63 Wessel Road, Rivonia, 2128 PO Box 2597, Rivonia, 2128 South Africa
Tel: +27 (0) 11 803 5726 **Fax:** +27 (0) 11 803 5745 **Web:** www.gcs-sa.biz

Sand Draai PV and CSP Hydrogeological Desktop Study

Report

Version – 1

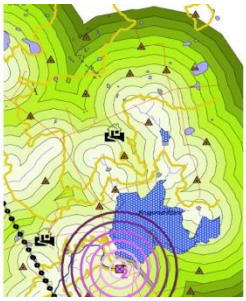
October 2014

Client: Royal Haskoning DHV

GCS Project Number: 14-529

Client Reference: 14-529

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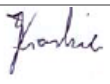
DOCUMENT ISSUE STATUS

Report Issue	1		
GCS Reference Number	GCS Ref - 14-529		
Client Reference	14-529		
Title	Sand Draai PV and CSP hydrogeological Desktop Study		
	Name	**Signature**	**Date**
Author	Claudia du Plessis		October 2014
Document Reviewer	Kobus Troskie		October 2014
Director	Alkie Marais		October 2014

EXECUTIVE SUMMARY

GCS (Pty) Ltd (GCS) was appointed by Royal HaskoningDHV (Pty) Ltd to undertake the hydrogeological impact assessment for the proposed Solafrica Sand Draai Solar Power (CSP) and Photovoltaic project, located near Upington in the Northern Cape Province. The aim of this assessment was to assess the baseline groundwater conditions for the local aquifer system and to supply an indication of possible risks to the groundwater environment accordingly from a desktop perspective.

The following basic steps were applied:

- A desktop study was conducted which included the analysis of data obtained from the National Department of Water Affairs' National Groundwater Archive (NGA);
- Available specialist reports were obtained from Royal HaskoningDHV and were reviewed accordingly; and
- Data obtained from the NGA were mapped for reporting purposes.

Locality & Hydrology

The proposed site is situated on the farm Sand Draai, approximately 75km south east of Upington in the Northern Cape Province. A gravel road is located in the western section of the proposed site and is characterised by relatively flat topographic terrains. A non-perennial drainage line is located on the southern portion of the site. The Orange River is located 2.3km west, downgradient of the site.

Geology and Hydrogeological Setting

The general geology of the site mainly comprises of red, coarse grained brown windblown sands of the Gordonia Formation, Kalahari Group. Quartz-muscovite schist, quartzite, quartz-amphibole schist and greenstone of the Groblershoop Formation, Brulpan Group, outcrops approximately 5km south west of the CSP tower area, as well as in the southern section of the site. Calcrete also outcrops in the southern section of the site approximately 8km southwest from the proposed CSP tower area.

Groundwater use takes place in the farms located further away from the Orange River. Groundwater abstraction consists mainly of domestic use, with estimated low scale abstraction in the form of submersible pumps and windmills.

According to the 1:500 000 Hydrogeological Map of Upington/Alexander Bay (2714), the proposed site is associated with fractured aquifers based on the geology. The yield from the local aquifers range from 0 to 0.2l/s. The site falls within the quaternary catchment D73D. Data obtained from GRDM data indicates that the area receives a mean annual precipitation of 185.2mm. The average annual recharge for the area is 0.45mm.

Potential Impacts on the Groundwater Environment

The potential impacts associated with the proposed development on the groundwater environment include potential contamination due to accidental spillage and the storage of heat transfer fluid which is a synthetic oil, hydrocarbon contamination arising from spills or leaks from heavy machinery used during the construction phase and contamination from spills or leaks of hazardous products stored on site;

As part of the detailed EIA investigation, a hydrocensus will be conducted to confirm groundwater users and groundwater samples will be collected to obtain baseline chemistry conditions. Based on the results of the field investigation as part of the EIA, additional work may be required in the form of detailed geophysical investigations and intrusive work in the form of drilling and construction of monitoring boreholes.

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1 INTRODUCTION

GCS (Pty) Ltd (GCS) was appointed by Royal HaskoningDHV (Pty) Ltd to undertake the hydrogeological impact assessment for the proposed Solafrica Sand Draai Solar Power (CSP) and Photovoltaic project, located near Upington in the Northern Cape Province. The aim of this assessment was to assess the baseline groundwater conditions for the local aquifer system and to supply an indication of possible risks to the groundwater environment accordingly from a desktop perspective.

The following basic steps were applied:

- A desktop study was conducted which included the analysis of data obtained from the National Department of Water Affairs' National Groundwater Archive (NGA).
- Available specialist reports were obtained from Royal HaskoningDHV and were applied accordingly; and
- Data obtained from the NGA were mapped for reporting purposes.

The proposed Concentrated Solar Power (CSP) and PV project will consist of:

- One 150 MW CSP plant, based on Parabolic Trough;
- One 150 MW CSP Plant, based on Central Receiver technology; and
- One 125 MW Photovoltaic CSP plant.

The above infrastructure is proposed on the farm Sand Draai in the Northern Cape Province in South Africa. Solafrica also intends to develop the two (2) CSP plants with significant amounts of thermal storage. The two technologies used are detailed below:

Central Receiver/Power Tower: The heliostats, sun-tracking glass mirrors are mounted on an axis which reflects the sunlight to a central receiver, which is situated on the top of a single central tower, or alternatively on a number of smaller central towers. The concentrated beam radiation is absorbed by a heat exchanging receiver, which converts heat to a working fluid (i.e. molten salt or water) which is in turn used to generate steam for conventional power generation (SolAfrica, 2011).

