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DESKTOP GEOTECHNICAL SCOPING REPORT
for
MOOKODI INTEGRATION PROJECT, VRYBURG

Client: Sivest   Date: July 2010 Job No:10162

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1 INTRODUCTION

Sivest approached Geostrategies to supply specialist geotechnical input for the Mookodi Integration Project proposed for the North West Province.

The project involves the linking of an existing Eskom 132kV Distribution Power Line from the Vryburg Municipal Substation to the proposed Bophirima Distribution Substation. From Bophirima, distribution lines will be constructed to two further proposed Eskom facilities referred to as the Kalplaats substation and Mookodi Transmission substation.

Geotechnical scoping studies are required as part of the Environmental Impact Assessment of the above project.

Sivest will be responsible for the collation and integration of all spatial data emanating from the specialist studies, and for the production of final composite maps for the study.

Geostrategies were appointed by Sivest as a specialist geotechnical consultant to carry out the required work, on the 19th April 2010.

2 SCOPE OF WORK

The scope of the work was as follows :

2.1 Scoping Phase

Desktop study to determine anticipated geological and geotechnical conditions along the following Eskom 132kV Electrical Distribution Lines :

a Route from proposed Bophirima Substation to proposed Kalplaats Substation (approx 89 Kms) - Alternative routes 1 & 2

b Route from proposed Bophirima Substation to existing Vryburg Municipal Substation (approx 7 Kms) - Alternative routes 1 & 2 - Above Ground

c Route from proposed Bophirima Substation to existing Vryburg Municipal Substation (approx 7 Kms) - Alternative routes 1 & 2 - Underground

d Route from proposed Bophirima Substation to proposed Mookodi Transmission Substation (approx 14 Kms)

2.2 Objective of the Report

The desktop assessment was undertaken to achieve the following objectives :

- Assess the nature of the geology across the powerline routes.
- Attempt to identify geological and geotechnical conditions which may prove to be problematic for the siting of the proposed powerlines.
- Attempt to identify geological and geotechnical conditions which may prove to be problematic for the siting of the proposed substations.

2.3 Method of Investigation

The desktop study involved the investigation of the following sources :-

Study of the published 1:250 000 Geological Survey geology maps, covering the areas under investigation

Study of the relevant 1:50 000 Topographic maps, covering the areas under investigation.

Reference to published literature on the characteristics of the anticipated rock and soils to be encountered, as well as the anticipated foundation solutions in such materials.

Refer to previous geotechnical investigations carried out in similar geotechnical terrains. This will comprise both Geopractica reports, as well as reports compiled by other engineering consultants.

3 GEOLOGY AND ANTICIPATED SOIL TYPES

From the 1:250 000 geological maps (2624 Vryburg & 2724 Christiana) it was determined that the geology along the power lines routes was highly variable and complex. In order to simplify the numerous geological boundaries, each boundary has been given a numeric value. The description of the geological formations along each separate powerline route is referenced using these numbers.

The system of numbering is clearly marked on the respective geological maps, onto which the powerline routes have been designated.

According to the contour map of climatic N values for South Africa compiled by Weinert, Vryburg falls into the area with an N value of 8.2.

This would indicate that the most likely method of weathering of the host bedrock would be due to mechanical disintegration, as opposed to chemical weathering in the areas of the country having a higher annual rainfall.

The weathering profile in these more arid regions of the country, should therefore favour the generation of a thinner residual soil horizon, than would be the case in moist, wet coastal regions.

Table 1 below, is a summary of all the geological formations that have been identified along the routes, as well as an indication of the anticipated residual soils types that will be developed from the weathering of the individual host bedrock types.

	Table 1 : Basic Geology of study area		
Route section	**Rock Type / Lithology**	**Geological Unit**	**Anticipated main soil types**
1 and 2 1 and 3	Aeolian sand **overlying** Granite, Granite Gneiss, Migmatite, Schist & Amphibolite	Gordonia Formation, Kalahari Group, Quaternary Period overlying Swazian Intrusives	Transported, silty, medium to coarse grained sandy soils
2 and 4 3 and 4 4 and 7	Andesitic Lavas - Sub-outcrops	Allanridge Formation, Ventersdorp Supergroup	Clayey transported soils, overlying clayey residual soils.
5 and 6	Diabase Dykes - Outcrops	Intrusive Rocks of Jurassic Age	Hard rock diabase, with scattered large boulders

	Table 1 : Basic Geology of study area		
Route section	**Rock Type / Lithology**	**Geological Unit**	**Anticipated main soil types**
7 and 8	Andesitic Lavas - Outcrops	Allanridge Formation, Ventersdorp Supergroup	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface
8 and 9	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
9 and 10	Andesitic Lavas - Outcrops	Allanridge Formation, Ventersdorp Supergroup	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface
10 and 11	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
11 and 12	Quartzites, Siltstones, Shales, Conglomerates - Sub-outcrops	Griqualand West Sequence, Vryburg Formation	Fine gravelly sand (Quartzites) Silty soils (Siltstones & Shales) Sandy coarse gravels (Conglomerates)
12 and 13	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
13 and 14	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
14, 15 and16	Andesitic Lavas - Outcrops	Allanridge Formation, Ventersdorp Supergroup	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface
17	Andesitic Lavas - Outcrops	Allanridge Formation, Ventersdorp Supergroup	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface
17, 18 and19	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
14 and 19	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
13 and 20	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
21 and 22	Dolomite with interbedded Shale - Outcrops	Boomplaas Member, Schmidtsdrift Formation, Campbell Group, Griqualand West Sequence	Transported slightly clayey, gravelly sandy soils or silty soils overlying abundant, hard, chert gravels in a clayey sand matrix (residual dolomites) or silty soils (residual shales). Also hard rock chert and dolomite outcrops at surface.
22 and 23	Contact zone between Dolomites & Andesitic Lavas	Contact Campbell Group & Vryburg Formation	as for either 21 and 22 above, or 23 and 24 below
23 and 24	Andesitic Lavas - Outcrops	Vryburg Formation, Griqualand sequence.	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface

	Table 1 : Basic Geology of study area		
Route section	**Rock Type / Lithology**	**Geological Unit**	**Anticipated main soil types**
24 and 25	Diamictites & Shales - Sub-outcrops with Quaternary, alluvial sands and clays near river	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
25 and 26	Andesitic Lavas - Outcrops	Vryburg Formation, Griqualand sequence	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface
26 and 27	Shales & Siltstones with interbedded Dolomites - Outcrops	Clearwater Member, Schmidtsdrift Formation, Campbell Group, Griqualand West Sequence	Transported slightly clayey, gravelly sandy soils or silty soils overlying abundant, hard, chert gravels in a clayey sand matrix (residual dolomites) or silty soils (residual shales and siltstones) Also hard rock chert and dolomite outcrops at surface.
27 and 28	Andesitic Lavas - Outcrops	Vryburg Formation, Griqualand West Sequence	Thin horizon of clayey transported soils, overlying clayey residual soils. Scattered hard rock andesite outcrops at surface
28 and 29	Diamictites & Shales - Sub-outcrops	Dwyka Formation, Karoo Sequence	Silty transported soils, overlying sandy silts (residual shales) or clayey sands with a variable gravel portion (residual diamictites)
29 and 30	Aeolian Sands	Quaternary Age	Transported, silty, medium to coarse grained sandy soils

With reference to the numbered geological maps A,B & C, the following geological terrains will apply to each respective powerline route :

3.1 Bophirima Substation to Kalplaats Substation

3.1.1 *Section 1 - 2 and 1 - 3*

Aeolian Sand (Gordonia Formation, Kalahari Group, Quaternary Period)
overlying
Swazian Intrusives (Undifferentiated granite, gneiss, migmatite, schist and amphibolite.)

The general geology over this section of the route, comprises ancient intrusive rocks which have subsequently been metamorphosed (altered) by the effects of increasing pressure and temperature within the prevailing geological environment within the Swazian Geological Era.

The original intrusive rocks have been changed to produce gneisses, migmatites, schists and amphibolites.

These rocks have subsequently been overlain by recent wind blown sands of Aeolian age.

The prevailing geotechnical conditions can therefore be expected to comprise relatively deep and loose silty sands, overlying competent metamorphic bedrock. The depth of residual soils derived from the weathering of the parent rock is anticipated to not be significant.

Due to their loose nature, the Aeolian Sands can be anticipated to be highly compressible if subjected to foundation loading.

3.1.2 *Section 2 - 4, 3 - 4, & 4 - 7*

Andesitic Lavas - Sub-outcrops (Allanridge Formation Ventersdorp Supergroup)

This portion of the route is underlain by intrusive lavas of andesitic composition. The lavas normally weather to greenish grey and yellow brown, clayey & silty soils, which normally exhibit expansive characteristics. The thickness of this residual horizon can be significant.

The andesitic lavas can be expected to be overlain by a blanket of recent transported soils, comprising sands with a variable silt content.

The prevailing geotechnical conditions can be anticipated to comprise a relatively thin sandy hillwash horizon, underlain by clayey and sandy silt residual soils. Hard andesitic lava bedrock will be intersected at depth.

As the andestic lavas have been characterized as being a sub-outcrop, it is assumed that only scattered rock outcrops will be visible at surface.

3.1.3 *Section 5 and 6*

Diabase Dykes - Outcrops (Intrusive Rocks of Jurassic Age)

Over this section are intrusive diabase dykes. These features represent liquid volcanic magma which has worked its way to surface through sub-vertical cracks and fissures in the surrounding geological sequences.

They normally represent extended linear features on surface, of variable width. The diabase dykes at this locality have been described as outcrops. This would indicate that in the field they will be represented as thin, fairly low hillocks comprised of hard rock diabase. Numerous large diabase boulders can be anticipated at surface, on, and in the immediate vicinity of, the dyke.

With regards to the geotechnical characteristics of these features, difficulty will be encountered in identifying a suitably level base for the pylon foundations, and some rock excavation or limited blasting may be required to produce the required level founding platforms.

The elevated profile of the diabase dyke rock outcrops will also effect the horizontal distance between the suspended power lines and the existing ground surface.

3.1.4 *Section 7 and 8*

Andesitic Lavas - Outcrops (Allanridge Formation, Ventersdorp Supergroup)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 - 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.1.5 *Section 8 - 9*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

The underlying geology over this section will comprise diamictite and shale rock types, assigned to the Dwyka Formation.

The Dwyka period was one associated with glaciation, and the diamictites are thought to be glacial in origin. Diamictites therefore comprise a wide variety of angular rock fragments, plucked from the rocks over which the glacier moves. Upon melting the fragments varying in size from clay fraction to boulders, are deposited into fluvial and lacustrine environments. The sediments ultimately consolidate into diamictite and shale rock types.

