural drainage channels should be maintained and used as much as possible;
- Due to the type of soil in the area it is assumed that the soil will be highly permeable with relatively low run-offs generated;
- Minimise any effects on the natural flora and fauna, and ensure there are no indirect impacts on any surrounding designated sites;
- No large amount of water should be allowed to dam on site;
- A maintenance plan should be developed for any installed stormwater systems;
- Pollution prevention and environmental protection legislation should be adhered too.

9. PRELIMINARY 1:100 FLOOD LINES AND RISK ASSESSMENT

Due to the location of the proposed development it can be expected that a 1:100 year flood for the wind energy facility will not be a limiting factor. For accurate flood line calculations a detailed topographical survey of the area is required. To determine where existing watercourses are crossed by either new or existing roads a 1:50 000 topographical maps of the Leeuwberg area was used to overlay the positions of the turbines, roads, substations etc. as shown in **Figure 9.1** below. The water courses are all non-perennial with no or very low water flows observed. According to Figure 9.1 there are approximately 28 point where the road crosses a watercourse. However site observations confirmed that no culverts or bridges are present indicating that these watercourses do not warrant concern.

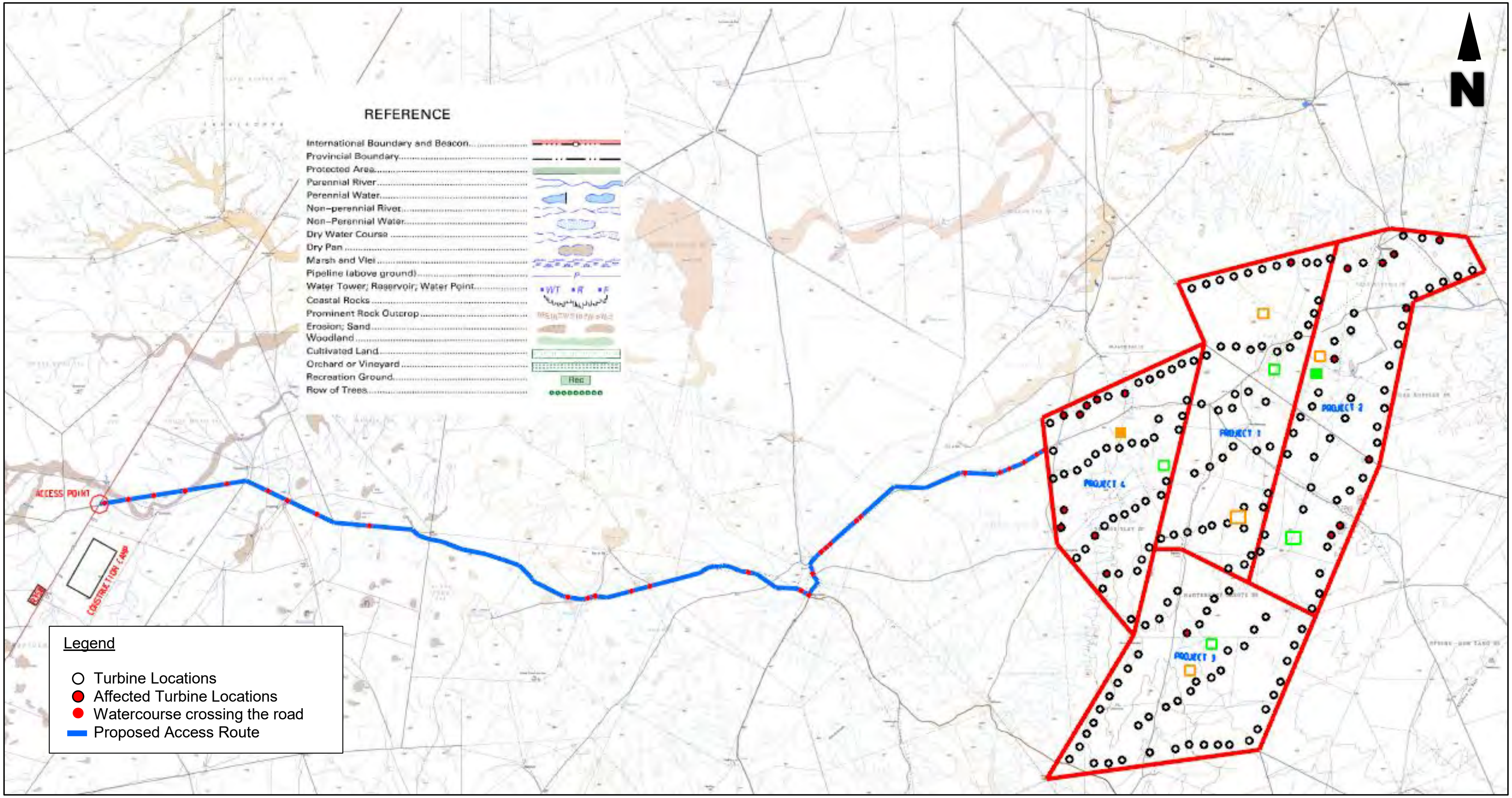


Figure 9.1 - Existing Watercourse Crossings

10. ESKOM GRID CONNECTION ANALYSIS

10.1 Review of Existing Connection Options

Mainstream has provided SMEC with two options for connection to the Eskom grid. These options present two different routes taken by the connecting line to connect the collector substation to the nearest Eskom substation. A diagram of the routes is given in **Figure 10.1** below.

Figure 10.1 - Provisional Grid Connection Line Routes

A Google earth image of the proposed connections is provided in **Figure 10.2** below; this gives an indication of terrain.