Parabolic Trough: A parabolic trough system reflects solar radiation to a focal point called the absorber tube located at the focal point. Solar energy is then transferred to a working fluid which is used to drive a conventional power cycle (SolAfrica, 2011).

2 SCOPE OF WORK

The objective of the desktop/baseline assessment is listed below:

- A desktop study including a description of the general geology and hydrogeological conditions;
- A graphic representation of the existing boreholes revealed by the National Groundwater Archive (NGA);
- Identify possible problem areas associated with groundwater;
- Spatial distribution of boreholes within the site area and the neighbouring farms;
- Risk assessment based on the data obtained during the investigation;
- Reporting, detailing baseline, impact assessment and management measures;
- Final report incorporating finding of the study.

3 METHODOLOGY

3.1 Desktop Study

GCS assessed all available geological and hydrogeological data. All existing groundwater data was reviewed and assessed during the desktop study.

A study of the 1:50 000 topographical, 1:250 000 geological, 1:500 000 hydrogeological maps and satellite images were conducted during the desktop study. All relevant information was sourced from the client as well as from the relevant governmental departments. Any existing groundwater data captured in the National Groundwater Archive (NGA), obtained from the Department of Water Affairs was utilised.

The following data sources will be used during the study:

- Topographic 1:50 000 maps;
- Geological 1:250 000 map;
- Hydrogeological 1:500 000 map;
- GRDM, Groundwater Resource Directed Measures;
- The National Groundwater Archive (NGA), Department of Water Affairs;
- The hydrogeological baseline assessment conducted by GCS in 2010 on the neighbouring Bokpoort site;
- All available information as made available by the client.

4 SITE DESCRIPTION

4.1 Site Details

The proposed site is situated on the farm Sand Draai, approximately 75km south east of Upington, in the Northern Cape Province, falling under the jurisdiction of the Siyanda District Municipality. A gravel road is located on the western section of the proposed site and is characterised by relatively flat topographic terrains. Non perennial drainage line are located on the southern portion of the site. The Orange River is located 2.3km west, downgradient of the site. Intensive agriculture, including vineyards and domestic food farms has developed along the banks of the Orange River.

4.2 Topography and Hydrology

The study area is generally characterised by Dune Hills (parallel crests) and Lowlands in the northern part and extremely irregular plains in the south, sloping towards the Orange River in a south-westerly direction (Figure 4-1). Evidence of non-perennial drainage lines could be viewed from aerial imagery in the southern part of the proposed site, but these areas are only expected to contain flowing water during periods of exceptional high rainfall. No significant wetlands, estuaries, Ramsar Sites or major dams are present within the immediate vicinity of the study site.

4.3 Land use

The presence of cultivated land and settlements were noted on the southern part of the farm. The Sishen-Saldanha railway line is adjacent to the south-eastern part of the farm.

The land use surrounding the proposed site area is as follows:

North: Vacant land

East: Bokpoort CSP (under construction)

