Geotechnical Desktop Report for the proposed Hekpoort-Cashan power line and substation servitude

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Eskom Holding Limited SOC

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Geotechnical Desktop Report for the proposed Hekpoort-Cashan power line and substation servitude

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Disclaimer

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1 Introduction and Scope of Report

SRK Consulting (South Africa) Pty Ltd (SRK) was appointed by Eskom (the "Client") on 26 July 2014 to compile a Basic Assessment Report (BAR) for a proposed power line route and new substation site location linking the newly proposed Cashan Substation to the existing Hekpoort Substation within Gauteng Province.

Several specialist studies are being undertaken to provide more detailed information on the environmental aspects that may be affected by the proposed project.

This report serves as a specialist geotechnical study at desktop level that will form part the BAR submission. The report covers an assessment of the general expected geotechnical conditions of the study area, based on readily available desktop data and also the information provided by the Client.

2 Background and Brief

2.1 Background of the project

Eskom is in the process of expanding their power supply grid by supplying additional substations to areas in need of additional capacity and supplying electricity to areas with increasing electricity demand in the North West and Gauteng Province.

The proposed project includes the construction of a new substation in Cashan and a power line of approximately 13 km power line to the existing Hekpoort Substation. The proposed Cashan Substation (100x120 m) falls within the Gauteng Province, north-west of Krugersdorp and it is intended to alleviate the power supply demands experienced by Eskom in the area.

The proposed Cashan Substation will be connected to the existing Hekpoort Substation via an 88 kV power line which runs approximately 13 km in a north easterly direction from Cashan into the North West Province. There are two proposed alternatives for the power line, they are indicated in Appendix A-Figure 1, Figure 2, Figure 3 (attached at the back of this report) and in Figure 4-1 below.

2.2 Scope of Geotechnical Desk Top Evaluation

A desktop study involves the review of all available geological and geotechnical information relating to the area.

The following critical geotechnical factors have to be considered when assessing a site, these include:

- Inundation (flooding),
- Slope instability,
- Excavation,
- Soil activity (heave, collapse etc.),
- Erosion potential, and
- Shallow water table conditions.

To confirm and provide additional detail regarding the geotechnical conditions a site walk over survey and intrusive ground investigation will be necessary.

3 Available Information

The following data and literature was consulted and assessed as part of this desk top evaluation:

- 1:250 000 scale Geological Reference 2526-Rustenburg.

- Google Earth.
- Climatological data held in the SRK database.
- Proposed power line route spatial data as provided by the Client.
- Email correspondence from Ms Fiona Evans (SRK-Pretoria Office) dated 27 June 2013 detailing the approximate length of the power line servitude and area size of the proposed Cashan Substation.
- Probablistic Seismic-Hazard Maps for South Africa (Version 1, 2003), issued by the Council for Geoscience.
- Brink A.B.A., (1979). Engineering Geology of Southern Africa. Volume 1: The first 2 000 million years of geological time, Chapter 8-9, pp 249-276.

4 Results

A description of the geotechnically relevant aspects of the study area is provided in the following sections and is based on the review of the available data and information mentioned above.

4.1 General site locality and description

The proposed power line route alternatives from the proposed Cashan Substation to the existing Hekpoort Substation runs in a north easterly direction in Gauteng for approximately 9 km, it then crosses into the Bojanala District Municipality, within the Local Municipality of Madibeng of the North West Province for 1 km.

The proposed substation is located approximately 27 km North West of the town of Krugersdorp, approximately 35 km South West of the town of Brits, and approximately 54 km North West of Johannesburg as the crow flies.

The Hartebeespoort Dam can be found 25 km South West of the Cashan Substation.

Appendix A, Figure 1 and Figure 2, provides the locality of the proposed power line routes and substations on the 1:50 000 topographic map and the aerial photo map for the area respectively.

The main land use of the area is agricultural and the associated residential properties. The proposed power line routes both run along existing infrastructure. The northern route runs along the R536 and R560 roadways and the southern route option alongside gravel coarse district roads and a historic railway line. The railway line indicated on the available topographic map is not clearly visible in Google Earth and hence is thought to be no longer in use.

Borrow area excavations are mapped and also visible in Google Earth in close proximity to the Hekpoort Substation and along the southern route alternative.

