GEOTECHNICAL AND GEOHYDROLOGICAL STUDY REPORT FOR RHODES 2 SOLAR PARK. GCS-RP/07/2016

Report Prepared for Miko Energy (Pty)Ltd

Report Prepared for

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v.01	Prelim report excl lab results	CdB	2015-02-07
v.02	Increase footprint from 201 to 250 ha in v.03	CdB	2015-02-10

Document Sign Off

Carel de Beer

Executive Summary

Miko Energy (Pty) Ltd contracted Geotechnical Consult Services (GCS) to conduct desktop geotechnical and geohydrological assessment for a proposed solar energy generation facility with associated infrastructure and structures on a footprint up to 250ha in extent on the Farm Rhodes 269, Kuruman RD, located in the Joe Morolong Local Municipality, John Taolo Gaetsewe District Municipality, Northern Cape Province

The Rhodes 2 Solar Park is preliminarily planned on he Farm Rhodes 269, directly north of the planned Rhodes 1 Solar Park, developed by Mira Energy. The detvelopment area is located on a plain land facet, 4 km north of Hotazel and 40km north of Kathu

The site is underlain by aeolian sand between 3.5 and 17m thick overlying kalahari clay. Bedrock in the area is in the order of 30m deep. The proposed development area is located on the watershed between D41K and D41L with an annual rainfall of 223mm and a calculated groundwater recharge of 6.83mm. A total of 16 trial pits were profiled and two soil samples collected for analysis during previous studies. The whole study area is underlain by very loose to loose aeolian sand. Settlement and collapsible grain structure is identified as problem soils encountered on the site. Normal strip footing foundations with light reinforcing is recommended for conventional structures. Rammed steel or wooden piled foundations are recommended for PV arrays. Rammed ramming trials is recommended to define the suitable length if the founding structures. The expected excavatability on site is soft to 2.2m. Sidewall collapse do occur in trenches deeper than 1.5m. No shallow groundwater conditions are expected. Mining activities in the area will not have an impact on the design and construction of the proposed solar energy facility. No material suitable as road construction material are available on site.

The geotechnical Risk Classification for the site is A2 due to the potential for collapse of the soil structure under load. For the planned solar park this in not a significant risk.

The whole site is classified as **DEVELOPABLE with minor PRECAUTIONS and is regarded low risk with respect to the intended development of the solar park**.

From a geotechnical perspective the proposed development area is suitable or the proposed development

No boreholes were available on site to collect water samples.

The groundwater quality in the area is has an elevated dissolved salts and will result in scaling on surfaces of the solar panels. The water quality is suitable for domestic use. The shallow aquifer is vulnerable and if groundwater is considered as a source of water for construction and cleaning, the deep fractures rock aquifers should be targeted. Mine dewatering in the area may impact the availability of groundwater over the long run therefore it is

recommended that water for construction and cleaning be sourced from the Vaal Gamagara pipeline.

The water quality of the shallow aquifer is generally hard.

Adequate water supply for the construction and cleaning phases has to be confirmed through a take-off agreement with the relevant water management authorities of the Vaal Gamagara pipeline

To follow on this study, it is recommended that the following be adopted prior to final design and construction:

- A design level geotechnical investigation including a site investigation and report, to define the design parameters for the selected foundation solution.
- Piling trials to determine the required length of piles, given different materials and profiles, suitable for the planned installation.
- Conduct a detailed geohydrological study to define target areas for groundwater abstraction, if water supply from the Vaal Gamagara pipeline is not a viable option.
- Drill and test the target area to ensure that sufficient groundwater is available for the proposed development.

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1. INTRODUCTION

1.1. TERMS OF REFERENCE

Miko Energy (Pty) Ltd contracted Geotechnical Consult Services (GCS) to conduct desktop geotechnical and geohydrological assessment for a proposed solar energy generation facility with associated infrastructure and structures on a footprint up to 250ha in extent on the Farm Rhodes 269, Kuruman RD, located in the Joe Morolong Local Municipality, John Taolo Gaetsewe District Municipality, Northern Cape Province, 7 km North of Hotazel and 50 km North of Kathu

The Rhodes 2 Solar Park is preliminarily planned on the Farm Rhodes 269, directly north of the planned Rhodes 1 Solar Park, developed by Mira Energy and already authorized by the DEA (DEA Ref. 14/12/16/3/3/2/664).

The geotechnical and geohydrological information collected during previous studies for Rhodes 1 and East Solar Projects by GCS are used to define the geotechnical conditions for the proposed Rhodes 2 Solar Energy Facility

This investigation form part of the Environmental Impact Assessment (EIA) Process for the applicant, who wish to establish up to a 100MW photovoltaic solar energy generation facility on the identified 250ha portion of the property.

1.2. SCOPE OF WORK

The scope of work for this project as per Proposal no: GCS/PR/07/2016 for an Environmental Impact Assessment:

- Desktop assessment of soil and rock stratigraphy on the site
- Confirmation of soil and rock stratigraphy on site
- Evaluate the geotechnical land use and recommend the land use potential of the property at a scoping level Environmental Impact Assessment (EIA).
- Identification of geohydrological conditions on the site
- Identification of groundwater impacts
- Assess the groundwater quality
- Propose a groundwater management plan

1.3. LIMITATIONS

The information provided in this specialist report is based on information provided by the applicant and or the applicant's representatives, published scientific literature, maps, and information published in the public domain and that collected by Geotechnical Consult Services during the site visit in MARCH 2014.

1.4. AUTHOR'S CREDENTIALS AND &DECLARATION OF INDEPENDENCE

The Author of this report Carel J de Beer is a professional engineering geologist, registered with the South African Council of Natural and Scientific Professions (Pri. Sci. Nat # 400211/05). Carel has 19 years' experience in the mining and civil industries and is a member if the South African institute of Rock Engineers.

The compilation of the report, and any other work done by Geotechnical Consult Services (GCS) for the Applicant Company, is strictly in return for professional fees. Payment for the work is not in any way dependent neither on the outcome of the work, nor on the success or otherwise of the Company's own business dealings. As such there is no conflict of interest in GCS undertaking the study as contained in this document.

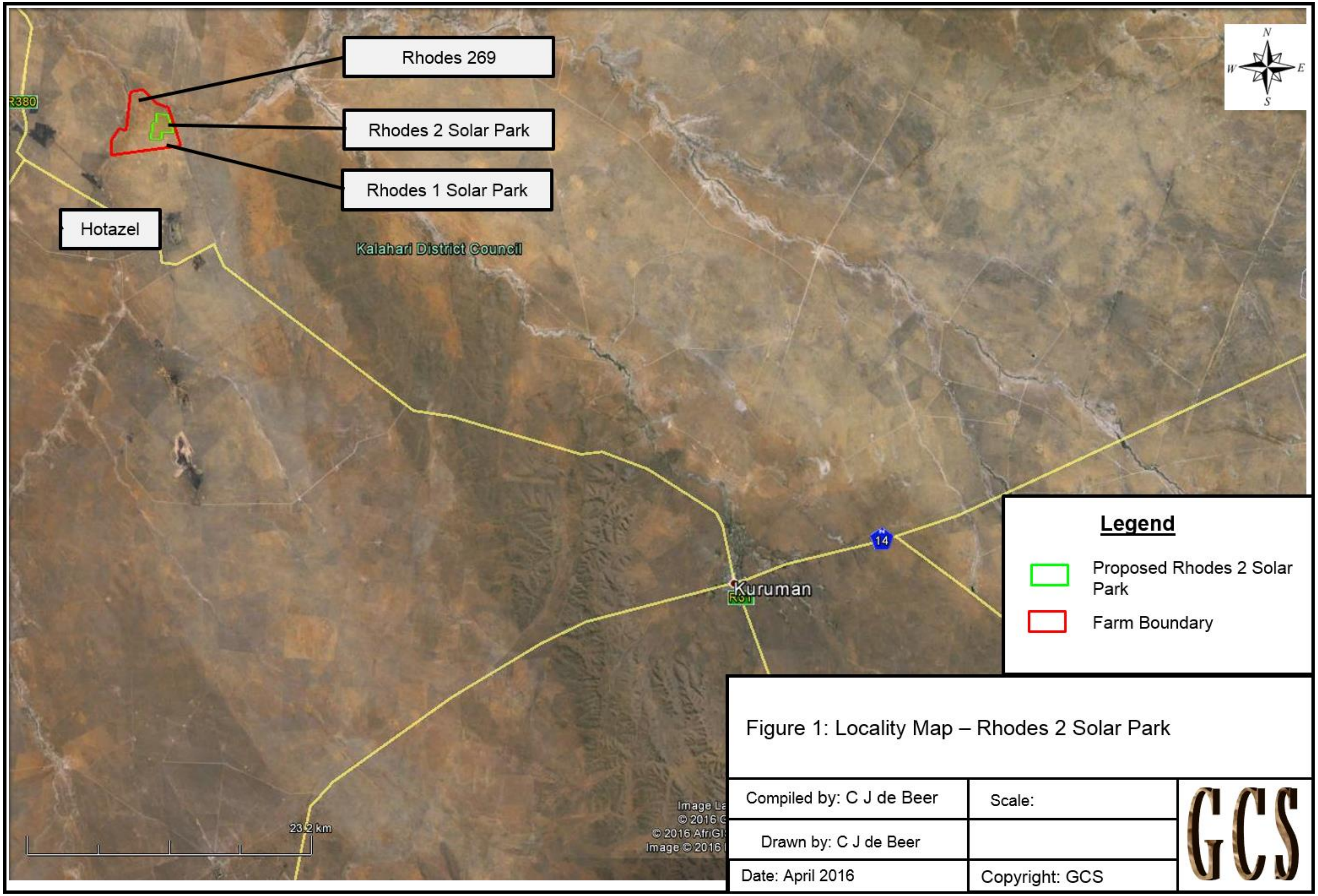

Figure 1: Locality Map – Rhodes 2 Solar Park

2. SITE INFORMATION

2.1. LOCATION

Miko Energy (Pty) Ltd is proposing the development of a renewable solar energy facility in a key strategic location in terms of the connection to the Eskom grid and in terms of the favorable solar irradiation. The proposed site is the Farm Rhodes 269 Kuruman RD is located 7 km North of Hotazel and 50 km North of Kathu. (Figure 1).

The proposed Rhodes 2 Solar Park is located close to the following mines:

- 1.5 km east from the Assmang mine on Portion 1 of the Farm Gloria 266;
- 8 km south-east from the Assmang mine on Farm N' Chwaning 267;
- 4.0 km north from the Hotazel mine, on the Farm Hotazel 280;
- 6 km north-east from the Kalagadi Manganese mine, under construction on Farm Umtu 281 and Olive Pan 282.

Access to the Rhodes 2 Solar Park will be from a secondary road from R31. Two new on-site access roads, 8.0 m wide) and 235 m long (Rhodes 2) are envisaged.

The proposed 100MW Photovoltaic (PV) Power Plant will have footprint of up to 250 hectares.

a) to the Eskom Hotazel distribution substation, 8 km south of the project site, or
b) to the Eskom Umtu distribution substation / planned Eskom Hotazel transmission substation, 4 km south-west of the project site, via a new 132 kV power line approximately 11 km long.

2.2. CLIMATE

Hotazel (the closest town with climatic record, 7 km south of the site) is a summer rainfall area and has an average rainfall of about 223mm per year. Minimum rainfall of 0mm is in June and the maximum rainfall of 50mm is in February. The average daily maximum temperature is 33.2°C during summer and 19.1°C in winter. The coldest temperature occurs during July with an average night temperature of 1°C.

The Weinert climatic N-number for the area is 9. This indicates that the climate is semi-arid and that physical mineral grain disintegration is the predominant mode of weathering.

2.3. TOPOGRAPHY AND DRAINAGE

The study area is underlain by a plain land facet with a gentle undulating to flat topography with a gradient of 1.3%. The average elevation of the study area is 1049 mamsl with the lowest point 1045 mamsl and the highest point 1052 mamsl (figure 2).

The permeability of the sand is high and all but the heaviest rainfall penetrate the soil immediately. Sheet wash does occur along preferred pathways but the water sink into the ground after some distance. No Pans or wetland areas were identified on site. Sub surface drainage is expected to occur towards the Gamagara River.