An identifying feature of the diamictites are abundant angular rock fragments and pebbles of various size and origin, cemented into a fine matrix.

The diamictites generally weather to clayey sand soils with a varying gravel content. The depth of the residual weathered horizon in normally not very thick.

The shales in contrast can be expected to weather to a greater depth , producing residual silty soils which can be potentially expansive.

These Dwyka sediments can also be anticipated to be overlain by a thin sequence of sandy, poorly consolidated, hillwash materials. The more competent underlying residual diamictite and shale soils, should however occur at a limited depth below present ground surface.

3.1.6 *Section 9 and 10*

Andesitic Lavas - Outcrops (Allanridge Formation, Ventersdorp Supergroup)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 and 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.1.7 *Section 10 and 11*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 and 9.

3.1.8 *Section 11 and 12*

Quartzites, Siltstones, Shales, Conglomerates (Griqualand West Sequence, Vryburg Formation)

The underlying geology over this section will comprise siltstone and shale rocks, as well as possible quartzite rocks and conglomerate formations, all belonging to the Griqualand West Sequence of the Vryburg Formation. These rocks types are all sedimentary, having been transported by water and deposited as sediments which have become consolidated into rock due to the overburden pressure of more recently deposited materials.

The siltstones and shales can be anticipated to weather to produce residual silty soils which can be potentially expansive.

The quartzites and conglomerates in comparison, can be anticipated to weather to sands and gravels of low potential expansiveness.

A thin covering horizon of sandy, poorly consolidated hillwash soils can also be expected.

3.1.9 *Section 12 and 13*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 and 9

3.2 Bophirima Substation to Vryburg Municipal Substation

3.2.1 *Section 13 and 14*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 - 9

Route Alternative 1

3.2.2 *Section 14, 15 and 16*

Andesitic Lavas - Outcrops (Allanridge Formation, Ventersdorp Supergroup)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 - 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.2.3 *Section 17*

Andesitic Lavas - Outcrops (Allanridge Formation, Ventersdorp Supergroup)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 - 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.2.4 *Section 17, 18 and 19*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 and 9

Route Alternative 2

3.2.5 *Section 14 and 19*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 - 9

3.3 <u>Bophirima Substation to Mookodi Transmission Substation</u>

3.3.1 *Section 13 and 20*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 and 9

3.3.2 *Section 21 and 22*

Dolomite with interbedded Shale - Outcrops - (Boomplaas Member, Schmidtsdrift Formation, Campbell Group, Griqualand West Sequence)

The anticipated underlying geology over this section of the route are dolomite formations containing interbedded shale horizons.

The Dolomites represent the existence in geological time of an ancient inland sea in which bacteria were in the process of releasing oxygen into the atmosphere, and in so doing removing carbon dioxide from the atmosphere , and precipitating it as carbonates such as limestone rocks. (algal photosynthesis and inorganic precipitation)

During a chemical process of alteration (diagenesis) the limestones are converted to dolomites. Also formed are secondary silicates in the form of hard chert deposits. Additional sedimentation during this period into the inland sea, results in interbedded shale and dolomite formations. (syndepositional environment)

The bedrock profile within the dolomites is highly variable with hard, steep, dolomite pinnacles with deeply weathered slots in between. These hard rock dolomite pinnacle can occur close to surface or at a significant depth, and can be widely separated or closely spaced. These features are due to the fact that dolomites can be easily dissolved by slightly acid ground waters, percolating downward from surface, into the underlying formation.

This dissolution of the dolomite bedrock can result in the formation of underground cavities and caverns, resulting in the formation of sinkholes up to the surface, as well as gradual subsidence of the ground surface to form doline depressions.

On the West Rand, most sinkhole and doline formation was related to the draw down of the local watertable, due to underground mining operations. Human development could also be the triggering mechanism for the formation of sinkholes and dolines, due to the ingress of surface water into the underlying formation due to leaking sewers, water storage ponds, water taps, stormwater drains as well as water services to residential and commercial buildings.

The dolomite residuum typically comprises silts and sands with a variable angular chert gravel content. Also present can be zones of very soft, highly compressible, manganiferous clay (wad). A feature of dolomite terrains is that soil conditions can actually become worse, deeper down in the profile.

Dolomite profiles may either be chert rich or chert poor. Subsidence within the chert rich formations has a lower occurrence than subsidence within the chert poor residuum, where silty and waddy soils are more prevalent.

A further factor which reduces the risk profile of dolomite terrains, is the presence of a thick and non erodible blanketing soil layer, over the underlying dolomite formation.

The interbedded shale bedrock on the other hand, can be anticipated to weather to a residual silty soil, that could be potentially expansive.

3.3.3 *Section 22 and 23*

Contact zone between Schmidtsdrift, Dolomites
&
Vryburg Formation, Andesitic Lavas

As this zone runs along the geological contact between the dolomites with interbedded shales, and the andesitic lavas, any of these geological rock types could be present comprising the subsoils beneath the powerline foundations.

For an indication of geological residual soil types that could be present, reference should be made to both Section 3.3.2 as well as Sections 2 - 7.