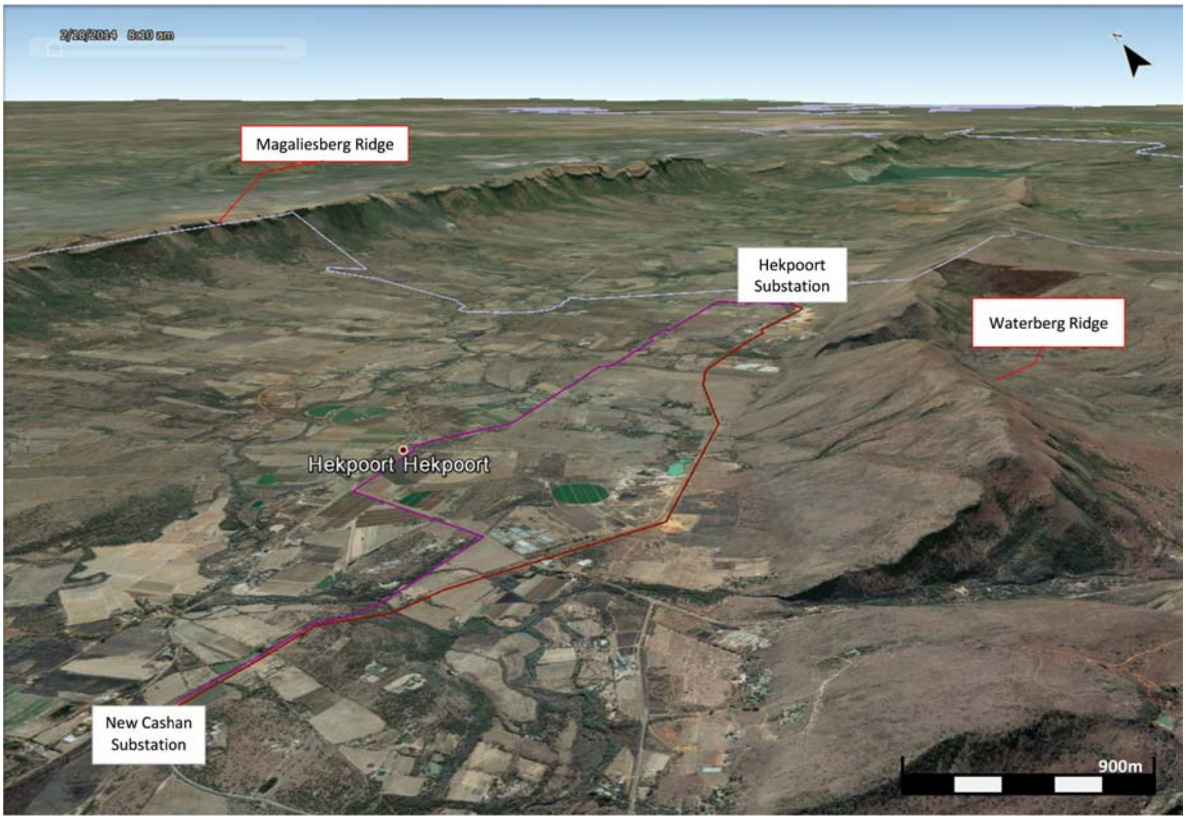
4.2 Topography and surface drainage

The study area resides within the relatively flat valley in between the Magaliesberg Ridge, forming the highest ground to the north west of the Hekpoort area (reaching an altitude of 1700 m above mean sea level) and the Waterberg ridge south east of the study area. In general, the topography of the study area is gently undulating moving from the Cashan Substation site towards the existing Hekpoort Substation in a north easterly direction.

Appendix A-Figure 1 illustrates the topographic variance to the north west and south east of the study area. Figure 4-1 below provides an oblique view using Google Earth imagery of the two routes and the proposed Cashan Substation site looking towards the north east.

The overall regional topography grades towards the north of Hekpoort or the greater Brits-Rustenburg area.

The proposed power line routes cross the Magalies River about 1.5 km to the north east of the proposed Cashan Substation site. The routes cross other non-perineal tributary streams to this water course at about 6.5 km and 8.52 km along the route/s moving from Cashan towards the existing Hekpoort Substation.



srk consulting	**HEKPOORT-CASHAN** GENERAL TOPOGRAPHY AND DRAINAGE-OBLIQUE GOOGLE IMAGE	Project No. 465044

Figure 4-1 Oblique view extract from Google earth showing general topography and drainage

4.3 Climate

To assess the climate of the study area fifty years of historic data measured by the Hekpoort weather station and rain gauge between 1950 and 1999 was used. The climate in the study area can be described as sub-tropical of the Highveld, with the wettest months being from November to January, and driest in June to July.

According to the available data, the mean annual rainfall for the area has been estimated at 601.9 mm per annum. Highest rainfall is experienced in January, with an average of 107.6 mm and the lowest rainfall in July with a reported average of 1.6 mm. The coolest month is June with average maximum and minimum temperature of 22.2°C and -2.8°C respectively. While January is the warmest month with average maximum and minimum temperature of 31.9°C and the mean annual minimum is 11.6°C. Frost occurs in most years between May and August.

The above data confirmed that the study area falls within the region of South Africa with annual rainfall more than 500 mm. According to Weinert's climatic N-value (Weinert, 1980) the site falls within a region where 2<N<5. It also falls within a sub-humid area based on Thornthwaite's moisture index. From this it is concluded that chemical weathering is expected to be the predominant mode of weathering of the in-situ rocks.

