STEINKOPF,

NAMA KHOI LOCAL MUNICIPALITY

PHASE 1 ENGINEERING GEOLOGICAL INVESTIGATION

to DETERMINE the POTENTIAL for TOWNSHIP DEVELOPMENT

at STEINKOPF,

NAMA KHOI LOCAL MUNICIPALITY, NORTHERN CAPE PROVINCE.

Georeference: 2917BC Steinkopf

GEOSET cc

CK 1999/65610/23

Engineering geologist:

DAVID S. VAN DER MERWE

B.Sc. (Hons)(Enggeol.)(Pret.)

Pr. Sci. Nat. Reg. Nr. 400057/96; MSAIEG Reg. Nr. 93/154; NHBRC Reg. Nr. 600444.

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GEOSET CC
CK Nr. 1999/65610/23

P O Box / Posbus 60995
KARENPARK 0118
TEL/FAX: 012 5251004
WEBFAX: 086 658 3190
e-mail: davidsvdm@webmail.co.za
CEL: 082 925 4075

CONSULTING ENVIRONMENTAL AND ENGINEERING GEOLOGISTS
RAADGEWENDE OMGEWINGS- EN INGENIEURSGEOLOE

ENGINEERING GEOLOGIST / INGENIEURSGEOLOOG:
David S. van der Merwe: Pr Sci Nat, MSAIEG.

REPORT ON THE ENGINEERING GEOLOGICAL INVESTIGATION CONDUCTED AT STEINKOPF, NAMA KHOI LOCAL MUNICIPALITY, NORTHERN CAPE PROVINCE.

Executive Summary

A phase 1 engineering geological investigation with reference to GSFH-2 specification was conducted on the proposed development site at Steinkopf, Nama Khoi Local Municipality, Northern Cape Province, with the aim to assess aspects such as geology, relief and subsoil conditions which may influence the planned urban development in the area. The area is underlain by gneiss, granodiorite or adamellite of the Stalhoek Complex, Vioolsdrift Suite, but is locally covered by recent aeolian sand and calcrete gravel. No dolomite occurs on site and no stability investigation and evaluation is required. The mechanical properties of the soil layers were determined by means of laboratory tests performed on disturbed samples taken during the profiling of trial pits. The obtained site information is evaluated with regard to the development of masonry structures by the application of standard evaluation techniques. Development zonation for township development according to the NHBRC and SAIEG guidelines were done, indicating the geotechnical conditions of the site. **Normal construction** techniques will be required to enable proper development. This includes the use of **compaction techniques** and **site drainage** as described. Some severe problems regarding **excavatability** are be expected across the site inducing an elevated development cost, and a competent TLB, excavator, pneumatic tools and blasting will be required to reach installation depths for services in many places. These proposed mitigation measures will be sufficient to successfully address the anticipated geotechnical problems and to ensure the sustainable development as planned.

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Extract from: THE SOUTH AFRICAN INSTITUTE OF ENGINEERING GEOLOGISTS (SAIEG), 1997. Guidelines for Urban Engineering Geological Investigations.

GEOSET CC
CK Nr. 1999/65610/23

P O Box / Posbus 60995
KARENPARK 0118
TEL: 012 525 1004
WEBFAX: 086 658 3190
e-mail: davidsvdm@webmail.co.za
CEL: 082 925 4075

CONSULTING ENVIRONMENTAL AND ENGINEERING GEOLOGISTS
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REPORT ON THE ENGINEERING GEOLOGICAL INVESTIGATION CONDUCTED AT STEINKOPF, NAMA KHOI LOCAL MUNICIPALITY, NORTHERN CAPE PROVINCE.

1. INTRODUCTION AND TERMS OF REFERENCE

On request of Maxim Planning Solutions, and on behalf of Barzani, an engineering geological investigation was conducted for the proposed development on the property for the Steinkopf, Nama Khoi Local Municipality, Northern Cape Province, and communication between us and the abovementioned parties lead to the field work, commencing on 4 March 2020.

The aim of this investigation was to identify and evaluate any possible engineering geological problems before commencement of proper township proclamation.

This report is based on the in-situ evaluation of all the representative soil horizons within the ground profile, visual results of the site visit and other relative exposed geotechnical properties on site and derived from interpretation of laboratory results.

The proposed site is located at Steinkopf, Nama Khoi Local Municipality, approximately 112 hectares in size. It is situated east of south of the existing Steinkopf town. Figures 1-4 in Appendix A delineates the site.

2. INFORMATION USED IN THE STUDY

The following was consulted during the investigation:

1.3.1 The geological map 2917BC Steinkopf. Scale 1:250 000. The Geological Survey of South Africa.

1.3.2 The topography map 2917BC Steinkopf. Scale 1:50 000.The Chief Directorate: Surveys and Land Information, Mowbray.

3. SITE DESCRIPTION

3.1 PHYSIOGRAPHY

3.1.1 Topography

The site is located on a slope from 794 to 819 masl towards the centre portion of the site, and then westwards into the Doring River which drains southwards towards the Buffels River.

3.1.2 Climate

The region is characterized by summer rainfall with thunderstorms, with annual very low rainfall figures of 205 mm for Springbok recorded at the closest weather stations to the site. Winters are dry with frost common. The warmest months are normally December and January with February the warmest month, and the coldest months are June and July.

An analysis of the data confirms a Weinert's N-Value in the order of 2 for Hopetown.

The mechanical disintegration of rocks will therefore be dominant over chemical decomposition, and shallow soil horizons will be expected in areas of poor drainage, underlain by igneous rocks.

Storm water drainage and road pavement design must incorporate the climatic extremes above.

3.1.3 Vegetation

The area is typically characterized by Kalahari Thornveld *veld type* (Acocks, 1988).

The site itself is covered by sparse grasslands of which some was used as agriculture land, and a few indigenous thorn trees are present on site.

4. NATURE OF INVESTIGATION

4.1 SITE INVESTIGATION

All available information (paragraph 1.3) was studied before and during the site visit.

The investigation commenced with a desk study, where all relevant information is collected and compiled on a base map. The site was divided into land forms, after which the accuracy of the information was checked by means of a field visit.

Test pits were dug and representative disturbed samples were collected and tested. The position of the test pits are represented in FIGURE 4 (Appendix A). The soil profiles were described by a registered engineering geologist according to the methods described by Jennings *et al* (Jennings 1973). This method describes each horizon in terms of moisture content, colour, consistency, structure, type of soil and origin of the soil.

Disturbed samples of the soil materials were taken for laboratory analysis. The grading of the soils were determined by sieve and hydrometer analysis, resulting in cumulative grading curves.

The mechanical properties of the soil material are described in terms of the liquid limit and plasticity index (determined by means of the Atterberg Limit tests) and the linear shrinkage. These values can be used to calculate the potential expansiveness of the soils, and to evaluate the materials for use as construction material. The consistency of a soil is described by means of its Atterberg limits, where the effect of a change in the moisture content on the consistency of a cohesive soil is measured. According to Cernica (1982) these tests are useful "mostly for soil identification and classification".

It can also be used to determine the mechanical properties of cohesive soil material[1].

The linear shrinkage test to determine the percentage shrinkage that can be expected, is performed by wetting a soil to approximately its liquid limit and drying the resultant paste in a linear shrinkage mould.

The potential expansiveness of a soil depends upon its clay content, the type of clay mineral, its chemical composition and mechanical character. A material is potentially expansive if it exhibits the following properties (Kantey and Brink, 1952):

- a clay content greater than 12 percent,
- a plasticity index of more than 12,
- a liquid limit of more than 30 percent, and
- a linear shrinkage of more than 8 percent.

The potential expansiveness (low, medium, high, very high) is calculated by means of Van der Merwe's method (Van der Merwe, 1964), where the equivalent plasticity index versus the clay content of the material is plotted on a graph divided into heave categories. If any sample in the study area classifies as potentially expansive, the amount of heave or mobilization in mm measured on the surface will be calculated.

4.2 LABORATORY TESTS

The minimum requirements for areas 112ha large is 11 samples for foundation indicator tests (GFSH-2 guideline). This may vary and is sometimes limited according to the variability of the geotechnical character such as limited depths of test pits before refusal of the TLB, as well as the uniformity or simplicity of a site. Only 8 samples were tested as the material consisted mainly of calcrete gravel and rock without the possibility of sampling matrix material or soil.

No free swell tests were done as all these areas falls within the drainage features and outside the developable areas.

No consolidometer or collapse potential tests were done as it was impossible to secure any undisturbed soil sample required for these tests.

No soil chemistry samples were tested as all new developments use synthetic pipes

[1] Note that cohesionless soils (i.e. sandy material) cannot be tested for plasticity or collapse potential as this material does not contain enough fines to exhibit consistency. The taking of undisturbed samples is not possible due to disintegration.

not reactive to soil aggressiveness.

The disturbed samples taken during the investigation were tested by the accredited laboratory of Specialised Testing Laboratory in Pretoria to determine their physical properties. Indicator tests include a grading analyses, the determination of Atterberg limits and linear shrinkage. The original laboratory results and a summary of results are represented in Table A, Appendix C.

5. SITE GEOLOGY AND GROUNDWATER CONDITIONS

5.1 Geology

The site is underlain by gneiss, granodiorite or adamellite of the Stalhoek Complex, Vioolsdrift Suite, but is locally covered by recent aeolian sand and calcrete gravel.

Locally, the site is covered by alluvial gravel and calcrete.

No dolomite occurs on site and a stability investigation and evaluation is not required.

5.2 Groundwater Conditions

Plate flow is the dominant drainage pattern on site, with a prominent drainage channel in the centre portion of the site. Drainage occurs in a westerly direction towards a drainage feature and then in a southern direction towards the Doring River and later the Buffels River.

The permanent or perched water table on site is deeper than 1,5m below ground surface.

6. GEOTECHNICAL EVALUATION

6.1 ENGINEERING AND MATERIAL CHARACTERISTICS

6.1.1 SOIL PROFILES

According to the generic specification GFSH-2 guidelines, the minimum number of test pits for an area of 112ha is calculated to 34 test pits, but according to the specification of SAIEG in our document on Guidelines for Urban Engineering Geological Investigation, 1997, Table 1 (Appendix D), at least 12 test pits should be adequate for areas with a low variable geotechnical character and sites where extensive development with services exist with limited access and almost fully built-up and fenced, or where more than half of the site is developed and serviced and for the formalization of the planning process such as this site. We recorded positions, photographed, described and characterized 40 test positions covering this site.

All terrain land forms or mapping units were extensively sampled and more than adequate representative characterization of each unit took place.

The soil profiles with accompanied plates of profiles and rock outcrop are represented in Appendix B.

Typical soil profile

Dry to slightly moist and moist, red to dark brown, loose to dense, open textured sand with gravel of calcrete. Aeolian & pedogenetic.
Large calcrete boulders & gravel with refusal on hard pan calcrete or slightly weathered gneiss. Pedogenetic or residual gneiss.

