IXOPO, KWAZULU-NATAL

PHASE 1 ENGINEERING GEOLOGICAL INVESTIGATION

to DETERMINE the POTENTIAL for TOWNSHIP DEVELOPMENT

at IXOPO, UBUHLEBEZWE LOCAL MUNICIPALITY, KWAZULU-NATAL.

Georeference: 3030AA Ixopo

GEOSET cc

CK 1999/65610/23

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REPORT ON THE ENGINEERING GEOLOGICAL INVESTIGATION CONDUCTED AT IXOPO, KWAZULU-NATAL.

Executive Summary

A phase 1 engineering geological investigation with reference to GSFH-2 specification was conducted on the proposed development site at Ixopo, KwaZulu-Natal, with the aim to assess aspects such as geology, relief and subsoil conditions which may influence the planned urban development in the area. The site is underlain by dark grey shale, carbonaceous shale or siltstone of the Pietermaritzburg Formation of the Ecca Group, Karoo Supergroup. Some dolerite intrusion in the form of dykes and sills are also present in the area. Locally the lithology is covered by sand and ferricrete or quartz gravel. 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. The **potentially slightly to medium collapsible and compressible and medium expansive** soil (site **class H2-H3/C1** with **15mm and up to 30mm and even in excess of 30mm** movement measured at surface) requires **modified normal to special construction** with proper compaction techniques as described. Steep slopes may limit development and major slope failures could be inflated during long periods of consistent rain fall. No problems regarding excavatability can be expected on the site with no refusal of the TLB. 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.

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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REPORT ON THE ENGINEERING GEOLOGICAL INVESTIGATION CONDUCTED AT IXOPO, KWAZULU-NATAL.

1. INTRODUCTION AND TERMS OF REFERENCE

On request of Maxim Planning in Klerksdorp, an engineering geological investigation was conducted for the proposed development on the property in Ixopo, KwaZulu-Natal, and communication between us and the abovementioned parties lead to the field work, commencing in June 2019.

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 development site is at Ixopo, KwaZulu-Natal, approximately 30 hectares in size. It is situated east of the road to Umzimkulu. It comprises of portions of Erf 174 and of the remainder of Erf 175 and Erf 2281, Ixopo.

Figures 1-4 in Appendix A delineates the site.

2. INFORMATION USED IN THE STUDY

The following was consulted during the investigation:

2.1 The geological map 3030 Port Shepstone. Scale 1:250 000. The Geological Survey of South Africa.

2.2 The topography map **3030AA Ixopo**. 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 steep to very steep northeastern slope from 1030 at the river to 1140 masl towards the water reservoir and communication tower on the site.

3.1.2 Climate

The region is characterized by summer rainfall with thunderstorms, with annual high rainfall figures of almost 900mm (827 mm for Ixopo and 897mm per annum for Pietermaritzburg), recorded at the closest weather stations to the site. Winters are dry with no frost. The warmest months are normally December to March and the coldest months are June and July.

An analysis of the data confirms a Weinert's N-Value in the order of 1,3 for Ixopo, KwaZulu-Natal. The chemical disintegration of rocks will therefore be dominant over mechanical decomposition, and deep soil horizons will be expected even 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 Mixed Bushveld veld with Tropical and Savanna Type (Bushveld) *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 30 ha large is 8 samples for foundation indicator tests (GFSH-2 guideline), and 6 samples were tested. This may sometimes vary and is limited according to the accessibility, the extent of development of infrastructure on site, as well as the variability of the geotechnical character and simplicity of a site. We had access problems with our investigation.

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

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[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 dark grey shale, carbonaceous shale or siltstone of the Pietermaritzburg Formation of the Ecca Group, Karoo Supergroup.

Some dolerite intrusions in the form of dykes and sills are also present in the area.

Locally the lithology is covered by hillwash comprising clayey sand with quartz and ferricrete gravel.

No dolomite occurs on site and no stability investigation is required.

5.2 Groundwater Conditions

The dominant drainage pattern on site comprises of a series of dendritic streams and some drainage channels intersect the site.