4.4 Regional and structural geology

According to the 1: 250 000 scale Geological map, 2526 Rustenburg, the study area is underlain by laminated slate and shales of the Silverton Formation interbedded with sandy thickly bedded, coarse grained gritty quartzites in places. These rocks were later intruded by north east- south west trending hybrid diabase sills and diabase dykes. These lithologies form part of the Pretoria Group of the Transvaal Supergroup.

Surficial deposits of the Quaternary age are noted to be present in the study area and these are generally unconsolidated to semi-consolidated transported soil of mixed origin.

The geological map indicates that these rocks can be overlain by in situ soils and/or massive to stratified hillwash, colluvium and scree.

An overview of selected structural geological features with a potential to be crossed by the proposed power line route/s project is presented below:

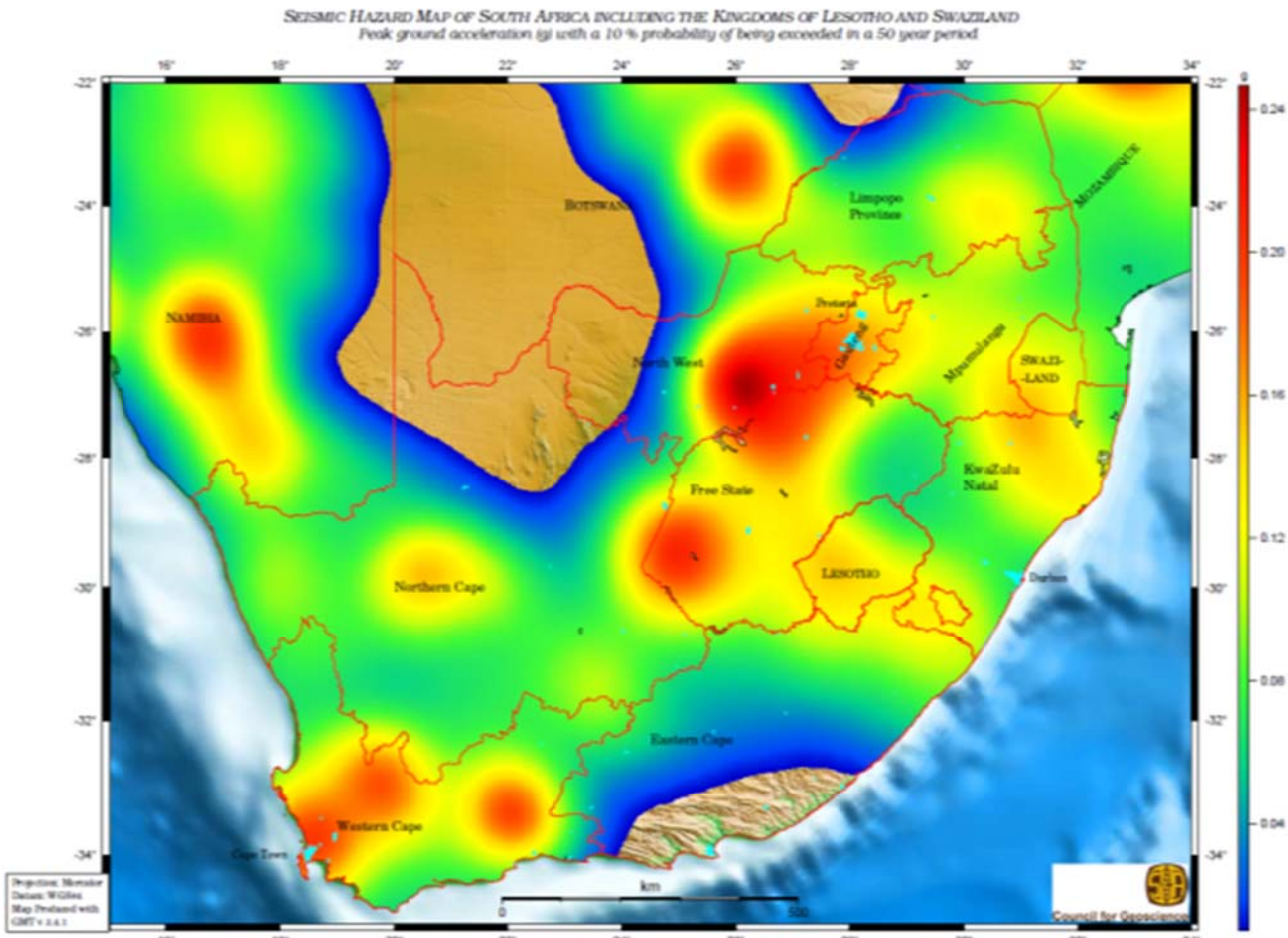
- Diabase sills and dykes - Several diabase sill and dyke intrusions occur within the proposed study area and power line route/s are likely to intersect two or more of the north east-south west trending diabase dykes as presented by the geology map.
- Faults – Several faults occur within the region of Hekpoort, a number of north west-south east faults are mapped, displacing the diabase, quartzites and shales of the Pretoria Group in places. No major faults were mapped crossing the specific routes proposed, however small scale faults may be present.