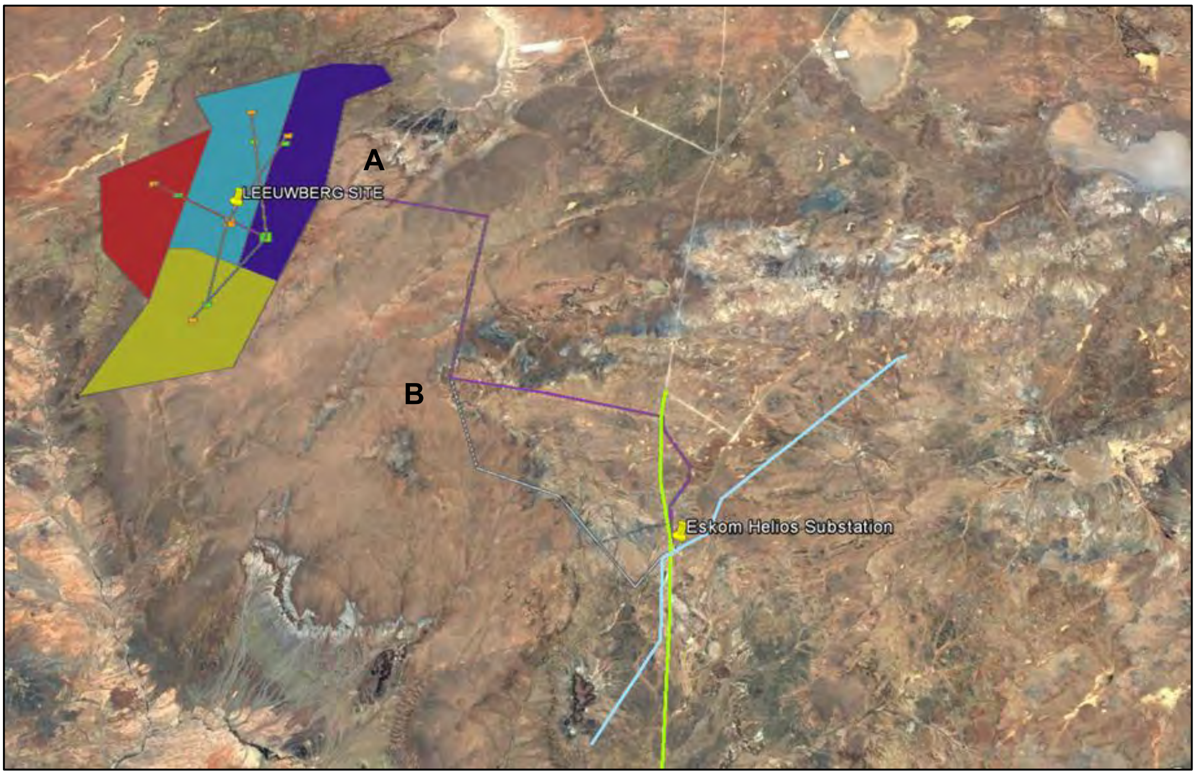


Figure 10.2 - Grid Connection Line Routes

10.1.1 Constructability Option 1

The first option presents a route of approximately 40km. The assumption for this connection option is that a 132kV or 400kV double circuit line will be used to connect the windfarms to the Eskom Helios Substation. It is however possible that following the detailed grid connection studies the maximum generation of 235MW could possibly require to be evacuated at 400 kV rather than 132kV. The potential issues are discussed below.

1) **Eskom Substation Extension**

Any extensions to Helios will be aided by the fact that there is additional space around the substation for additional bays. This will be aided by the fact that existing geotech data will be available from Eskom to aid with specification of excavations, foundations and backfill material. This does not appear to pose any constructability risks. Helios substation presently has a 132kV and a 400kV busbar

Construction works may require partial outages of adjacent equipment and bays to allow safe working clearances to be maintained at all times. This is a high priority issue with Eskom and would require extensive coordination to reach agreement on a suitable plan of action.

2) **OHL Route**

The line route from point A to point B for both options is the same for approximately 20km thereafter they diverge to separate routes. This common section is relatively flat and keeps to stand boundaries and is likely not to have any constructability risks.

The route taken by the line extends over a mountainous region and crossing over ephemeral river beds. This will require that careful design will be required to mitigate the impact to tower heights and span lengths to allow for adequate clearance during times when the rivers flow. Since the profile will have greater variances in elevation that option 2, this option will be more complex / expensive to construct than option 2. The type of ground material would also influence the footings and foundations that can be built hence the tower will need to be designed to accommodate this. This section of this report does not comment on Geotechnical variations between option 1 and option 2, this is dealt with elsewhere. The elevation profile is given below.

The part of the line route passing through the mountainous region would also be difficult to access for maintenance or repair teams which may therefore impede restoration time if an outage occurs. It may be worth considering two single circuit lines if this option is chosen.

10.1.2 Constructability Option 2

The second option is a more direct route with a total length of approximately 40km and does not pass over as much of the mountainous region as Option 1. It is assumed this is also a double circuit 132kV or 400kV OHL. Some of the potential issues are given below.

1) Eskom Substation Extension

This option approaches Helios substation from the North. The 400kV line approaches from the North-East into the substation. The OHL would thus have to cross this 400kV line or any other lines built recently. Crossing other lines can be difficult but is achievable if effort is made to maintain clearances (electrical and working). Eskom will need to be informed and approve the works well ahead of time.

2) OHL Route

The line route from point A to point B for both options is the same for approximately 20km thereafter they diverge to separate routes.

Option 2 passes over less mountainous terrain and close to a dirt road. This dirt road could provide access for maintenance and repair crew to the line offering an advantage over Option 1. Crossing over rivers is also not as much of a concern with this option. The elevation profile of the line route is given below.

10.2 Alternative Grid Connection Options

While an in depth analysis of connection options is not the subject of this report, this would be considered in detail during further technical studies when an application is made to Eskom, the high level assessment of the connection options available provides sufficient context and helps with the determination of the works associated with such a connection.

10.2.1 Voltage Selection

When considering a grid connection option it is important to first consider the voltage that the proposed connection should occur at. For the LWEF the expected export capacity of each project is anticipated to be 235MW. This would necessitate catering for an evacuation capacity of 940MW for all four projects.

At this level of power export the most suitable grid connection shall occur on the high voltage (HV) transmission network (=> 132kV). The available connecting voltages in the area are 66kV, 132kV and 400kV at Helios Substation.

The power evacuation required being 940MW would eliminate 66kV as an option as this would not be technically efficient (losses would be too great). However the relatively short distance from the LWEF to the substation (35km as the crow flies) would mean it is possible to connect at 132kV to Helios Substation however multiple lines (or multi-circuit lines) would need to be constructed from the LWEF to Helios in order to evacuate that amount of power. Another option is to connect at 400kV and build a single line to Helios Substation. Both these options shall be considered for connection.

10.2.2 Grid Connection Type

Grid connection can be achieved through two means:

- A direct connection to a substation; or
- A line turn-in (cutting into an existing line).

A direct connection would involve building a line directly from LWEF to the Helios Eskom substation. This may also require the extension of the Eskom substation including the existing substation building and the equipping of new line bays. While a more costly solution, it is generally quicker to implement under the self-build process.

A turn-in connection would involve cutting into an existing transmission or distribution line. This option does not require any extension to existing substation unless deep network strengthening is required. However this option would also require the line to be switched off for a period during construction which may be difficult to implement. Consultation with Eskom would also be extended as there would be a need to integrate and reconfigure existing network equipment and functions as well as planning for future expansion. This could cause delays to the implementation process.

Two possible options have been identified as possible connection options, these are described below.

1) Option 1 – 132kV

According to information contained in the *"Transmission Development plan 2016 – 2025"* and *"Generation Connection Capacity Assessment of the 2016 Transmission Network (GCCA-2016)"* Helios substation is due for an extension to be completed by Q2 2017. This extension will include the installation of a 400/132kV 500MVA transformer. Of this capacity 276MW is committed to other renewable projects leaving 224MW available for connection. This is insufficient for the evacuation capacity required for the LWEF, this would therefore require deep network strengthening in the form of the addition of another 350-400MVA 400/132kV transformer. These works would be paid for by the developer.

The anticipated scope of works would be as follows:

- Construction of four 132kV Overhead Lines (OHLs) from the windfarm main substation to Helios Substation;
- Extension of Helios Substation yard to accommodate four additional line bays and one additional transformer bay;
- Construct, install and equip additional 400/132kV transformer bay for one additional transformer;
- Construct, install and equip four additional 132kV line bays;
- Install and configure protection and control equipment;
- Upgrade and/or reconfigure existing secondary plant (buszone, batteries, etc.)

This option is likely to be the most expensive and complex option to implement given the multiple lines and additional transformer required. The process may be prolonged by Eskom due to coordination difficulties given the extensive scope of works. The line route that would need to be taken may also be difficult to implement given the nearby mountainous region and river runs that would need to be negotiated. This route would need to be approved by an environmental study and route survey. Extension of the 132kV yard may also prove difficult given the current layout of the substation.

2) Option 2 – 400kV

The *"Generation Connection Capacity Assessment of the 2022 Transmission Network (GCCA-2022)"* indicates that the available capacity on the 400kV network is 570MW which would be able to cater for the entire evacuation capacity of the LWEF. The anticipated scope of works is as follows:

- Construction of a 400kV OHLs from the windfarm main substation to Helios Substation;
- Extension of Helios Substation 400kV yard to accommodate the additional line bay;
- Install and configure protection and control equipment;
- Construct, install and equip additional 400kV line bay;
- Upgrade and/or reconfigure existing secondary plant (buszone, batteries, etc.) if required.