3.3.4 *Section 23 and 24*

Andesitic Lavas - Outcrops - (Vryburg Formation, Griqualand West Sequence)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 - 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.3.5 *Section 24 and 25*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence) with Quaternary, alluvial sands and clays near river

As for Sections 8 and 9

3.3.6 *Section 25 and 26*

Andesitic Lavas - Outcrops - (Vryburg Formation, Griqualand West Sequence)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 - 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.3.7 *Section 26 and 27*

Shales & Siltstones with interbedded dolomites. (Clearwater Member, Schmidtsdrift Formation, Campbell Group, Griqualand West Sequence)

The anticipated underlying geology over this section of the route are shale and siltstone formations with interbedded dolomites.

The rock sequences anticipated are similar to those described in Section 3.3.2 above, for the Boomplaas Member of the Schmitsdrift Formation. In this instance the sequence has been identified as belonging to the Clearwater Member of the Schmitsdrift Formation.

The difference here is that the Shales and Siltstones dominate, with the Dolomites forming a subsidiary interbedded sequence, which can be assumed to be much thinner and less prevalent, than in the case of the Boomplaas Formation.

The subordinate nature of the dolomites can also be expected to reduce the risk of sinkholes and dolines,, frequently associated with this geological rock type.

The predominant residual soil type can be anticipated to be silty sands. In the areas of interbedded dolomite, the residuum will typically comprise silts and sands with a variable angular, chert, gravel content. Also present can be zones of very soft, highly compressible, manganiferous clay (wad)

As with the Boomplaas dolomite, the risks of unfavourable ground conditions developing will be related to the human development present, and other factors such as water ponds, dams, stormwater drains, rainwater collection areas etc.

3.3.8 *Section 27 and 28*

Andesitic Lavas - Outcrops - (Vryburg Formation, Griqualand West Sequence)

As for Sections 2 and 7.

Over this section of the route the geological map indicates that outcrops can be anticipated, not sub-outcrops as for Section 2 - 7.

This will mean that the recent, transported soil cover can be anticipated to be thinner, and that localized outcrops of hard, andesite bedrock will be exposed at surface.

3.3.9 *Section 28 and 29*

Diamictites & Shales - Sub-Outcrops - (Dwyka Formation, Karoo Sequence)

As for Sections 8 and 9

3.3.10 *Section 29 and 30*

Quaternary Aeolian Sands

These sand are recent wind blown sediments of Aeolian age.

The prevailing geotechnical conditions in this zone can be expected to comprise relatively deep and loose, silty sands.

Due to their loose nature, the aeolian sands can be anticipated to be highly compressible if subjected to foundation loading.

4 GENERAL ANTICIPATED FOUNDING CONDITIONS

The various geological formations that the powerlines will cross, weather to produce residual soils that typically have certain common characteristic geotechnical parameters.

Each typical soil type will be discussed below, considering the potential problems which can be generally anticipated, as well as possible geotechnical solution.

4.1 Recent Transported Soil Types

It can be anticipated that the entire route will have a surface cover of recent transported soils. The thickness of this cover can be expected to vary, according to the recent geological depositional processes that were active at the time. Main critical factors will be the general topography of the areas at the time of the sedimentation cycle as well as the presence of large rivers and lakes.

As these transported sediments were laid down in recent geological times, they will not have undergone any significant consolidation. They can therefore be considered to be of a loose consistency, and could experience significant settlement under applied foundation loading.

With regards to alluvial deposits, these could exhibit settlement if of a soft consistency, as well as expansive behaviour if of a high plasticity.

Most structures are therefore founded at the base of these recent transported materials, on the more competent residual soil horizons.

Alternately, the loose / soft / potentially expansive soils are removed down to a specified depth, and replaced with well compacted, inert, granular fill materials, which provide a competent base for the proposed structures.

4.1.1 *Wind Blown Aeolian Sands*

These soils have been transported under the action of wind. They usually form relatively deep horizons, and at surface display characteristic undulating sand dune features.

Due to their method of deposition, these sandy soils are generally of low cohesion and consistency, and can be expected to settle under foundation loading.

Where this sandy surface horizons is thick, the most appropriate geotechnical solution would be to excavate to a specified depth, and re-compact the removed soils back up to foundation level. This solution is referred to as constructing and engineered soil mattress.

If the horizon is thin, structures could be founded on competent underlying residual soil horizons.

4.1.2 *Water Transported Hillwash*

These soils have been transported by water and , generally over fairly short distances, from higher ground down to lower areas.

They usually form more cohesive soils than the aeolian sands, but are also of generally low consistency.

A further characteristic of these soils is that over time, downward percolating rain water carrying dissolved cementing solutions, can create bridges between the individual soil particles. On saturation of these soils under foundation loads, these soil bridges can break down, resulting in significant collapse settlement.

The geotechnical solution to founding in such soils is to place the foundation on an engineered soil mattress as described 4.1.1 above.

4.1.3 *Water Transported Alluvium*

Alluvium is sediments that have been deposited from rivers, either after overflowing their banks in periods of flooding, or as alluvial fans entering lakes and lagoons, as well as bottom sediments dropped as the velocity of the river was impeded and reduced.

These sediments can include boulders, gravels and sands, as well as fine silts and clays.

The coarse gravel and sandy soils are often suitable as a founding medium, provided they are not immediately underlain by very soft silt or clayey soils.

The alluvial clays can however be a problem, as they could exhibit settlement or expansive behaviour. Where materials of high plasticity are present at founding elevation, it is recommended that they be excavated out, and replaced with well compacted, inert, granular materials as described in 4.1.1 above.

4.2 Pedogenic Formations

4.2.1 *Ferricrete and Calcrete*

Where a fluctuating perched water table occurs, the near surface permeable soils can become cemented by iron or lime rich solutions, to form well cemented ferricrete or calcrete horizons.