South: Orange River, cultivated land and small settlements

West: Vacant land

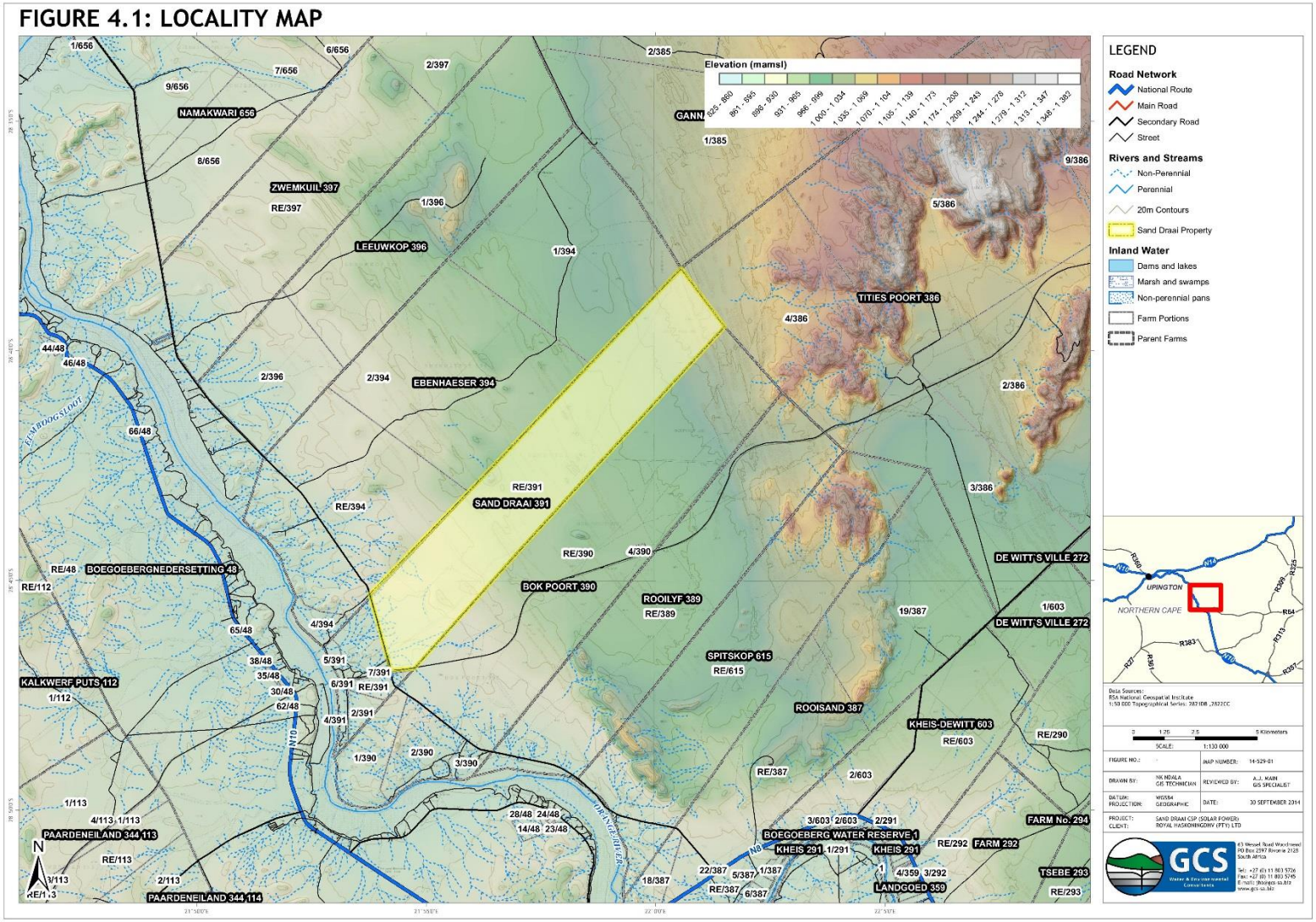


Figure 4-1: Locality Map

5 GEOLOGICAL DESKTOP STUDY

5.1 Site Geology

According to the 1:250 000 geological map sheet, Postmasburg (2822), the geology of the area is generally characterised by the metamorphosed sediments and volcanics intruded by granites and is known as the Namaqualand Metamorphic Province. The proposed CSP plant site is sited on red, coarse grained brown windblown sands of the Gordonia Formation, Kalahari Group (refer to Figure 5-1). Dune ridges occur in the northern portions of the site and is characterised by NNW-SSE orientation. Quartz-muscovite schist, quartzite, quartz-amphibole schist and greenstone outcrops approximately 5km south west of the CSP tower area, as well as in the southern section of the site. Calcrete also outcrops in the southern section of the site approximately 8km southwest from the CSP tower area (