Figure 2: Topography – Rhodes 2 Solar Park

Legend	Compiled by: C J de Beer	Scale:	GCS
Study Area	Drawn by: C J de Beer		
Section line	Date: April 2016	Copyright: GCS	

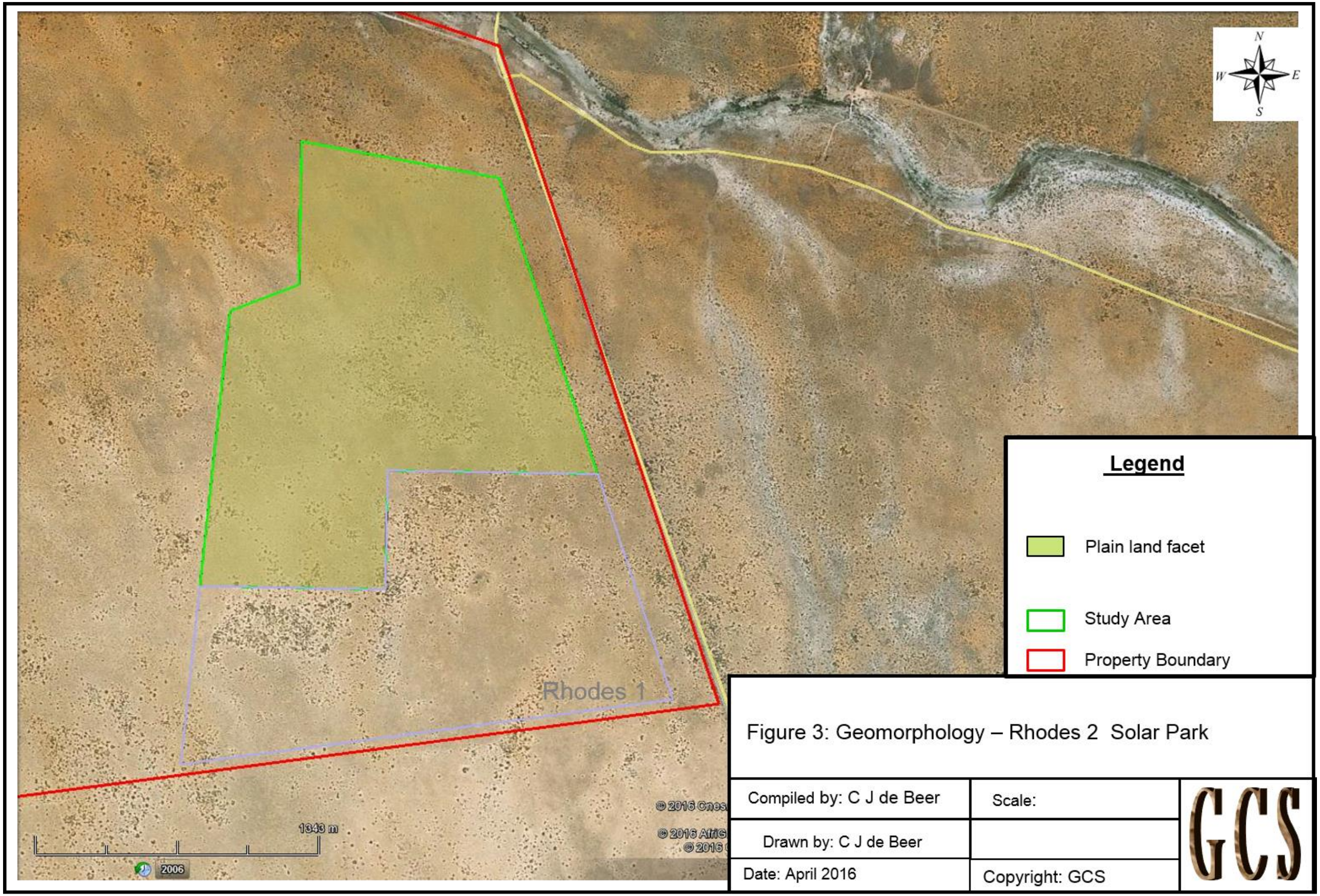

Figure 3: Geomorphology – Rhodes 2 Solar Park

2.4. REGIONAL GEOLOGY

The site is underlain by unconsolidated recent aeolian sand of the Kalahari Formation (Qs) (figure 3). The unconsolidated recent deposits varies in thickness of as little as 3m to over 17m thick overlying calcrete and clay. Competent bedrock occur at depths of 21m to 37m.

PHOTO 1: KALAHARI SAND

2.5. ENGINEERING GEOLOGY

Any geotechnical investigation carried out in areas occupied by aeolian sand deposits should make the initial assumption that the soil have a collapsible fabric. A collapsible fabric is normally associated with an open textured, low density, soil with individual grains being separated by a bridging material. The bridging material in either clay (predominantly kaolinite) or iron oxides calcium and other salts. Double oedometer or modified single oedometer test are the most widely used laboratory tests to determine the modulus of compressibility. In the field, plate bearing tests are successful where-as cone penetration test are known to grossly overestimate the allowable bearing pressure owing to the high resistance to probing in these soils.

In a partially saturated condition the aeolian sands have a relatively high sear strength because of the apparent cohesion imparted to the soil by pore water suctions. In the presence of a collapsible fabric an instantaneous decrease in in shear strength occurs when

the soil is saturated. Thus in conditions where the soil can be saturated under load, design should be carried out for conditions of zero cohesion and an effective angle of internal friction of between 31 and 36 degrees.
Studies indicate that when the plasticity of the aeolian sands are low and very little fines exist in the soil CBR values of up to 30 can be obtained. With an increase in plasticity the strength of the sand was found to drop significantly to a CBR of ~5.
Even relatively lightly loaded structures such as single storey buildings and light steel framed structures may be subjected to excessive settlement as a result of collapse occurring in the founding soil. As collapse settlement mat take place e=years after construction buildings may show no sign of deformation until large settlements suddenly takes place following the triggering mechanism of water penetrating into the foundation soils. As collapse settlement may be localised- it can be the result of leaking pipes next to the foundation.
Piling in general is considered a good foundation solution for soils with a collapsible character. In loose, low density soils the use of driven piles have the added benefit that compaction of the soil surrounding the pile is achieved during installation.

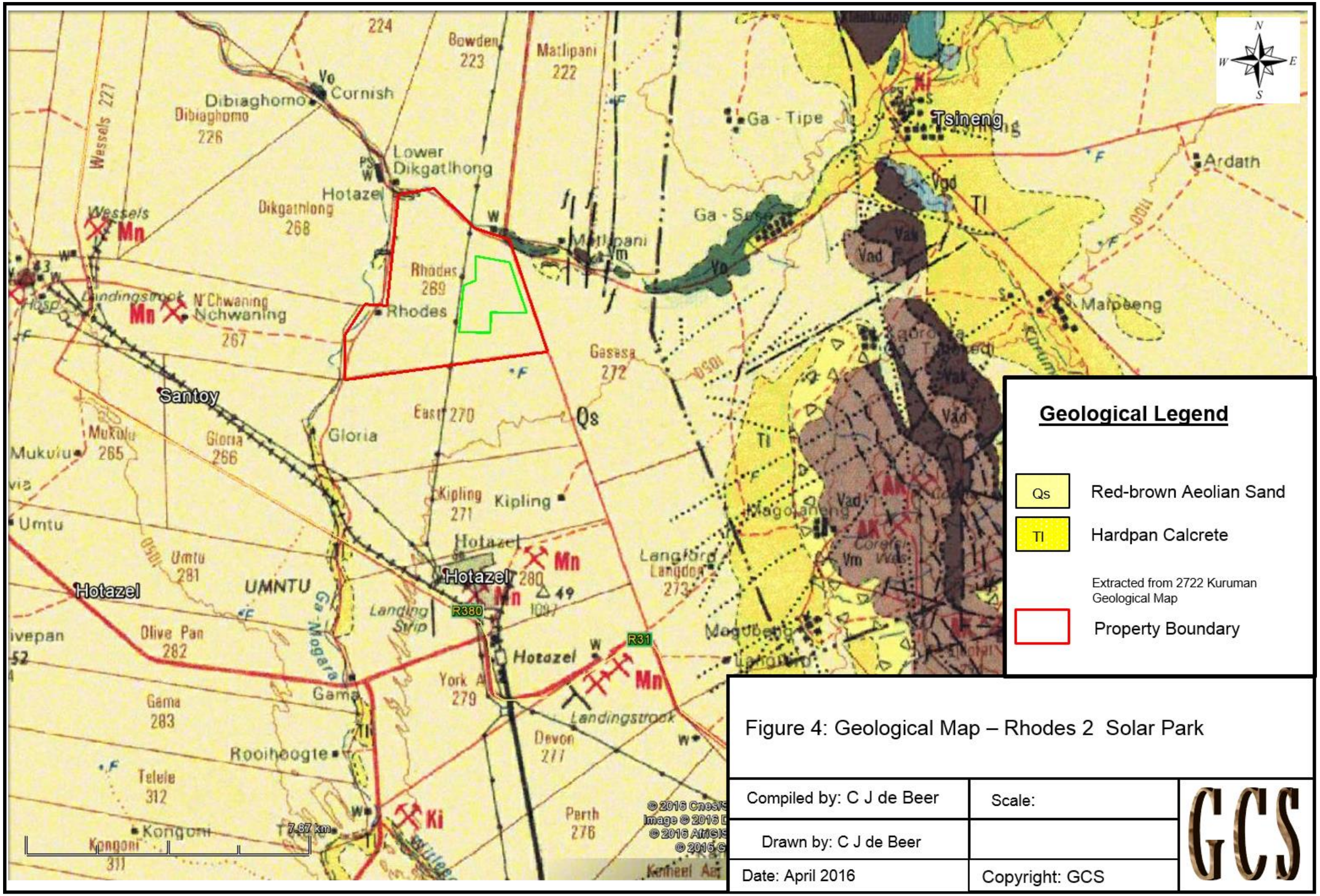

Figure 4: Geological Map – Rhodes 2 Solar Park

Compiled by: C J de Beer	Scale:
Drawn by: C J de Beer	
Date: April 2016	Copyright: GCS

GCS

2.6. GEOHYDROLOGY AND SURFACE RUN-OFF

The site is straddling the boundary between quaternary catchment D41K and D41L. The quaternary catchments fall within the Eastern Kalahari Groundwater region. The recorded mean annual precipitation is 223 mm per annum, with an annual run-off of 1 mm. The groundwater recharge is 6.83 mm per year and the groundwater level of the area is 30m below surface. The Eco status is category B for both quaternaries.

The development area is underlain by recent unconsolidated sand that forma perched primary aquifer above the calcrete clay contact. At depth the primary aquifer occurs in the fractured rock network within the sedimentary layers of the Hotazel formation.

No large scale abstraction of groundwater occur east of the Gamagara River. Open cast mining at the Gloria Manganese mine result in local dewatering west of the river. The existing borehole on the farm is not operational All the water used on the farm is taken from the Vaal Gamagara pipeline.

TABLE 1: QUATERNARY STATISTICS

Quaternary	**Units**	**D41K**	**D41L**
Area	Km^2	4212.7	5374.7
Mean Annual Rainfall	mm/a	344	391
Mean Annual Run-off	mm/a	1	2
No Flow	%	56	52
Base Flow	mm/a	0	0
Recharge	mm/a/ha	6.38	11.07
General Authorization	m^3/ha/a	0	45
Population	persons	7907	112408
Eco Status		A	B
Current use	Mm^3/a	1.06	3.99
Exploitation Potential	Mm^3/a	10	83

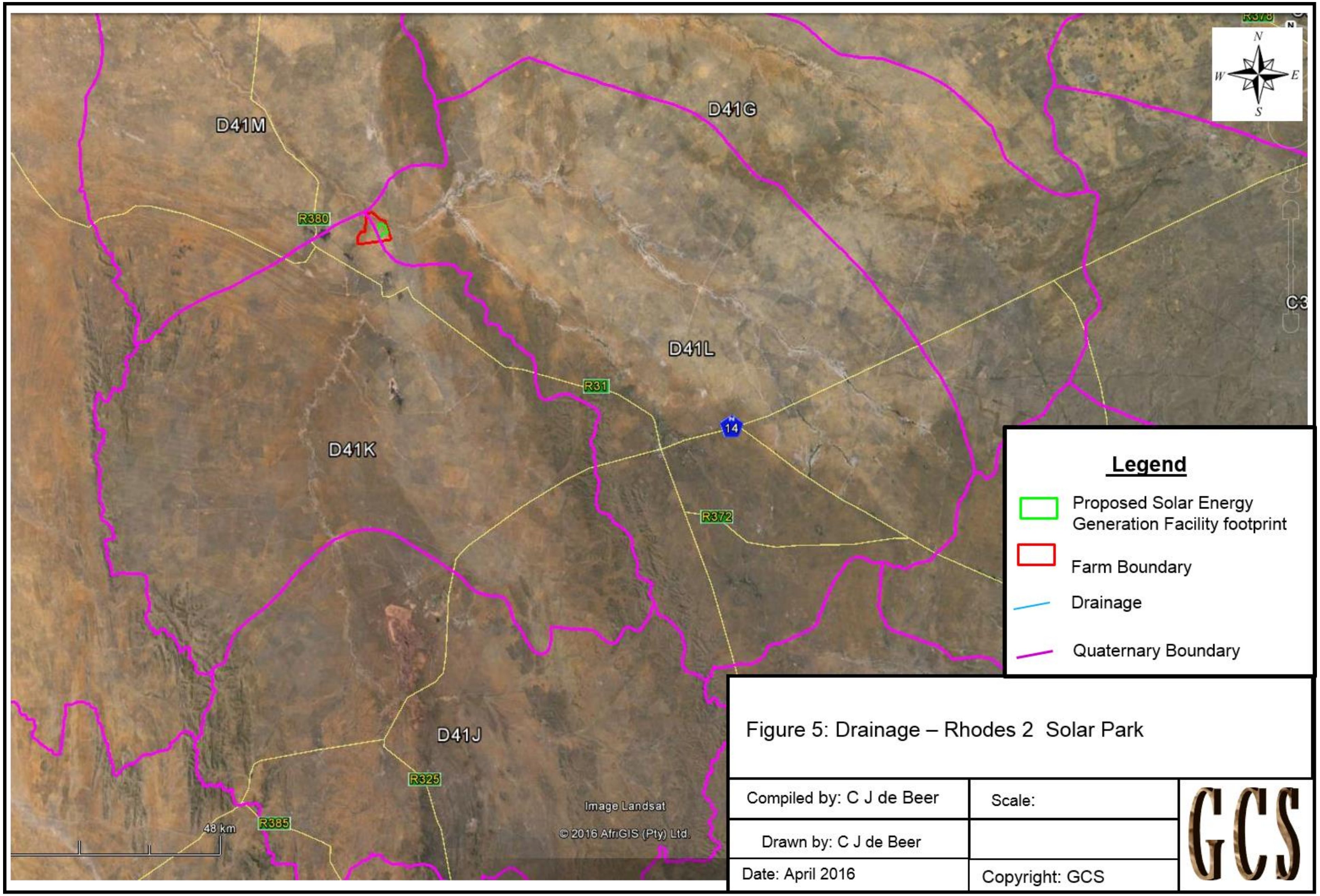

Figure 5: Drainage – Rhodes 2 Solar Park

Compiled by: C J de Beer	Scale:	GCS
Drawn by: C J de Beer		
Date: April 2016	Copyright: GCS	

2.7. SEISMIC HAZARD

The Southern African region is known for its relative seismic stability. Only a small number of medium-intensity earthquakes have occurred since the 17th century.