Due to the high consistency and competence of these soils, they provide a good founding medium for lightly loaded structures. If of a hardpan nature, some difficulty may occur during excavation, to provide a level founding surface.

4.3 Sedimentary Rock Types

These rock types have all been laid down by water born agents, and have over geological time been consolidated by overburden pressure into solid rock.

4.3.1 *Diamictites*

These soils are characterised by abundant inclusions of different rock fragments in a fine grained matrix. This is a function of a moving glacier plucking rock fragments from the surface over which it is travelling, and latter dumping these fragments when the glacier starts melting. They could also be a function of deposition by a high velocity transporting source, once its velocity becomes impeded.

The residual soils produced from the weathering of this rock type, are typically composed of gravelly silty sands, which usually provide a suitable founding medium for lightly loaded structures.

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4.3.2 *Conglomerates*

Conglomerates comprise a cemented mass of cobbles, gravels and sands, and on weathering produce correspondingly gravelly sandy soils, suitable as a founding medium.

4.3.3 *Shales and Siltstones*

These rock types weather to produce very fine grained, silty soils, which can be moderately expansive in behaviour.

The plasticity of the soils at founding level need to be assessed, and if they appear to have a significantly high Plasticity Index, then an engineered soil mattress may be required.

If the competence and plasticity of these residual soils is seen to significantly reduce with depth, it may be possible to found at a slightly deeper depth.

4.4 Chemical Sedimentary Rock Types

4.4.1 *Dolomites*

These rocks are formed due to biological synthesis and inorganic precipitation, in an ancient inland sea.

As these rocks are highly soluble by slightly acidic ground waters, under these conditions the possibility exists for the formation of sinkholes and doline depressions.

These features generally only occur where static or flowing water is present, such as human settlements, water dams, irrigation trenches, stormwater drains etc.

Where none of these are present, the risk of sinkholes are considerably reduced.

The sandy and gravelly composition of soils derived from dolomite and chert residuum, normally make the upper horizons suitable for founding in.

4.5 Volcanic Rock Types

These rocks have been derived form liquid volcanic magmas of certain mineralogical content, cooling and solidifying at various depths within the earth.

4.5.1 *Diabase*

These rock types form dykes (vertical pipes) and sills (horizontal layers) due to magma being forced to surface through cracks and fissures in the upper crust.

Due to the rapid cooling of the liquid magma, the resulting rock is crystalline and hard, and reasonably resistant to weathering.

They characteristically form extended linear low ridges across the countryside.

They may present some problems as a founding medium due to their ridge like topography, as well as scattered large, talus boulders rolling down from higher up.

Individual bases for structures may also be difficult to cut into areas of hard rock.

4.5.2 *Andesites*

These rock types typically produce plastic, clayey and silty soils which may potentially expansive.

The plasticity of the soils at founding level need to be assessed, and if they appear to have a significantly high Plasticity Index, then an engineered soil mattress may be required.

If the competence and plasticity of these residual soils is seen to significantly reduce with depth, it may be possible to found at a slightly deeper depth.

4.6 Metamorphic Rock Types

Metamorphic rocks result from the physical and chemical alteration of existing rocks, due to an increase in pressure and temperature on them, induced by a range of geological processes.

4.6.1 *Quartzites, Granite Gneiss's, Migmatites*

These are generally hard, course grained rocks, which decompose to form gravelly and sandy soils. Where suitably competent, these residual soils produce a suitable founding medium for lightly loaded structures.

4.6.2 *Schists*

Schists are highly sheared and foliated rocks, containing primary minerals such as mica, quartz, felspar, amphibole and sometimes graphite and talc.

The platy and elongated fibrous minerals such as mica, graphite and talc, generally make such soils difficult to adequately compact, to form a solid soil base. Mixing with more granular, transported sandy soils may be required to improve their compactibility.

These soils are not however likely to be significantly active.

4.6.3 *Amphibolite*

This rock type contains the primary minerals of hornblende and plagioclase.

Due to the fact that they represent previous igneous rocks that have been metamorphosed, they are anticipated to produce fine, gravelly, silty and sandy soils of reasonably low plasticity and potential expansiveness.

Where suitably competent, these residual soils produce a suitable founding medium for lightly loaded structures.

5 GENERAL ANTICIPATED FOUNDING CONDITIONS FOR THE VARIOUS SUBSTATIONS

From information supplied by the client, full geotechnical investigations will be carried out at each proposed substation site.

The comments made below are therefore very general, and based on anticipated geological and geotechnical conditions, that will need to be confirmed during the proposed investigations mentioned above.

5.1 Kalplaats Substation

This substation is situated on metamorphic rocks such as granite gneiss, quartzites, or schists, and anticipated geotechnical conditions bare covered in section 4.6 above.

5.2 Bophirima Substation

This substation is situated on Diamictites, whose anticipated geotechnical conditions are discussed in 4.3.1 above.

6 Seismic Hazard Zoning

According to the Seismic Hazard Map of South Africa, as presented in Figure 2, Appendix 2, indicates that Vryburg falls within the very high risk zone for seismic tremors.

The estimated peak ground acceleration is estimated to fall within the 0.2 - 0.24 ms range. According to this chart, there is a 10% probability that this peak ground acceleration could be exceeded within a 50 year period.