FIGURE 5.2: GEOLOGY MAP

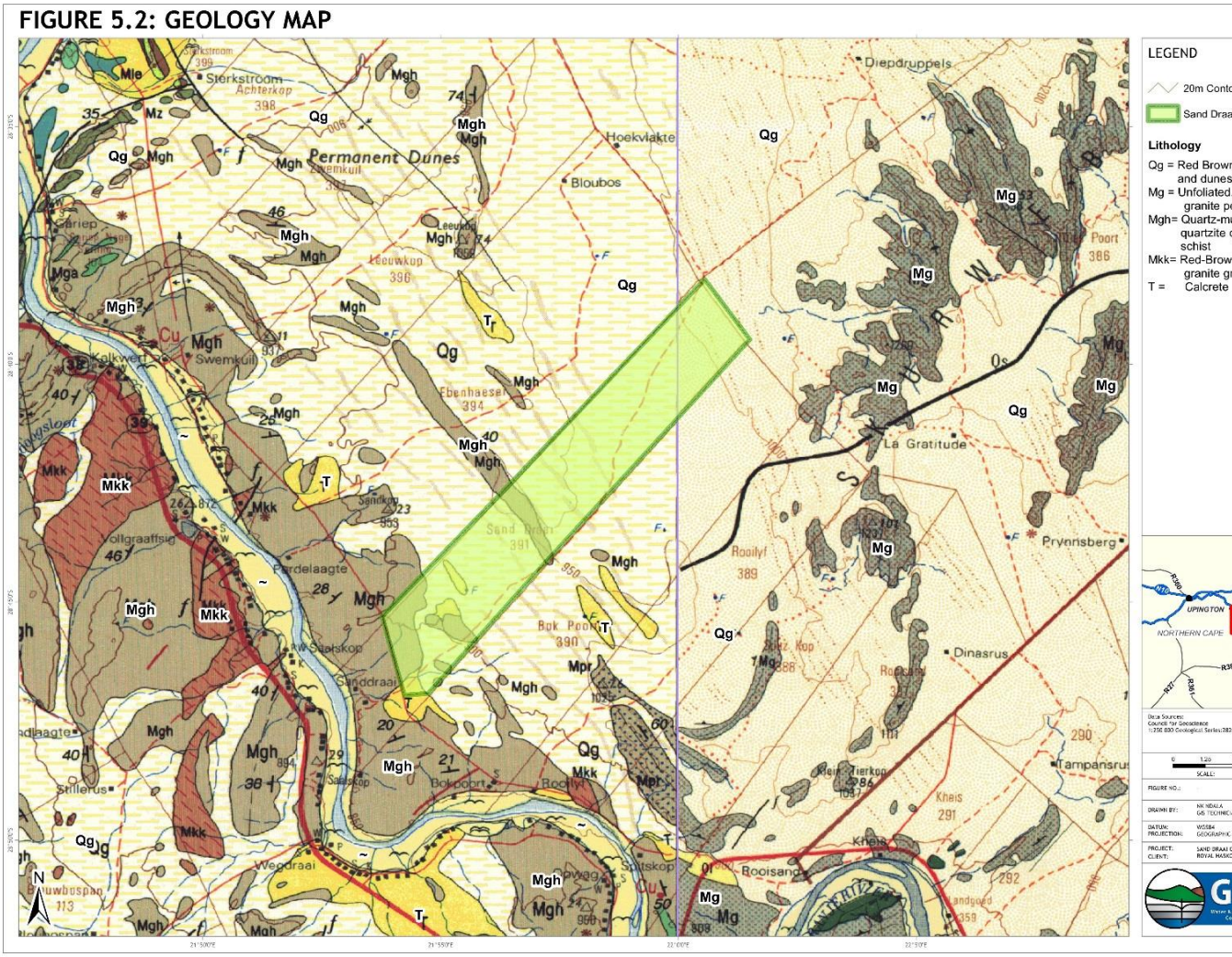
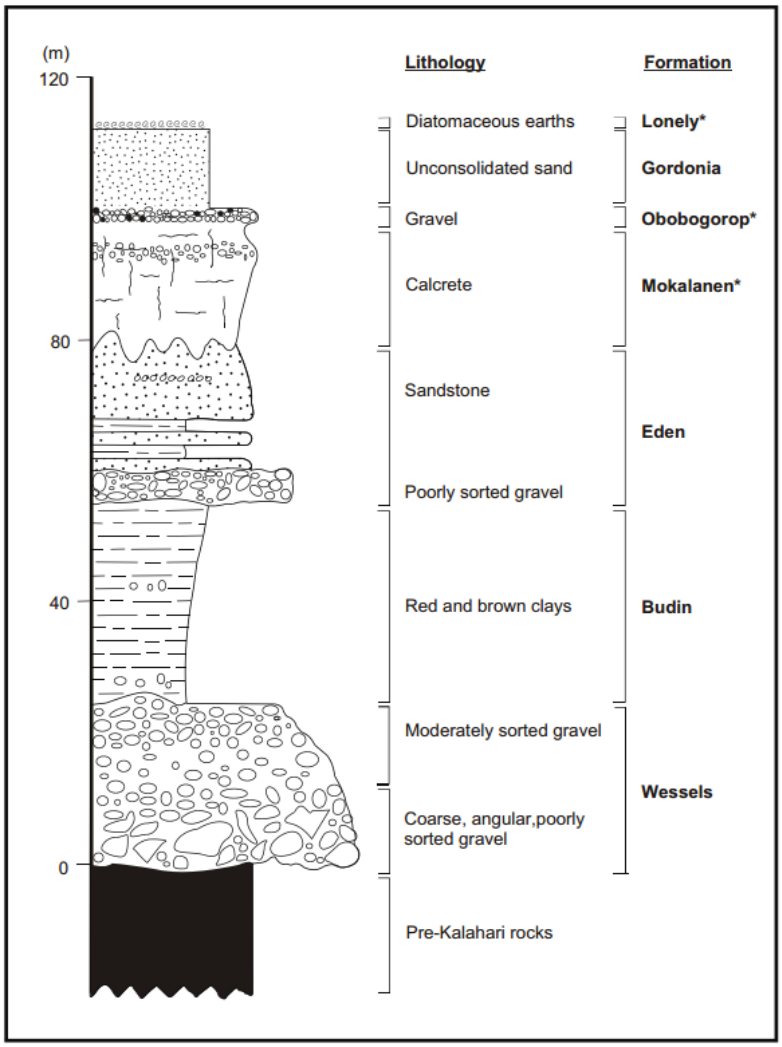


Figure 5-2).



* = Name not yet accepted by The South African Committee for Stratigraphy (SACS).

Figure 5-1: Schematic Stratigraphy of the Kalahari Group in South Africa (I. Haddon, 2005)