Appendix A-Figure 3 provides an extract of the Rustenburg geological map sheet showing the regional geology in relation to the proposed power line routes and new proposed Cashan Substation.

4.5 Seismicity

Seismic Hazard is generally described as being the physical effect of ground movement for a specific period of time and magnitude. Based on the study conducted by the Council for Geoscience (CGS), South Africa has two types of seismic events, namely natural earthquakes and mine tremors, which are associated with local mining activities. Shapira et. Al., (1989), as presented in the CGS study, indicated that South Africa is characterized by intraplate seismicity with sporadic occurrences of tectonic or natural earthquakes.

The seismic hazard map of South Africa is presented in Figure 4-2 below. According to this map, the cooler colours represent lower seismic hazard while the warmer colours represent higher hazard. The study area is located in an area where the peak ground acceleration is expected to be between 0.12 to 0.16 g (gravity, g). This denotes the peak ground acceleration with a 10% probability of being exceeding in 50 years.



srk consulting	**Cashan Station and Power lines, Hekpoort** SEISMIC HAZARD MAP	Project No. 465044

Figure 4-2 Seismic Hazard Map of South Africa, Lesotho and Swaziland

According to the SABS 0160-189 (as amended 1990, 1991, and 1993), code of practice for "The general procedures and loading to be adopted in the design of buildings", the area does not fall within the hazard class Zone I or Zone II as denoted and defined by the code and is therefore not subject to any additional design requirements in this regard.

4.6 Groundwater conditions

No nearby information of groundwater borehole data was available for review, however from the available topographic and drainage information and literature on the area it is expected that the region has a relatively shallow water table and high natural soil moisture content.

5 Geotechnical Evaluation

The Geological map figure (Appendix A-Figure 3) suggests that the underlying soils and rock expected to be present along both routes options as well as the substation site is likely to be very similar and hence no clear comparison is made in the discussion between the two routes below. Most of the desk top findings for the various soils and rock types that occur in the area are considered generic and assumed to be applicable to varying degrees to both routes and the substation site. Only when more detailed invasive investigations are completed within follow on phases can specific ground conditions be obtained and evaluated.

5.1 General Discussion

From the geological information available the dominant materials expected to be encountered are transported soils of mixed origin (mostly derived from the Daspoort Formation quartzites, Silverton Formation shales and intrusive diabase) and residual soils developed from the intrusive diabase sills and dykes and Silverton Formation shale. Due to the climatic conditions of the study area it is expected that the residual soil profiles will be relatively deeply developed.

The literature reviewed has numerous examples of problems experienced within the soils from these origins with regards heave and settlement. The soils developing from both the Silverton shale and intrusive diabase have been described as hydromorphic. Some excavation issues can also be expected.

The desk top study has enabled an assessment of some of the critical geotechnical factors as listed at the start of this report; these are discussed in the section below.

5.2 Review of critical and sub-critical geotechnical factors

5.2.1 Inundation (flooding)

No floodline studies were available for the area.

From the review of the topography data and using the satellite imagery available the site does not seem to fall within the flood plain of any major rivers or streams.

A detailed assessment by a hydrologist is recommended in this regard to ensure critical infrastructure is not placed or planned within a floodline.

5.2.2 Slope instability

The proposed power line route/s and new substation site straddles and is situated on relatively gentle sloping ground with no current slope instability issues noted. Slope instability associated with construction activities will be addressed during the field investigation when more information regarding the size and type of foundation excavations required is known.

Excavations within the Pretoria Group shales are often associated with sliding failures along uncommonly smooth and even bedding planes along the direction of the dip. Care therefore needs to be taken when deep excavations are made into shale bedrock. Highly weathered diabase sills are also prone to cause slope instability when excavations into the highly decomposed soils or weathered rock occurs.

5.2.3 Excavation

From the data reviewed the possibility of excavation difficulties cannot be ruled out. The presence of diabase intrusions in this area are normally associated with advanced weathering compared to the surrounding parent rock it intrudes. The diabase rock, where not completely weathered can also be associated with highly jointed structure. These properties usually pose a challenge when tunnelling or within open excavations as the weak zones tend to disintegrate and fail into the opened excavation or tunnel.

From the literature reviewed, topography and general geology expected it is anticipated that excavation class of the materials on site will range from “soft” to “intermediate” up to the depth required for foundation construction. Where bedrock is encountered it is expected that intermediate to hard rock excavation will be required (SANS 1200-D Earthworks, May 2007).