Eskom needs to take these seismic hazard predictions into account, when designing the power line pylons, as well as their concrete foundations.

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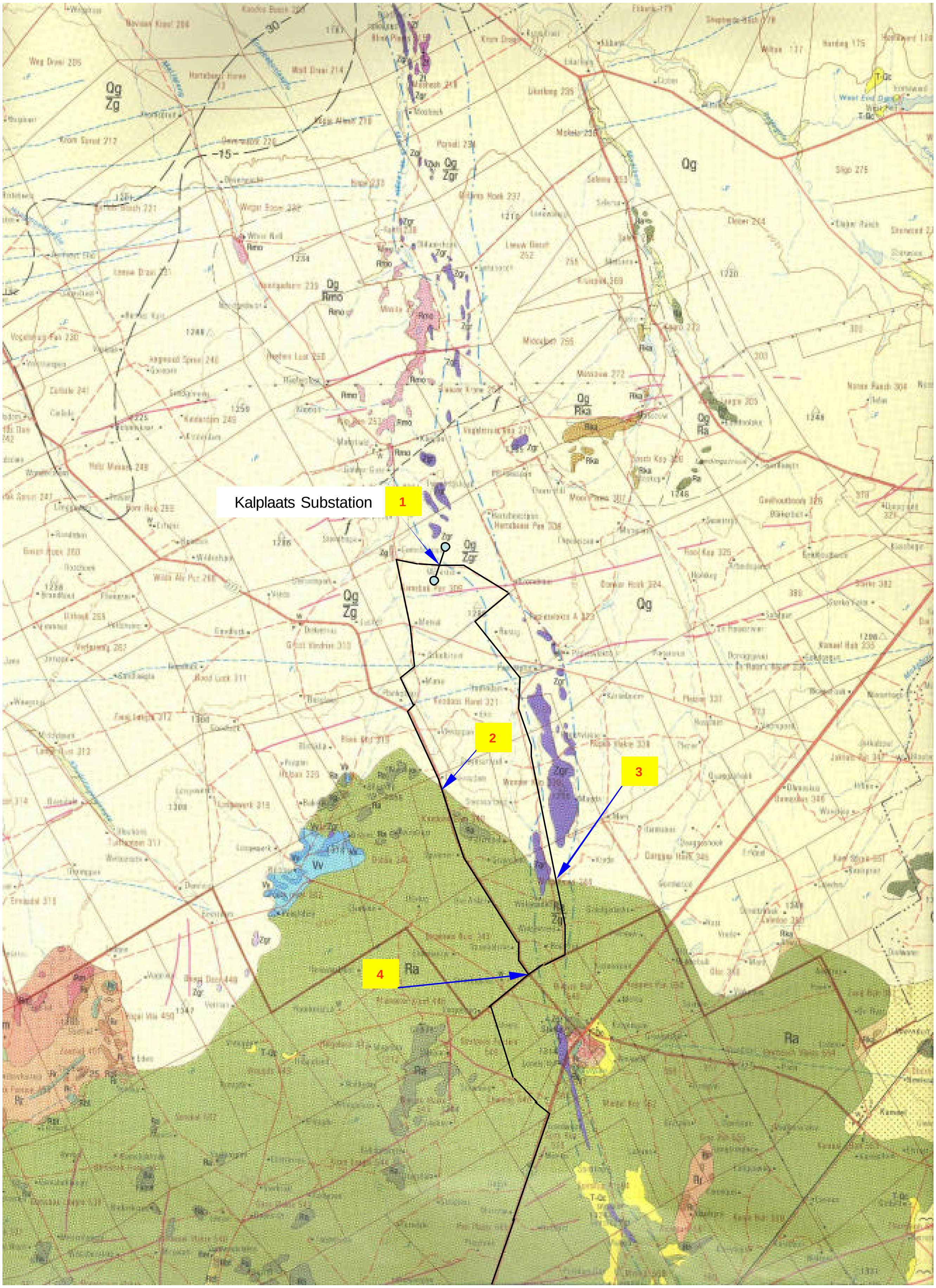
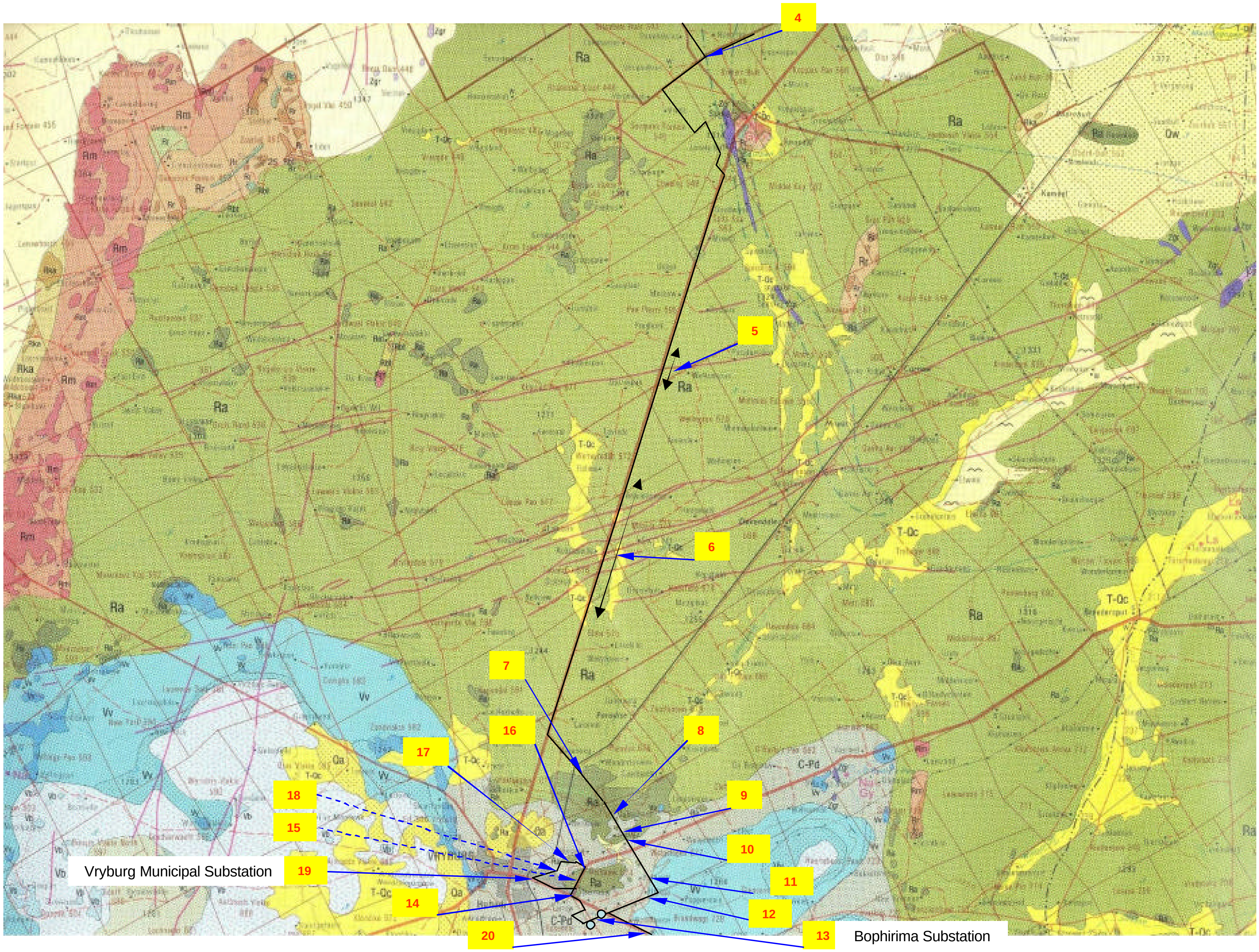
APPENDIX 1