FIGURE 5.2: GEOLOGY MAP

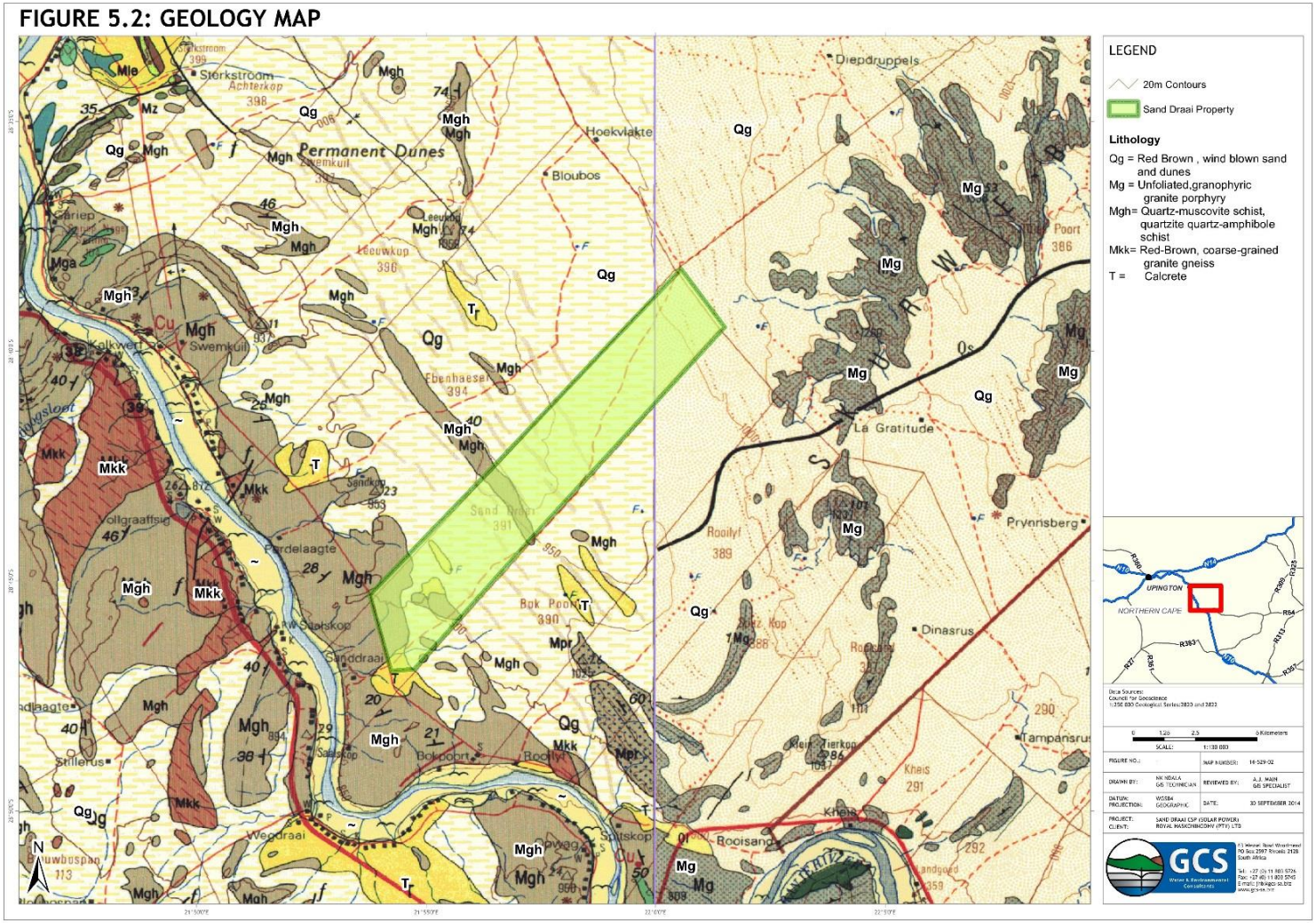


Figure 5-2: Geology Map

6 HYDROGEOLOGICAL DESKTOP STUDY

6.1 Site Specific Hydrogeology

According to the 1:500 000 Hydrogeological Map of Upington/Alexander Bay (2714), the proposed site is associated with fractured aquifers based on the geology. The average borehole yields associated with these aquifers, range from 0 to 0.2l/s.

It was indicated in the Environmental Impact Assessment report for the neighbouring Bokpoort site (SolAfrica, 2011) that water will be used for the operation of the proposed CSP plant for steam generation, cooling, the domestic needs of plant workers, and for the washing of the plant mirrors. These water volumes when applied over the estimated plant area may increase the groundwater recharge at the site, raising the local water table and mobilising any contaminants at the site into the groundwater.

6.2 Quaternary Catchment

Data from relevant hydrogeological databases including, the National Groundwater Archive (NGA) was obtained from the Department of Water Affairs. The proposed site area fall within quaternary catchment: D73D, as indicated in Table 6-1.

Table 6-1: Summarized Quaternary Catchment Information (GRDM, 2010)

Quaternary Catchment	Total Area (km^2)	Recharge mm/a	Current use Mm^3/a	Exploitation Potential Mm^3/a	Rainfall mm/a
D73D	4290.4	0.45	0.05	8	185.2

6.3 Groundwater Levels

The farms abstract water from the Orange River for irrigation purposes, even though the river water requires some treatment before it is ready for domestic use. Groundwater use takes place on the farms located further away from the river. During a hydrocensus conducted by GCS in 2010, seven boreholes were identified within close proximity to the site. The majority of boreholes were equipped with wind pumps. As tabulated in Table 6-2 groundwater on these farms were mainly used for domestic purposes and livestock (cattle and sheep) farming. Water level measurements could not be taken from the farm boreholes.

Groundwater samples were collected from BH2, BH3 and BH5 during the previous hydrocensus. The pH and Total Dissolved Solids (TDS) recorded in BH2 and BH3 were 8.06 and 7.36 and 490mg/l and 420mg/l, respectively. Elevated Electrical Conductivity (EC), sodium, calcium, chloride and nitrate (NO_3) concentrations were recorded in BH2. BH5 indicated slightly elevated EC and nitrate (NO_3) concentrations.

The local aquifers can be classified as minor, according to Parsons Aquifer Classification system, due to the limited use of groundwater in the area.

During the EIA phase a detailed hydrocensus will be conducted surrounding the proposed site.