Although the cost to build a 400kV line and line bay at a substation is much more expensive this would likely be cheaper than the multiple 132kV lines and additional transformer required by the connection described above. While a simpler connection option to implement this may also be prolonged due to extensive consultation required with Eskom as this is a transmission asset. Again the mountainous region would make the proposed route difficult to negotiate and would need to achieve environmental approval through the relevant studies and surveys.

A possible upgrade to 765kV at Helios Substation is possible in the future and may have an impact on whether Eskom would allow a connection at 400kV at this time. Close coordination with their planning unit is thus required for this option.

3) Overhead Line Route

Mainstream provided SMEC with two options for an overhead line (OHL) to Helios Substation as shown below in **Figure 10.3**. SMEC analysed these options and suggested another alternative route. This route can be used for both connection options above. This route aims to avoid the mountainous region between the windfarms and Helios Substation. A possible overhead line route is provided in the **Figure 10.4** below.

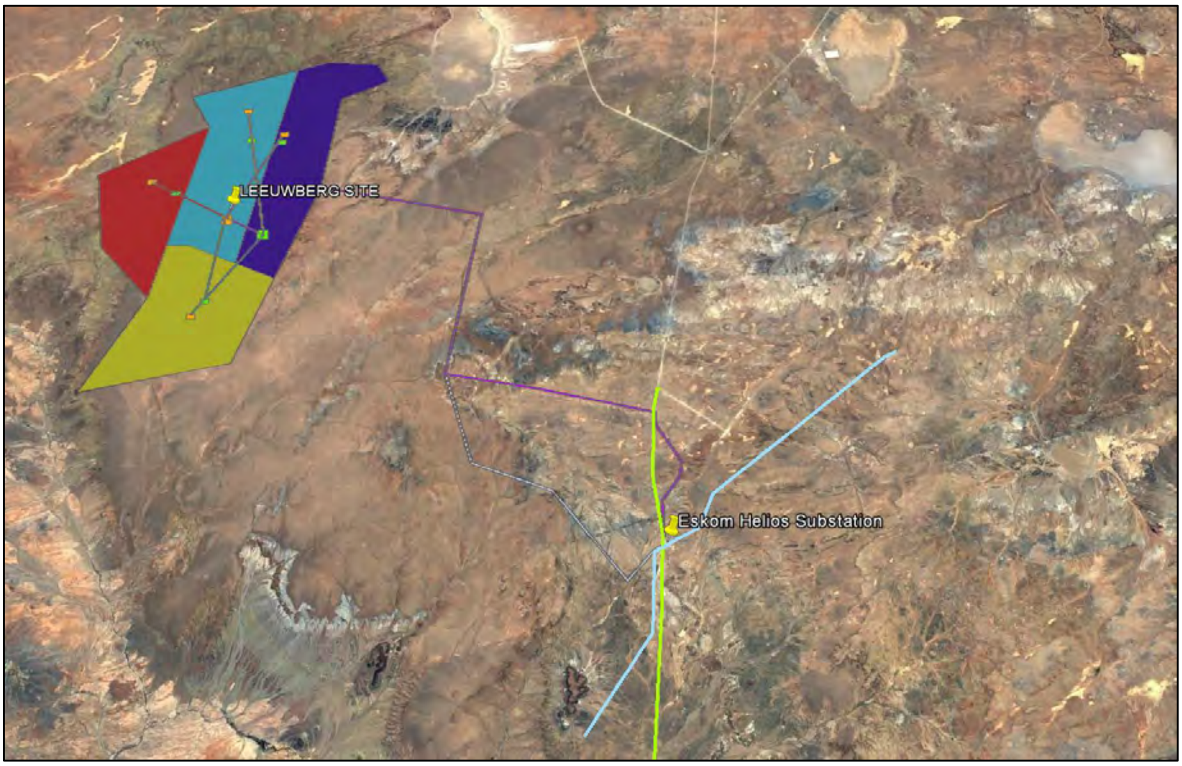


Figure 10.3 - Mainstream Proposed OHL Routes

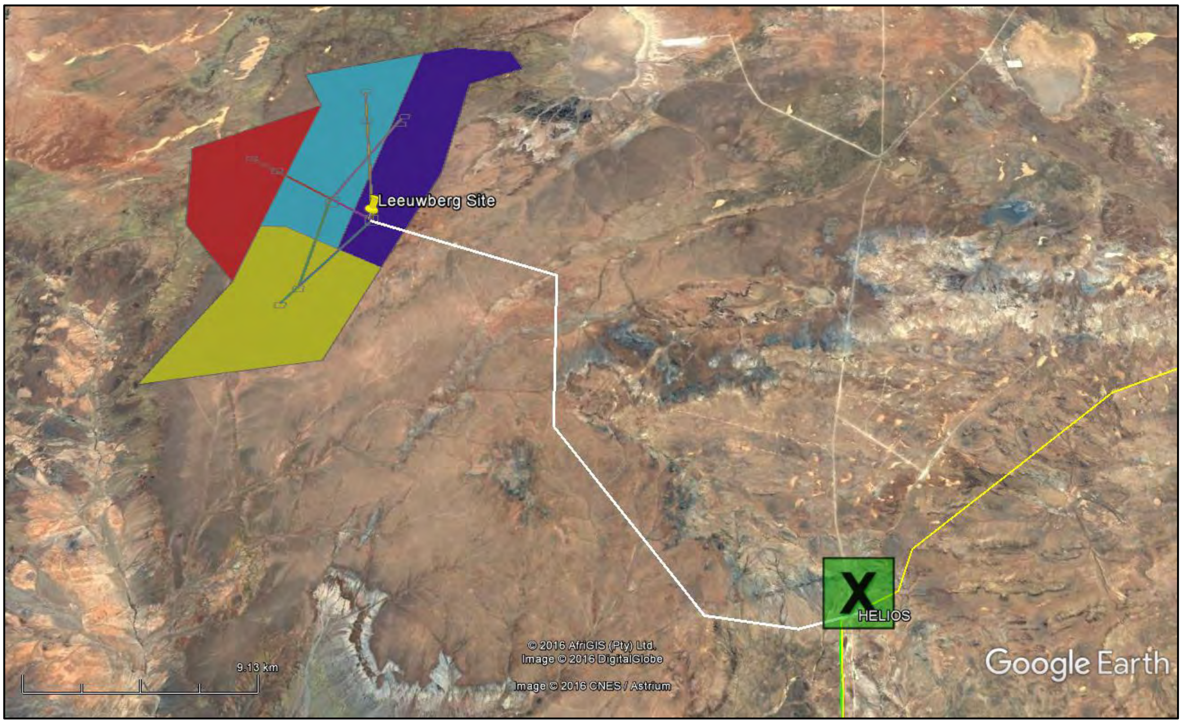


Figure 10.4 - SMEC Proposed OHL Route

The elevation profile below shows the profile of the route taken above. The profile shows that the elevation is around 950m with elevation gain and losses along the route not being too sharp or sudden. This would aid in designing towers suitable for the route without too much extra reinforcing or strengthening.

Figure 10.5 - Elevation Profile of Proposed OHL Route

4) Helios Substation

Figure 10.6 below shows the Google Earth image of Helios Substation. This shows that there is sufficient space around the substation to extend for additional bays at 400kV however the 132kV yard may be more difficult to extend given the current layout. The 132kV yard may need to be extended next to the 400kV yard or 66kV yard at an angle to the current yard placement.