GEOLOGICAL ROUTE MAPS


Kalplaats Substation
1
2
3
4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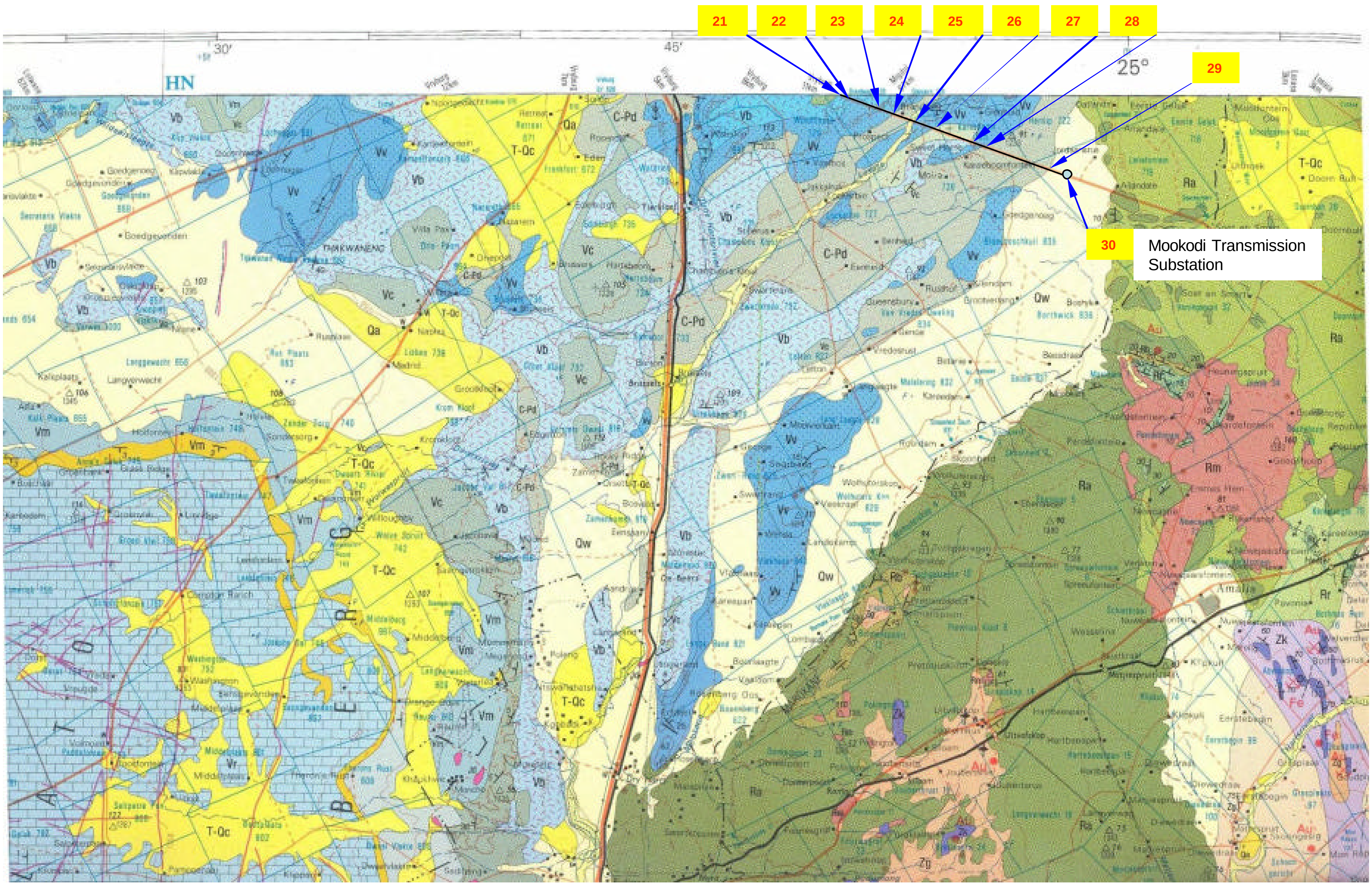
Vryburg Municipal Substation
Bophirima Substation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Mookodi Transmission Substation
30'
45'
25°
HN