Table 6-2: Data Obtained from the Hydrocensus Survey Conducted by GCS in 2010

Site ID	Farm Name	Farm Owner/ Manager	Contact Details	S Coordinate	E Coordinate	Equipment	pH	TDS (mg/l)	Use	Comments
BH1	Sand Draai	Johannes Fourie	083 785 0626	-28.78569	21.89017	-	-	-	Unused	Borehole located next to a farm workers' house. The wind pump is broken. The hole is blocked with stones.
BH2	Rooilyf	Hennie Jooste	083 388 5314	-28.81411	21.94856	Wind pump	8.06	490	Domestic	Borehole located next to a farm dwellers village along the Loop 16 gravel road.
BH3	Bokpoort	Chris Honiball	082 372 3467	-28.73536	21.97234	Submersible pump	7.36	420	Domestic	Borehole located west of the farm house. Water is used for two farm owner's homes and in the farm workers' village.
BH4	Bokpoort	Chris Honiball	082 372 3467	-28.72458	21.9926	Wind pump	-	-	Stock watering	Borehole located on the wild game farm.
BH5	Bokpoort	Chris Honiball	082 372 3467	-28.71084	21.9999	Wind pump	-	-	Stock watering	Borehole located on a goat and sheep farm. Water is pumped into a concrete tank for stock watering.
BH6	Bokpoort	Chris Honiball	082 372 3467	-28.7692	21.93741	Wind pump	-	-	Stock watering	Borehole located on a sheep farm. Water is pumped into two concrete tanks for stock watering.
BH7	Rooilyf	Hennie Jooste	083 388 5314	-28.79907	21.96237	Wind pump	-	-	Stock watering	Borehole located on a sheep farm.

6.3.1 National Groundwater Archive (NGA)

Borehole information derived from the Department of Water Affairs (DWA), National Groundwater Archive (NGA) allowed for an assessment of the hydrogeology, aquifers and water levels in the area.

Three NGA (National Groundwater Archive) boreholes are present within an 8km radius of the site. Table 6-3 lists the details of the NGA boreholes plotted on Figure 6-1. Water level data and water use were not available for boreholes, BH1 and BH2. Groundwater levels were obtained for BH3 in 1978, 1982 and 1983 and ranged from 37 to 65mbgl.

Borehole labelled BH2 on Figure 6-1, (and in Table 6-3) is located within a 1km radius of the site. Data regarding the use could not be obtained from the NGA database.

Table 6-3: NGA Borehole Data

ID	Geosite Info Identifier	Latitude	Longitude	Water Level Measurement Date	Water Level (mbgl)
BH1	2822CA00012	-28.68924	22.00993	-	-
BH2	2822CA00042	-28.65868	22.01048	-	-
BH3	2821DB00006	-28.6748	21.92763	20/06/1978	65
				25/03/1982	37
				18/08/1983	61