5.2.4 Soil activity

The silty to clayey transported and/or residual soils that can develop from the diabase dykes or sills in the area can be associated with high soil activity during moisture fluctuations. Generally the area is expected to have a relatively shallow water table and the soils, a high natural moisture content. Therefore the problem is more due to settlement, and not heave, that occurs when soils desiccate during long periods of drought.

Differential movement where a development straddles different rock and/or soil types with varying degrees of soil heave and settlement characteristics are common in the region. This possibility must be investigated and designed for to limit potential damage to the structures.

The Pretoria Group sedimentary strata (of which the Silverton Formation shales form part) are generally associated with shallow red to yellow residual soils of less than 2 m thick and consist entirely of inert materials (i.e. not subject to soil heave). These soils are generally not associated with foundation problems.

However, some exceptions have been noted to occur within the Silverton shales where overlain by a thick superficial pediment of transported soils derived from the nearby Daspoort quartzite ridge. The case studies noted soft white residual soils with a high clay content of mostly montmorillonite clay minerals, indicating its highly expansive nature.

From the geological map data and satellite imagery reviewed the Silverton shales in the study region may well have similar characteristics as noted above; based on the expected transported soil cover and the colour of the soils observed in the opened borrow pit areas.

It is not clear whether the phenomenon described above is related to a specific stratigraphic unit within the Silverton Formation or with hydromorphic development produced by the presence of a water table at shallow depth below a pediment.

The properties and influence of these soils will have to be reviewed in detail considering the proposed structures and their proposed loads during the field investigation. It would also be advisable that, should the transported soils encountered be in excess of a standard trial hole depth (usually around 3-5 m), deeper soil investigation be initiated to confirm the properties of the residual soils below the transported soil cover. The need for this would however depend on the loads imposed and the general sensitivity of the proposed structures to heave and settlement.

5.2.5 Erosion potential

The erosion potential of the study area is relatively low due its gentle topography. No signs of extensive erosion gulleys or erosion damage were noted during review of the available satellite imagery.

5.2.6 Shallow water table conditions

From the data reviewed the presence of shallow water conditions (perched water tables) cannot be confirmed or ruled out.

From the available information it is believed that the area can be associated with shallow water table conditions, however this would require confirmation during filed investigations.

5.2.7 Collapsible soils

The soils derived from the directly underlying lithologies within the study area do not generally weather to form collapsible soil structures, however, this cannot be ruled out until a field investigation of the soils have confirmed this.

Transported soil profiles could potentially be associated with collapsible soil fabric, should they occur within a favourable topographic environment where leaching of the profile can occur to leave behind a collapsible grain structure.

5.2.8 Compressible soils

It is expected that the soils within the study area will display some degree of compressibility and this would require appropriate settlement testing in order to confirm the magnitude of settlement that can be expected.

Large settlements concerns are mostly associated with possible desiccation of active soils during long periods of drought as noted in Section 5.2.4 above.

5.2.9 Soil permeability

The presence of clayey and low permeability soils is expected. Transported soils may be of variable nature depending on their origin and nature of transportation. The soil properties can generally only be confirmed following intrusive field investigation.

5.2.10 Dispersive soils

No signs of extensive erosion dongas/gulleys were noted in the information reviewed and therefore it is believed that the specific soils on site and nearby areas are not prone to erode extensively as in the case of dispersive soils.

5.2.11 Soil aggressivity

The chemical constituents of the soils cannot be confirmed, but from previous experience the soils developed from these type of rocks are usually not highly aggressive towards concrete and/metal but may be moderately aggressive. This will however need to be confirmed with the appropriate testing.

6 Conclusions and Recommendations

From the above desk top evaluation it is considered that both the proposed power line route alternatives and the Cashan Substation site should in all practicality be suitable for development once detailed geotechnical information is available. It is also recommended that floodline information be consulted to confirm where potential flood risk areas are to ensure the proposed developments take this into account. Furthermore, care must specifically be taken with regards the identification of active soils and their extent and conditions where large or deep foundation excavations may be required.

No fatal geotechnical flaws have been identified for either of the proposed routes thus far and expected geotechnical constraints are considered similar for both power line route options. It is expected that the foundation design technology available should allow the safe development of the proposed structures within the study area, provided good knowledge of the geotechnical conditions are obtained via future investigations.