Drainage occurs in a northeastern direction towards the Umkomaas River, and then later into the Indian Ocean.

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 30ha is calculated to 23 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 3 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 the site is developed and serviced during the formalization of the planning process such as this site.

We recorded positions, photographed, described and characterized 18 test positions covering the site. During our investigation 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 steep areas are represented in Appendix B.

Typical soil profile

Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
Slightly moist, orange to reddish brown, soft, intact silty clay. Residual highly weathered shale, underlain by
Slightly moist, khaki orange stained red becoming pink or light grey, soft, laminated silty clay. Moderately to slightly weathered shale.

Near refusal of the competent TLB was noted on sandy clay or shale gravel in depths exceeding 2,2m.

No problems regarding excavatability can be expected on the site, and a competent TLB will be adequate to reach installation depths for services as the average near refusal depths ranged between 2,2m and 3,8m.

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 medium collapse potential and compressibility of the hillwash with a low to medium and highly expansive potential of the material (according to the method of Van der Merwe, 1964).

The hillwash had high clay percentages and it ranged from 34 to 55%, with high plasticity indexes of 17 up to 23, and linear shrinkage percentages of 8 to 12,5%, and liquid limits between 44 and up to 52. The Unified classification was mainly CH (2 samples) as inorganic clay with high plasticity or fat clay and CL (3 samples) as inorganic clay with low to medium plasticity, indicating the presence of an active clay such as montmorillonite, with a PRA classification of mainly A-7-6 (4 samples) as highly compressible high volume change clay to A-7-5 (2 samples) as highly compressible silty clay.

The range of test results are typical of hillwash with a different origin of shale to mudstone and where the material has a large variety of composition as the transported material are presented in the form of sand or clay lenses along or towards drainage features.

An Unconfined Compressive Strength Test of a remoulded sample of test pit I1 @ 0,8m depth was done and it had a stress value of 654 kPa at an axial strain of 2,48 %.

The Triaxial saturated consolidated undrained (CU) with pore water pressure (PWP) measurements of 3 specimens from test pit I8 at 2,0m were also done indicating the effective shear resistance angle of 35 degrees and a cohesion strength of 3 kPa.

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 Ixopo, KwaZulu-Natal.

6.2 SLOPE STABILITY AND EROSION

The potential for lateral soil movement or erosion is high, and the loose sandy silty clay is easily washed away during thunderstorms.

Additional to local slope instability within opened trenches and the collapse of pit side walls, other slope instability of deeply weathered hillwash is expected within these relative steep areas, and the possibility of a major slope failure could be inflated during long periods of consistent rain fall.

The cut and fill operations should also be concluded with proper compaction of the filling material to fit engineer's specification.

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

No problems regarding excavatability can be expected on the site, with no sub outcrop or shallow rock and outcrop areas that classified as hard rock excavation.

No problems regarding excavations of the upper hillwash is expected as it is easily excavated by the competent TLB, and it was classified as soft in restricted and non-restricted excavation (SANS 1200 D).

No problems regarding excavatability can be expected for excavations deeper than 1,5m and up to 2,2m of moderately to slightly weathered shale on the site, and a competent TLB or excavator will be adequate to reach installation depths for services. It was classified as soft becoming intermediate rock in depth in restricted and non-restricted excavation (SANS 1200 D).

To ensure the stability of excavations, it will need standard sidewall protection in all 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 medium collapsible and compressible and soil with a medium and highly expansive potential, foundations will require modified normal to special

treatment to withstand movement associated with the variable moisture content of the soil.

No problems regarding excavatability to 1,5m can be expected on the site.