Some severe problems regarding excavatability can be expected on the site, and a competent TLB, excavator, pneumatic tools and even blasting will be required to reach installation depths for services in many places, and the average refusal depth was calculated at less than 0,5m.

To ensure the stability of excavations, it will need standard sidewall protection in excavations exceeding 1,5m.

6.1.2 LABORATORY RESULTS

The laboratory tests indicated a slight collapse potential and compressibility of the matrix material with a low expansive potential of the material (according to the method of Van der Merwe, 1964). It had an expected range of total soil movement measured at surface as collapse calculated to less than 5mm consolidation or less than 7,5 mm swell, with a site classification of CR.

The laboratory result indicated that the samples had a clay content of less than 4%, a

linear shrinkage of less than 0,5%, the plasticity index was not determined as the material consisted of a slightly or non plastic matrix resulting that no liquid limit could be determined, and with a low expansive potential.

The Unified classification was SM (all 8 samples) as silty sand, poorly graded sand silt mixtures, and A-1-b (5 samples) as gravelly sand or graded sand that may include fines to A-2-4 (3 samples) as sand and gravel with low plasticity silt fines, according to the PRA classification.

The limited amount of samples tested are justified as the high calcrete gravel content with very limited sandy matrix material should have the same character across the site, as well as the limited depth of refusal of the competent TLB.

No mining activities on site or history of mining or contaminated land in the area were found.

The site is located far from any mining activities and in an inactive area regarding seismic activity.

Due to the level of development surrounding the area, the likelihood for the development of borrow pits on site are low.

All road building and construction materials for the building industry will be sourced from established commercial activities in and around Steinkopf.

6.2 SLOPE STABILITY AND EROSION

The potential for lateral soil movement or erosion is medium to high, and the loose sand is easily washed away during thunderstorms. Except for local slope instability within opened trenches and the collapse of pit side walls, no other slope instability is expected within these relative flat areas.

6.3 EXCAVATION CLASSIFICATION WITH RESPECT TO SERVICES

The excavation characteristics of the different soil horizons encountered have been evaluated according to the South African Bureau of Standards standardized excavation classification for earthworks (SABS – 1200D) and earthworks (small works – SABS 1200DA). In terms of this classification and the in-situ soil/rock consistencies as profiled, the relationships given below are generally applicable:

1. “soft excavation” - very loose/very soft through to dense or stiff.
2. “intermediate excavation” - very dense/very stiff through to very soft rock.
3. “hard excavation” - soft rock or better

Severe problems regarding excavatability can be expected on the site, and sub outcrop, shallow rock or outcrop areas were found that were classified as hard rock excavation, and the average refusal depth was calculated at less than 0,5m.

Problems regarding excavations of the upper material is expected and it is difficultly excavated by the competent TLB, and it was classified as intermediate in restricted and non-restricted excavation (SANS 1200 D).

Severe problems regarding excavatability can be expected for excavations deeper than 0,5m on the site, and a competent TLB or excavator, pneumatic tools and blasting will be required to reach installation depths for services. It was classified as intermediate to hard excavation in restricted and non-restricted excavation (SANS 1200 D).

To ensure the stability of excavations, it will need standard sidewall protection in excavations exceeding 1,5m.

6.4 IMPACT OF THE GEOTECHNICAL CHARACTER OF THE SITE ON SUBSIDY HOUSING DEVELOPMENTS

During the engineering geological investigation it is essential to determine and quantify the extent of potential problems associated with the area (addressed in **bold** below), before proper township proclamation. The ideal conditions for urban development may be listed as follows:

* A smooth surface gradient with slopes less than 12°. Accessibility should not be restricted by topography (plateau areas).
* No potential for slope instability features - landslides, mud flows.
* Easy **excavation** for foundations and installation of services (normal depth of 1,5 m required).
* Foundations above the ground water level or perched water table, with not too low permeability.
* Development above the **1:50 year flood line**.
* Adequate surface and subsurface drainage conditions, with minimal erosion potential.

* No presence of problematic soils, for example heaving clays, **compressible clays, sand with some collapse potential,** or dispersive soils, that will require expensive remedial measures.
* No potential for surface subsidence due to the presence of dolomite (sinkholes) or undermining.
* No damaging differential subsidence or movement (less than 5mm total movement at the surface allowed).
* The site should be placed away from potential pollutants such as waste disposal sites.

6.4.1 EVALUATION FOR URBAN DEVELOPMENT

Seepage and the presence of perennial fluctuations of ground water were not encountered on site, but a seasonal perched water table may exist.

Special care must be taken to ensure adequate surface drainage to prevent the accumulation of water next to structures.

The site contains slightly collapsible and compressible and soil with a low expansive potential, and foundations will require normal treatment to withstand movement associated with the variable moisture content of the soil.

Severe problems regarding excavatability to 1,5m can be expected on the site, and hard pan calcrete and gneiss rock and outcrop were noted on many portions of the site.

Retaining walls as well as slope stabilization measures are recommended on all constructed embankments exceeding 1,5m.

Storm water diversion measures such as ponding pools are recommended to control peak flows during thunderstorms.

All embankments must be adequately compacted and planted with grass to stop any excessive erosion and scouring of the landscape.

7. SITE CLASSIFICATION

By grouping together all the land facets with the same geotechnical characteristics, the site can be divided into development zones, this being the main objective or result of a phase 1 engineering geological investigation. Each zone can therefore be defined as a grouping of areas with specific geotechnical properties placing similar constraints upon development.

With the above-mentioned criteria in mind, the study area can be divided into typical development zones for residential development (SAICE, SAIEG & NHBRC, 1995):

Land suitable for development: Standard foundation techniques and normal construction with normal site drainage and standard building practice will be adequate for development.

Land suitable for development with precaution or risk: A few precautionary measures for problematic soils in this zone are necessary before urban development can be initiated, with a higher than normal cost implication to overcome geotechnical constraints. The risk of restricted excavatability for the placing of services induces a higher cost for development.

Land not suitable for development typically comprises of the drainage features that are susceptible to annual flooding below the 1:50 year flood line, and is also associated with perched water tables. Land in close proximity of unstable ground such as a potential slope failure or mud flow induced by rainfall is also not suitable for development.

On account of the field observations, laboratory results, previous experience and engineering properties of the soil, it is zoned as follows (SAIEG,1997 - See tabular explanation of classification in Appendix D):

7.1 Engineering Geological Zonation

Normal Development with risk:
Site Class CR/1A3F:
This zone represents the majority of the area and comprises of a relative thin top layer sandy material less than 0,75m in thickness of slightly collapsible and compressible or low expansive soil underlain by a competent pebble marker, calcrete or gneiss, with

estimated total movement of less than 7,5mm measured at surface with the risk of shallow rock, core stones and hard pan calcrete or gneiss rock outcrop adding a R or PR site class designation to the zone with problems relating to restricted excavation to less than 1,0m. Development on solid rock calcrete, calcrete rock outcrop known as hard pan calcrete or gneiss and will have an inflated cost where special pneumatic tools and blasting will be required for the installation of services. Normal foundation techniques will be adequate to enable proper development, with proper compaction within standard strip foundations and drainage provision that will be required. It is classified as CR in terms of the SAIEG & NHBRC guidelines (1995) or the SAICE Code of practice (1995), and 1A3F according to the classification for urban development (Partridge, Wood & Brink)(1993).

Suitable for development with precaution

Site Class PR:

Areas with a PR site class designation whith problems relating to restricted excavation to less than 0,5m, consisting of solid rock calcrete, calcrete rock outcrop known as hard pan calcrete or gneiss will have an inflated cost where special pneumatic tools and blasting will be required for the installation of services.

Site Class PQ:

Areas where small quarries or filling or dumping of spoil (Pq1) were identified must be rehabilitated before any construction can be allowed, and backfilling with an engineer's material may improve the developability of these zones, but these operations will dramatically increase the development cost in this zone.

Undevelopable:

Site Class PD:

Perennial drainage features with local steeper slopes within the upper channels and towards the river. The development is usually restricted to 32m from the centre of the river, and outside the 1:100 year floodline.

The geotechnical problems encountered will require normal foundation techniques and construction, with proper standard compaction techniques.

8. FOUNDATION RECOMMENDATIONS AND SOLUTIONS

8.1 *Consolidation or collapse settlement*

Site Class C (Estimated total Settlement of less than 5mm):

Normal Construction:

Minor collapse settlement requires normal construction (strip footing and slab on the ground) with compaction in foundation trenches and good site drainage.

Site Class C1 (Estimated total Settlement of between 5 and 10mm):

Modified normal construction:
Reinforced strip footing and slab on the ground.
Articulation joints at some internal and all external doors and openings.
Light reinforcement in masonry.
Site drainage and service/plumbing precautions recommended.
Foundation pressure not to exceed 50 kPa (single storey buildings).

Compaction of in situ soils below individual footings:
Remove in situ material below foundations to a depth and width of 1,5 times the foundation width or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content.
Normal construction with light reinforcement in strip foundation and masonry.

Deep strip foundations
Normal construction with drainage precaution.
Founding on a competent horizon below problem horizon.

Soil Raft
Remove in situ material to 1,0m beyond perimeter of building to a depth and width of 1,5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content.
Normal construction with lightly reinforced strip footings and masonry.

9. DRAINAGE

The site is located on a shallow slope towards the centre portion of the site, and then westwards into the Doring River which drains southwards towards the Buffels River.

Plate flow is the dominant drainage pattern on site, and a prominent drainage channel intersects the site.

Although no seepage or the presence of perennial fluctuations of ground water were not encountered on site, we expect that a seasonal perched water table may exist. A calcified profile indicates that some perennial water level fluctuations occur.

Ground water in the form of seepage was not intersected in any test pits during the investigation, but some problems are foreseen and normal water tightening techniques such as damp course on foundation levels are required.

The expected high permeability of the silty sand may lead to leachate from sanitation systems to reach the ground water, and a closed water borne sewage system is recommended.

Special care must be taken to ensure adequate surface drainage to prevent the accumulation of water next to structures.

Storm water diversion measures such as ponding pools are recommended to control peak flows during thunderstorms. All embankments must be adequately compacted and planted with grass to stop any excessive erosion and scouring of the landscape.

10. CONCLUSIONS

1. A site of approximately 112 hectares, Steinkopf, Nama Khoi Local Municipality, was investigated to determine the engineering geological properties that will influence township proclamation.

2. The site is underlain by gneiss, granodiorite or adamellite of the Stalhoek Complex, Vioolsdrift Suite, but is locally covered by recent aeolian sand and calcrete gravel.

3. Some severe problems are foreseen regarding the excavatability to 1,0m depth on site, and shallow rock, core stones and rock outcrop or hard pan calcrete or gneiss were identified almost across the site.

4. Zoning of the site revealed zones with minor constraints regarding the **compressibility, collapse potential** and the **expansive potential** of the soil.