It is recommended that further detail site investigations be conducted to confirm the geotechnical conditions along the final chosen route and substation site. This will allow the gathering of adequate site specific information on the soils and rock present to confirm conditions and complete recommendation for the foundation design of the facility.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

7 Selected Bibliography

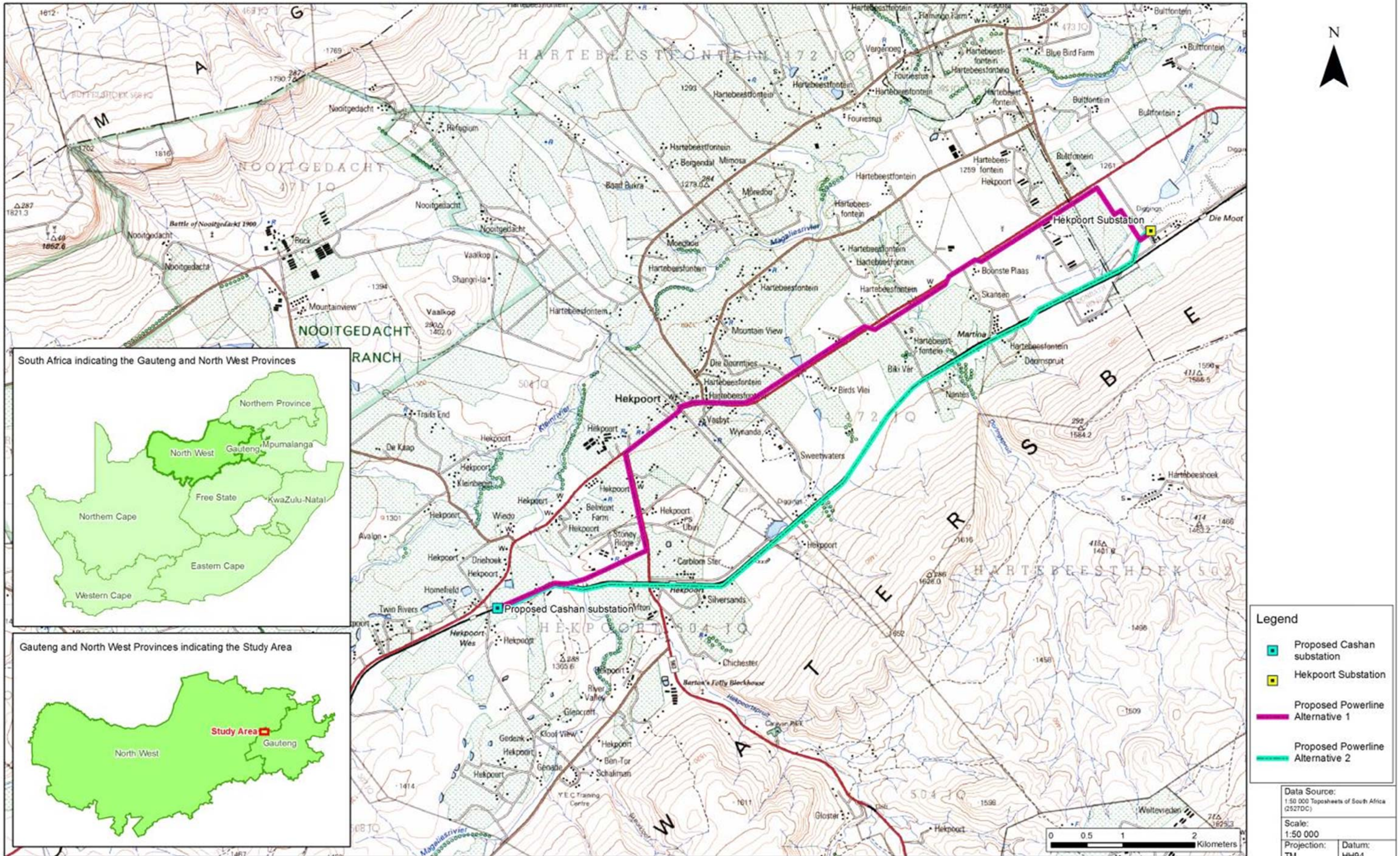
Brink A.B.A., (1979). *Engineering Geology of Southern Africa. Volume 1: The Karoo Sequence*, Chapter 7-8, pp 177-233.

SANS 1200D: *Standardized Specification for Civil Engineering Construction (All Parts). South African Bureau of Standards*, 1988

The Council of the South African Bureau of Standards. SABS 0160 – 1989: *The general procedures and loadings to be adopted in the design of buildings.* (1989, as amended 1993)

Appendices

Appendix A: Figures



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Date: 26/09/2014	Compiled by: MURA
Project No: 465044	Fig No: 1

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GEOTECHNICAL STUDY: PROPOSED HEKPOORT - CASHAN POWERLINE AND CASHAN SUBSTATION