Helios Substation is part of the Eskom's western corridor; this is a backbone transmission asset which transfers power form the generating centers to the load centers of the country. There are plans to upgrade this substation to 765kV in the future. This upgrade may provide additional evacuation capacity in the future however this upgrade is not scheduled for the near future.

Figure 10.6 - Helios Substation Location

10.3 Conclusion

From the high level analysis it is recommended that the 400kV connection option be investigated further as a possible grid connection option. This option may be easier to implement although consultation with Eskom will be extensive given that it is a transmission backbone asset.

The way forward with the Eskom grid connection is straight forward. The developer must make an application to Eskom for a grid connection for the LWEF. Eskom will then conduct their own studies to determine the most suitable connection option, this report may provide infeed into that study. Eskom will then issue a cost estimate letter (after payment of a fee) which will detail the results and recommendations of the study and the anticipated scope of works. In order to start the connection application contact must be made with the Grid Access Unit (GridAccessUnit@eskom.co.za).

Once the connection is agreed upon, Eskom will then need to produce a budget quote which will encompass the detailed design of the connection option. If the Client choses to proceed with the self-build route they may appoint a consultant to conduct these designs, if agreed by Eskom, and have the connection constructed by an Eskom approved contractor.

In parallel with the detailed design the Client will need their consultant to conduct grid code compliance studies to ensure the LWEF comply with the South African Renewable Grid Code regulations. The results of these tests will be verified with on-site test during commissioning.

11. INTERNAL ELECTRICAL CONNECTIONS ON LEEUWBERG SITE

11.1 LWEF Main Substation

It is envisaged that the supply voltages from the four substations would be 132kV for the LWEF as previously discussed in **Section 10.2.2**. From the main combiner substation, there will be a double circuit 132kV or 400kV OHL to Helios substation. These two options both allow for a connection to the 400kV main substation.

11.2 Connection of the substations to LWEF Substation

It is envisaged that the electrical connection line from the on-site substations (one per farm) to the combiner substation on the Leeuwberg site will be 132kV OHL.. The placement of substation will depend on positioning of turbines, limiting cable connection. These electrical routes will follow a straight line to minimize cable lengths to reduce cost and electrical losses. The preferred electrical substations and connection lines was previously highlighted in **Figure 4.4**.

11.3 Wind Turbine Connection to Substations

Each project has a substation functioning as a collector switching station. The turbines within a collector circuit are grouped and their combined generated power is routed along one pathway to the main substation through underground cables at 33kV. The routes these cables follow are usually along the internal road network where possible. Where two internal roads intersect, suitable ducting must be provided so as to not disrupt the cables or to apply additional pressure from passing vehicles. **Figure 11.1** shows a typical cable routing along an internal road.

A technical determination will need to be made whether the 33kV cables will be sufficient to carry the power (47 x 5MW totaling 235MW) over the distance to the main substation.

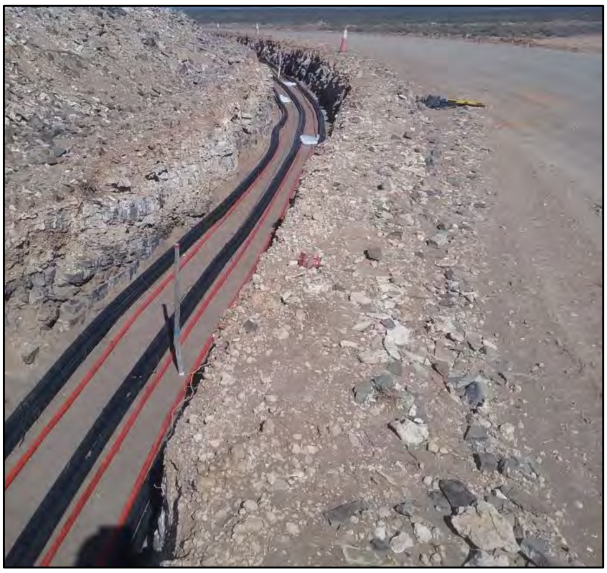


Figure 11.1 - Electrical Connection to Substation along Internal Road

12. CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions

This engineering services report has outlined the engineering issues/risks that may have an impact on the potential feasibility and constructability of the proposed Leeuwberg Wind Energy Farm (LWEF) project near Loeriesfontein. The LWEF project comprises 4 individual projects, each project proposing the construction of 47 turbines. Each project is expected to generate 235MW (940MW in total). This report has illustrated various studies such as Transportation Routes, Water Sources, Geotechnical, Material Sources, Electrical Grid Connection and Stormwater Management that will be required before the implementation of this project.

12.1.1 Traffic Generation

Each project is anticipated to generate between 3000 – 4000 HGV trips over the construction period of 9-12 months per project. This equates to approximately 64 HGV's per day which will likely enter and exit the site throughout the day. Assuming all four projects are constructed concurrently, the vehicle trips would increase to 250 HGV's per day. In addition the HGV's, each project is expected to generate 43 light vehicles.

The impact of these vehicles on the public roads is low, on account that the surrounding roads carry low volumes of traffic and that additional traffic would be small because the arrival and departure profiles of construction vehicles would be relatively even throughout the day. No capacity issues are anticipated on either the N7, R358 or local access roads.

Approximately 1742 abnormal loads are anticipated to deliver the wind turbine components, Padmount transformers, Main Transformer and OHL pole segments. The arrival of these vehicles are also likely to be spread across the entire 48 month construction period.

The operational and maintenance period is not expected to exceed 10 vehicles coming to site per day.

12.1.2 Transportation Routes

The information received from Mainstream Power Engineers, desktop research and a site visit conducted in preparing this report identified two manufactures of wind turbines as Gestamp Factory in Atlantis (Towers) and Saldanha Harbour (Blades). Two main routes from manufactures to site where also identified as either the N1 or N7. It was concluded that the current abnormal route via the N1 is long, expensive and has cost implications both to the haulier and ultimately Mainstream. Alternatively, the N7 offers significant benefits and every effort should be made to support this route as the preferred "Main Route" for the LWEF project.

This report also reviewed access routes from the N7 to the site. After identifying and evaluating the numerous available access routes, two access points where selected as suitable options; a western access point via the P2948 and an eastern access via the DR2972. The P2948 access route was the preferred route on account that it is closer and easier to travel to the N7. The N7, being a national road is the most suited road to carry high volumes of HGV's without causing significant pavement damage. The N7 also carries low vehicle volumes, which offers safety benefits to other motorists.

The construction activities associated with the development of the Wind Energy Farm will attract greater heavy vehicle numbers on the road than are currently recorded. The total number of abnormal loads anticipated in these routes over a 48 month period is approximately 1692 vehicles. Therefore road construction and maintenance on access routes will be required. Maintenance may include re-grading, new gravel wearing course, dust control slurry and stormwater drainage.

12.1.3 Water Sources

This report identified activities that will require water during the construction of this project such as human consumption, dust Suppressions, earth works, turbine foundation construction (concrete) and ablution facilities. The total estimated water required for the construction will be approximately 756m^3/day. A commercial water source was identified as a possible option for human consumption and concrete water, whereas the water from site can be used for construction purposes. The water required can be stored in a temporary reservoir on site and mitigation measures should be in place to protect the water from contamination and wastage.

12.1.4 Geotechnical

From the available site information, conditions on the site are generally seen as favourable for the proposed development. However precautionary measures for foundations will have to be incorporated in the design and construction of the proposed development due to the medium hard/ hard excavatability of hardpan (cemented) calcrete, soft rock shale, soft rock dolerite and hard rock shale. Also the instability of excavation side walls within fractured bedrock.