5. The following zones were identified on the site:

Normal Development with risk:

Site Class CR/1A3F: This zone represents the majority of the area and comprises of a relative thin top layer sandy material less than 0,75m in thickness of slightly collapsible and compressible or low expansive soil underlain by a competent pebble marker, calcrete or gneiss, with estimated total movement of less than 7,5mm measured at surface with the risk of shallow rock, core stones and hard pan calcrete or gneiss rock outcrop adding a R or PR site class designation to the zone with problems relating to restricted excavation to less than 1,0m. Development on solid rock calcrete, calcrete rock outcrop known as hard pan calcrete or gneiss and will have an inflated cost where special pneumatic tools and blasting will be required for the installation of services. Normal foundation techniques will be adequate to enable proper development, with proper compaction within standard strip foundations and drainage provision that will be required. It is classified as CR in terms of the SAIEG & NHBRC guidelines (1995) or the SAICE Code of practice (1995), and 1A3F according to the classification for urban development (Partridge, Wood & Brink)(1993).

Suitable for development with precaution

Site Class PR: Areas with a PR site class designation whith problems relating to restricted excavation to less than 0,5m, consisting of solid rock calcrete, calcrete rock outcrop known as hard pan calcrete or gneiss will have an inflated cost where special pneumatic tools and blasting will be required for the installation of services.

Site Class PQ: Areas where small quarries or filling or dumping of spoil (Pq1) were identified must be rehabilitated before any construction can be allowed, and backfilling with an engineer's material may improve the developability of these zones, but these operations will dramatically increase the development cost in this zone.

Undevelopable: Site Class PD: Perennial drainage features with local steeper slopes within the upper channels and towards the river. The development is usually restricted to 32m from the centre of the river, and outside the 1:100 year floodline.

6. **Normal and special construction** techniques will be required to enable proper development. This includes the use of **compaction techniques** and **site drainage** as described.

7. **This investigation was done to reveal the geotechnical properties on site with the techniques as described to form our opinion. Although every possible factor during the investigation was dealt with, it is possible to encounter variable local conditions. This will require the inspection of foundations by a competent person to verify expected problems.**

Engineering geologist:

DAVID S. VAN DER MERWE

B.Sc. (Hons)(Enggeol.)(Pret.)

Pr. Sci. Nat. Reg. Nr. 400057/96; MSAIEG Reg. Nr. 93/154; NHBRC Reg. Nr. 600444.

11. BIBLIOGRAPHY

ACOCKS, J.P.H., 1988. “Veld types of South Africa.” Memoir no. 57 The Botanic Survey South Africa.

BRINK, A.B.A., 1979. "Engineering geology of Southern Africa Vol. 1". Building Publications, Pretoria.

BRINK, PARTRIDGE & WILLIAMS, 1982. "Soil Survey for Engineering." Clarendon Press, Oxford.

BRINK, PARTRIDGE & WILLIAMS. Priorities for the Application of Engineering Geology in Developing Countries. Department of Geology, University of the Witwatersrand.

FISHER, G.J., 1994. “The selection of cemetery sites in South Africa.” Proceedings of the Fourth Symposium on Terrain Evaluation and Data Storage, Midrand, August 1994.

HUNT, R.E., 1984. “Geotechnical Engineering Investigation Manual.” McGrawHill.

JENNINGS, J.E., BRINK, A.B.A & WILLIAMS, A.A.B., 1973. "Revised guide to soil profiling for civil engineering purposes in South Africa". The Civil Engineer in South Africa, Vol. 15, No.1, January 1973.

PARTRIDGE, T.C., WOOD, C.K., and BRINK, A.B.A., 1993. Priorities for Urban Expansion within the PWV Metropolitan Region: The Primacy of Geotechnical Constraints. South African Geographical Journal, Vol 75, pp 9 - 13.

SOUTH AFRICAN INSTITUTE OF CIVIL ENGINEERS/INSTITUTION OF STRUCTURAL ENGINEERS, 1995. Code of Practice: Foundations and Superstructures for Single Storey Residential Buildings of Masonry Construction. Joint Structural Division, Johannesburg.

SWARTZ, K., 1985. “Problem Soils in South Africa - State of the art: Collapsible Soils”, The Civil Engineer in South Africa, July 1985.

THE NATIONAL HOME BUILDERS REGISTRATION COUNCIL (NHBRC), 1995. Standards and guidelines, first issue, May 1995.

THE SOUTH AFRICAN INSTITUTE OF ENGINEERING GEOLOGISTS (SAIEG), 1997. Guidelines for Urban Engineering Geological Investigations.

VAN DER MERWE, D.H., 1964. “The prediction of heave from the plasticity index and percentage clay fraction of soils”. The Civil Engineer in South Africa., June 1964.

WEATHER BUREAUX, 1988. “Climate of South Africa. Climate statistics up to 1984.

WEINERT, H.H., 1980. "The natural road construction materials of Southern Africa", Academica, Cape Town.

APPENDICES

APPENDIX A: FIGURES

Figure 1: Steinkopf, Nama Khoi Local Municipality: Regional Locality Map.
Figure 2: Steinkopf, Nama Khoi Local Municipality: Topography Map.
Figure 3: Steinkopf, Nama Khoi Local Municipality: Geology Map.
Figure 4: Steinkopf, Nama Khoi Local Municipality: Engineering Geological Zone Map with Test Pit Positions on Google Image.

APPENDIX B: SOIL PROFILES

Soil Profiles Tabled Summary
Soil Profile Descriptions
Soil Profile Photographs

APPENDIX C: LABORATORY RESULTS

Table A: Summary of Laboratory Results
STL Summary of Laboratory Results
STL Laboratory Result

APPENDIX D: TABULAR EXPLANATION OF ZONING

Extract from: THE SOUTH AFRICAN INSTITUTE OF ENGINEERING GEOLOGISTS (SAIEG), 1997. Guidelines for Urban Engineering Geological Investigations.

Table 1. Categories of Urban Engineering Geological Investigation

Table 2. Geotechnical Classification for Urban Development:
Partridge, Wood & Brink (1993)

Table 3. Residential Site Class Designations:
SAICE, SAIEG & NHBRC (1995)