On the other hand, between 40 and 60 tremors occur monthly, which occur primarily in the gold mining areas of Gauteng, North West and the Free State. Although the effects of these events are much less serious than those caused by larger earthquakes, extensive damage has occurred in one or two cases.

The seismically active areas in South Africa are broadly divided into two groups in SABS 0160 (1989), namely those where seismic activity is due to natural seismic events (Zone 1 areas), and those where it is predominantly due to mining activity (Zone 2 areas). It has been shown that mine tremors are not likely to produce any significant structural response in buildings with natural vibration frequencies of less than 2 Hz. Stiff structures such as low-rise, load-bearing masonry structures are therefore influenced the most by mining tremors

With reference to the South African National Standards document:

"SANS 10160-4: BASIS OF STRUCTURAL DESIGN AND ACTIONS FOR BUILDINGS AND INDUSTRIAL STRUCTURES — PART 4: SEISMIC ACTIONS AND GENERAL REQUIREMENTS FOR BUILDING"

The SANS 10160-4 document define seismic zones applicable to South Africa Figure 1. Two zones are identified, namely:

a) Zone I: Natural seismic activity and

b) Zone II: Regions of mining-induced and natural seismic activity.

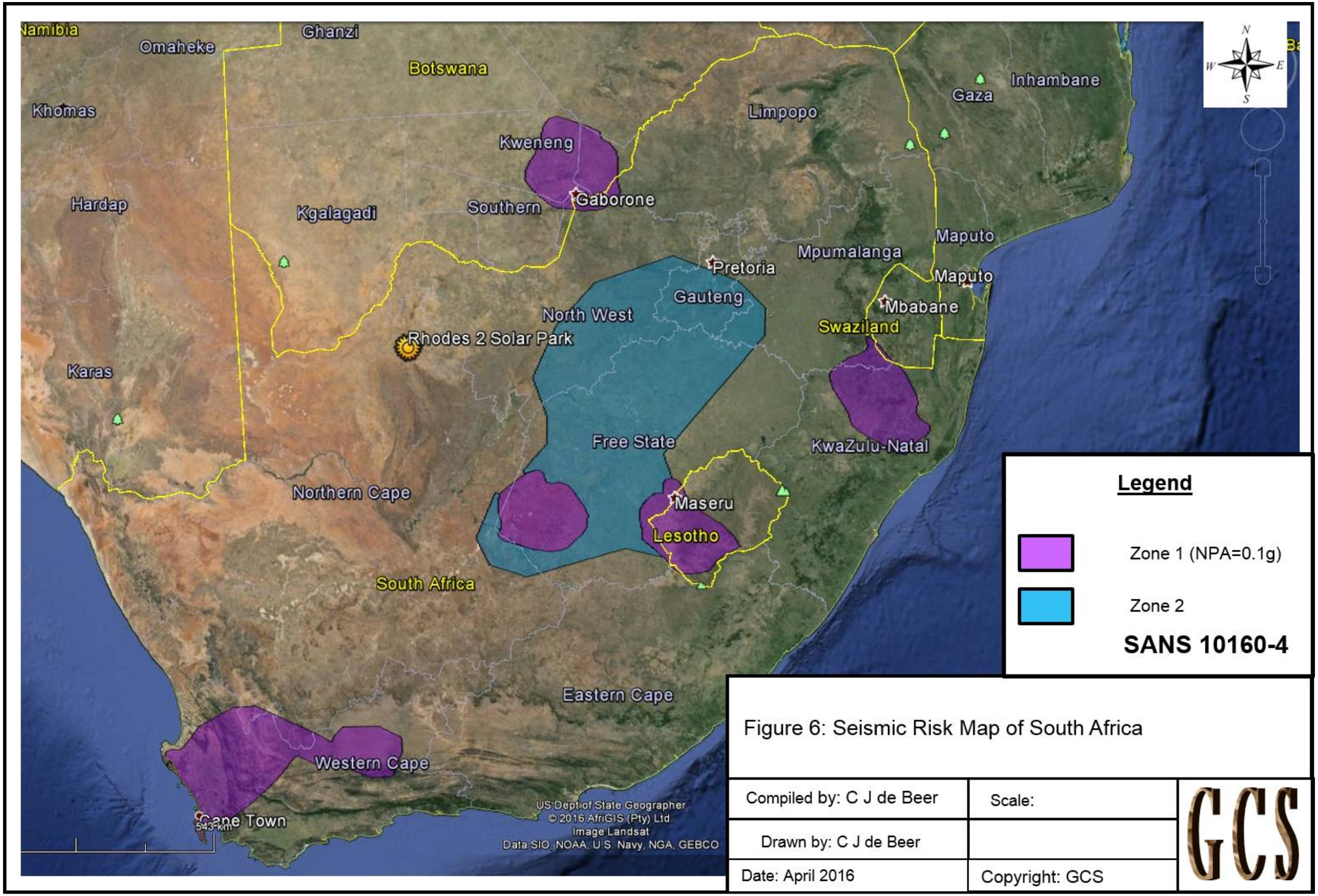

Figure 6: Seismic Risk Map of South Africa

NOTE: The above zones are determined from the seismic hazard map which presents the peak ground acceleration with a 10% probability of being exceeded in a 50-year period. It includes both natural and mining-induced seismicity).

Reference peak ground acceleration is defined for buildings located in Zone 1. Buildings of Importance Class I, II and III (Table 1) in Zone II need only comply with the minimum requirements for structural and non-structural components and with the requirements for ties, continuity and anchorage, all as detailed in clause 9. Buildings of Importance Class IV in Zone II shall be treated as buildings located in Zone 1.

TABLE 2: SEISMIC RISK CLASSES

1	2	3
Importance Class	**Buildings**	**Importance factor ϒi**
I	Buildings of minor importance for public safety, e.g. agricultural buildings, ect.	0.8
II	Ordinary buildings, not belonging to the other categories	1.0
III	Buildings for which seismic resistance are of importance in view of the consequences associated with the collapse, e.g. schools, assembly halls, cultural institutions, ect.	1.2
IV	Buildings for which integrity during earthquakes is of vital importance for protection, e.g. hospitals, fire stations, power plants, ect	1.4
Note: The numbering of importance classes differ from those in the Eurocode where from these definitions were taken.		

The Rhodes 2 Solar Park site is situated outside the risk areas (Zone 1 and Zone 2).Therefore, no provision has to be made for seismic loading in the design of the structures or foundations.

3. DATA COLLECTION

3.1. DESKTOP STUDY

During the desktop study all the available information was collected and used to compile field maps and design the field investigation. A field map was compiled for the fieldwork stage from Google Earth images, site plans, and the 1:250 000 (2822 Kuruman) Geological Map.

Groundwater and quaternary information was collected from the national groundwater database and the Chart program of the Department of Water affairs.

3.2. FIELDWORK

No fieldwork were conducted for this study. All the information presented here was inferred from work conducted by Geotechnical Consult services on surrounding properties. A total of 16 trial pits were excavated and profiled north and west of the site under consideration for the Rhodes 1 and East Solar Projects, as indicated in figure 7, using a Bell 315 SK tractor-loader-back-actor (TLB) with a reach limit of 3.2m.

The different soil horizons encountered in the trial pit was described using the moisture, color, consistency, structure, soil type and origin (MCCSSO classification system), standard descriptors.

Two disturbed soil samples (ED3a and ED4a) were collected from the soil horizons encountered.

A water sample was collected from a borehole on the farm Rhodes.

3.3. LABORATORY TESTING

The following laboratory tests were conducted by Road Lab, a civil engineering materials laboratory in Kimberley, on the two selected disturbed soil samples collected from the trial pits:

- Grading analysis, including hydrometer tests (particle size distribution)
- Determination of Atterberg limits (shrinkage limit, plastic limit and liquid limit)
- Soil pH and electrical conductivity

Results of the above-mentioned tests were interpreted and used to substantiate a description of the site's geotechnical condition.

The water samples were tested at Set Point Laboratories, an SANSAS registered laboratory, according to SANS 241 specification.

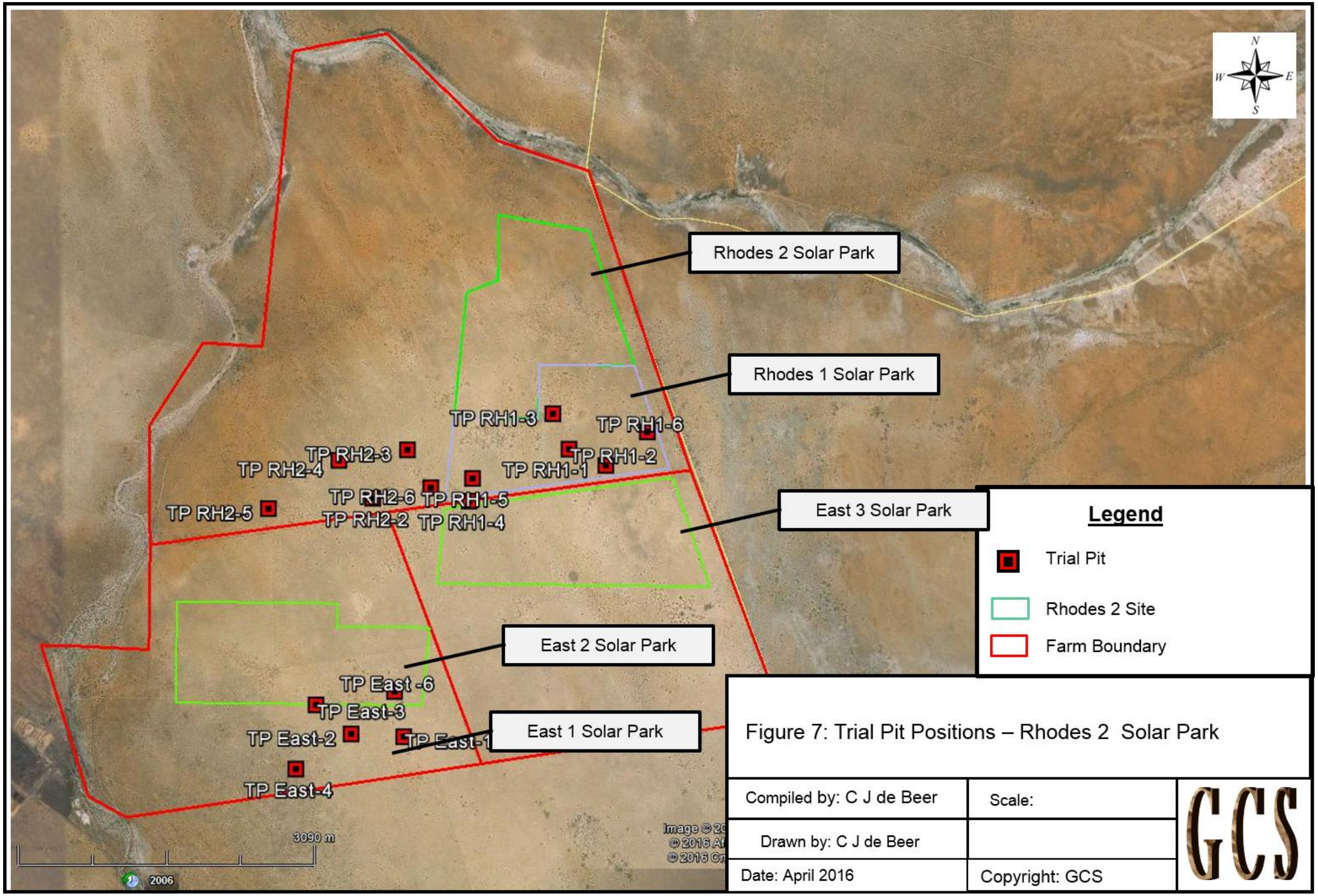

Figure 7: Trial Pit Positions – Rhodes 2 Solar Park

3.4. BOREHOLES ON SITE

There are two boreholes on the property (figure 7). The one borehole is located lose to the homestead , outside the study area and will not be available for the project. The second borehole is located in the south eastern corner of the farm. This borehole is available for the project. The borehole is only 18m deep and equipped with a centrifugal pump. During the site visit the borehole yield was tested by filling a 20 litre drum twice at 30 minute intervals while the pump was running. The container was filled within 75 s and 85 s respectively. The owner of the farm indicated that the borehole can only be pumped for 3 hours / day otherwise the pump runs dry. At the time the owner used the borehole as a source of water for game and cattle.

3.5. PROPOSED WATER USE

3.5.1. WATER REQUIREMENTS DURING THE CONSTRUCTION PHASE OF THE PROJECT

The construction phase will last maximum 15 months.

A) Construction of internal gravel roads

- Water is necessary for the construction of internal gravel roads, in order to get the gravel compacted to optimum moisture content (OMC).
- The surface of internal gravel roads will be approximately 100,000m^2.
- 50 liters of water / m^2 of internal of roads will be required.

B) Workers

- Approximately 100 people are expected to be employed during the construction period, although this number can increase to 200 for short periods of time during peak construction periods.
- Each worker needs 30 litres / 8 working hours for sanitary use.
- Water consumption will be:
  - 100 people x 30 l/person x 330 working days = 990 m^3 over 15 months,

C) Concrete production

- Concrete is necessary for the basements of the medium-voltage stations, the high-voltage loop-in loop-out substation, the control building and the warehouse and for the foundations of the mounting systems. The overall amount of concrete to be produced will be of approximately 10,000 m^3
- 200 litres of water are needed for 1 cubic meter of concrete.