12.2 Recommendations

The following recommendations are made:

1. A detailed Traffic Management Plan should be completed once the project details are finalised and before construction can commence.
2. Material for construction purposes must be sourced from site to reduce costs;
3. Groundwater from the site can be used for human consumption and construction considered that it will be treated. A water purification plant to be constructed on site in order to treat this water before use.
4. Water should be stored on site so that it can be readily available for use.
5. A detailed Geotechnical and Electrical investigation will be required.
6. A detailed soil chemical analysis and soil resistivity test will also be required.
7. It is recommended that the 400kV connection option be investigated further as a possible grid connection option. This option may be easier to implement although consultation with Eskom will be extensive given that it is a transmission backbone asset.

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7) *Generation Connection Capacity Assessment of the 2016 Transmission Network (GCCA-2016)*
8) *Generation Connection Capacity Assessment of the 2022 Transmission Network (GCCA-2022)*
9) *TRH11: Administrative Guidelines for Granting of Exemption Permits for the Conveyance of Abnormal Loads' 1st Edition, July 2009.*
10) *TRH 11: Dimensional and Mass Limitations and Other Requirements for Abnormal Load Vehicles' 8th Edition, March 2010.*
11) *Engineering Service Report for the Proposed Kangnas Wind Farm , bvi Engineers, February 2013.*
12) *EIA Report, Chapter16-Traffic Impact Assessment, Mulilo Renewable Projects Developments*
13) *Drought Status Report No.4, K. Majola, Integrated Water Resource Studies, March 2016*
14) *General Wind Turbine Site Requirements, Siemens Wind Power, Rev.00, April 2012*

APPENDIX A – SCOPE OF WORKS

MAINSTREAM RENEWABLE POWER SOUTH AFRICA

South Africa Mainstream Renewable Power Developments (Pty) Ltd.
PO Box 45063,
Claremont 7735, South Africa.
www.mainstreamrp.com

Tel: +27 21 657 4040
Fax: +21 21 671 5665
info-southafrica@mainstreamrp.com

PRELIMINARY ENGINEERING: SCOPE OF WORK

1. Transportation studies
   a. How many and what type of vehicles required during construction and operation?
   b. How would the extra traffic impact the regional and local roads, including status quo description of road conditions?
   c. Risk assessment of additional traffic in the region?
   d. Basic traffic and road management (and maintenance) programme for regional and access roads to the development
2. Access to site
   a. Propose best location of access point/s and route to the site from public roads considering technical, environmental and land access constraints
   b. Risk assessment on access point/s and road construction assessment
   c. Supply basic design description if required for permitting
3. Internal project roads
   a. Prelim route layout considering technical, environmental and land access constraints
   b. Risk assessment on constructability
   c. Length of new roads, length of existing
   d. Supply basic design description if required for permitting
   e. Roads data supplied in kmz or shapefile format.
4. Propose best locations for the project infrastructure
   a. Substations
   b. Operation and maintenance buildings,
   c. Laydown areas
   d. Site compound
   e. Overall risk assessment on infrastructure location, flooding, geotech and other environmental and engineering concerns
   f. Consider project electrical losses.
5. Water use and sources for the proposed development
   a. How much water is required during construction and operation?
   b. Where do we source this water?
   c. If water source is not onsite, what are the impacts on transport, piping and/or storing, and costs?
   d. If water is to be stored onsite, how, volume and location?
6. Desktop based Geotech study
   a. Overall constructability of the site
   b. Potential risks of constructing the required infrastructure
   c. Review Eskom requirements for the foundations of the Substations and consider proposed project location

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7. Material requirements of the project
    a. Are there commercial sources nearby, what is the contact details indicative cost of stone/gravel and transport?
    b. How much stone/gravel would be needed?
    c. How much stone/gravel can we secure from foundations and cut and fill?
    d. Can the stone/gravel requirements be sourced onsite?
    e. Possible locations of stone/gravel quarries onsite?
    f. Risk assessment of securing stone/gravel from the site?
8. Preliminary site-specific storm water management plan/s.
9. Basic site specific 1:100 flood line opinions and risk assessments.
    a. Based on public information available or as supplied by Mainstream
    b. Ensure this aligns with the wetland specialists findings/ delineation
10. Routing alternatives for the main electrical grid connection to Eskom's grid
    a. Consider technical, environmental and land access requirements
11. All information to be uploaded to Mainstream SharePoint data room
12. Geotechnical information supplied in shape file or kmz format.
13. One technical report to be submitted

APPENDIX B – RISK ASSESSMENT

Aspect/ Impact Pathway	Nature of impact	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility	Irreplaceability	Mitigation Measures	Significance of Impact/Risk = Consequence x Probability		Ranking of Impact/ Risk	Confidence Level
										Without Mitigation	*With Mitigation*		
CONSTRUCTION AND DECOMMISSIONING PHASES													
Access Points	Various alternatives to access site	Negative	Local	Long term	Slight	Likely	No	Replaceable	• Three alternative access points were originally considered i. Access via DR2972 to eastern boundary of LWEF ii. Access via DR2972 to southern boundary of LWEF iii. Access via R358 to western boundary of LWEF • Option iii was preferred option because i. Most suitable route for abnormal loads; ii. It allows all vehicle types to use the same route; iii. Only 1 access point needed; iv. Maximum use of N7 which is most suitable for HGV use; v. N7 currently not heavily utilised and therefore attractive.	Low	Low	3	
Abnormal Vehicle Generation	Increase in the number of abnormally sized vehicles travelling along the N7 and R358	Negative	Regional	Short term	Moderate	Very likely	No	Replaceable	• New abnormal route proposed along N7 instead of N1, saving 1000km per trip • N7 more suited for abnormal vehicles due to lower vehicle volumes • N7 shortest route from Saldanha and Atlantis • Local improvements proposed to enable route for abnormal vehicle use. • Disruption to other road users minimised.	High	Low	5	
Traffic Generation	Increase in traffic	Negative	Region al	Short term	Moderate	Very likely	Yes	Replaceable	• All abnormal vehicles will need to obtain a permit from the Provincial Government of Northern Cape and Western Cape at least 2 months in advance of transporting the first wind turbine components; • Ensure that roadworthy and safety standards are implemented at all times for all construction vehicles; • Plan trips so as to avoid travelling during the peak hours as far as possible (06:00-08:00 and 16:00-17:00).	Low	Low	4	
	Accidents with pedestrians, animals and other drivers on the surrounding tarred/gravel roads	Negative	Local	Long term	Extreme	Likely	No	High irreplaceability	• Road kill monitoring programme (inclusive of wildlife collisions record keeping) should be established and fences (such as Animal fences) installed, if needed to direct animals to safe road crossings along the primary access roads to the site; • Adhere to all speed limits applicable to all roads used; • Implement clear and visible signage at the intersection of the N7 and the R358.	High	Moderate	3	
	Impact on air quality due to dust generation, noise and release of air pollutants from vehicles and construction equipment	Negative	Local	Medium term	Moderate	Unlikely	Yes	Replaceable	• Implement management strategies for dust generation e.g. apply dust suppressant along the affected road segments, exposed areas and stockpiles; • Postpone or reduce dust-generating activities during periods with strong wind; • Earthworks may need to be rescheduled or the frequency of application of dust control/suppressant increased; • Ensure that all construction vehicles are roadworthy and drivers adhere to any additional safety standards imposed by the Health and Safety Manager; • Ensure that all construction equipment is well maintained and serviced regularly.	Moderate	Low	4	
	Change in quality of surface condition of the roads	Positive	Local	Long term	Slight	Likely	Yes	Replaceable	• Construction activities will have a higher impact than the normal road activity and therefore the road should be inspected on a weekly basis for structural damage; • Implement management strategies for dust generation e.g. apply dust suppressant on gravel roads, exposed areas and stockpiles; and • Develop a Road Maintenance Plan for the primary access to the site to addresses the following: vi. Grading requirements; vii. Dust suppressant requirements; viii. Drainage requirements; ix. Signage; and x. Speed limits.	Low	Low	4	
OPERATION AND MAINTANANCE PHASE													
Traffic Generation	Increase in traffic	Negative	Region al	Short term	Slight	Very likely	High	Replaceable	• Adhere to requirements made within Traffic Management Plan; • Restricted access to site; and • Ensure that where possible, staff members carpool to site.	Very low	Very low	5	
	Accidents with pedestrians, animals and other drivers on the surrounding tarred/gravel roads	Negative	Local	Long term	Extreme	Likely	No	High irreplaceable	• Adhere to all speed limits applicable to all roads used; • Ensure clear and visible signage is present. • Install speed cameras along R358 between Loeriesfontein and the site	High	Moderate	3	
	Impact on air quality due to dust generation, noise and release of air pollutants from vehicles and construction equipment	Negative	Local	Medium term	Moderate	Unlikely	Yes	Replaceable	• Implement management strategies to reduce dust generation; • Limit noisy maintenance/operational activities to daytime only.	Moderate	Low	4	