LOCALITY MAP INDICATING THE STUDY AREA

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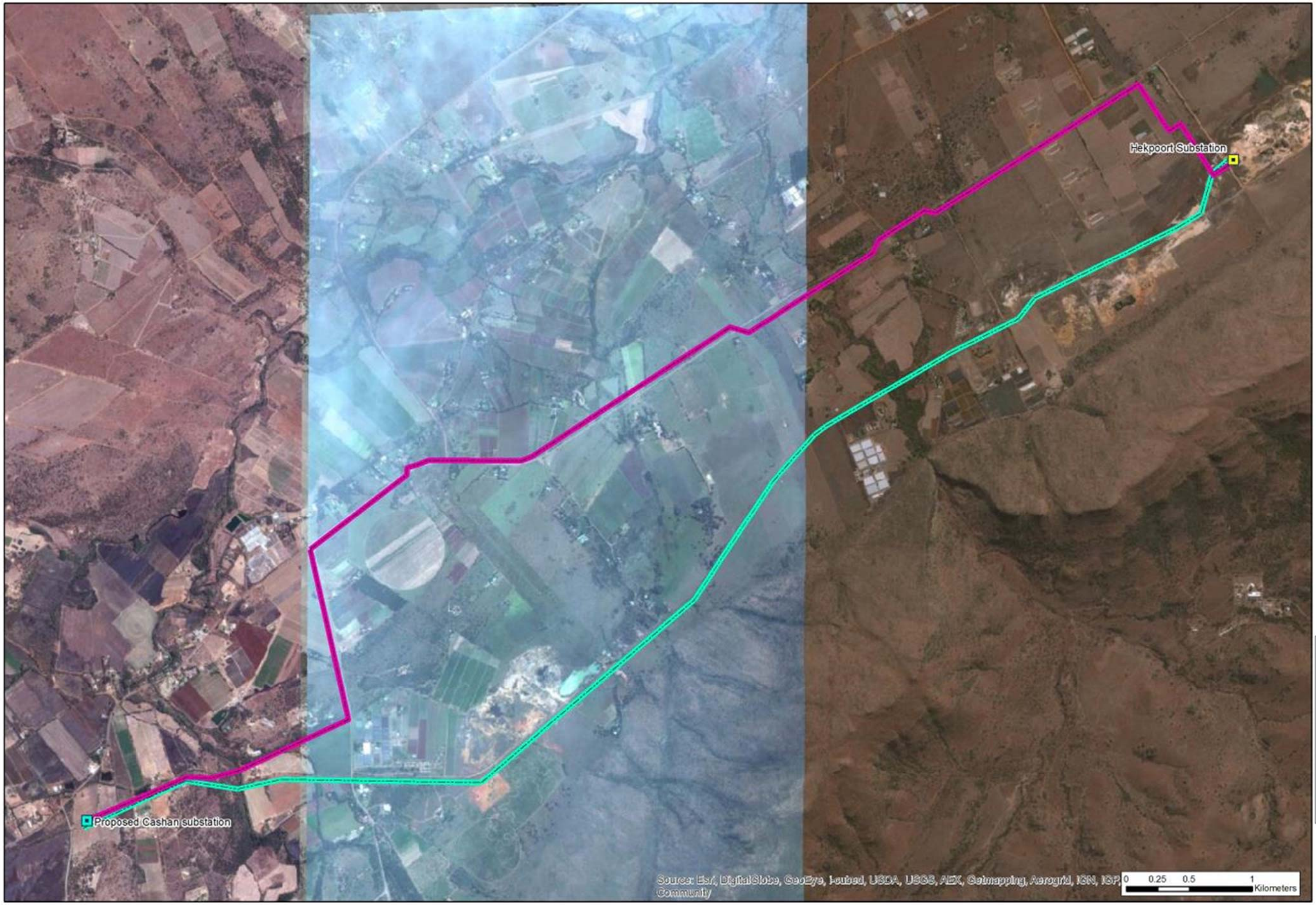
Revision: A Date:26 09 2014



Legend

- Proposed Cashan substation
- Hekpoort Substation
- Proposed Powerline Alternative 1
- Proposed Powerline Alternative 2

Data Source:	
Scale: 1:30 000	
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Central Meridian/Zone: Lo27	
Date: 24/03/2014	Compiled by: MURA
Project No: 465044	Fig No: 2