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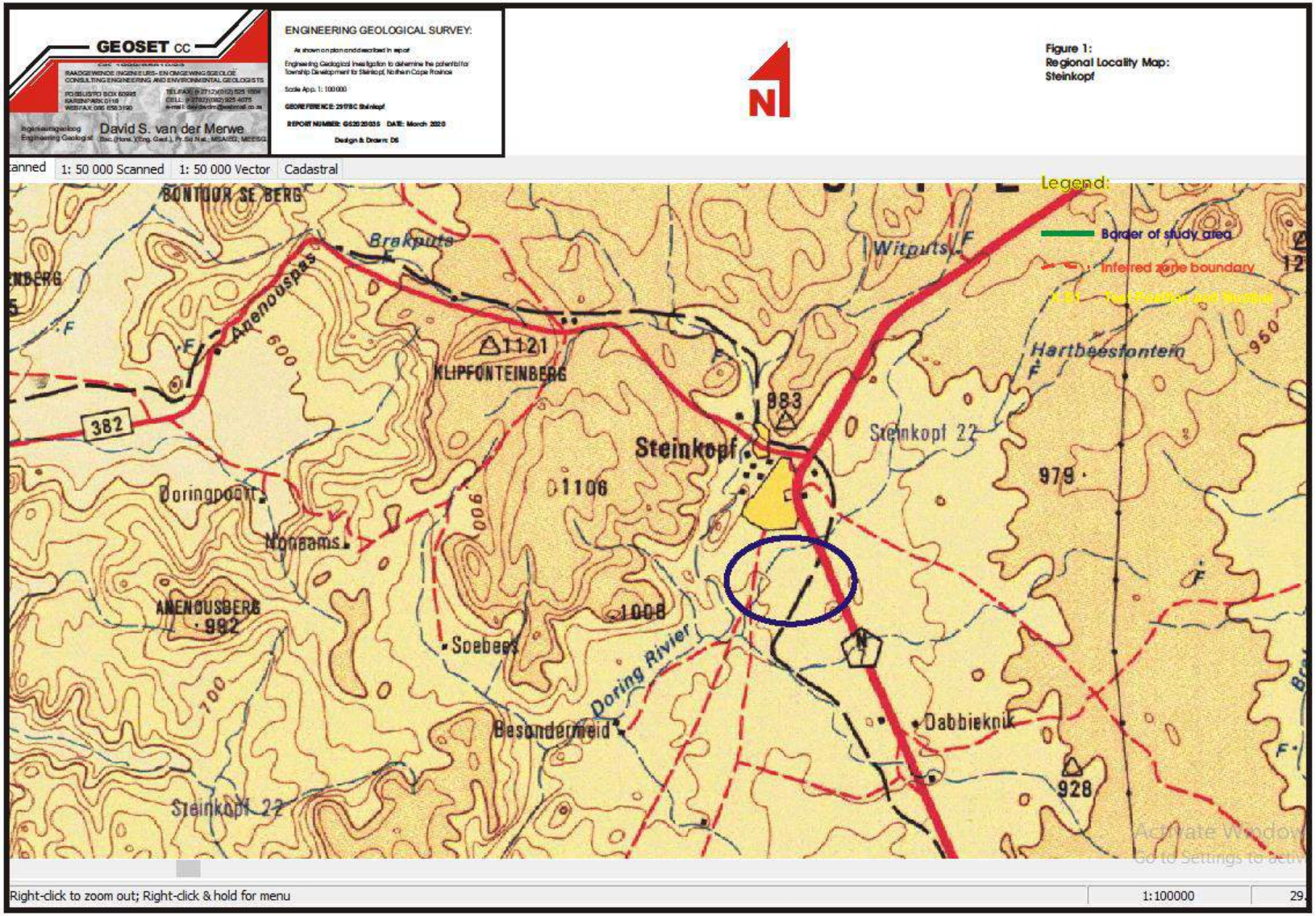
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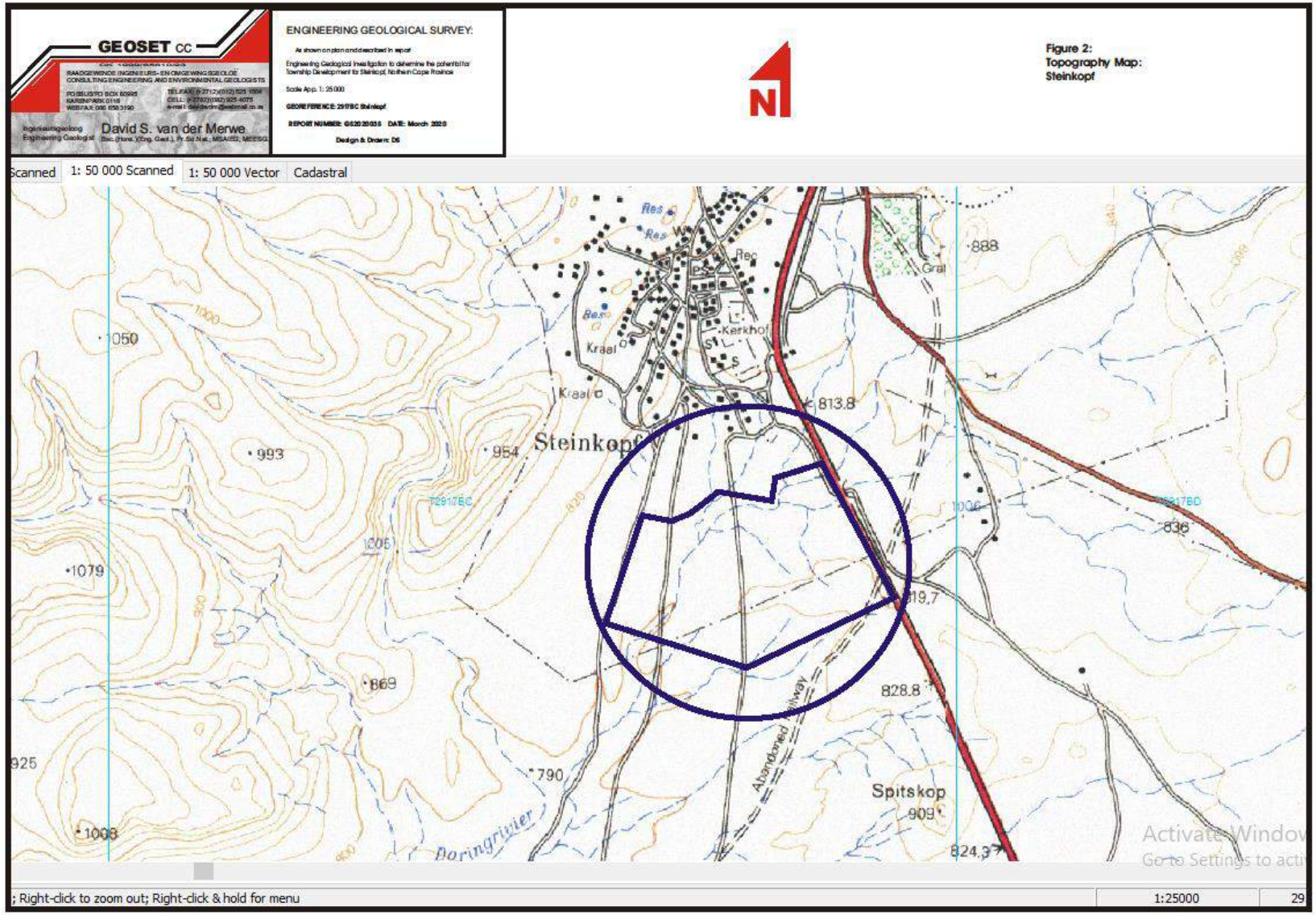
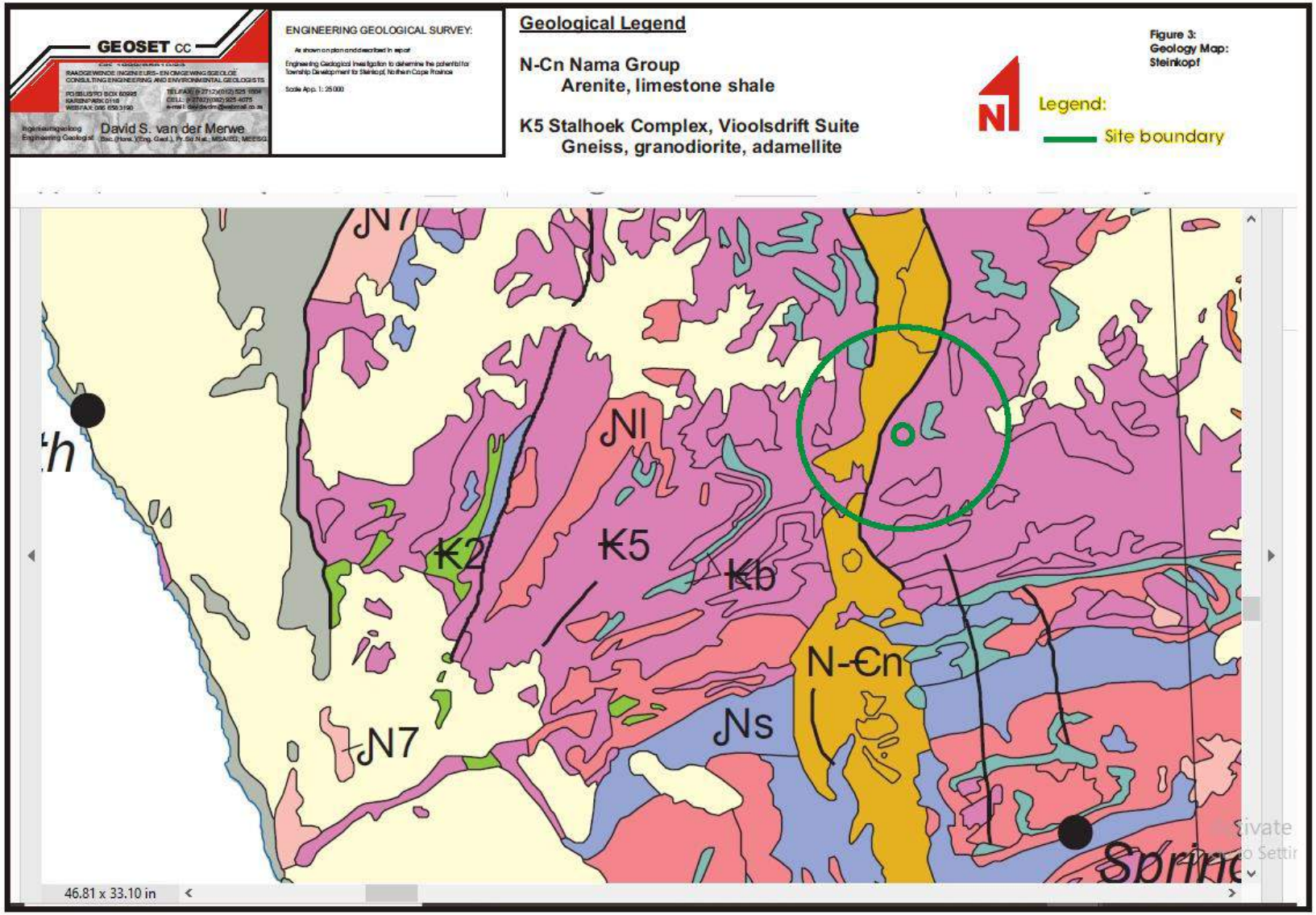
ENGINEERING GEOLOGICAL SURVEY:
Figure 1:
Regional Locality Map:
Steinkopf
1: 50 000 Scanned
1: 50 000 Vector
Cadastral
Legend:
Border of study area
Inferred zone boundary
BONTDOUR SE BERG
Brakputs
Witputs
Arenouspas
KLIPFONTEINBERG
1121
983
Steinkopf
Steinkopf 22
Hartbeesfontein
979
950
600
900
700
382
1106
Doringpoort
Nouwams
ARENOUSBERG
992
1008
Soebees
Doring Rivier
Besonderheid
Dabbieknik
928
Steinkopf 22
Right-click to zoom out; Right-click & hold for menu
1:100000


GEOSET CC
ENGINEERING GEOLOGICAL SURVEY:
David S. van der Merwe
Figure 2:
Topography Map:
Steinkopf
Scanned
1: 50 000 Scanned
1: 50 000 Vector
Cadastral
Steinkopf
Kraal
Kerkhof
Spitskop
Doringrivier
Abandoned railway
; Right-click to zoom out; Right-click & hold for menu
1:25000


GEOSET CC
ENGINEERING GEOLOGICAL SURVEY:
Geological Legend
N-Cn Nama Group
Arenite, limestone shale
K5 Stalhoek Complex, Vioolsdrift Suite
Gneiss, granodiorite, adamellite
Figure 3:
Geology Map:
Steinkopf
Legend:
Site boundary
David S. van der Merwe
N7
Nl
K2
K5
Kb
N-Cn
Ns
N7
Spring
46.81 x 33.10 in

GEOSET CC
CK 1999/65610/23
RAADGEWENDE INGENIEURS- EN OMGEWINGSGEOLOË
CONSULTING ENGINEERING AND ENVIRONMENTAL GEOLOGISTS
POSBUS/PO BOX 60995
KARENPARK 0118
WEBFAX: 086 658 3190
TEL/FAX: (+2712)/(012) 525 1004
CELL: (+2782)/(082) 925 4075
e-mail: davidsvdm@webmail.co.za
Ingenieursgeoloog
Engineering Geologist
David S. van der Merwe
Bsc.(Hons.)(Eng. Geol.), Pr.Sci.Nat.; MSAIEG; MEESG.

ENGINEERING GEOLOGICAL SURVEY

As shown on plan and described in report

Engineering Geological Investigation to determine the potential for Township Development for Steinkopf, Northern Cape Province

Scale App. 1: 100 000

GEOREFERENCE: 2917BC Steinkopf

REPORT NUMBER: GS202003S DATE: March 2020

Design & Drawn: DS

Engineering Geological Zones

Normal Development with risk:

Site Class CR/1A3F: This zone represents the majority of the area and comprises of a relative thin top layer sandy material less than 0,75m in thickness of slightly collapsible and compressible or low expansive soil underlain by a competent pebble marker, calcrete or gneiss, with estimated total movement of less than 7,5mm measured at surface with the risk of shallow rock, core stones and hard pan calcrete or gneiss rock outcrop adding a R or PR site class designation to the zone with problems relating to restricted excavation to less than 1,0m. Development on solid rock calcrete, calcrete rock outcrop known as hard pan calcrete or gneiss and will have an inflated cost where special pneumatic tools and blasting will be required for the installation of services. Normal foundation techniques will be adequate to enable proper development, with proper compaction within standard strip foundations and drainage provision that will be required. It is classified as CR in terms of the SAIEG & NHBRC guidelines (1995) or the SAICE Code of practice (1995), and 1A3F according to the classification for urban development (Partridge, Wood & Brink)(1993).