***Boreholes highlighted in red are located within a 1km radius of the site**

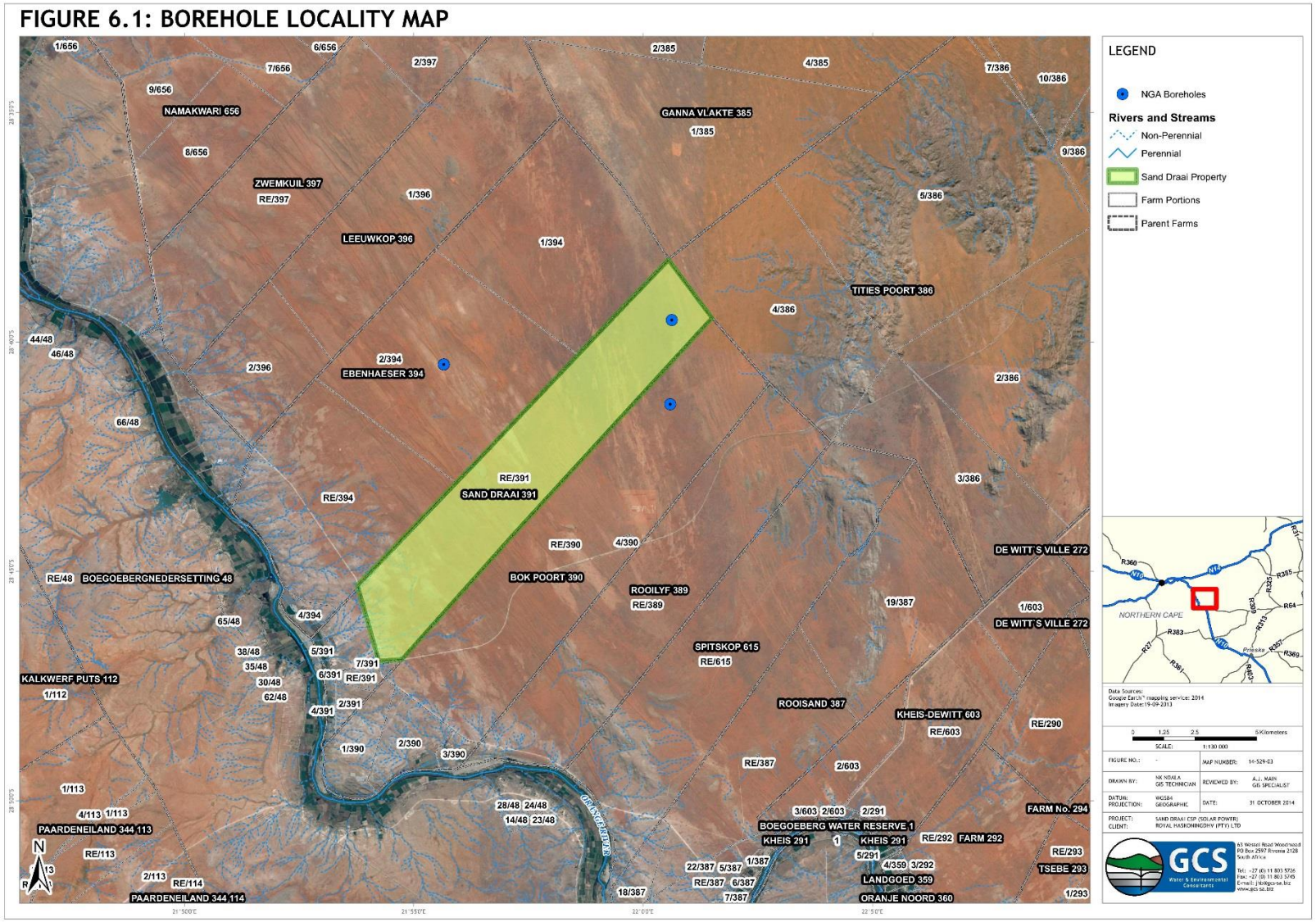


Figure 6-1: Borehole Locality Map

7 SITE IMPACT ASSESSMENT

7.1 Background

It is indicated in the Environmental Impact Assessment for the adjacent Bokpoort site (SolAfrica, 2011) that the solar power station will not use any groundwater. As no information was provided regarding this, it is assumed this will be the case for the Sand Draai site. Water will be pumped from the Orange River to the site and used for steam generation, cooling, washing of the plant mirrors and in the plant workers change rooms.

According to the Environmental Impact Assessment conducted for the Bokpoort site (SolAfrica, 2011) the potential negative environmental impacts from this development include water and soil contamination resulting from liquid sodium/potassium nitrate salt used to collect heat from the boilers.

It was also indicated in the Environmental Impact Assessment report for the Bokpoort site that an auxiliary power plant that uses hydrocarbon fuel (diesel driven generator) will be constructed at the site. Leakage of fuel from this plant into the subsurface may result in the contamination of groundwater resource. These can, however, be mitigated and could be considered acceptable with proper planning and management of the facilities.

According to the Environmental Impact Assessment report for the Bokpoort site (SolAfrica, 2011) the following hazardous chemical substances and asphyxiants may typically be stored on-site:

- Nitrogen: Used for inertisation purposes (HTF expansion system);
- Turbine Oil;
- Mirror cleaning chemicals: Mirrors are cleaned with pressurised demineralised water;
- HTF (Heat Transfer Fluid): 1 950 000 kg contained within receiver tube system;
- Water treatment chemicals;
- Other solvents during maintenance.

7.2 Groundwater - Potential Impacts

The following potential groundwater impacts associated with the proposed CSP and PV plant were identified. The risks and impacts apply to all site infrastructure discussed.

Contamination from the Heat Transfer Fluid (HTF)

Heat transfer fluid is a synthetic thermal oil or water which is circulated through the thermal plant and absorbs the collected energy and is subsequently heated to around 400°C which is then circulated through the system continually until the water side of the system is heated enough to produce steam. The cooled heat transfer fluid is pumped to the central receiver tubes where the cycle repeats. This is a closed system and loss of HTF will be minimal. However, small volumes of the fluid will be lost and will need replacement. Used HTF will be stored in small volumes on site and removed occasionally and disposed of at an appropriate waste disposal facility. It is the minor loss/accidental spillages of HTF during circulation as well as the small volumes which will be stored on site which may pose a threat of groundwater contamination.

It is assumed that this is the method and product (synthetic oil) which will be used as the working fluid in the system based on the neighbouring solar farm details.

Construction Phase – Hydrocarbon Contamination

During the construction phase, hydrocarbon contamination is possible due to accidental spills of diesel/oils, etc. from the usage of heavy machinery and construction vehicles on site. Spillages may occur which may impact both the soil and groundwater environment. The impacts are costly and difficult to clean up, however, only small amounts envisaged.

Hazardous Products Stored on Site

An auxiliary heating system/boiler is required on site maintain the temperature of the heat transfer fluid above the freezing point in the CSP plant as well as for co-firing in order to supplement the thermal power and to maintain a minimum temperature during winter. Fuel used for co-firing and to heat the HTF will be stored in tanks on site.

Diesel will also be required to power a generator during the construction phase and potentially a standby generator during the operational phase. This fuel will also be stored on site.

Potential hydrocarbon contamination may arise due to leaking tanks or accidental spillages during transport or handling of the product. All fuel storage tanks must be bunded on site.

A more detailed risk assessment with mitigation measures will be compiled during the EIA phase.

8 SENSITIVITY MAPPING

All the components of the project identified during the desktop investigation have been collated and plotted on a sensitivity map as indicated in Figure 8-1. The following components were identified as sensitive areas:

- Faults or lineaments;
- Production boreholes as indicated by the NGA borehole database;
- A buffer area of 100 metres from the rivers.

These areas highlight the sensitive areas according to sensitivity categories including: very high sensitivity, high sensitivity, moderate sensitivity and low sensitivity.

The area within the 100m buffer of the Orange River is considered highly sensitive. The 100m buffer areas surrounding the non-perennial rivers are considered moderate sensitivity since these areas are only expected to contain flowing water during periods of exceptional high rainfall. The areas associated with the NGA boreholes are considered highly sensitive, however, the presence of these boreholes will be confirmed during the hydrocensus survey that will form part of the EIA phase. Areas associated with faults or lineaments are considered highly sensitive although none fall within the site area.