Aspect/ Impact Pathway	Nature of impact	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility	Irreplaceability	Mitigation Measures	Significance of Impact/Risk = Consequence x Probability		Ranking of Impact/ Risk	Confidence Level
										Without Mitigation	*With Mitigation*		
	Change in quality of surface condition of the roads	Positive	Local	Long term	Slight	Likely	Yes	Replaceable	• Execute Road Maintenance Plan.	Low	Low	4	
CUMULATIVE IMPACTS													
Traffic Generation	Increase in traffic	Negative	Regional	Long term	Moderate	Very likely	High	Replaceable	N/A	Low	Low	4	
GEOTECHNICAL IMPACTS													
Foundation Excavatibility	Hardpan calcrete / soft rock shale encountered during excavation	Negative	Local	Short term	Slight	Very likely	No	Replaceable	• Preliminary geotechnical investigation has identified possible locations of calcrete/shale deposits; • Wind turbine foundations positioned to avoid areas requiring excavation of hardpan calcrete; • Foundations can be constructed above hardpan calcrete if bearing capacities of 200 - 500kPa can be achieved during testing.	Very low	Very low	5	
	Dolerite rock / hard rock shale encountered during excavation	Negative	Local	Short term	Extreme	Likely	No	Replaceable	• Preliminary geotechnical investigation has identified possible locations of dolerite outcrops; • Wind turbine foundations positioned to avoid excessive excavation of dolerite material due to high excavation costs; • Foundations can be constructed above dolerite/shale in-situ material if the bearing capacities are greater than 1000kPa.	High	Moderate	3	
	Instability of excavation side walls within fractured bedrock	Negative	Local	Short term	Moderate	Unlikely	Yes	Replaceable	• Precautionary measures to be incorporated in the design and construction of the proposed foundations.	Moderate	Low	4	
MATERIAL													
Material Availability	Material Source	Positive	Local	Long term	Moderate	Very likely	Yes	Replaceable	• Make use of possible quarry on site for concrete aggregate that includes the use of the hard rock dolerite sill.	Very low	Very low	5	
	Material Quantities and Qualities	Negative	Local	Long term	Extreme	Likely	Yes	Replaceable	• Ensure that the site is drilled to access the material quantities; and • Carry out laboratory testing to confirm the durability of the material.	High	Moderate	3	
STORMWATER IMPACTS													
Increased Stormwater	Flooding of site / access road	Negative	Local	Short term	Slight	Very likely	High	Replaceable	• Adhere to requirements made within Stormwater Management Plan; • Stormwater runoff be directed to the lower edge of gravel road;	Moderate	Very low	4	
	Erosion of land	Negative	Local	Long term	Extreme	Likely	No	High irreplaceable	• Ensure water courses follow natural terrain as far as possible; • Ensure initial road upgrades consider drainage to limit extent of erosion.	High	Moderate	3	

APPENDIX C – SOUT RIVER BRIDGE CLEARANCE

BRIDGE No.	:	B4258 "Sout River"	SPANS	:	(6) 24.5 m
ROAD NO.	:	N7-5	EARTH COVER	:	-
km DISTANCE	:	25.2	ROAD WIDTH	:	12.2 m

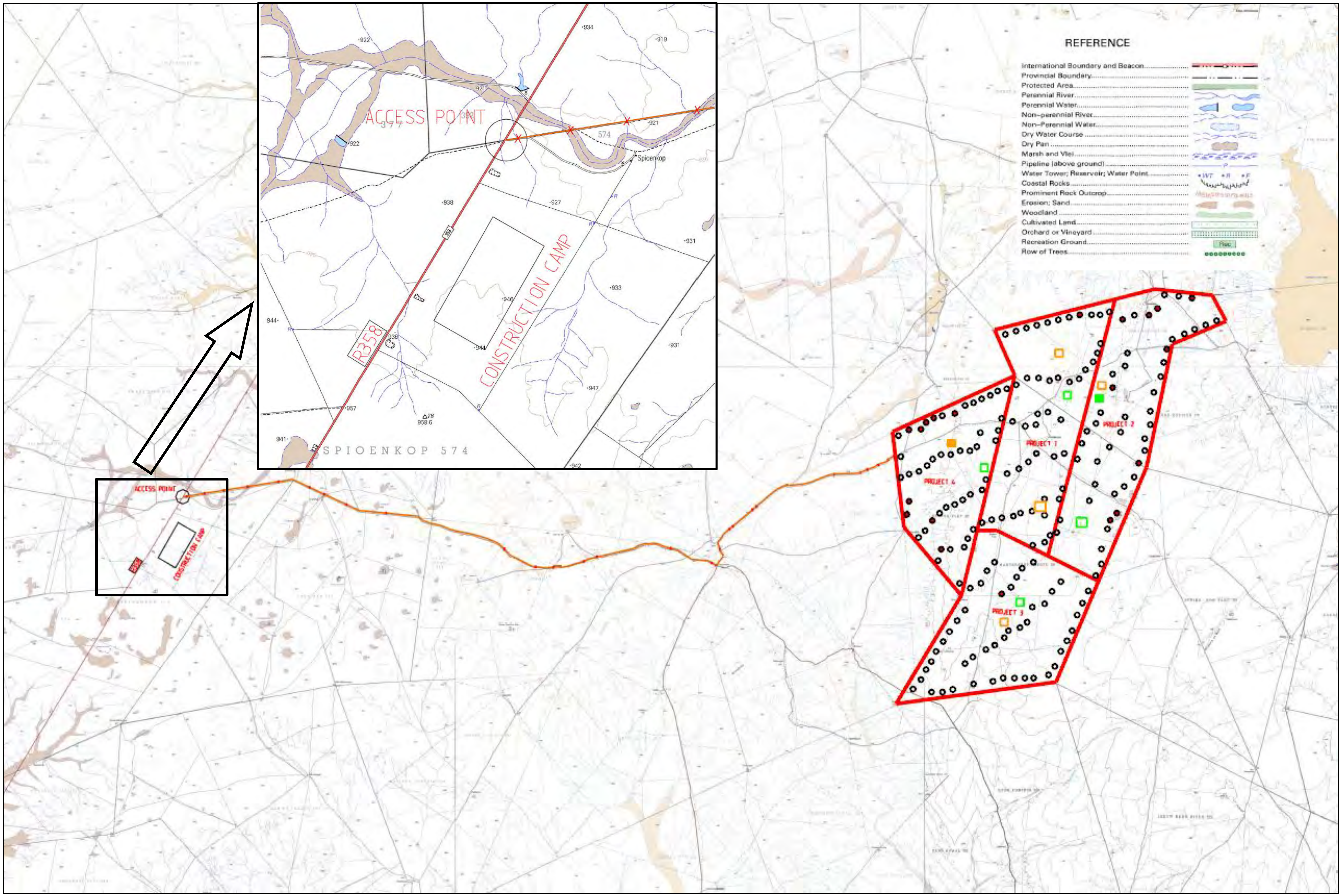
CAPACITY : Historic information
Bridge capacity sufficient

GENERAL : The super structure comprises of six SS pre-cast beams and slab. The skew is 24.43°.