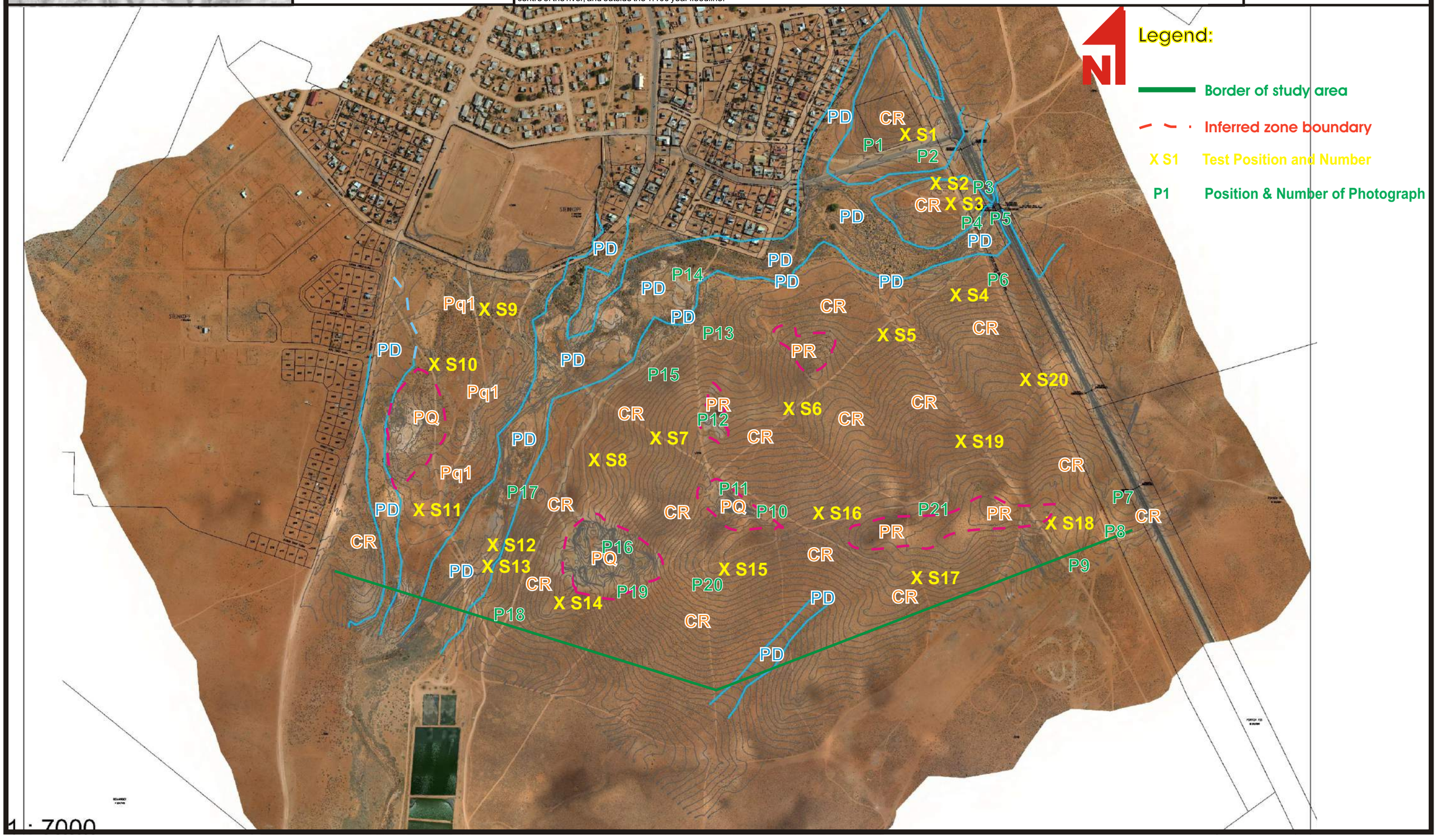
Suitable for development with precaution

Site Class PR: Areas with a PR site class designation whith problems relating to restricted excavation to less than 0,5m, consisting of solid rock calcrete, calcrete rock outcrop known as hard pan calcrete or gneiss will have an inflated cost where special pneumatic tools and blasting will be required for the installation of services.

Site Class PQ: Areas where small quarries or filling or dumping of spoil (Pq1) were identified must be rehabilitated before any construction can be allowed, and backfilling with an engineer's material may improve the developability of these zones, but these operations will dramatically increase the development cost in this zone.

Undevelopable: Site Class PD: Perennial drainage features with local steeper slopes within the upper channels and towards the river. The development is usually restricted to 32m from the centre of the river, and outside the 1:100 year floodline.

Figure 4:
Engineering Geological Zone Map with test positions on Google Image: Steinkopf



APPENDIX B: SOIL PROFILES

Soil Profiles Tabled Summary
Soil Profile Descriptions
Soil Profile Photographs

	Test Pit Nr		Samples Depth m	Pebble Marker 0m to m	Residual gneiss to m	Site Class	Remarks	GPS Coordinates X Coord	GPS Coordinates Y Coord		Test Pit Nr
S	1			0,5	0,7+	CR	Refusal on calcified gneiss.	29˚16'14,44" S	17˚44'27,44" E	S	1
S	2		0.4	0.3	0,7+	CR	Refusal on calcified gneiss.	29˚16'17,05" S	17˚44'29,25" E	S	2
S	3		0.2	0.7	1,0+	CR	Refusal on calcified gneiss.	29˚16'18,57" S	17˚44'30,16" E	S	3
S	4		0.2	0.3	0,7+	CR	Refusal on calcified gneiss.	29˚16'23,54" S	17˚44'30,12" E	S	4
S	5			0.3	0,7+	CR	Refusal on calcified gneiss.	29˚16'26,79" S	17˚44'24,85" E	S	5
S	6			0.3	0,4+	CR	Refusal on calcified gneiss.	29˚16'31,41" S	17˚44'18,68" E	S	6
S	7		0.2	0.4	0,6+	CR	Refusal on calcified gneiss.	29˚16'33,24" S	17˚44'08,96" E	S	7
S	8		0.2	0.3	0,4+	CR	Refusal on calcified gneiss.	29˚16'34,84" S	17˚44'04,34" E	S	8
S	9			0.1	0,5+	CR	Refusal on calcified gneiss.	29˚16'25,16" S	17˚43'56,42" E	S	9
S	10			0.3	0,4+	CR	Refusal on calcified gneiss.	29˚16'29,50" S	17˚43'53,17" E	S	10
S	11			0	0+R	CR	Photo: Calcified gneiss outcrop	29˚16'40,05" S	17˚43'51,98" E	S	11
S	12			0.2	0,3+	CR	Refusal on calcified gneiss.	29˚16'42,05" S	17˚43'55,62" E	S	12
S	13					CR	Photo: Bridge with gneiss outcro	29˚16'43,07" S	17˚43'55,18" E	S	13
S	14		0.2	0.3	0,4+	CR	Refusal on calcified gneiss.	29˚16'44,25" S	17˚44'01,63" E	S	14
S	15			0.2	0,4+	CR	Refusal on calcified gneiss.	29˚16'41,65" S	17˚44'13,07" E	S	15
S	16			0.2	0,6+	CR	Refusal on calcified gneiss.	29˚16'38,55" S	17˚44'20,14" E	S	16
S	17		0.2	0.3	0,6+	CR	Refusal on calcified gneiss.	29˚16'42,88" S	17˚44'28,32" E	S	17
S	18			0.2	0,3+	CR	Refusal on calcified gneiss.	29˚16'39,33" S	17˚44'37,46" E	S	18
S	19			0.2	0,4+	CR	Refusal on calcified gneiss.	29˚16'33,99" S	17˚44'31,77" E	S	19
S	20		0.2	0.3	0,6+	CR	Refusal on calcified gneiss.	29˚16'30,19" S	17˚44'35,90" E	S	20

8 Disturbed samples were taken.

No water was encountered in any test pit

A JCB 3DX 4X4 Super TLB was supplied by Jaco from Mass Hire in Springbok, operated by Ralph.

All the test pits were dug to the refusal depth of the TLB usually in calcrete or on calcified gneiss.

The moisture content of the soil profiles were usually described as dry and sometimes as slightly moist.

The aeolian sand usually consisted of silty sand and underlain by calcrete gravel or calcified gneiss or gneiss boulders.

The consistency of the soil increased with increasing depth and was described as very loose.

Refusal was noted on calcrete or calcified gneiss as medium hard rock.

Refusal on the calrete or calcified gneiss was noted in all test pits, with an average refusal depth of less than 0,5m.

Soil Profile Nr: S1

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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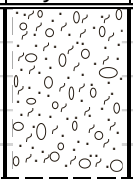
Consulting Engineering & Environmental Geologists
Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			
0.2			Abundant, small & medium, angular to sub rounded, pebbles & cobbles of gneiss
0.3			& calcrete, clast supported in a subordinate matrix of orange brown, dry
0.4			aeolian silty sand. Pebble marker.
0.5			
0.6			
0.7			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'14,44" S
WGS84 datum	Y Coord:	17˚44'27,44" E

Soil Profile Nr: S2

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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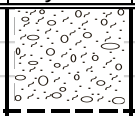
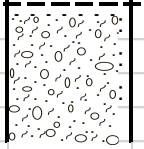
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Abundant, small & medium, angular to sub rounded, pebbles & cobbles of gneiss
0.2			& calcrete, clast supported in a subordinate matrix of orange brown, dry
0.3			aeolian silty sand. Pebble marker.
0.4		●	
0.5		S2-0,4	
0.6			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.
0.7			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S2-0,4.

Lat/long	X Coord:	29˚16'17,05" S
WGS84 datum	Y Coord:	17˚44'29,25" E

Soil Profile Nr: S3

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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Consulting Engineering & Environmental Geologists
Raadgewende Ingenieurs- en Omgewingsgeoloë
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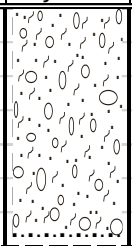
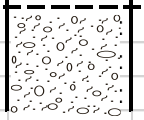
KARENPARK 0118 **Webfax:** 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			
0.2			
0.3		●	Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.4		S3-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.5			Calcified pebble marker.
0.6			
0.7			
0.8			
0.9			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.
1.0			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S3-0,2.

Lat/long	X Coord:	29˚16'18,57" S
WGS84 datum	Y Coord:	17˚44'30,16" E

Soil Profile Nr: S4

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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Consulting Engineering & Environmental Geologists
Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995 **Tel:** 012 525 1004
KARENPARK 0118 **Webfax:** 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2		S4-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3		●	Calcified pebble marker.
0.4			
0.5			
0.6			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.
0.7			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S4-0,2.

Lat/long	X Coord:	29˚16'23,54" S
WGS84 datum	Y Coord:	17˚44'30,12" E

Soil Profile Nr: S5

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3			Calcified pebble marker.
0.4			
0.5			
0.6			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.
0.7			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'26,79" S
WGS84 datum	Y Coord:	17˚44'24,85" E

Soil Profile Nr: S6

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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Consulting Engineering & Environmental Geologists
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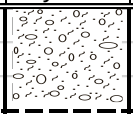
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Abundant, small & medium, angular to sub rounded, pebbles & cobbles of gneiss
0.2			& calcrete, clast supported in a subordinate matrix of orange brown, dry
0.3			aeolian silty sand. Pebble marker.
0.4			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'31,41" S
WGS84 datum	Y Coord:	17˚44'18,68" E

Soil Profile Nr: S6

Soil Profile Nr: S7

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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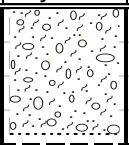
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2		S7-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3		●	Calcified pebble marker.
0.4			
0.5			
0.6			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S7-0,2.