D) Vehicle cleaning

As mitigation measure, the cleaning of vehicles like excavators, mechanical diggers and pile rammers will be done once or twice per month and no during working days, also in order to not increase the water requirement during the construction activities.

Furthermore, in order not to waste a large amount of water, high pressure cleaners will be used.

On the whole, the water requirement for cleaning activity is very low.

The overall and average water consumption during construction is detailed in the following table.

TABLE 3: WATER CONSUMPTION DURING THE CONSTRUCTION PHASE OF THE PROJECT

WATER REQUIREMENT DURING THE CONSTRUCTION PHASE		
DESCRIPTION	**UNIT**	**TOTAL**
Timeframe of the construction activities	*months*	15
Timeframe of the construction activities	*days*	450
Timeframe of the construction activities	*working days*	330
Overall water consumption for internal roads	m^3	8220
Overall water consumption for sanitary use	m^3	2640
Overall water consumption for concrete production	m^3	4800
Overall water consumption	m^3	**15 660**

Over the 15 month period the average daily water requirement for the project will be 34.8m^3/day. Storage tanks will be sized in order to provide a reserve of water of approximately 200 cubic meters.

3.5.2. WATER REQUIREMENTS DURING THE OPERATIONAL PHASE OF THE PROJECT

During operation, water is only required for the operational team on site (sanitary use), as well as for the cleaning of the solar panels.
Further water consumption may be only for routine washing of vehicles and other similar uses.

3.5.2.1. WATER FOR SANITARY USE

Approximately 35/40 people will be employed during the operation phase of the PV power plant, which will have a lifetime of 25 - 30 years.
The Eenduin Solar Park will be in operation 7 days per week; therefore personnel will operate according to shifts. The surveillance team will be present during day-time, night-time and weekends. The average number of people working at the site on the same time will be of 14 people daytime and 6 people at night.

The average daily water consumption for sanitary use is estimated to be 60 litres / day / person per 20 people (14 people daytime and 6 people at night). The daily water consumption will be approximately 1,200 litres/day.

3.5.2.2. WATER CONSUMPTION TO CLEAN THE PV MODULES

The cleaning activities of the solar panels will take place twice a year.

It is assumed that up to 1.0 liters per m^2 of PV panel surface will be needed.
Therefore, the amount of water for cleaning is up to 850 m^3 per cleaning cycle and 2,550 m^3 per year.

PV modules cleaning activity can last less than 1 month. If the cleaning activity lasts approximately 2 weeks (12 working days), the daily water consumption will be approximately 71,000 liters/day, over 12 days.

3.5.3. Overall water consumption during operation

The daily water requirement will be approximately 1,200 liters/day over 12 months for sanitary use (i.e. 36,000 l/month and 438 m^3/year).

The water consumption will increase up to 72,200liters/day during the cleaning of the solar modules (71,000liters/day for cleaning activity and 1,200 for sanitary use), which will last less than a month and will occur three times per year during the dry period. Indeed PV modules are perceived as self-cleaning with the rain.

It is further proposed that 90,000 litres of water will be stored in storage tanks for fire, emergency and washing of panels three times a year.

The overall and average water consumption during operation is detailed in the table 3 below.

TABLE 4: WATER CONSUMPTION DURING THE OPERATIONAL PHASE OF THE PROJECT

WATER REQUIREMENT DURING THE OPERATIONAL PHASE		
DESCRIPTION	**UNIT**	**TOTAL**
Average daily water consumption for sanitary use	*l/day*	4,350
Average daily water consumption during cleaning activity (*)	*l/day*	110,000
Annual water consumption for sanitary use	***m^3/year***	**1574.7**
Annual water consumption for PV modules cleaning activities (twice/year)	***m^3/year***	**2640**
ANNUAL WATER CONSUMPTION DURING OPERATION	***m^3/year***	**4214.7**
DAILY WATER CONSUMPTION DURING OPERATION (average over 365 day)	***m^3/day***	**11.55**
Equivalent water flow over 365 days	***l/s***	**0.134**

(*) over 22 working days, twice per year

The water requirement of the Rhodes 2 Solar Park amounts to 7990 m^3 during the construction phase, and 4.214.7 m^3/year during the operational phase (approximately 25 years).

For sanitary use 4 800l/day is required. During the cleaning cycle 110 000/day is required for three 12 days cycles per year.

3.6. WULA CLASSIFICATION

The estimated annual groundwater recharge (6.83 mm/m^2 per annum) from an average annual precipitation of 250mm falling on 964.27ha will result in 58,500m^3 of water available. The maximum annual water requirement for the project is 4214.7 m^3 per year. The scale of abstraction relative to recharge is 7.2%. (Table 4)

TABLE 5: WULA CLASSIFICATION

Size of property (ha)	964.27
Recharge (m^3/a)	65 859.64
Existing Abstraction	0
Proposed Abstraction (m^3/a	4214.7
Total Planned Abstraction (m^3)	4214.7
Scale of Abstraction	7.2 % Category A

For abstraction less than 60% of recharge a Category A level of assessment is required for the project under consideration. The WULA (Water Use License Application) calculation only assists the applicant in the determination of the level of assessment to be conducted and do not represent the groundwater available for abstraction.

The following minimum elements are required for successful application of a Water use license.

- Delineate resource units (default quaternary, unless geologically different)
- Delineate response units (same as resource unless existing information shows otherwise)
- Drainage (rivers and gauging stations in the resource unit area)
- Climate (average rainfall, reference source)
- Vegter regions (hydrological regions and recharge)
- Geo-hydrology – water quality, water levels, aquifer tests, main fracture zones – storage, sustainable yield, assurance of supply
- Aquifer status: Local expert consideration (reference source), natural /impacted (mapping these areas in the resource unit), importance (both socio-economic and strategic), vulnerability, dependent ecosystems, total current use, classification (Parsons and current resource classification system).
- Licensing conditions – water level, water quality, level of acceptable degradation?
- Monitoring requirements - according to the Category.
- Site visit necessary to validate all info - regional and applicant,

and specifically for a **Category A** application:

- Volume and purpose of the water required.
- Detail borehole census on the property in question. Information to be collected should include pump depth / borehole depth, depth to water-level, yield of the borehole, volume abstracted (daily, weekly, and monthly).
- Proximity to surface water discharges (springs, seeps, wetlands streams, rivers, lakes) and groundwater dependent ecosystems.
- Geo-referenced map of the property in question, with boreholes, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/diesel tanks, irrigation areas) depicted.
- Monitoring program - monthly water levels, monthly rainfall.

4. SITE INVESTIGATION RESULTS

4.1. SOIL PROFILES

The proposed solar park is underlain by aeolian sand of the Kalahari Formation. See appendix 1 for the soil profiles encountered in the trial pits around the site (see figure 9):

- Profile 1, Aeolian Sand

4.1.1. PROFILE 1: AEOLIAN SAND

The soil profile underlain by dry to slightly moist, loose, uniform pale orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin with grass roots, overlying slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. The sidewalls of the trial pits collapsed due to the loose consistent of the soil. No perched water table was encountered. The TLB excavated the soil with ease to reach limit (Table 5 and Photo 2).

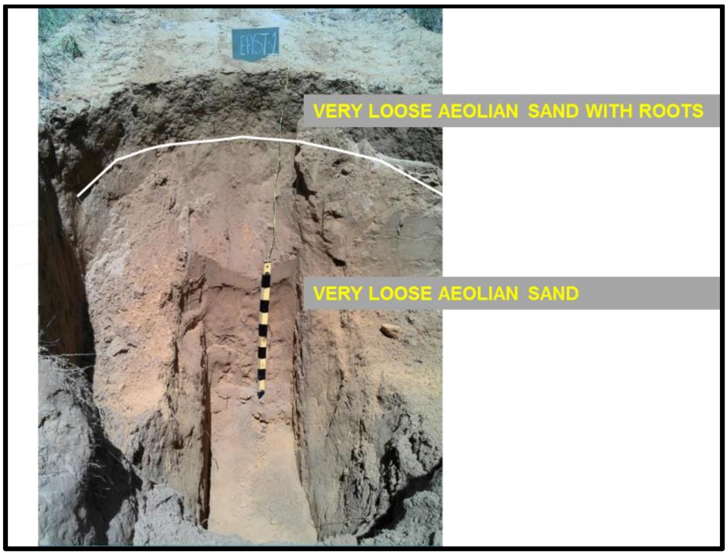

PHOTO 2: AEOLIAN SAND PROFILE

TABLE 6: PROFILE 1 CALCRETE AND CHARNOCKITE PROFILE

Soil Profile Description			
	Profile	**Depth to**	**Description**
		0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
		3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
			EOH @ 3.2m. No Refusal. Reach limit

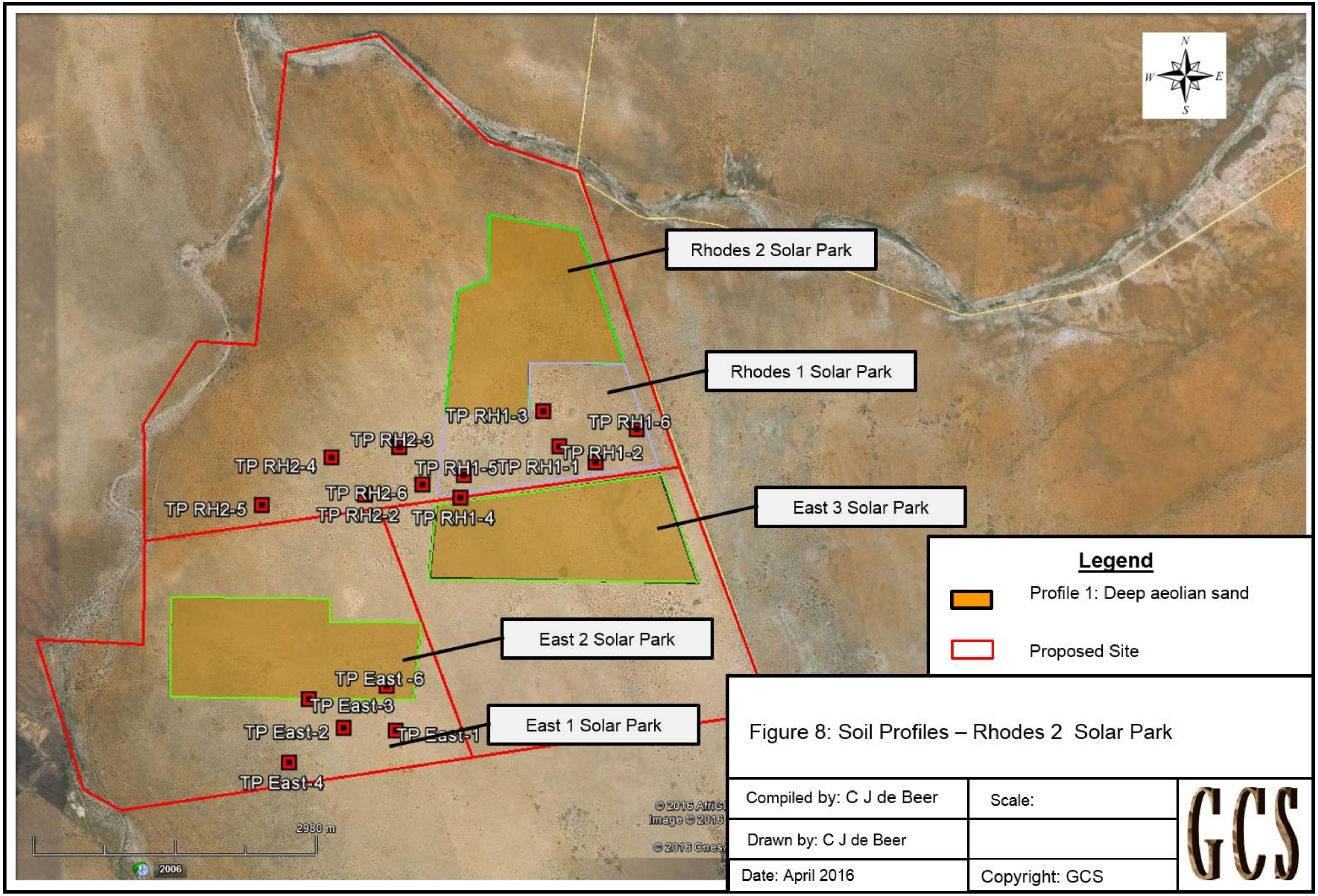

Figure 8: Soil Profiles – Rhodes 2 Solar Park

4.2. RESULTS OF THE LABORATORY TESTING

The results of the laboratory testing conducted on the two soil samples are summarized in table 9 below. The laboratory results are presented in Appendix 2.

The aeolian soil is non plastic and consist of a 55% fine sand and 45% silt mixture. The soil has a moderate to high collapse potential.

26

TABLE 7: SUMMARY OF LABORATORY RESULTS

Sample nr	Sample Point	Depth (m)	Indicator tests				Material Type[1]	Soil Settlement Potential	pH	Conductivity (mS/m	Soil Collapsibility	Soil Permeability ($cm.s^{-1}$)
			Clay %	Atterberg Limits								
				LL	PI	L S(%)						
EA-2a	EA-2	1.5	0	-	np	-	light yellow quartzitic sand	Med	5.15	3.77	low	$3x10^2$
EA-6a	EA-6	1.3	0	-	np	-	light yellow quartzitic sand	Med	-	-	low	$3x10^2$

1 [1]According to the Revised Standard on the Unified Soil Classification System

2 [2]Calculated using Van der Merwe's method

[3]Evaluated after comparison with typical soil grading curves (Knight, 1961 and Errera, 1977)

3

4.3. WATER QUALITY

The laboratory test results are presented in Appendix 3 and are summarized below in table 7.