Additional to local slope instability within opened trenches and the collapse of pit side walls, other slope instability of deeply weathered hillwash is expected within these relative steep areas, and the possibility of a major slope failure could be inflated during long periods of consistent rain fall. 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 erosion and excessive 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

Modified Normal to Special Development:

Site Class H2-H3/C1:

This zone comprises mainly of a medium expansive and compressible soil, with thickness in excess of 0,75m, and an expected range of 15 up to 30mm and even more than 30mm of total soil movement measured at surface, underlain in depth by shale or mudstone. Foundations will therefore require modified normal to special foundation techniques such as soil replacement by an engineered fill soil raft by removing all or part of the expansive horizon to 1,0m beyond the perimeter of the structure and replacing with inert backfill, compacted to 93%MOD ASSHTO density at or near optimum moisture content, where after normal strip footing foundations can be used. Special foundation techniques may also include the use of stiffened strip footings, stiffened or cellular rafts, lightly reinforced strip footings or reinforced boxed steel in slightly widened strip foundations, the use of split construction techniques or articulation joints at all internal and external doors and openings with light reinforcement (brickforce) in masonry. Site drainage, a concrete apron of 1,0m around all structures and plumbing and service precautions are advised. It is classified as H2 to H3 / C1 in terms of the NHBRC guidelines (1995) or the SAICE Code of practice (1995) and 2A2C2D2E as per the classification for urban development (Partridge, Wood & Brink).

Site class PS:

Steep slopes in excess of 12 degrees may require special cut and fill operations including proper compaction during construction and major slope failures could be inflated during long periods of consistent rain fall.

Site Class PQ:

Areas used for surface mining of construction material must be rehabilitated and properly backfilled to engineer's specification before development can be allowed.

Site Class PM:

Marshy areas due to a large diameter sewage pipe leakage must be permanently repaired and the problem solved before commencement of construction.

Undevelopable

Site Class PD/H3:

Drainage features intersect the site and the 1:100 year flood line must be used to specify the allowable distance of development from this possible flooded areas, with a minimum distance of 32m from the main streams.

The geotechnical problems encountered will require modified normal to special foundation techniques and construction, such as proper standard compaction techniques of cut and fill operations and reinforced steel in strip footing foundations or soil replacement with soil rafts, and even stiffened or cellular rafts.

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.

8.2 ***Expansive soil***

Site Class H (Estimated total heave of less than 7.5mm):

Soil tested as medium expansive with a clay layer thickness of up to 0,3m from surface

Normal construction:
Minor heave requires normal construction (strip footing and slab on the ground) with site drainage and service/plumbing precautions recommended.

Site Class H1 (Estimated total heave of between 7.5 and 15mm):

Tested as medium expansive with a clay layer thickness of between 0,45 to 0,85m from surface,
or a highly expansive clay layer of between 0,3 and 0,4m in thickness from surface
or a clay layer with a very high expansive potential of up to 0.3m.

Modified normal:
Lightly reinforced strip footings.
Articulation joints at all internal/external doors and openings
Light reinforcement in masonry.
Site drainage and plumbing/service precautions.

Or soil raft:
Remove all or part of expansive horizon to 1,0m beyond the perimeter of the construction and replace with inert backfill compacted to 93% MOD AASHTO density at -1% to 2% of optimum moisture content.
Normal construction with lightly reinforced strip footings and masonry.
Site drainage and plumbing/service precautions.

Site Class H2 (Estimated total heave of between 15 and 30mm):

Tested as medium expansive with a clay layer thickness of between 0,85 to 2,0m,
or highly expansive of between 0,4 and 0,85m in thickness measured from surface,
or a clay layer with a very high expansive potential of between 0.3 and 0.4m.

Soil raft:
See H1.

Stiffened or cellular raft:
Articulation joints or solid lightly reinforced masonry.
Site drainage and plumbing/service precautions.

Piled construction:
Piled foundation with suspended floor slabs with or without ground beams.
Site drainage and plumbing/service precautions.

Split construction:
Combination of reinforced brickwork/blockwork and full movement joints.
Suspended floors or fabric reinforced ground slabs.
Site drainage and plumbing/service precautions.

Site Class H3 (Estimated total heave of more than 30mm):

Soil tested as medium expansive with a clay layer thickness of more than 2,0m (>2,0m thick),
or highly expansive of more than 0,85m (0,85m or more in thickness),
or a clay layer with a very high expansive potential of more than 0.4m in thickness.
Foundations require special design by structural engineer of the following:

Soil raft:
As for H1.