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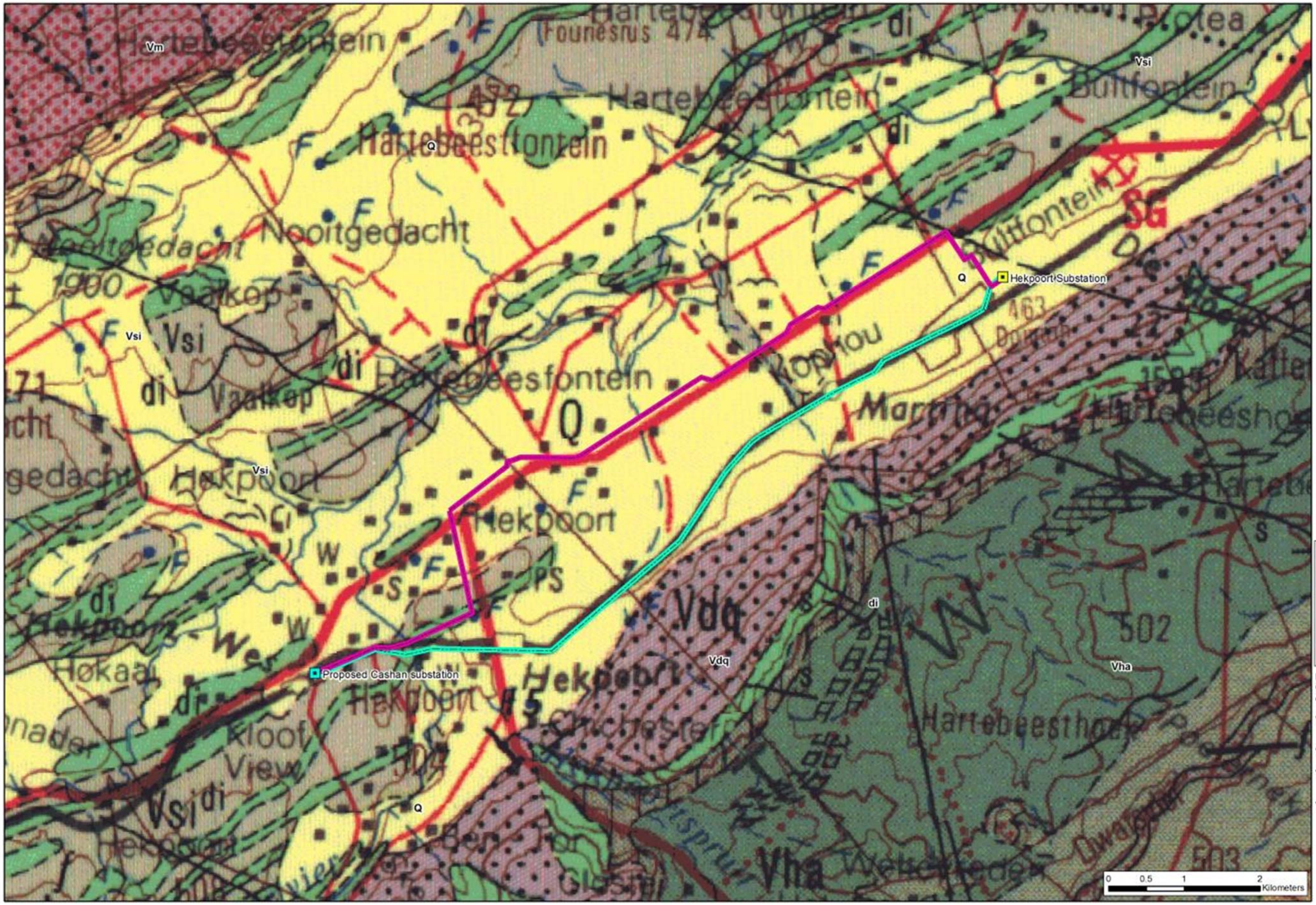
GEOTECHNICAL STUDY: PROPOSED HEKPOORT - CASHAN POWERLINE AND CASHAN SUBSTATION

AERIAL IMAGE SHOWING THE ORIENTATION OF THE PROPOSED DEVELOPMENT

Path: G:\465044_48V_ESKOM_CASHAN_VIA_PTA\8GIS\GISPROJ\MXD\Geotechnical_Assessment\465044_F2_Eskom_Cashan_Geotech_Aerial_A3L_C_26092014.mxd

Revision: A Date: 24 03 2014



Legend

- Proposed Cashan substation
- Hekpoort Substation
- Proposed Powerline Alternative 1
- Proposed Powerline Alternative 2

Key

Q - Surface deposits
di - Diabase dykes (Transvaal Diabase)
Vsi - Slate, shale, Hornfels, Quartzit (Silverton Formation-Pretoria Group)
Vdq - Quartzite (Daspoort Formation-Pretoria Group)
Vha - Andesite, Basalt, tuff, agglomerate (Hekpoort Formation-Pretoria Group)
Vm - Quartzite (Magaliesberg Formation-Pretoria Group)

Data Source: 1:50 000 Geological Maps of South Africa (2526)	
Scale: 1:50 000	
Projection: TM	Datum: HH94
Central Meridian/Zone: Lo27	
Date: 24/03/2014	Compiled by: MURA
Project No: 465044	Fig No: 3

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GEOTECHNICAL STUDY: PROPOSED HEKPOORT - CASHAN POWERLINE AND CASHAN SUBSTATION

GEOLOGY INDICATING THE PROPOSED DEVELOPMENT

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Revision: A Date: 24 03 2014

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