Lat/long	X Coord:	29˚16'33,24" S
WGS84 datum	Y Coord:	17˚44'08,96" E

Soil Profile Nr: S8

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2		S8-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3		●	Calcified pebble marker.
0.4			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S8-0,2.

Lat/long	X Coord:	29˚16'34,84" S
WGS84 datum	Y Coord:	17˚44'04,34" E

Soil Profile Nr: S9

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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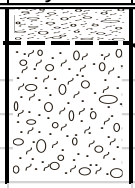
Consulting Engineering & Environmental Geologists
Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand. Calcified pebl
0.3			
0.4			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.
0.5			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'25,16" S
WGS84 datum	Y Coord:	17˚43'56,42" E

Soil Profile Nr: S9

Soil Profile Nr: S10

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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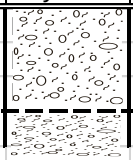
Consulting Engineering & Environmental Geologists
Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3			Calcified pebble marker.
0.4			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No sample.

Lat/long	X Coord:	29˚16'29,50" S
WGS84 datum	Y Coord:	17˚43'53,17" E

Soil Profile Nr: S12

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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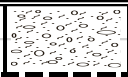
Consulting Engineering & Environmental Geologists
Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand. Calcified pebb
0.3			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'42,05" S
WGS84 datum	Y Coord:	17˚43'55,62" E

Soil Profile Nr: S14

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2		S14-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3		●	Calcified pebble marker.
0.4			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S14-0,2.

Lat/long	X Coord:	29˚16'44,25" S
WGS84 datum	Y Coord:	17˚44'01,63" E

Soil Profile Nr: S14

Soil Profile Nr: S15

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand. Calcified pebb
0.3			
0.4			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'41,65" S
WGS84 datum	Y Coord:	17˚44'13,07" E

Soil Profile Nr: S16

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand. Calcified pebb
0.3			
0.4			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.
0.5			
0.6			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'38,55" S
WGS84 datum	Y Coord:	17˚44'20,14" E

Soil Profile Nr: S17

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2		S17-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3		●	Calcified pebble marker.
0.4			
0.5			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.
0.6			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S17-0,2.

Lat/long	X Coord:	29˚16'42,88" S
WGS84 datum	Y Coord:	17˚44'28,32" E

Soil Profile Nr: S17

Soil Profile Nr: S18

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand. Calcified pebb
0.3			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'39,33" S
WGS84 datum	Y Coord:	17˚44'37,46" E

Soil Profile Nr: S19

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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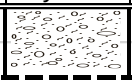
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2			sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand. Calcified pebb
0.3			
0.4			Refusal on dry, light brown & white, dense, intact, silty sandy gravel. Calcified gneiss.

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	29˚16'33,99" S
WGS84 datum	Y Coord:	17˚44'31,77" E

Soil Profile Nr: S20

DATE: 4 March 2020
JOB NR: GS202003S
PROJECT NAME: Steinkopf
TOWN: Extension
CLIENT: Maxim / Barzani
TLB Contractor: Mass Hire: Jaco
TLB Machine: JCB3DX 4X4 Super New
TLB Operator: Ralph

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Raadgewende Ingenieurs- en Omgewingsgeoloë
P.O. Box / Posbus 60995
KARENPARK 0118
Tel: 012 525 1004
Webfax: 086 658 3190
e-mail: davidsvdm@webmail.co.za **Cell:** 082 925 4075
Engineering Geologist: David S. van der Merwe.
Ingenieursgeoloog: Pr. Sci. Nat., MSAIEG.

Depth bngl (m)	Soil Profile Symbol	Sample Nr Symbols	Description of soil and properties
0.1			Dry, orange brown, loose, open textured, silty sand with small & medium, angular to
0.2		S20-0,2	sub rounded, pebbles & cobbles of gneiss & calcrete, aeolian silty sand.
0.3		●	Calcified pebble marker.
0.4			
0.5			Refusal on dry, light brown white, dense, intact, silty sandy gravel. Calcified gneiss.
0.6			

Notes:
1. Refusal on calcified gneiss.
2. No groundwater was intersected.
3. ● Disturbed sample S20-0,2.

Lat/long	X Coord:	29˚16'30,19" S
WGS84 datum	Y Coord:	17˚44'35,90" E

Soil Profile Nr: S20


S1
ROSS


S2


S3


S4


55
ROSS


56


S7


S8


S9


S10


S12

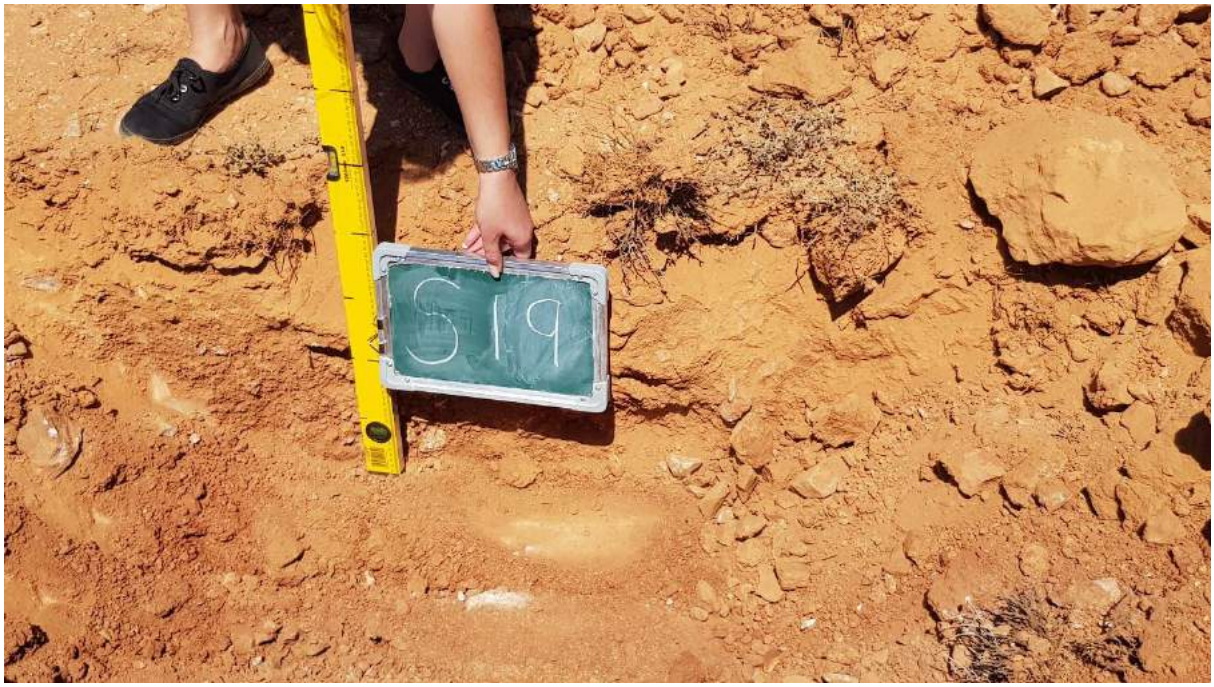

S14


S15


S16


S17


S18


S19


S20

P1

P2

P3

P4

P5

P6

P7

P8

P9

P10

P11

P12

P13

P14

P15

P16

P17

P18

P19

P20

APPENDIX C: LABORATORY RESULTS

Table A: Summary of Laboratory Results
STL Summary of Laboratory Results
STL Laboratory Results

Table A Summary of Laboratory Results

Stats	Depth		Material	Clay	Classification		% Linear	Plasticity	Liquid	Expan-
8	Nr	m	Description	%	Unified	PRA	Shrinkage	Index	Limit	siveness
1	S2	0,4	sand & gravel	3	SM	A-1-b	0.5	SP	ND	L
2	S3	0,2	sand	4	SM	A-2-4	0.5	SP	ND	L
3	S4	0,2	sand	1	SW-SM	A-1-b	0	NP	ND	L
4	S5	0,2	sand	2	SW-SM	A-1-b	0	NP	ND	L
5	S7	0,2	sand	3	SM	A-2-4	0	SP	ND	L
6	S8	0,2	sand	2	SM	A-2-4	0.5	SP	ND	L
7	S14	0,2	sand	3	SM	A-1-b	0	NP	ND	L
8	S17	0.2	sand	3	SM	A-1-b	0.5	SP	ND	L
Material possibly expansive if value:				>12%			>8%	>12	>30	Exp?

Table A Legend

Unified

8 According to the revised ASTM-Standard on the "Unified Soil Classification System" (Weinert).

8 SM: Silty sand; poorly graded sand silt mixtures

2 SW: Well graded sand, gravelly sand with little or no fines.

PRA

8 Public Roads Classification (Brink, Partridge & Williams).

5 A-1-b: Gavelly sand or graded sand may include fines.

3 A-2-4: Sand & gravel with low plasticity silt fines.

8 Expansiveness according to Van der Merwe's method (Brink, Partridge & Williams).

8 L: Low

0 L/M: Low to medium expansiveness

0 M: Medium

0 H: High

A clayey material is potentially expansive with the following properties (Kantey and Brink, 1952):

0 a clay content greater than 12 percent,

0 a linear shrinkage of more than 8 percent,

0 a plasticity index of more than 12, and

0 a liquid limit of more than 30 percent

3 NP: Not plastic: sandy material with no cohesion

5 SP: Slightly plastic with little cohesion

8 ND: not determined

Specialised Testing Laboratory (Pty) Ltd
Unit 1, 13 Boulbokke Street, Kraaibosch C186
Kowie | 072 674 6363 | testing@stlab.co.za
Gerie | 082 309 4448 | gerie@stlab.co.za
www.stlab.co.za

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Client Name: Geoset
Project Name: Steinkopf
Job Number: DVM-108
Date: 09-Apr-20
Method: SANS 3001 GR1, GR3 GR10, GR12 GR20, GR30, GR31, GR40, GR50, GR53, GR54 & BS 1377 (where applicable)

SUMMARY OF TEST DATA

Grading & Hydrometer Analysis (% Passing)