The substructure comprises RC wall type piers and RC wall type abutments with straight return wing walls.

Overhead rail steel bridge with a vertical clearance of 5.392

APPENDIX D – SITE COMPOUND LOCATION



REFERENCE
International Boundary and Beacon
Provincial Boundary
Protected Area
Perennial River
Perennial Water
Non-perennial River
Non-Perennial Water
Dry Water Course
Dry Pan
Marsh and Vlei
Pipeline (above ground)
Water Tower; Reservoir; Water Point
Coastal Rocks
Prominent Rock Outcrop
Erosion; Sand
Woodland
Cultivated Land
Orchard or Vineyard
Recreation Ground
Row of Trees
ACCESS POINT
CONSTRUCTION CAMP
R358
Spioenkop
SPIOENKOP 574
PROJECT 1
PROJECT 2
PROJECT 3
PROJECT 4

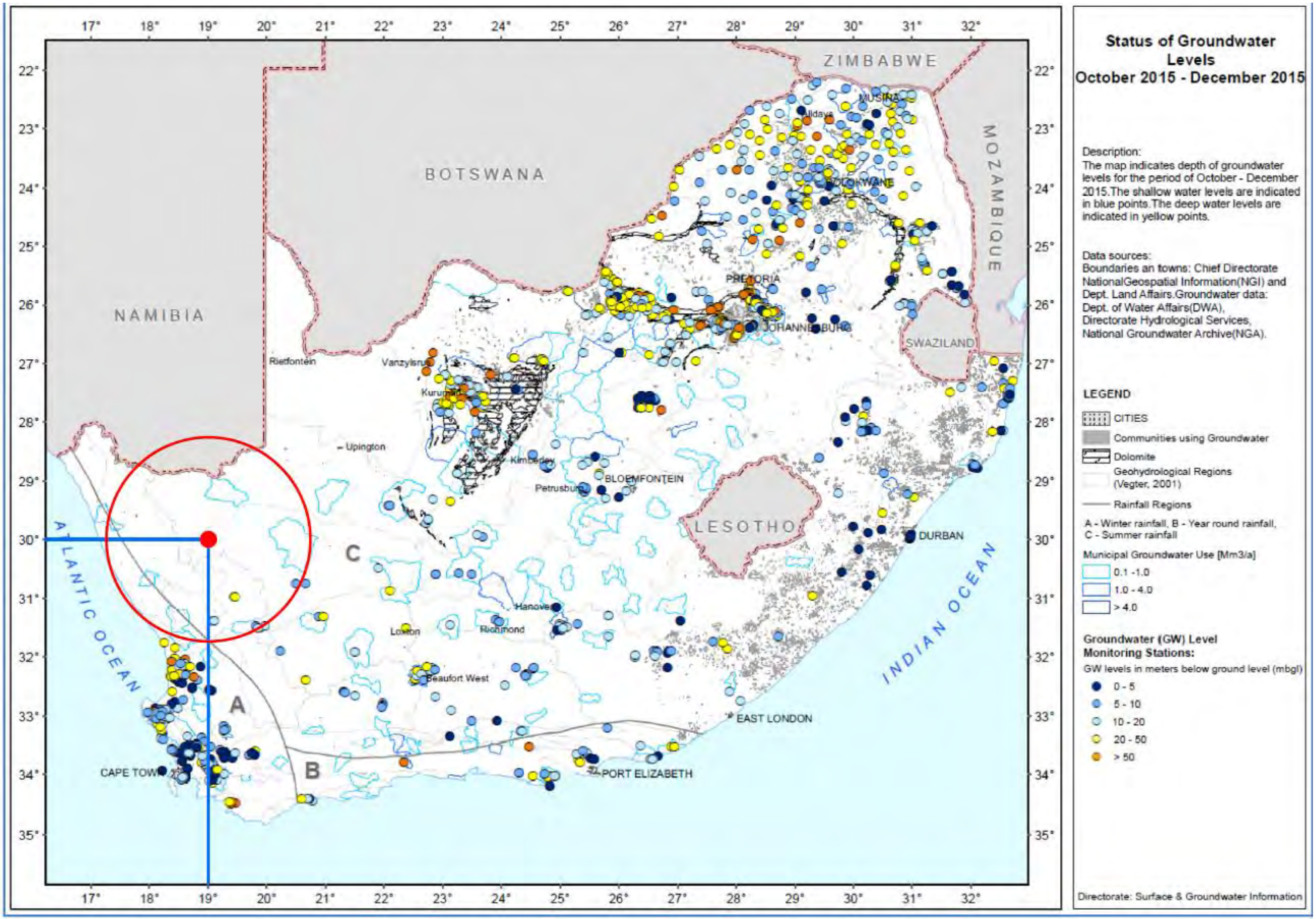
APPENDIX E – WATER USAGE CALCULATION

INTERNAL ROADS		
	Quantity	**Unit**
Allowable width of Track	8	m
Thickness of road layer	0.15	m
Assumed length of gravel laid per week	1200	m
Days per week	6	days
Length of gravel per day	200	m
Volume laid per day	240	m^3
Material properties (Assume G4 gravel)	2200	kg/m^3
Mass of Material per day	528	x1000 kg/day
Water required (Optimum moisture content)	8%	%
Water Requirements per day	**42.24**	**m^3/day**
CONSTRUCTION CAMP		
Approximate Area	32000	m^2
Layer thickness	0.25	m
Number of Construction Camp	1	No.
Total Volume of Material Needed	8000	m^3
No. of storage and site compound built	0.05	per day per storage area and compound
Volume of Material Needed	400	m^3/day
Material properties (Assume G4 gravel)	2200	kg/ m^3
Mass of Material per day	880	x 1000 kg/day
Water (Moisture content)	8%	%
Water Requirements per day	**70.40**	**m^3/day/ over a 20-day period**
HARDSTAND AREA		
Approximate Area*	1611	m^2
Thickness of road layer	0.25	m
Assumed Number of hardstand areas per week	2	No.
Volume of Material Needed	805.50	m^3/week
Days per Week	6	days
Volume of Material Needed	134.25	m^3/day
Material properties (Assume G4 gravel)	2200	kg/ m^3
Mass of Material per day	295.35	x 1000 kg/day
Water (Moisture content)	8%	%
Water Requirements per day	**23.63**	**m^3/day/ over a 6-day period**
CONCRETE CONSTRUCTION OF FOOTINGS		
Total Volume of Material needed	398	m^3/per footing
Water Requirements per footing	103	m^3/per footing
Number of footings constructed	2	No./week