The water sample collected from the borehole pump has elevated chloride, nitrate, selenium and sodium levels that support the high TDS count and conductivity (refer to table 8). According to the SANS 241 drinking water standards the raw water is not suitable for human consumption.

The drinking water should be treated by osmosis prior to consumption. The high salt load will also make the water unusable for cleaning the solar panels as using the water will cause scale build-up on the panel surfaces.

It is recommended that a new borehole targeting the fractured rock aquifer be used to supply water for the project as the water quality will be better. Alternatively water can be sourced from the Vaal Gamagara Pipeline.

TABLE 8: SUMMARY OF GROUNDWATER CHEMISTRY TEST RESULTS

	Method no	Unit of measurement	SANS 241:2006 Standard – Operational limit	Eenduin Canal
Micro Biological parameters				
Bacteria		Colonies/1ml		-
Coliforms		Colonies/100ml		-
E.coli		Colonies/100ml		-
Chemical properties and parameters				
pH	M460	value @ 25^{0}C	5.0-9.5	8.1
Conductivity	M461	mS/m @ 25^{0}C	<150	159
Total Dissolved Solids	#	mg/L	<1000	937
Turbidity	#	NTU	<1	0.6
Colour		Hazen Units	<20	1
Ammonia Nitrogen	M464	mg/L N	<1.0	<0.1
Nitrate & Nitrate Nitrogen	M467	mg/L N	<10	16.3
Chloride	M469	mg/L Cl^-	<200	283
Fluoride	M475	mg/L F^-	<1.0	0.30
Sulphate	M476	mg/L $SO4^=$	<400	150
Calcium	M474	mg/L Ca	<150	68.8
Magnesium		mg/L Mg	<70	4.12
Potassium		mg/L K	<50	6.38
Sodium		mg/L Na	<200	239
Zinc		mg/L Zn	<5.0	<0.06
Aluminium	M474	mg/L Al	<300	<0.15
Antimony		mg/L Sb	<10	<0.50
Arsenic		mg/L As	<10	4.61
Cadmium		mg/L Cd	<5	<0.10
Total Chromium		mg/L Cr	<100	<3.00
Cobalt		mg/L Co	<500	0.21
Copper		mg/L Cu	<1000	1.29
Iron		mg/L Fe	<200	<0.10
Lead		mg/L Pb	<20	<0.001
Manganese		mg/L Mn	<100	<0.002
Mercury		mg/L Hg	<1	<0.0001
Nickel		mg/L Ni	<20	<0.01
Selenium		mg/L Se	<20	35.3
Uranium		mg/L U	<0.07	-
Vanadium		mg/L V	<200	8.26

5. GEOTECHNICAL SITE EVALUATION

The proposed development may have impacts on the geo-environment which may directly or indirectly affect the other environmental processes. This report focused on the soil and bedrock, but excludes features such as caves, addits, middens worship rocks etc., which are important as historical, cultural, archeological or religious heritage sites. Important or prominent geological features (Geo-sites) that contribute to the aesthetic scenery or geological interest such as fossil sites, prominent rock outcrops or features are also considered in this study. The expected geotechnical impacts and conditions are also presented in this section.

5.1. PROBLEM SOILS

The aeolian sand has a collapsible character being uniformly graded with bridges formed between the sand grains consisting of clay or oxides..

5.2. FOUNDATION SOLUTIONS

For the solar panel structures it is recommended that rammed piles be used as the depth of the loose sand allow sufficient shear resistance to be developed. The type and shape of the material used to manufacture the piles will determine the length of the piles as the material across the site fairly homogeneous. For the other conventional structures on site either normal strip foot foundations with compacted trenches is recommended. The trenches should be wetted during the compaction process. (Figure 9)

Dynamic compaction and impact rolling is recommended for as foundation treatment of roads. Settlements in excess of 100mm can be expected after compaction. The discard material from the nearby manganese mines can be used to construct the road layers.

5.3. EXCAVATABILITY AND INSTALLATION OF SERVICES

Using the COLTO Standard excavatability is classified as hard (boulders larger than $0.1m^3$, blasting or pneumatic and Mechanical rock breaking tools required) or soft (all other conditions) (Figure 10).

For this site the excavatability below surface is classified as soft to at lRhodes 2.5m below surface. Sidewall collapse occurred in all the trial pits excavated. The potential for collapse of side walls of deep excavations is high. It is recommended that the sidewalls of any excavation deeper than 0.8m be battered back to a 1:1.5 grade slope or shored.

5.4. SHALLOW GROUNDWATER

No Shallow groundwater conditions were encountered in any of the trial pits on site.

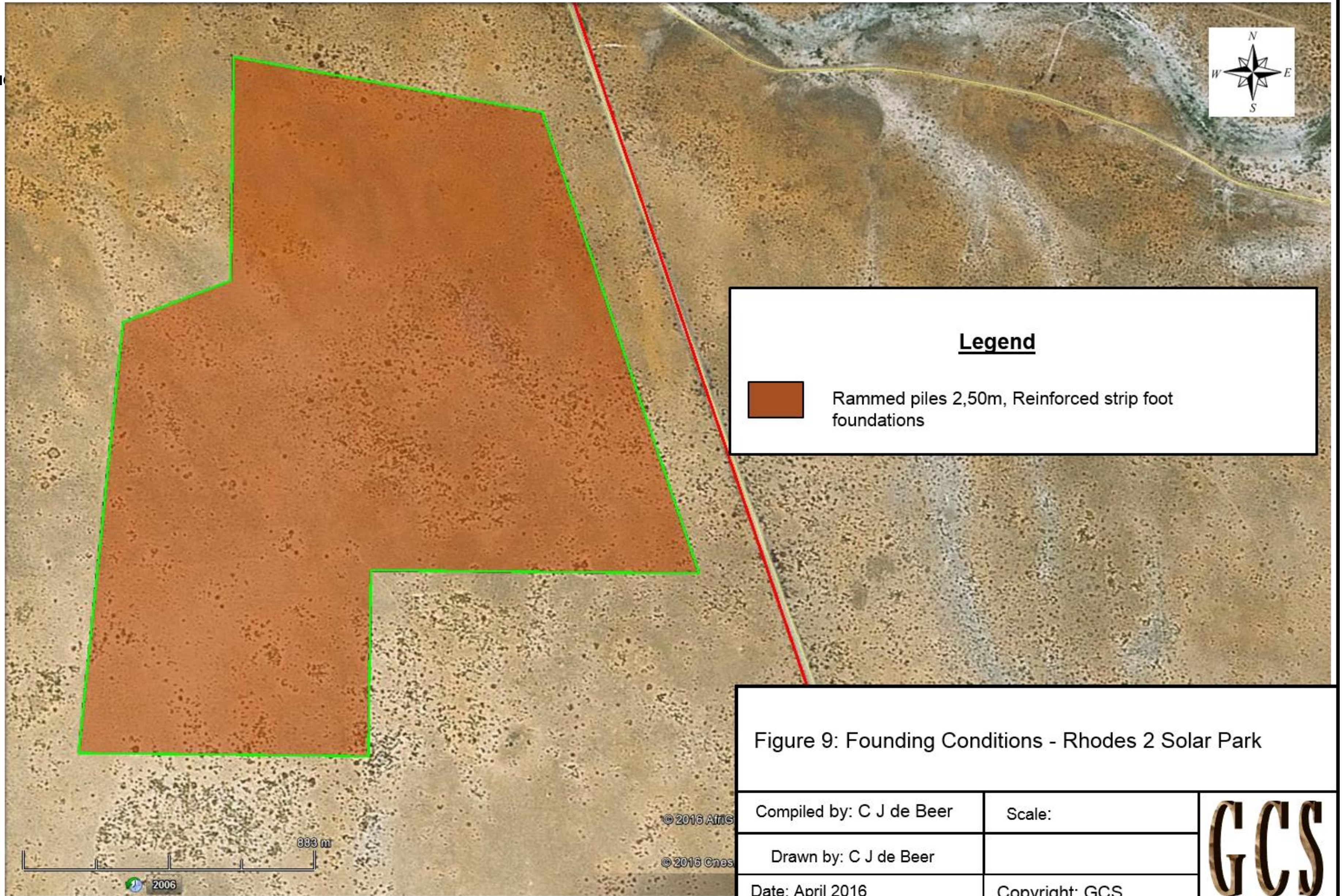

Figure 9: Founding Conditions - Rhodes 2 Solar Park

Compiled by: C J de Beer	Scale:	GCS
Drawn by: C J de Beer		
Date: April 2016	Copyright: GCS	

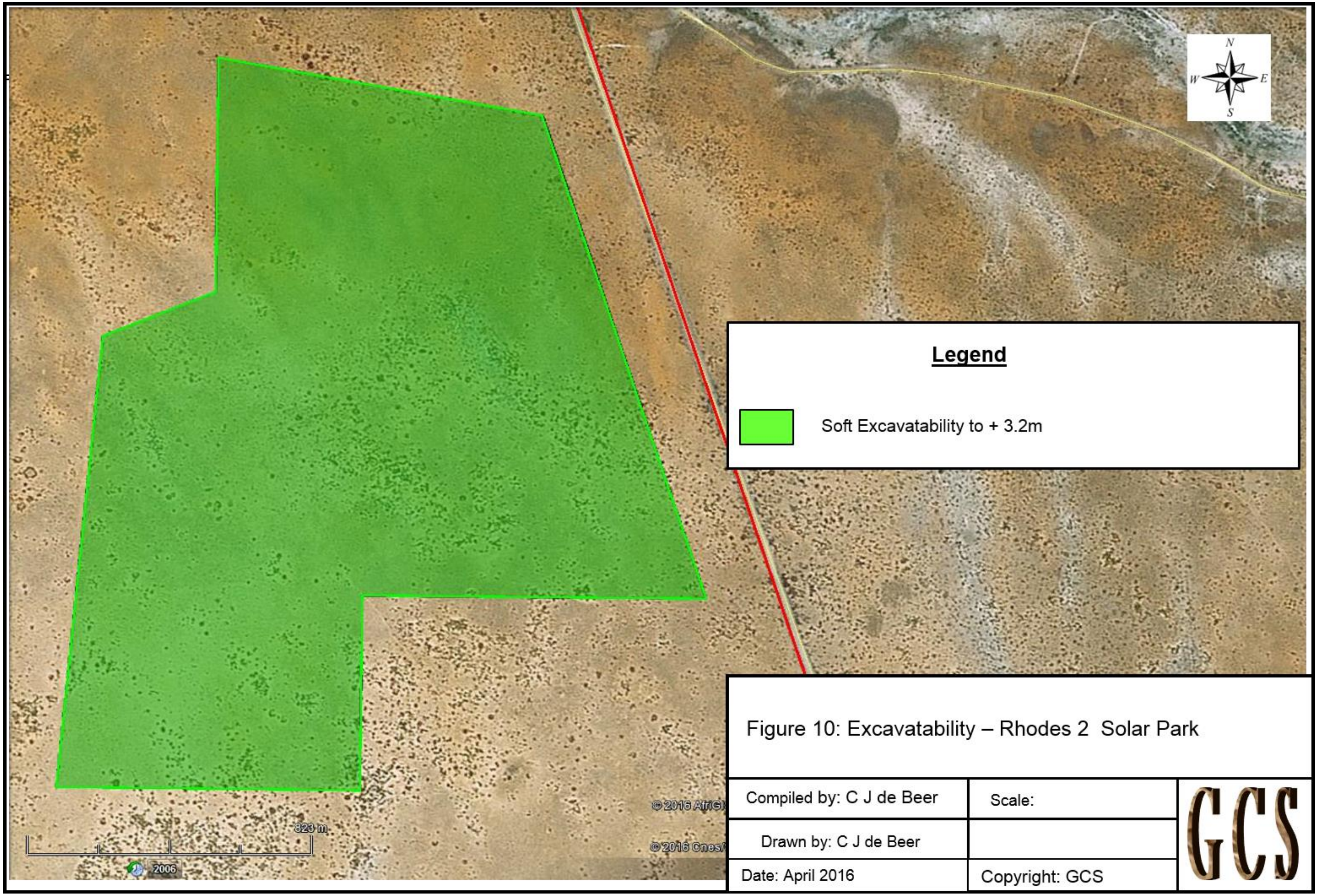

Figure 10: Excavatability – Rhodes 2 Solar Park

5.5. CONSTRUCTION MATERIALS

The soil present on site is not expected to be suitable for use as construction materials.

5.6. MINING

No mining activities (past or present) occurred in the property. Nearby mining activities at the Gloria Manganese Mine is unlikely to impact on the geotechnical aspects of the project.