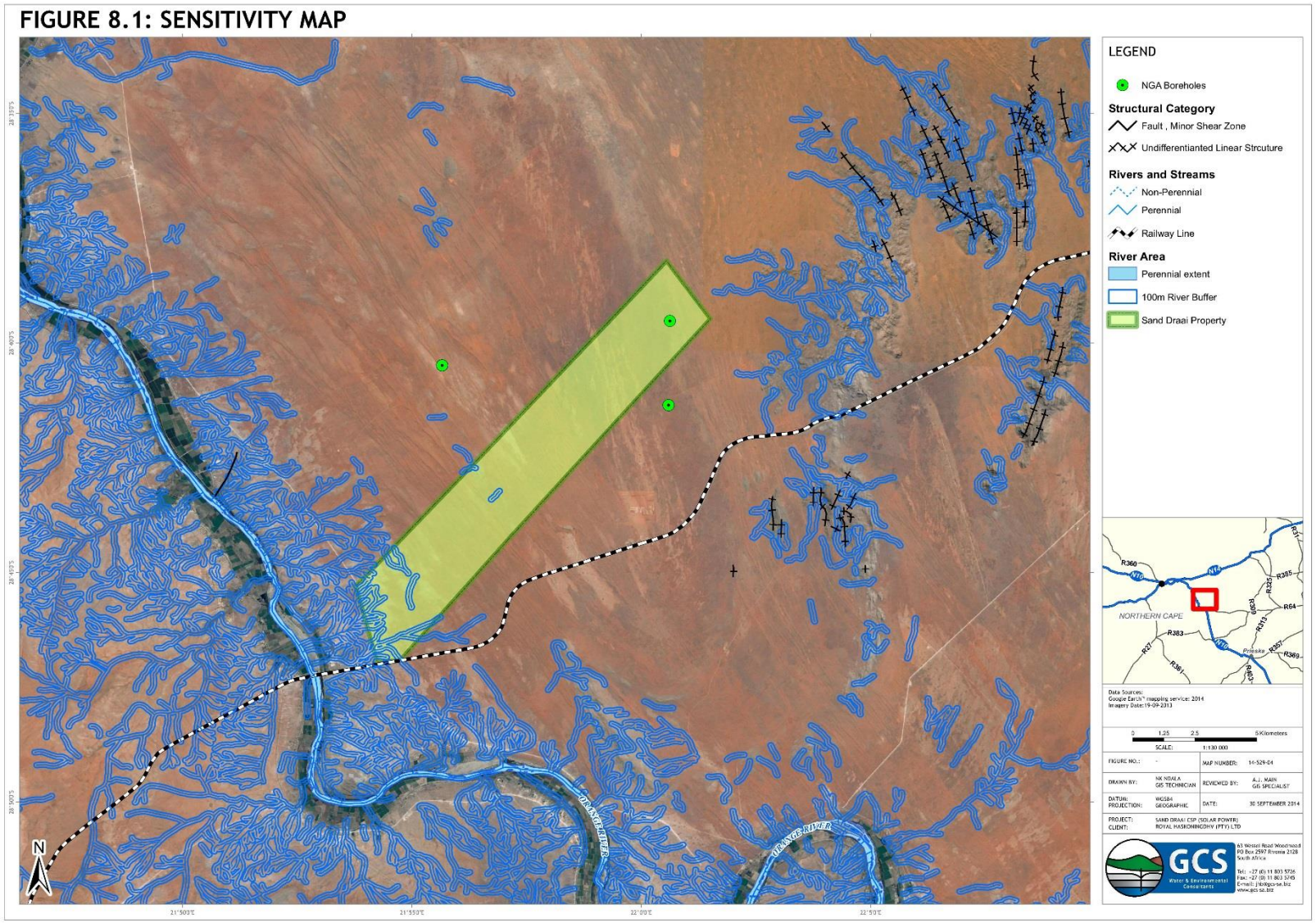


Figure 8-1: Sensitivity Map

9 CONCLUSIONS AND RECOMMENDATIONS

- The Proposed Thermal Solar Plant site is situated on the farm Sand Draai 391, approximately 75km south east of Upington and 14km north west of Groblershoop, in the Northern Cape Province. It is bounded on the south by the Orange River and is characterised by relatively flat topographic terrains. Evidence of non-perennial drainage lines could be viewed from aerial imagery in the southern part of the proposed site, but these areas are only expected to contain flowing water during periods of exceptional high rainfall;
- The general geology of the site mainly comprises red, coarse grained brown windblown sands of the Gordonia Formation, Kalahari Group. Dune ridges occur in the northern portions of the site. Quartz-muscovite schist, quartzite, quartz-amphibole schist and greenstone outcrops approximately 5km south west of the CSP tower area, as well as on the southern section of the site. Calcrete also outcrops in the southern section of the site approximately 8km southwest from the CSP tower area;
- The hydrogeological map of the area indicates that the fractured aquifer type occurs in the area. The yield from the local aquifers range from 0 to 0.2l/s.
- Groundwater use takes place in the farms located further away from the Orange River. Groundwater in these farms is used mainly for domestic purpose and livestock (cattle and sheep) farming;
- The potential impacts associated with the proposed development on the groundwater environment include potential contamination due to accidental spillage and the storage of heat transfer fluid which is a synthetic oil, hydrocarbon contamination arising from spills or leaks from heavy machinery used during the construction phase and contamination from spills or leaks of hazardous products stored on site;
- As part of the detailed EIA investigation, a hydrocensus will be conducted to confirm groundwater users and groundwater samples will be collected to obtain baseline chemistry conditions.

10 REFERENCES

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