APPENDIX 2

WEINERTS CLIMATIC ZONES

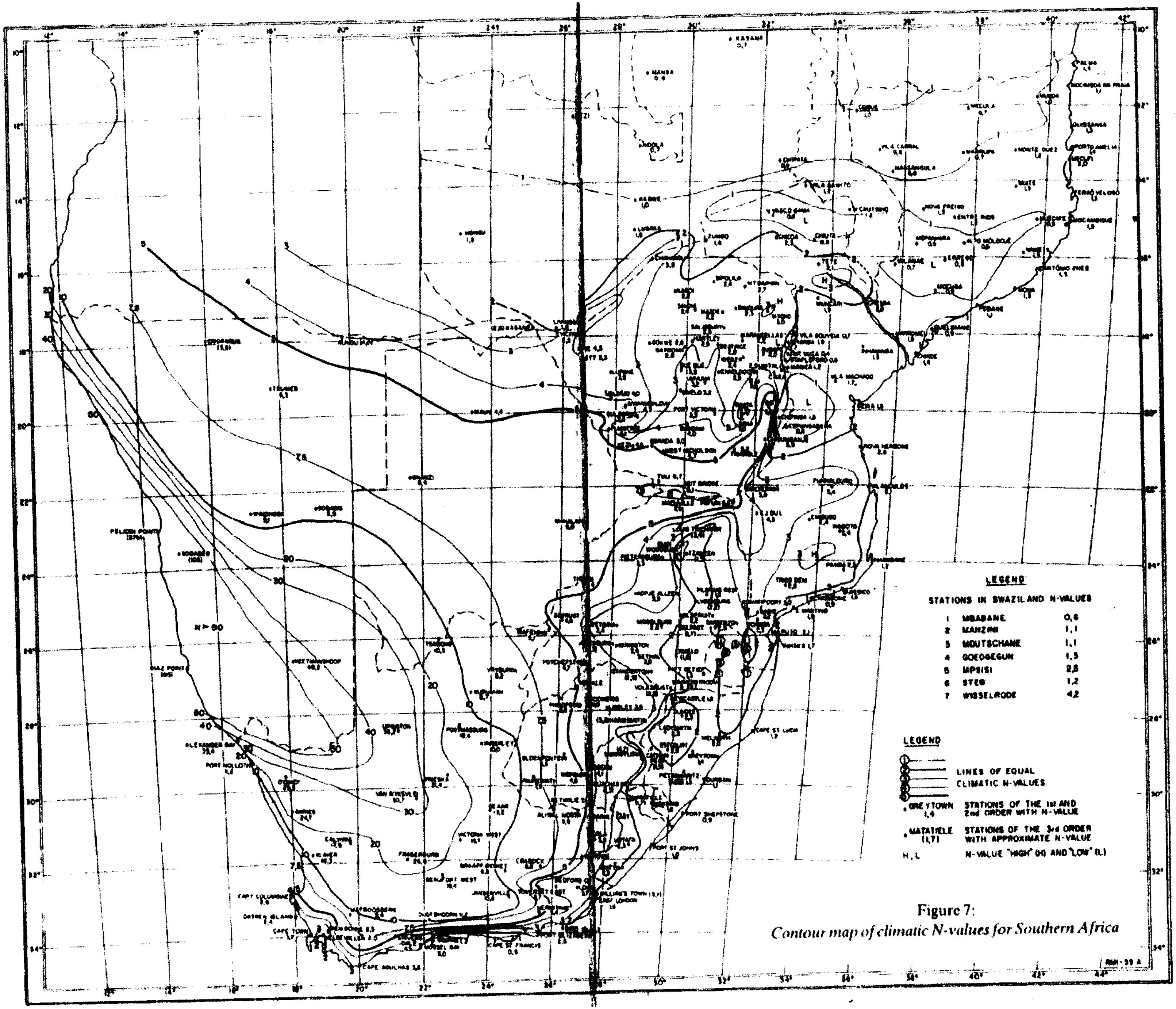

Figure 7:
Contour map of climatic N-values for Southern Africa

APPENDIX 3

SEISMIC HAZARD ZONING

4.1 MAP 1: SEISMIC HAZARD MAP OF SOUTH AFRICA

Peak ground acceleration (g) with a 10 % probability of being exceeded in a 50 year period