5.7. GEOTECHNICAL RISK ASSESSMENT

Based on information collected and tests conducted the two option areas is evaluated per soil profile area defined and classified according to the geotechnical classification for urban development proposed by Partridge, Wood and Brink) summarized in table 9 below)

TABLE 9: GEOTECHNICAL RISK CLASSIFICATION

CONSTRAINT		MOST FAVOURABLE (1)	INTERMEDIATE (2)	LEAST FAVOURABLE (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totaling a depth of less than 750 mm in thickness*	Any collapsible horizon or consecutive horizons totaling a depth of more than 750 mm in thickness*	A least favorable situation for this constraint does not occur
B	Seepage	Permanent or perched water table more than 1.5m below ground surface	Permanent or perched water table less than 1.5m below ground surface	Swamps and marches
C	Active Soil	Low soil-heave anticipated*	Moderate soil-heave anticipated	High soil-heave potential anticipated
D	Highly Compressible Soil	Low soil compressibility anticipated*	Moderate soil compressibility anticipated	High soil compressibility anticipated
E	Erodibility of Soil	Low	Intermediate	High
F	Difficult to excavate to 1.5m depth	Scattered or occasional boulders. Less than 10% of volume*	Rock or hardpan pedocretes between 10% and 40% of the total volume	Rock or hardpan pedocretes more than 40% of the total volume
G	Undermined Ground	Undermining at a depth greater than 240m below surface (except where total extraction mining has not occurred	Old undermined areas to a depth of 90 – 240 m below surface where stope closure has ceased	Mining within less than 90-240 m from surface or where total extraction mining has taken place
H	Stability (Dolomite and Limestone	Possibly stable. Areas of dolomite overlain by Karoo rocks or intruded by sills. Areas of Black Reef Rocks. Anticipated Inherent risk class 1	Potentially characterized by instability. Anticipated inherent Risk Classes 2-5	Known sinkholes and dolines in the area. Anticipated Inherent Risk Classes 6-8
I	Steep slopes	Between 2 and 6 degrees	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape) Slopes between 6 and 12 degrees and less than 2 degrees (all other regions)	More than 18 degrees (Natal and Western Cape) More than 12 degrees (all other regions)
J	Areas of unstable natural Slopes	Low Risk	Intermediate risk	High Risk (especially in areas subject to Seismic activity)

K	Areas subject to Seismic Activity	10% probability of an event less than 100 cm/s² within 50 years	Mining induced seismicity more than 100cm/s².	Natural Seismic activity more than 100 cm.s².
L	Areas subjected to flooding	A most favorable situation for this constraint does not occur	Areas adjacent to a known drainage channel or floodplain with a slope of less than 1%	Areas within a known drainage channel or floodplain

*These areas are designated 1A, 1C, 1D or 1F where localized occurrences of the constraint may arise.

Soil profile areas 1 to 4 is classed according to the Geotechnical Land Use Classification and the results is presented in tables 10 to 14 below.

5.7.1. PROFILE 1: AEOLIAN SAND

The geotechnical risk for the development area for the proposed East Solar Park, is classified as Class 2(A2), due to the collapse potential of the deep loose soil.

TABLE 10: GEOTECHNICAL RISK EVALUATION PROFILE 1 AREA

Constraint		Site condition	Class
A	Collapsible soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness	2
B	Seepage	Permanent or perched water table more than 1.5 m below the ground surface	1
C	Active soil	Low soil heave potential anticipated	1
D	Highly Compressible soil	Low soil compressibility anticipated	1
E	Erodibility of soil	Low	1
F	Excavatability to 1.5 m	Rock or hardpan pedocretes between 10% and 40% of the total volume	1
G	Undermined ground	Undermining at a depth greater than 240 m below surface (except where total extraction mining occurred)	1
H	Stability (dolomite and limestone)	No potential for karstification and possibly stable. Including areas of dolomite overlain by Karoo rocks or intruded by sills. Areas of Black Reef rocks (anticipated inherent risk class 1)	1
I	Steep slopes	Slopes are between 2 and 6 degrees	1
J	Unstable Natural Slopes	Low risk	1
K	Seismicity	10% probability of an event less than 100cm/s occurs within 50 years	1
L	Areas subjected to flooding	Potential for flooding is low	1

5.8. LAND USE EVALUATION

5.8.1. LAND USE AREA A

Land Use Area A covers the soil profile 1 and 2 areas and is classified as **DEVELOPABLE with PRECAUTIONS and is regarded low risk with respect to the intended development of the solar park**. The soil profile consists of transported aeolian soil of more than 3m thick. The excavatability is soft with the potential for sidewall collapse in trenches. The recommended foundation solution for tracker based and fixed solar panels is rammed, steel or wooden piles of approximately 2.5m long. For fixed frames, strip foot foundations founded at0.6m is recommended. For conventional structures strip foot foundations founded with light reinforcing is recommended.

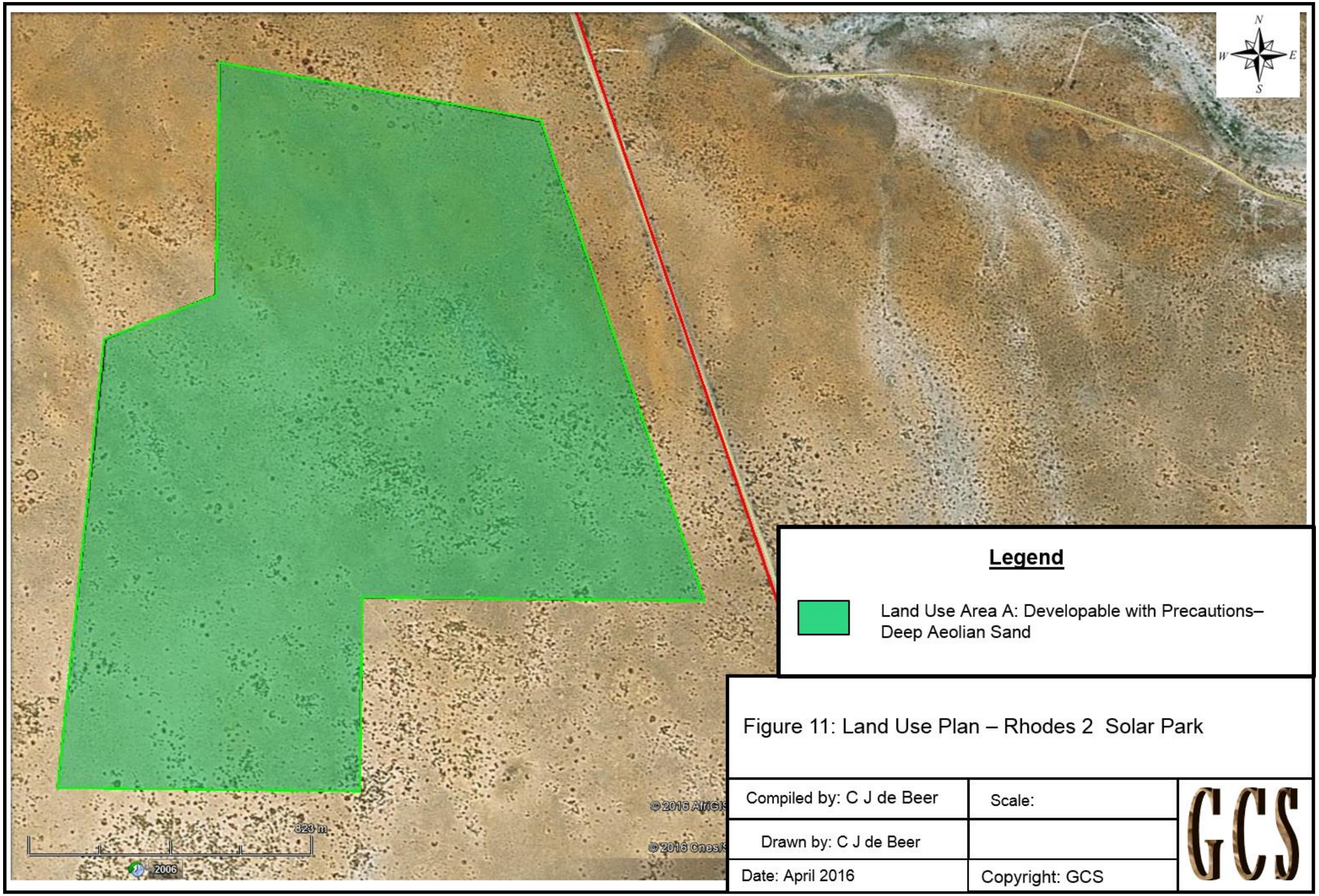

Figure 11: Land Use Plan – Rhodes 2 Solar Park

6. GROUNDWATER EVALUATION

6.1. GROUNDWATER LEVEL

The groundwater level in the area is deeper than 30m as per the National Groundwater Database.

6.2. GROUNDWATER POTENTIAL AND AQUIFER BOUNDARIES

Due to the featureless topography and poor rock exposure, it was difficult to identify aquifer boundaries. The shallow aquifer is capable of 0.1 to 0,3 l/s yield only.

The pump yield was determined at 0.36 l/s (1300 l/h) the borehole con however only sustain that pump rate for 3-4 hours per day. This indicate a maximum daily yield of 4000l/day. The daily water demand for the project (both Rhodes Projects)is 15 320 l/day.

The existing borehole is only capable of supplying 26% of the demand, therefore a new borehole will have to be located. It is recommended that the fracture rock aquifer located below the Kalahari sediments be targeted at depths between 80 and 120 m below surface as a source of water for the project.

The open pit and underground mining will have an effect on the waterlevels in the long term due to the dewatering of the mining areas, therefore deep aquifers, below the mining level should be targeted for a reliable groundwater source. Drilling and abstraction borehole construction will be expensive.

If a take-off agreement with Sedibeng Water can be agreed, using water from the Vaal Gamagara pipeline for the construction phase and cleaning of the panels, will be the preferred option.

6.3. SUSTAINABLE ABSTRACTION

The water needed for both the construction phase (7,990 m3) and the operational phase (2,138m3/year) will be provided from a new borehole to be drilled on site or alternatively from the Vaal Gamagara pipeline.

With the information available at this time it is recommended that the borehole be equipped with a pump that can deliver 3 600 l/hour and that the borehole not be pumped for more than 12 hours per day during the construction phase. Twice a year during the cleaning period the borehole can be pumped for 19 hours per day to yield the required 72 200 l/ day for 12 days to clean the solar panels.

During the operational phase the daily water use is only 1 200 l/day for sanitary use.

6.4. GROUNDWATER MANAGEMENT PLAN

The average water consumption during operation is 4800 l/day. The peak water consumption, over a 12 day period, twice a year is 110 000 l/day for cleaning the solar panels, during the 15 month construction phase the water demand is 15 660 l/day.

The sustainable yield of 3600 l/hour (50% of the indicated average yield) of boreholes in the area is more than sufficient to supply the project with enough water to fulfil all the requirements during the construction period, the high demand cleaning period and general use.

By varying the time the borehole is pumped per day, the total water demand for the project can be catered for. During the construction phase sufficient water can be obtained in 4.35 hours per day, allowing the borehole to recover for 19 hours. During the high demand period, when the solar panels are cleaned the borehole should be pumped for no more than 20 hours per day. During the normal operation, 1 hour 20 minutes of pumping will be sufficient to supply the project with potable water.

Due to water quality constraints the alternative source for water, especially for cleaning the panels, the Vaal Gamagara pipeline is the preferred option.

Groundwater can still be used for potable water and if required a water filtration system can be installed to supply clean drinking water on site.

6.5. GROUNDWATER MONITORING

The water level in the production borehole should be measured once a week before the pump is started. The weekly pump rate from the production borehole is also to be recorded at the same time the water level is measured. The pump rate and water level recorded, has to be filed and presented when renewal application for the water license is submitted. Daily rainfall statistics also has to be recorded.

To conduct the necessary monitoring, a flow meter is to be installed at the borehole. To measure the water level, it is recommended that a 20mm PVC pipe be installed with the pump equipment in the boreholes to allow a dip meter to be lowered into the borehole for measuring the water level. The PVC pipe serves as a sleeve in which the dip meter is lowered into the borehole. It protects the dip meter against getting stuck or tangled in the borehole. The water levels should be measured after recovery and before draw-down start.

7. RECOMMENDATIONS

To follow on this study, it is recommended that the following be adopted prior to final design and construction:

- A design level geotechnical investigation including a site investigation and report, to define the design parameters for the selected foundation solution.
- Conduct a detailed geohydrological study to define target areas for groundwater abstraction if water supply from the Vaal Gamagara pipeline is not a viable option.
- Drill and test the target area to ensure that sufficient groundwater is available for the proposed development.

8. CONCLUSIONS

- The development area on a plain land facet, 4 km north of Hotazel and 40km north of Kathu
- The site is underlain by aeolian sand between 3.5 and 17m thick overlying kalahari clay. Bedrock in the rea is in the order of 30m deep.
- The proposed development area is located on the watershed between D 41 K and D41L with an annual rainfall of 223mm and a calculated groundwater recharge of 6.83mm
- A total of 16 trial pits were profiled and two soil samples collected for analysis during previous studies.
- The whole study area is underlain by very loose to loose aeolian sand
- Settlement and collapsible grain structure is identified as problem soils encountered on the site
- Normal strip footing foundations with light reinforcing is recommended for conventional structures.
- Rammed steel or wooden piled foundations are recommended for PV arrays.
- Rammed ramming trials is recommended to define the suitable length if the founding structures.
- The expected excavatability on site is soft to at lRhodes 2.2m. Sidewall collapse do occur in trenches deeper than 1.5m.
- No shallow groundwater conditions are expected.
- Mining activities in the area will not have a impact on the design and construction of the proposed solar energy facility
- No material suitable as road construction material are available on site.
- The geotechnical Risk Classification for the site is A2 due to the potential for collapse of the soil structure under load. For the planned solar park this in not a significant risk.
- The whole site is classified as **DEVELOPABLE with minor PRECAUTIONS and is regarded low risk with respect to the intended development of the solar park**.

- **From a geotechnical perspective the proposed development area is suitable for the proposed development**
- No boreholes were available on site to collect water samples.
- The groundwater quality in the area is has an elevated dissolved salts and will result in scaling on surfaces of the solar panels. The water quality is suitable for domestic use. The shallow aquifer is vulnerable and if groundwater is considered as a source of water for construction and cleaning the deep aquifers should be targeted. Mine dewatering in the area may impact the availability of groundwater over the long run therefore it is recommended that water for construction and cleaning be sourced from the Vaal Gamagara pipeline.
- The water quality is generally hard.
- A detailed geohydrological investigation is required to assess availability of groundwater for the project.
- Adequate water supply for the construction and cleaning phases has to be confirmed through a take-off agreement with the relevant water management authorities of the Vaal Gamagara pipeline

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10. APPENDIX A – SOIL PROFILES

Soil Profile EAST-1 (East Solar Park)

Profiled by C. de Beer
Diameter
Depth 3.20 m
Type: Trial pit

Co-coordinates:
X-coord -27.17012
Y-coord 22.94884
Z-coord m
(WGS'84 decimal degrees)

Contractor Pierre
Machine Bell 315 SK
Operator Johannes

Soil Profile Description

Profile	Depth to	Description
	0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
	3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
		EOH @ 3.2m. No Refusal. Reach limit

Notes:
1 No Seepage or perched watertable.
2 No sample collected
3 No DCP tests conducted.