Sample	S2	S3	S4	S5	S7	S8	S14	S17
Depth (m)	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Lab No	DVM-108-1026	DVM-108-1027	DVM-108-1028	DVM-108-1029	DVM-108-1030	DVM-108-1031	DVM-108-1032	DVM-108-1033
53.0	100	100	100	100	100	100	100	100
37.5	100	100	100	100	100	100	100	100
26.5	96	100	100	100	100	100	100	100
19.0	91	100	100	100	100	100	100	100
13.2	91	99	97	100	97	100	99	99
9.5	91	99	96	100	96	100	98	99
6.7	87	98	93	100	96	99	96	99
4.75	82	97	91	98	95	97	94	98
2.00	61	91	84	94	91	90	87	92
1.00	47	80	64	76	78	75	70	66
0.425	34	60	43	47	57	52	49	47
0.250	24	44	28	28	39	40	35	33
0.150	19	30	19	18	26	30	24	23
0.075	13	20	12	11	16	23	17	17
0.060	10	14	7	9	14	18	14	12
0.050	9	13	6	7	12	16	12	11
0.035	7	9	4	5	9	12	10	9
0.020	6	7	4	4	7	9	7	7
0.006	5	6	2	3	5	4	5	5
0.002	3	4	1	2	3	2	3	3
GM	1.92	1.29	1.61	1.48	1.36	1.35	1.47	1.44

Atterberg Limits

LL (%)	-	-	-	-	-	-	-	-
PI (%)	SP	SP	NP	NP	SP	SP	NP	SP
LS (%)	0.5	0.5	0.0	0.0	0.5	0.5	0.0	0.5

pH & Conductivity

pH								
EC (S/m)								

MDD / OMC

MDD (kg/m^3)								
OMC (%)								

CBR

100%								
98%								
97%								
95%								
93%								
90%								
Swell (%)								

UCS (MPa)

100%								
97%								
90%								

COLTO Classification

Remarks:

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Unit 1, 13 Bloubokkie Street, Roedeospoort 0186
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Gerie | 082 309 4448 | gerie@stlab.co.za
www.stlab.co.za

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Client Name: Geoset
Project Name: Steinkopf
Job Number: DVM-108
Date: 2020-04-09
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Sheet Ref: R-STL-011-Rev02

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	S2	S3	S4	Sample	S2	S3	S4
Depth (m)	0.4	0.2	0.2	Depth (m)	0.4	0.2	0.2
Lab No	DVM-108-1026	DVM-108-1027	DVM-108-1028	Lab No	DVM-108-1026	DVM-108-1027	DVM-108-1028
53.0	100	100	100	Liquid Limit (%)	-	-	-
37.5	100	100	100	Plastic Limit (%)	-	-	-
26.5	96	100	100	Plasticity Index (%)	SP	SP	NP
19.0	91	100	100	Linear Shrinkage (%)	0.5	0.5	0.0
13.2	91	99	97	PI of whole sample	-	-	-
9.5	91	99	96				
6.7	87	98	93	% Gravel	39	9	16
4.75	82	97	91	% Sand	51	77	77
2.00	61	91	84	% Silt	7	10	6
1.00	47	80	64	% Clay	3	4	1
0.425	34	60	43	Activity	0.0	0.0	0.0
0.250	24	44	28				
0.150	19	30	19	% Soil Mortar	61	91	84
0.075	13	20	12				
0.060	10	14	7	Grading Modulus	1.92	1.29	1.61
0.050	9	13	6	Moisture Content (%)	N / T	N / T	N / T
0.035	7	9	4	Relative Density (SG)*	2.65	2.65	2.65
0.020	6	7	4				
0.006	5	6	2	Unified (ASTM D2487)	SM	SM	SW-SM
0.002	3	4	1	AASHTO (M145-91)	A - 1 - b	A - 2 - 4	A - 1 - b

Remarks: *: Assumed
N / T: Not Tested

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Roelof | 072 674 6349 | roelof@stlab.co.za
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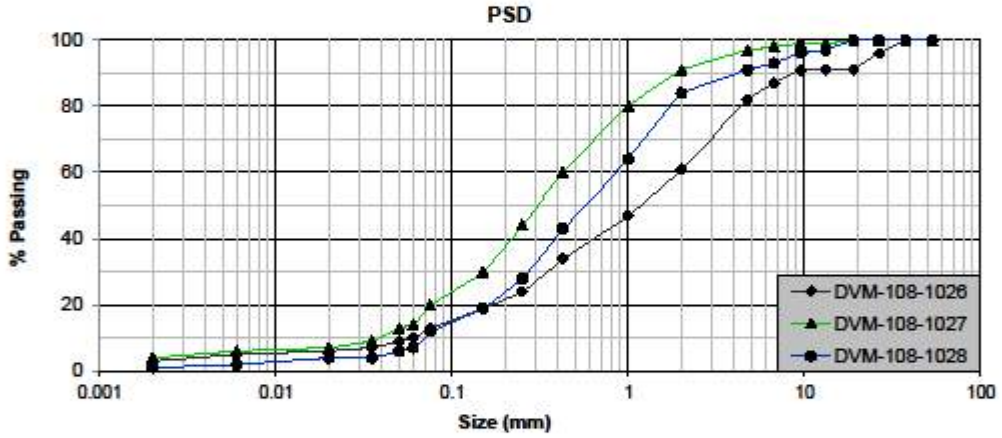
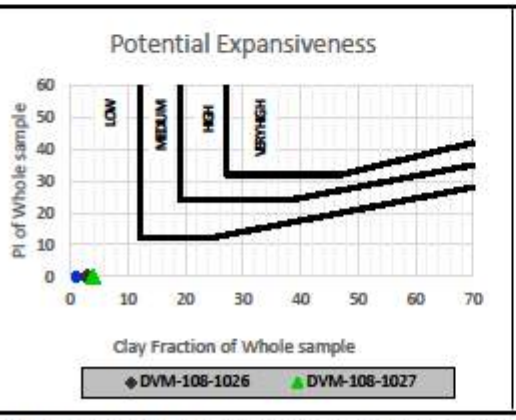
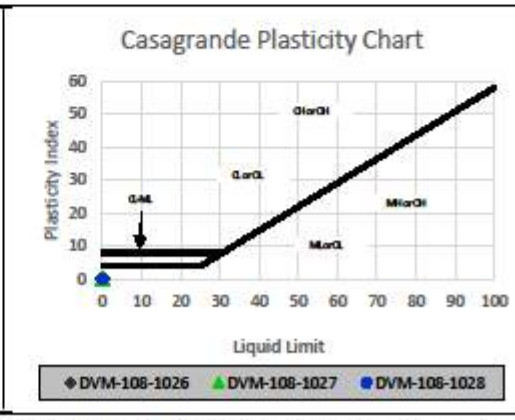
Client Name:	Geoset
Project Name:	Steinkopf
Job Number:	DVM-108
Date:	2020-04-09
Method:	SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Sheet Ref: R-STL-011-Rev02







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Client Name: Geoset
Project Name: Steinkopf
Job Number: DVM-108
Date: 2020-04-09
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Sheet Ref: R-STL-011-Rev02

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	S5	S7	S8	Sample	S5	S7	S8
Depth (m)	0.2	0.2	0.2	Depth (m)	0.2	0.2	0.2
Lab No	DVM-108-1029	DVM-108-1030	DVM-108-1031	Lab No	DVM-108-1029	DVM-108-1030	DVM-108-1031
53.0	100	100	100	Liquid Limit (%)	-	-	-
37.5	100	100	100	Plastic Limit (%)	-	-	-
26.5	100	100	100	Plasticity Index (%)	NP	SP	SP
19.0	100	100	100	Linear Shrinkage (%)	0.0	0.5	0.5
13.2	100	97	100	PI of whole sample	-	-	-
9.5	100	96	100				
6.7	100	96	99	% Gravel	6	9	10
4.75	98	95	97	% Sand	85	77	72
2.00	94	91	90	% Silt	7	11	16
1.00	76	78	75	% Clay	2	3	2
0.425	47	57	52	Activity	0.0	0.0	0.0
0.250	28	39	40				
0.150	18	26	30	% Soil Mortar	94	91	90
0.075	11	16	23				
0.060	9	14	18	Grading Modulus	1.48	1.36	1.35
0.050	7	12	16	Moisture Content (%)	N / T	N / T	N / T
0.035	5	9	12	Relative Density (SG)*	2.65	2.65	2.65
0.020	4	7	9				
0.006	3	5	4	Unified (ASTM D2487)	SW-SM	SM	SM
0.002	2	3	2	AASHTO (M145-91)	A - 1 - b	A - 2 - 4	A - 2 - 4

Remarks: *: Assumed
N / T: Not Tested

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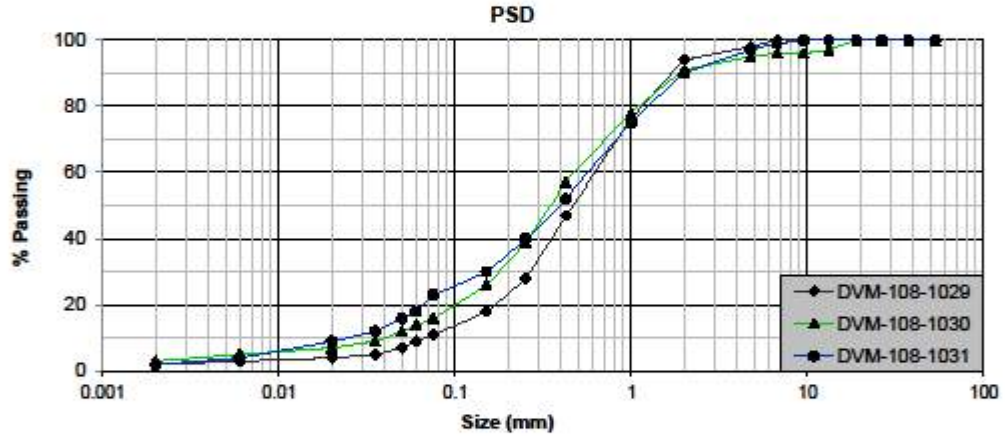
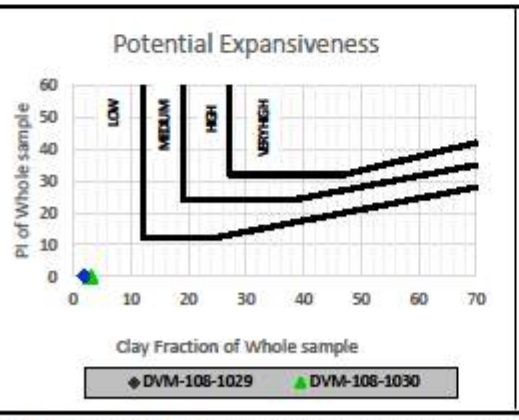
Unit 1, 13 Bloubokkie Street, Roedeloopoort 0186
Roelof | 072 674 6349 | roelof@stlab.co.za
Gerie | 082 309 4448 | gerie@stlab.co.za
www.stlab.co.za