Stiffened or cellular raft:
As for H2.

Piled construction:
As for H2.

9. DRAINAGE

The site is located on steep to steeper slopes mainly towards the northeast.

A few dominant drainage patterns exist on site with the Umkomaas River located further northeast of the site, flowing eastwards into the Indian Ocean.

No seepage but the presence of perennial fluctuations of ground water were encountered on site, proving that a seasonal perched water table exist. A ferruginised 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 30,53 hectares, Ixopo, KwaZulu-Natal,was investigated to determine the engineering geological properties that will influence township proclamation.

2. The site is underlain by dark grey shale, carbonaceous shale or siltstone of the Pietermaritzburg Formation of the Ecca Group, Karoo Supergroup. Some dolerite intrusions in the form of dykes and sills are also present in the area. Locally the lithology is covered by hillwash.

3. Additional to local slope instability within opened trenches and the collapse of pit side walls, other slope instability of deeply weathered hillwash is expected within these relative steep areas, and the possibility of a major slope failure could be inflated during long periods of consistent rain fall. Cut and fill operations should also be concluded with proper compaction of the filling material to fit engineer's specification.

4. No problems are foreseen regarding the excavatability to 1,5m depth on site.

5. Zoning of the site revealed zones with some moderate constraints regarding the **collapse potential** and **the compressibility** of the soil.

6. The following zones were identified:

Engineering Geological Zonation

Modified Normal to Special Development:

Site Class H2-H3/C1: This zone comprises mainly of a medium expansive and compressible soil, with thickness in excess of 0,75m, and an expected range of 15 up to 30mm and even more than 30mm of total soil movement measured at surface, underlain in depth by shale or mudstone. Foundations will therefore require modified normal to special foundation techniques such as soil replacement by an engineered fill soil raft by removing all or part of the expansive horizon to 1,0m beyond the perimeter of the structure and replacing with inert backfill, compacted to 93%MOD ASSHTO density at or near optimum moisture content, where after normal strip footing foundations can be used. Special foundation techniques may also include the use of stiffened strip footings, stiffened or cellular rafts, lightly reinforced strip footings or reinforced boxed steel in slightly widened strip foundations, the use of split construction techniques or articulation joints at all internal and external doors and openings with light reinforcement (brickforce) in masonry. Site drainage, a concrete

apron of 1,0m around all structures and plumbing and service precautions are advised. It is classified as H2 to H3 / C1 in terms of the NHBRC guidelines (1995) or the SAICE Code of practice (1995) and 2A2C2D2E as per the classification for urban development (Partridge, Wood & Brink).

Site class PS: Steep slopes in excess of 12 degrees may require special cut and fill operations including proper compaction during construction and major slope failures could be inflated during long periods of consistent rain fall.

Site Class PQ: Areas used for surface mining of construction material must be rehabilitated and properly backfilled to engineer's specification before development can be allowed.

Site Class PM: Marshy areas due to a large diameter sewage pipe leakage must be permanently repaired and the problem solved before commencement of construction.

Undevelopable

Site Class PD/H3: Drainage features intersect the site and the 1:100 year flood line must be used to specify the allowable distance of development from this possible flooded areas, with a minimum distance of 32m from the main streams.

7. **Modified normal and special construction** techniques will be required to enable proper development. This includes the use of **compaction techniques** as described.

8. **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.**

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APPENDICES

APPENDIX A: FIGURES

Figure 1: Ixopo, KwaZulu-Natal: Regional Locality Map.
Figure 2: Ixopo, KwaZulu-Natal: Topography Map.
Figure 3: Ixopo, KwaZulu-Natal: Geology Map.
Figure 4: Ixopo, KwaZulu-Natal: Engineering Geological Zone Map with Test Pit Positions on Google Image.