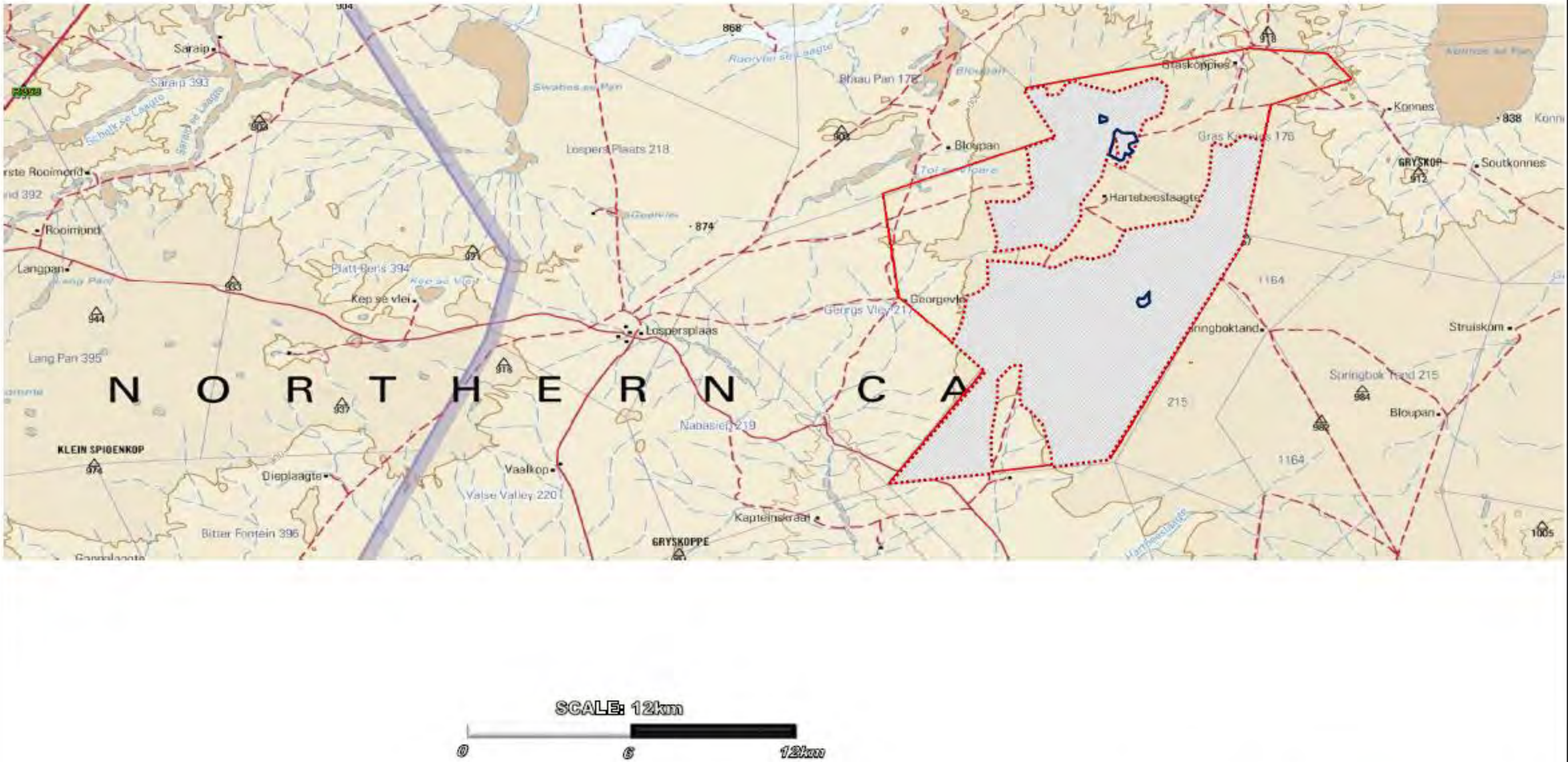
Water Requirements per footing	206	m^3/per footing
Days per Week	6	days
Water Requirements per day	**34.33**	**m^3/day**
BACKFILLING FOR CONSTRUCTION OF FOOTINGS		
Backfilling material per footing	398	m^3/per footing
No. of footings per week	2	No.
Volume of backfilling	796	per week
Days per Week	6	days
Volume of backfilling	132.67	m^3/per day
Material properties (Assume G4 gravel)	2200	kg/ m^3
Mass of Material per day	291.87	x 1000 kg/day
Water (Moisture content)	8%	%
Water Requirements per day	**23.35**	**m^3/day/ over a 6-day period**
DUSTSUPPRESSION		
Assumed Water Use	1	l/ m^2surface
Assumed Track length (road lengths that causes dust)	5000	m
Assumed Track Width (road width that causes dust)	5	m
Total area	25000	m^2/day
No. of Watering	2	times /per day
Assume Total Water Use	2	l/day/ m^2 surface
Total Water Usage	50	m^3/per day
Water Requirements per day	**50**	**m^3/per day**
SITE FACILITIES & EMPLOYEES		
Ablution Facilities & Wastages	5	m^3/per day
Employees	0.025	m^3/per day/employee
No. of Employees	127	employees
Employees	3.18	m^3/per day
Water Requirements per day	**8.18**	**m^3/per day**
TOTAL WATER REQUIREMENTS FOR LWEF CONSTRUCTION		
Estimated total	**252**	**m^3/per day**

Note *the area of the turbine hardstand used in the calculations above is a triangular hardstand example from SIEMENS E W EMEA ON PM2 manual Rev.00 attached as part of this report.

APPENDIX F – HISTORICAL GROUNDWATER LEVELS


Status of Groundwater Levels
October 2015 - December 2015
Description:
The map indicates depth of groundwater levels for the period of October - December 2015.The shallow water levels are indicated in blue points.The deep water levels are indicated in yellow points.
Data sources:
Boundaries an towns: Chief Directorate NationalGeospatial Information(NGI) and Dept. Land Affairs.Groundwater data: Dept. of Water Affairs(DWA), Directorate Hydrological Services, National Groundwater Archive(NGA).
LEGEND
CITIES
Communities using Groundwater
Dolomite
Geohydrological Regions (Vegter, 2001)
Rainfall Regions
A - Winter rainfall, B - Year round rainfall, C - Summer rainfall
Municipal Groundwater Use [Mm3/a]
0.1 -1.0
1.0 - 4.0
> 4.0
Groundwater (GW) Level Monitoring Stations:
GW levels in meters below ground level (mbgl)
0 - 5
5 - 10
10 - 20
20 - 50
> 50
Directorate: Surface & Groundwater Information
ZIMBABWE
BOTSWANA
NAMIBIA
MOZAMBIQUE
SWAZILAND
LESOTHO
ATLANTIC OCEAN
INDIAN OCEAN
MUSINA
POLOKWANE
PRETORIA
JOHANNESBURG
BLOEMFONTEIN
DURBAN
EAST LONDON
PORT ELIZABETH
CAPE TOWN
Rietfontein
Vanzylsrus
Upington
Kimberley
Petrusburg
Hanover
Richmond
Loxton
Beaufort West
A
B
C
17° 18° 19° 20° 21° 22° 23° 24° 25° 26° 27° 28° 29° 30° 31° 32°
22° 23° 24° 25° 26° 27° 28° 29° 30° 31° 32° 33° 34° 35°

APPENDIX G – QUARRY LOCATIONS



LEGEND:

Potential quarry sourses

Existing borrow pits (1:50 000 topographical maps)

forLeeuwberg Wind Power Project
SA Mainstream RP Construction (Pty) Ltd
Potential quarry site

26-10--2016

SMEC South Africa

C1643

PLAN 1