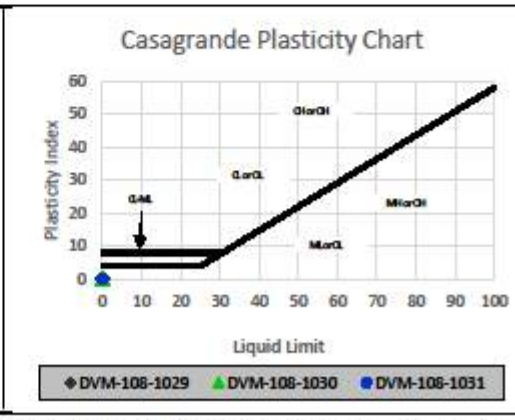
Client Name:	Geoset
Project Name:	Steinkopf
Job Number:	DVM-108
Date:	2020-04-09
Method:	SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Sheet Ref: R-STL-011-Rev02







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FOUNDATION INDICATOR

Sheet Ref: R-STL-011-Rev02

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	S14	S17		Sample	S14	S17	
Depth (m)	0.2	0.2		Depth (m)	0.2	0.2	
Lab No	DVM-108-1032	DVM-108-1033		Lab No	DVM-108-1032	DVM-108-1033	
53.0	100	100		Liquid Limit (%)	-	-	
37.5	100	100		Plastic Limit (%)	-	-	
26.5	100	100		Plasticity Index (%)	NP	SP	
19.0	100	100		Linear Shrinkage (%)	0.0	0.5	
13.2	99	99		PI of whole sample	-	-	
9.5	98	99					
6.7	96	99		% Gravel	13	8	
4.75	94	98		% Sand	73	80	
2.00	87	92		% Silt	11	9	
1.00	70	66		% Clay	3	3	
0.425	49	47		Activity	0.0	0.0	
0.250	35	33					
0.150	24	23		% Soil Mortar	87	92	
0.075	17	17					
0.060	14	12		Grading Modulus	1.47	1.44	
0.050	12	11		Moisture Content (%)	N / T	N / T	
0.035	10	9		Relative Density (SG)*	2.65	2.65	
0.020	7	7					
0.006	5	5		Unified (ASTM D2487)	SM	SM	
0.002	3	3		AASHTO (M145-91)	A - 1 - b	A - 1 - b	

Remarks: *: Assumed
N / T: Not Tested

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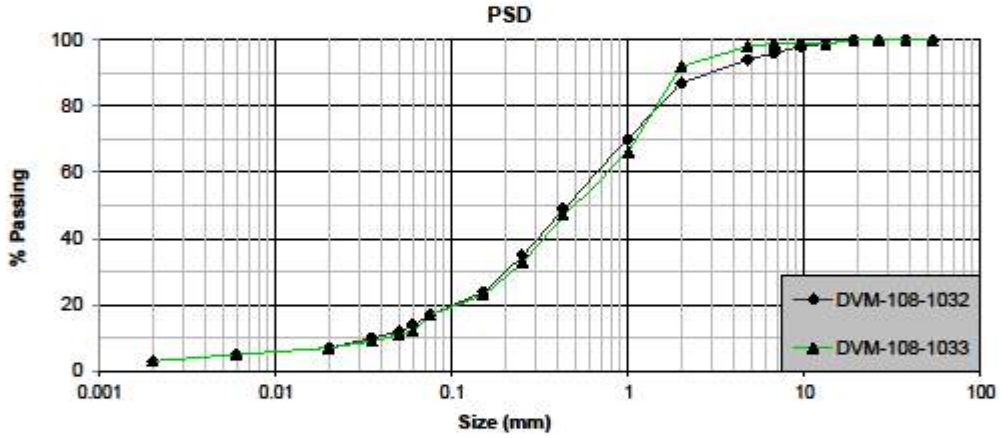

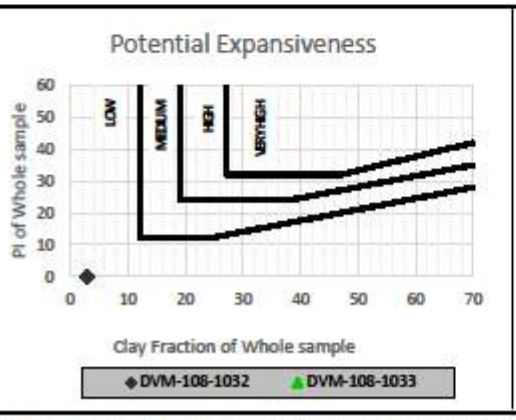

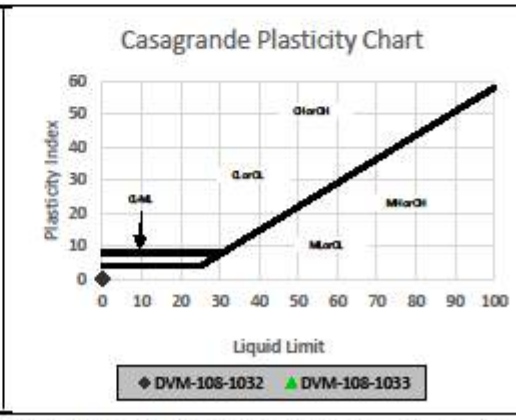

APPENDIX D: TABULAR EXPLANATION OF ZONING

Extract from: THE SOUTH AFRICAN INSTITUTE OF ENGINEERING GEOLOGISTS (SAIEG), 1997. Guidelines for Urban Engineering Geological Investigations.

Table 1. Categories of Urban Engineering Geological Investigation

Table 2. Geotechnical Classification for Urban Development: Partridge, Wood & Brink (1993)

Table 3. Residential Site Class Designations: SAICE, SAIEG & NHBRC (1995)

Table 1. CATEGORIES OF URBAN ENGINEERING GEOLOGICAL INVESTIGATION

Type	Planning Investigations		Urban Development Investigations		Specialised Investigations
Description	**Regional Engineering Geological Mapping (REGM)**	**Mapping for Urban Planning**	**Urban Development Investigation**	**Urban Development Investigation**	**Specialised Geotechnical Investigation**
Size of study area and field work	More than 1000 ha. Walk-over survey and limited test pits and soil sampling.	Less than 1000 ha. Walk-over survey.	Less than 10 ha. Test pits, trial holes and soil sampling.	More than 10 ha. Walk-over survey with trial pits and test holes and soil sampling.	Not relevant. Specific to type of specialised investigation.
Suggested number of test pits	A minimum of 3 test pits per land facet type.	None suggested. However, a limited number of test pits may be required at the discretion of the consultant.	Between 6 and 10 test pits.*	Between 1 and 6 test pits per 10 ha. depending on the size and variability of the area to as much as 1 test pit per hectare for highly variable sites.*	Dependent on the type of specialised investigation performed.
Mapping unit	Land systems and land facets.	Terrain types: 1 - most favourable 2 - intermediate 3 - least favourable	Soil classes: C, H, S and P and other (e.g. excavation, drainage features)	Soil classes: C, H, S and P and other (e.g. excavation, drainage features)	Not applicable.
Reference	Brink, Partridge and Williams (1982)	Partridge, Wood and Brink (1993)	SAICE Code of Practice (1995)	SAICE Code of Practice (1995)	Not relevant.
Consultants	Engineering geologists.	Engineering geologists and to a lesser extent geotechnical engineers.	Both engineering geologists and geotechnical engineers.	Both engineering geologists and geotechnical engineers.	Geotechnical engineers and to a lesser extent engineering geologists.

* Note that these figures are not intended to be absolute and should serve only as a guideline.

Table 2. GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT (after Partridge, Wood and Brink 1993)

CONSTRAINT		Most favourable (1)	Intermediate (2)	Least favourable (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness.*	Any collapsible horizon or consecutive horizons with a depth of more than 750 mm in thickness.	A least favourable situation for this constraint does not occur.
B	Seepage	Permanent or perched water table more than 1,5 m below ground surface.	Permanent or perched water table less than 1,5 m below ground surface.	Swamps and marshes.
C	Active soil	Low soil-heave potential predicted. *	Moderate soil heave potential predicted.	High soil-heave potential predicted.
D	Highly compressible soil	Low soil compressibility expected.*	Moderate soil compressibility expected.	High soil compressibility expected.
E	Erodability of soil	Low.	Intermediate.	High.
F	Difficulty of excavation to 1,5 m depth	Scattered or occasional boulders less than 10% of the total 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 100 m below surface (except where total extraction mining has not occurred.)	Old undermined areas to a depth of 100 m below surface where stope closure has ceased.	Mining within less than 100 m of surface or where total extraction mining has taken place.
H	Instability in areas of soluble rock	Possibly unstable.	Probably unstable.	Known sinkholes and dolines.
I	Steep slopes	Between 2 and 6 degrees (all regions).	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 seismic activity more 100 cm/s².	Natural seismic activity more than 100 cm/s².
L	Areas subject to flooding	A "most favourable" situation for this constraint does not occur.	Areas adjacent to a known drainage channel or floodplain with slope less than 1%.	Areas .within a known drainage channel or floodplain.

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

Table 3. RESIDENTIAL SITE CLASS DESIGNATIONS (SAICE, 1995)

TYPICAL FOUNDATION MATERIAL	CHARACTER OF FOUNDING MATERIAL	EXPECTED RANGE OF TOTAL SOIL MOVEMENTS (mm)	ASSUMED DIFFERENTIAL MOVEMENT (% OF TOTAL)	SITE CLASS
Rock (excluding mud rocks which exhibit swelling to some depth)	STABLE	NEGLIGIBLE	-	R
Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays)	EXPANSIVE SOILS	< 7,5 7,5 - 15 15 - 30 > 30	50% 50% 50% 50%	H H1 H2 H3
Silty sands, sands, sandy and gravelly soils	COMPRESSIBLE AND POTENTIALLY COLLAPSIBLE SOILS	< 5.0 5,0 - 10 > 10	75% 75% 75%	C C1 C2
Fine-grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils	COMPRESSIBLE SOIL	< 10 10 - 20 > 20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	VARIABLE	VARIABLE		P

NOTES:

1. The classifications C,H,R and S are not intended for dolomitic area sites unless specific investigations are carried out to assess the stability (risk of sinkholes and doline formation) of the dolomites. Where this risk is found to be acceptable, the site shall be designated as Class P (dolomitic areas).
2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as a percentage of the total soil movements are equal to about 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the total soil movements must be adjusted so that the resultant different movement implied by the table is equal to that which is expected in the field.
3. In some instances, it may be more appropriate to use a composite description to describe a site more fully e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement e.g. a Class R/S1 site. Alternatively, a further site investigation may be necessary since the final design solution may depend on the location of the building on a particular site.
4. Where it is not possible to provide a single site designation and a composite description is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions e.g. H-H1-H2 or C1-C2.
5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as Class S1 or S2 a as relevant and appropriate.
6. Sites containing contaminated soils include those associated with reclaimed mine land, land down-slope of mine tailings and old land fills.
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.
8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix - i.e. P(contaminated soils). Under certain circumstances, composite description may be more appropriate - e.g. P(dolomite areas)-C1.
9. Certain fills may contain contaminates which present a health risk. The nature of such fill should be evaluated and should be clearly demarcated as such.