GCS

Soil Profile EAST-2 (East Solar Park)

Profiled by C. de Beer
Diameter
Depth 3.20 m
Type: Trial pit

Co-coordinates:
X-coord -27.16984
Y-coord 22.94330
Z-coord m
(WGS'84 decimal degrees)

Contractor Pierre
Machine Bell 315 SK
Operator Johannes

Soil Profile Description

Profile	Depth to	Description
	0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
	3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
		EOH @ 3.2m. No Refusal. Reach limit

Notes:
1 No Seepage or perched watertable.
2 Disturbed Sample EAST-2A was collected from 1.5-2.5m
3 No DCP tests conducted.

Soil Profile EAST-3 (East Solar Park)

Profiled by C. de Beer
Diameter
Depth 3.20 m
Type: Trial pit

Co-coordinates:
X-coord -27.16711
Y-coord 22.93962
Z-coord m
(WGS'84 decimal degrees)

Contractor Pierre
Machine Bell 315 SK
Operator Johannes

Soil Profile Description

Profile	Depth to	Description
	0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
	3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
		EOH @ 3.2m. No Refusal. Reach limit

Notes:
1 No Seepage or perched watertable.
2 No sample collected
3 No DCP tests conducted.

GCS

Soil Profile EAST-4 (East Solar Park)

Profiled by C. de Beer
Diameter
Depth 3.20 m
Type: Trial pit

Co-coordinates:
X-coord -27.17309
Y-coord 22.93746
Z-coord m
(WGS'84 decimal degrees)

Contractor Pierre
Machine Bell 315 SK
Operator Johannes

Soil Profile Description

Profile	Depth to	Description
	0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
	3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
		EOH @ 3.2m. No Refusal. Reach limit

Notes:
1 No Seepage or perched watertable.
2 No sample collected
3 No DCP tests conducted.

GCS

Soil Profile EAST-5 (East Solar Park)

Profiled by C. de Beer
Diameter
Depth 3.20 m
Type: Trial pit

Co-coordinates:
X-coord -27.17243
Y-coord 22.94726
Z-coord m
(WGS'84 decimal degrees)

Contractor Pierre
Machine Bell 315 SK
Operator Johannes

Soil Profile Description

Profile	Depth to	Description
	0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
	3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
		EOH @ 3.2m. No Refusal. Reach limit

Notes:
1 No Seepage or perched watertable.
2 No sample collected
3 No DCP tests conducted.

GCS

Soil Profile EAST-6 (East Solar Park)

Profiled by C. de Beer
Diameter
Depth 3.20 m
Type: Trial pit

Co-coordinates:
X-coord -27.16590
Y-coord 22.94790
Z-coord m
(WGS'84 decimal degrees)

Contractor Pierre
Machine Bell 315 SK
Operator Johannes

Soil Profile Description

Profile	Depth to	Description
	0.50	VERY LOOSE SAND Dry, very loose, uniform pale orange brown, intact, fine sand with roots, of TRANSPORTED (AEOLIAN) origin
	3.20	LOOSE SAND Dry to slightly moist, loose, uniform orange brown, intact, fine sand, of TRANSPORTED (AEOLIAN) origin. Sidewall of trial pit collapsed
		EOH @ 3.2m. No Refusal. Reach limit

Notes:
1 No Seepage or perched watertable.
2 Disturbed Sample EAST-2A was collected from 1.5-2.5m
3 No DCP tests conducted.

11. APPENDIX B – SOIL LABORATORY TEST RESULTS

ROADLAB
Civil Engineering Materials Laboratory
(PTY) LTD • 1965/008083/07 • VAT No. 4660115884
Established 1965

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P O Box 1476 Germiston 1400
Tel: 011 828 0279 Fax: 011 828 0273
E-mail: info@roadlab.co.za
www.roadlab.co.za

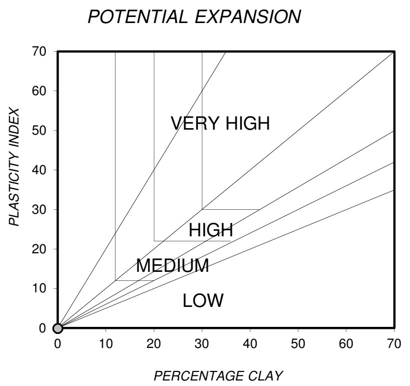
CLIENT : Geo Technical Consult
SITE : Rhodes 1 - Solar Pro

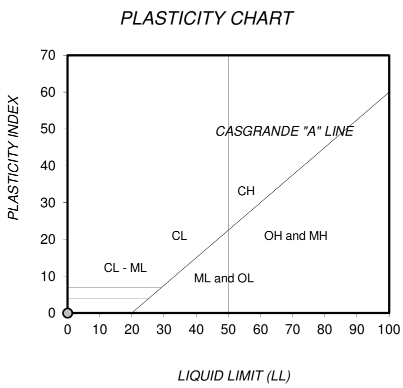
DATE REPORTED : 07-Mar-14
CHAINAGE : AV-1A
LAYER : 1.2m
SAMPLE No. : S1056
SAMPLE DESCRIPTION : Light Reddish Orange Quartz & Quartzitic Sand

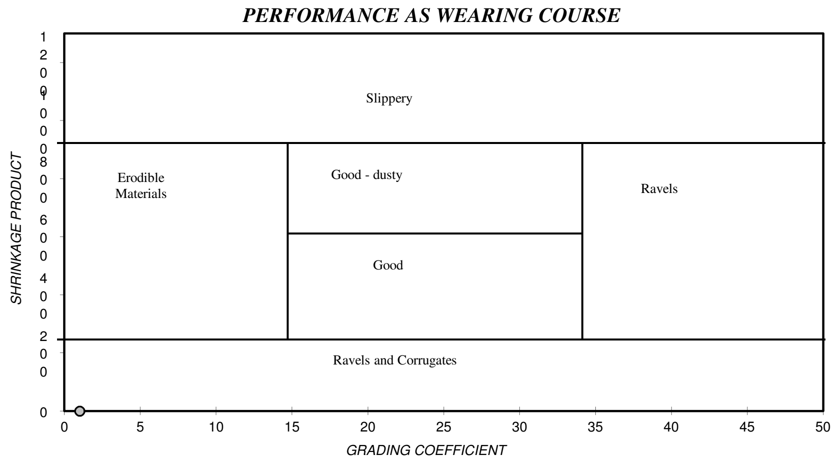
FOUNDATION INDICATOR TEST RESULTS

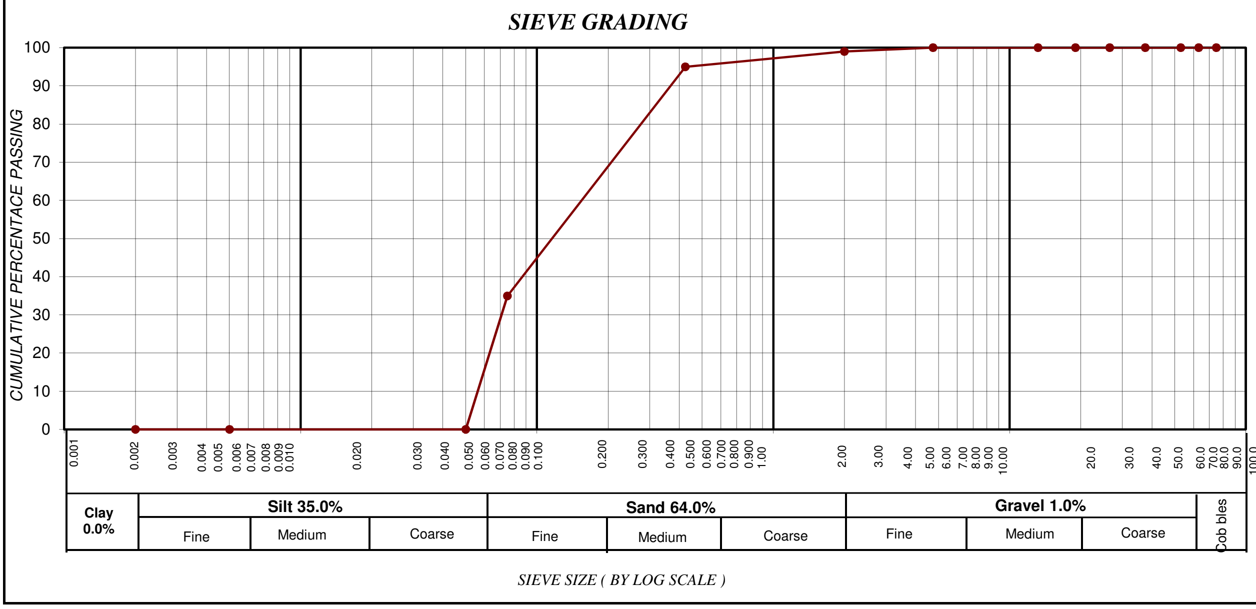
Material description

Sieve analysis Cumulative percentage passing (mm)	75.0	100
	63.0	100
	53.0	100
	37.5	100
	26.5	100
	19.0	100
	13.2	100
	4.75	100
	2.000	99
	0.425	95
	0.250	75
	0.150	55
	0.075	35
	0.050	0
	0.005	0
	0.002	0
Soil Mortar Analysis % < 2.00mm	2.000 - 0.425	4.0
	0.425 - 0.250	20.0
	0.250 - 0.150	20.0
	0.150 - 0.075	20.0
	< 0.075	35.4
Effective size		0.005
Uniformity Coefficient		22.8
Curvature Coefficient		7.4
Oversize Index		0.0
Shrinkage Product		0.0
Grading Coefficient		1.0
Grading modulus		0.71
Atter-berg Limits	Liquid Limit	0
	Plasticity Index	NP
	Linear Shrinkage	0
Unified Soil Classification		SC
U.S. Highway Classification		A-2-4(0)
pH - Value		N/A
Conductivity mS/cm		N/A









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Civil Engineering Materials Laboratory
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Established 1965

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Tel: 011 828 0279 Fax: 011 828 0273
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www.roadlab.co.za

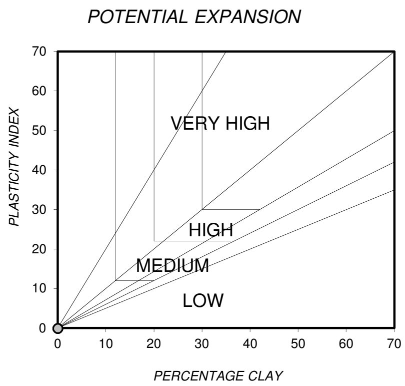
CLIENT : Geo Technical Consult
SITE : Rhodes 1 - Solar Pro

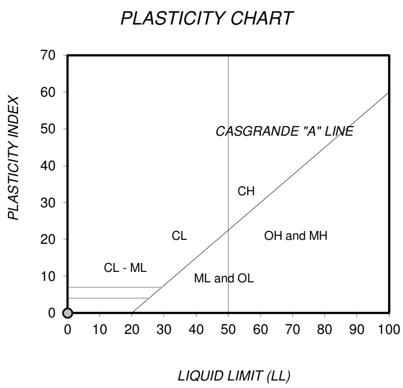
DATE REPORTED : 07-Mar-14
CHAINAGE : AV-10A
LAYER : 0.6-1.2m
SAMPLE No. : S1057
SAMPLE DESCRIPTION : Light Red Brown Calcrete

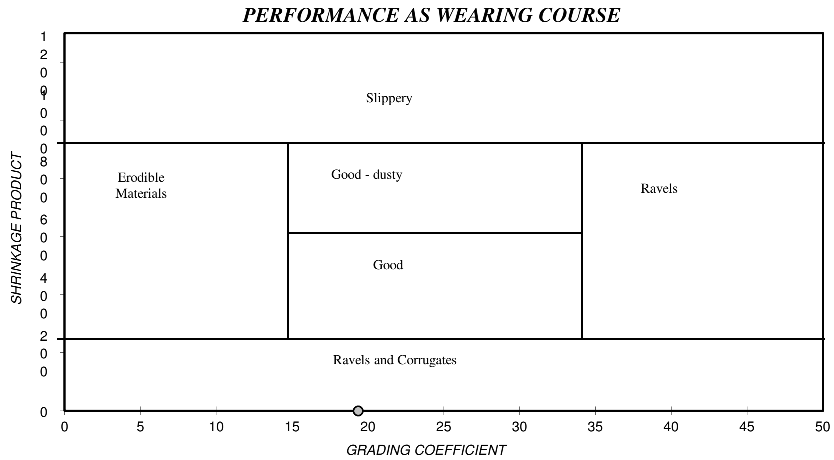
FOUNDATION INDICATOR TEST RESULTS

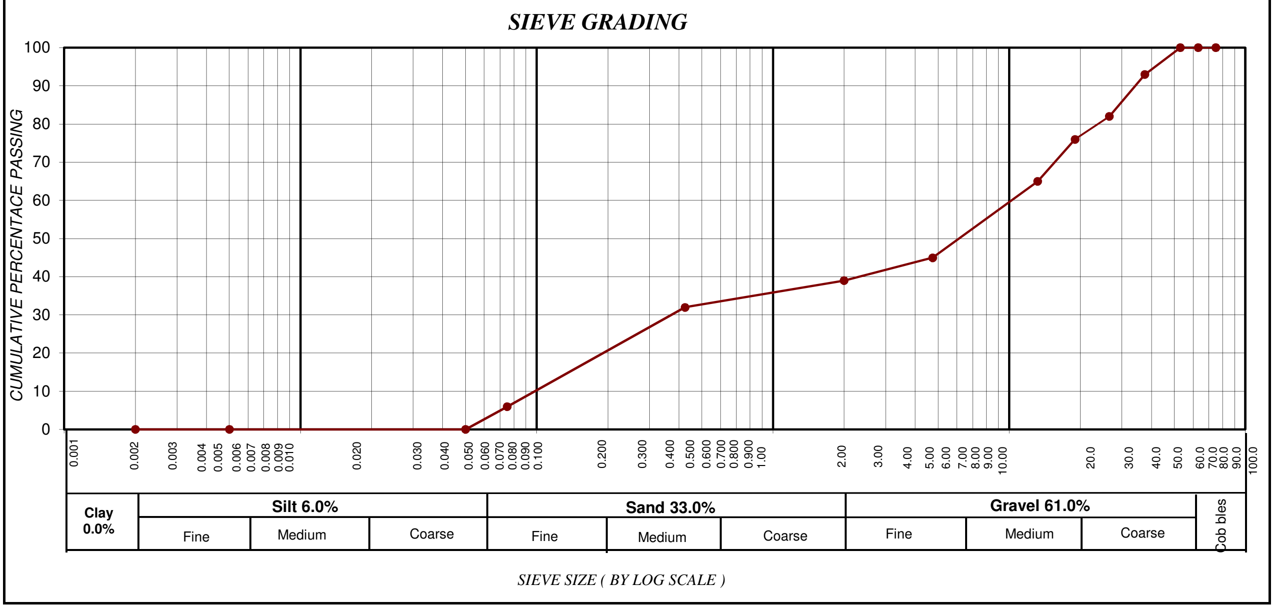
Material description

Sieve analysis Cumulative percentage passing (mm)	75.0	100
	63.0	100
	53.0	100
	37.5	93
	26.5	82
	19.0	76
	13.2	65
	4.75	45
	2.000	39
	0.425	32
	0.250	23
	0.150	15
	0.075	6
	0.050	0
	0.005	0
	0.002	0
Soil Mortar Analysis % < 2.00mm	2.000 - 0.425	7.0
	0.425 - 0.250	9.0
	0.250 - 0.150	8.0
	0.150 - 0.075	9.0
	< 0.075	15.4
Effective size		0.005
Uniformity Coefficient		22.8
Curvature Coefficient		7.4
Oversize Index		7.0
Shrinkage Product		0.0
Grading Coefficient		19.4
Grading modulus		2.23
Atter-berg Limits	Liquid Limit	0
	Plasticity Index	NP
	Linear Shrinkage	0
Unified Soil Classification		GP
U.S. Highway Classification		A-1-a(0)
pH - Value		N/A
Conductivity mS/cm		N/A









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92/GEO007-01-0001/14 2014/03/14

Geotechnical Consult Services
11 Jakkals Weg
Van Riebeeck Park
Kempton Park
1619

ATTENTION: Mr. C De Beer

Test Report : **AVONDALE SOLAR PARK - pH & CONDUCTIVITY TEST RESULTS**

Clients Marking: None
Sample Number: S1056-S1062
Sample delivered to: Roadlab

Date Sampled: 2014/03/02
Date Received: 2014/03/02

Sample Number	Layer / Road :	Temperature (°C) : Conductivity	Conductivity (ms/m)	Temperature (°C) : pH	pH Value
S1056	AV-1A	25.0	8.82	25.0	5.04
S1057	AV-10A	25.0	3.19	25.0	5.18
S1058	RH1-2A	25.0	3.77	25.0	5.15
S1059	EAST-6A	25.0	6.32	25.0	5.05
S1060	EAST-2A	25.0	5.75	25.0	5.17
S1061	SH-2A	25.0	6.83	25.0	5.16
S1062	SH-6A	25.0	11.04	25.0	5.13

Remarks :
The samples were subjected to analysis according to TMH 1
The results reported relate only to the sample tested
Further use of the above information is not the responsibility or liability of Roadlab
Documents may only be reproduced or published in their full context
Compiled By : Chanel van Biljon

12. APPENDIX C – WATER QUALITY LABORATORY TEST RESULT

For Attention:	Carel de Beer		
Customer:	Geotechnical Consult Services	**Report numbe**	WAT/14/00472
Postal address:	11 Jakkals Rd, Van Riebeeck Park	**Report issue d**	2014/03/19
Tel number:	0828716675	**Date complete**	2014/03/11
Fax Number:		**Order no:**	Paid

Water Analysis Report

Sample name			**South African National Drinking Water Standard (SANS 241:2006) Recommended operational limit**	Rhodes Solar project	
Sample date and time				2014/02/27	
Sample container description				1L Plastic Bottle	
Submission date				2014/03/06	
Sample type				Water	
Set Point ID				WAT/14/00472-00001	
Visual Inspection				N/A	
Method no	**Determinand**	**Unit**			
Chemical Properties and Parameters					
M464	**Ammonia Nitrogen**	**mg/L N**	< 1.0	<0.1	
M469	**Chloride**	**mg/L**	< 200	283	
#	**Colour**	**Hazen Units**	< 20	1	
M461	**Conductivity**	**mS/m @ 25°C**	< 150	159	
M475	**Fluoride**	**mg/L**	< 1.0	0.3	
M467	**Nitrate & Nitrite Nitrogen**	**mg/L N**	< 10	16.3	
M460	**pH**	**-**	5.0-9.5	8.1	
M476	**Sulphate**	**mg/L**	< 400	150	
#	**Total Dissolved Solids**	**mg/L @ 180°C**	< 1000	937	
#	**Turbidity**	**NTU**	< 1.0	0.6	
M474	**Aluminium (Al)**	**mg/L**	<0.3	<0.15	
M474	**Antimony (Sb)**	**µg/L**	<10	<0.50	
M474	**Arsenic (As)**	**µg/L**	<10	4.61	
M474	**Cadmium (Cd)**	**µg/L**	<5	<0.10	
M474	**Calcium (Ca)**	**mg/L**	<150	68.8	
M474	**Chromium (Cr)**	**µg/L**	<100	<3.00	
M474	**Cobalt (Co)**	**µg/L**	<500	0.21	
M474	**Copper (Cu)**	**µg/L**	<1000	1.29	
M474	**Iron (Fe)**	**mg/L**	<0.2	<0.10	
M474	**Lead (Pb)**	**µg/L**	<20	<1.00	
M474	**Magnesium (Mg)**	**mg/L**	<70	4.12	
M474	**Manganese (Mn)**	**µg/L**	<100	<0.02	
M474	**Mercury (Hg)**	**µg/L**	<1	<0.50	
M474	**Nickel (Ni)**	**µg/L**	<150	<1.00	
M474	**Potassium (K)**	**mg/L**	<50	6.38	

M474	**Selenium (Se)**	**µg/L**	<20	35.3	
M474	**Sodium (Na)**	**mg/L**	<200	239	
M474	**Vanadium (V)**	**µg/L**	<200	8.26	
M474	**Zinc (Zn)**	**mg/L**	<5	<0.06	

Please Note: **N/A: Not applicable** **RTF : Result to follow**

 # Non SANAS accredited methods.

Results only relate to the samples tested and are reported on an "as received" basis, unless otherwise specified.
This report may not be reproduced, except in full, without the written approval of Set Point Laboratories;
Results are subject to uncertainty of measurement, which are indicated on the enclosed information sheet.
While every effort is made to provide analysis of the highest accuracy, the liability of Set Point Laboratories is restricted to the cost of the analysis.

 # Comment:

Please refer to the recommended limits of the South African National Drinking Water Standard (SANS 241: 2006) in the green column.

Faheema Kaloo
(Report Compiler)

Thabisa Limba
Technical Signatory

Moses Lelaka
Technical Signatory

 # Tests marked "Non SANAS Accredited methods", as well as any comments, opinions or interpretations expressed in this report are not included in the SANAS Schedule of Accreditation for this laboratory.

INFORMATION SHEET TO ANALYSIS REPORT

Methods used, tests subcontracted and accredited ranges:

DETERMINAND	Method code	Accredited	Ave. Uncertainty	Technique	Analytical range
pH	M460	Yes	<1%	Electro-metric	0.2-14
Conductivity	M461	Yes	<1%	Electro-metric	1-20000 mS/m
Alkalinity	M463	Yes	<1%	Titration	10-2000 mg/L
Ammonia Nitrogen	M464	Yes	17.8% < 2.6 mg/L > 1%	Automated Photometric	0.1 - 77.6 mg/L
Nitrate Nitrogen	M465	Yes	Calculated from M467/466	Automated Photometric	Calculated from M467/466
Nitrite Nitrogen	M466	Yes	20.4 %	Automated Photometric	0 - 2 mg/L
Nitrate and Nitrate Nitrogen	M467	Yes	3.4 %	Automated Photometric	0.1 - 10mg/L
Orthophosphate Phosphorus	M468	Yes	8.8 %	Automated Photometric	0.1 -5 mg/L
Chloride	M469	Yes	3.0 %	Automated Photometric	3-100 mg/L
Fluoride	M475	Yes	25.5%	Automated Photometric	0.1 - 2 mg/L
Sulphate	M476	Yes	1.1 %	Automated Photometric	3 -100 mg/L

Hexavalent Chromium	M471	Yes	27.7 %	Automated Photometric	0.005 - 0.2 mg/L
Al	M474	Yes	3.3%	ICP-OES	0.15 - 15 mg/L
Ag	M474	Yes	0.32 ug/L	ICP-MS	0.50 - 50 ug/L
As	M474	Yes	3.7 %	ICP-OES	0.10 -15 mg/L
As	M474	Yes	0.33 ug/L	ICP-MS	0.50 - 50 ug/L
B	M474	Yes	4.4%	ICP-OES	0.35 - 15 mg/L
Ba	M474	Yes	3.5 %	ICP-OES	0.01 - 15 mg/L
Ba	M474	Yes	0.30 ug/L	ICP-MS	0.30 - 100 ug/L
Be	M474	Yes	4.9 %	ICP-OES	0.02 - 15 mg/L
Be	M474	Yes	0.37 ug/L	ICP-MS	0.10 - 50 ug/L
Ca	M474	Yes	2.7 %	ICP-OES	0.50 - 15 mg/L
Cd	M474	Yes	4.5 %	ICP-OES	0.02 - 15 mg/L
Cd	M474	Yes	0.36 ug/L	ICP-MS	0.10 - 50 ug/L
Co	M474	Yes	3.0 %	ICP-OES	0.02 - 15 mg/L
Co	M474	Yes	0.36 ug/L	ICP-MS	0.20 - 50 ug/L
Cr	M474	Yes	3.0 %	ICP-OES	0.05 - 15mg/L
Cr	M474	Yes	0.36 ug/L	ICP-MS	3 - 100 ug/L
Cu	M474	Yes	3.1 %	ICP-OES	0.10 - 15mg/L
Cu	M474	Yes	0.36 ug/L	ICP-MS	1 - 100 ug/L
Fe	M474	Yes	3.2 %	ICP-OES	0.10 - 15 mg/L
Hg	M474	Yes	0.04 ug/L	ICP-MS	0.50 - 5ug/L
K	M474	Yes	4.2 %	ICP-OES	0.04 - 15 mg/L
Mg	M474	Yes	2.9 %	ICP-OES	0.05 - 15 mg/L
Mn	M474	Yes	3.8 %	ICP-OES	0.02 - 15 mg/L
Mn	M474	Yes	0.40 ug/L	ICP-MS	0.25 - 50 ug/L
Mo	M474	Yes	3.2 %	ICP-OES	0.02 - 15 mg/L
Mo	M474	Yes	0.36 ug/L	ICP-MS	1.0 - 50 ug/L
Na	M474	Yes	7.7 %	ICP-OES	0.20 -15 mg/L
Ni	M474	Yes	3.0 %	ICP-OES	0.02 - 15 mg/L
Ni	M474	Yes	0.33 ug/L	ICP-MS	1.0 - 100 ug/L
Pb	M474	Yes	3.0 %	ICP-OES	0.05 - 15 mg/L
Pb	M474	Yes	0.37 ug/L	ICP-MS	1.0 - 100 ug/L
Si	M474	Yes	6.8 %	ICP-OES	0.25 - 15 mg/L

Sb	M474	Yes	0.35 ug/L	ICP-MS	0.50 - 50 ug/L
Se	M474	Yes	0.35 ug/L	ICP-MS	2.0 - 50 ug/L
Sn	M474	Yes	0.41 ug/L	ICP-MS	0.20 - 50 ug/L
Sr	M474	Yes	5.6 %	ICP-OES	0.01 - 15 mg/L
Sr	M474	Yes	0.32 ug/L	ICP-MS	0.50 - 50 ug/L
Th	M474	Yes	0.35 ug/L	ICP-MS	0.20 - 50 ug/L
Tl	M474	Yes	0.29 ug/L	ICP-MS	0.10 - 50 ug/L
U	M474	Yes	0.30 ug/L	ICP-MS	0.20 - 50 ug/L
V	M474	Yes	2.9 %	ICP-OES	0.10 - 15 mg/L
V	M474	Yes	0.36 ug/L	ICP-MS	0.20 - 50 ug/L
Zn	M474	Yes	4.9 %	ICP-OES	0.06 - 15 mg/L
Zn	M474	Yes	0.37 ug/L	ICP-MS	5.0 - 100 ug/L

Note: All other tests or elements reported are not accredited unless specified otherwise.
Record: Analysis report information sheet, revision status: 2011-09-12
Compiled and approved by: T Maré