APPENDIX B: SOIL PROFILES

Profiles with photographs

APPENDIX C: LABORATORY RESULTS

Indicator tests

APPENDIX D: TABULAR EXPLANATION OF ZONING

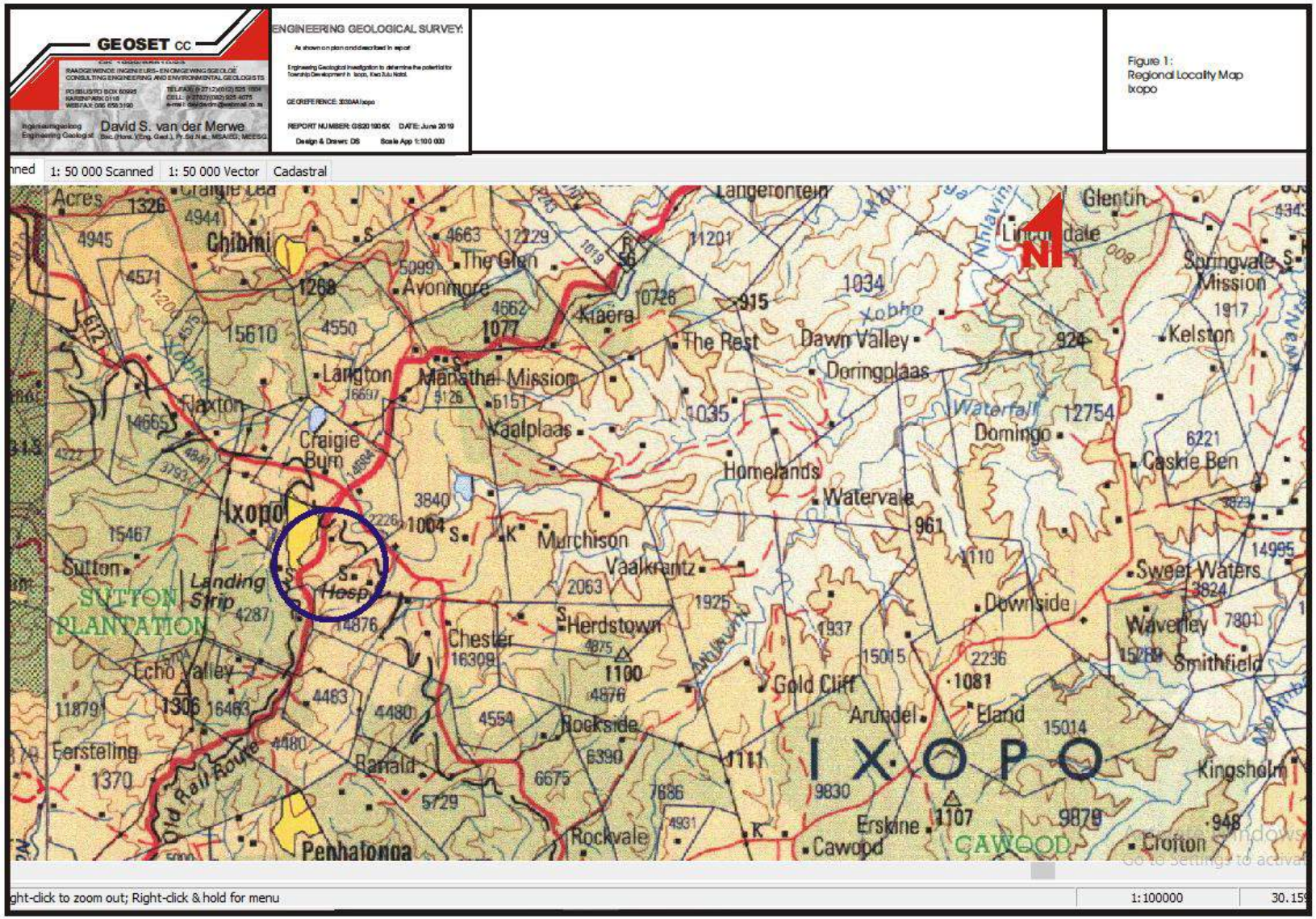
Extract from: THE SOUTH AFRICAN INSTITUTE OF ENGINEERING GEOLOGISTS (SAIEG), 1997. Guidelines for Urban Engineering Geological Investigations.

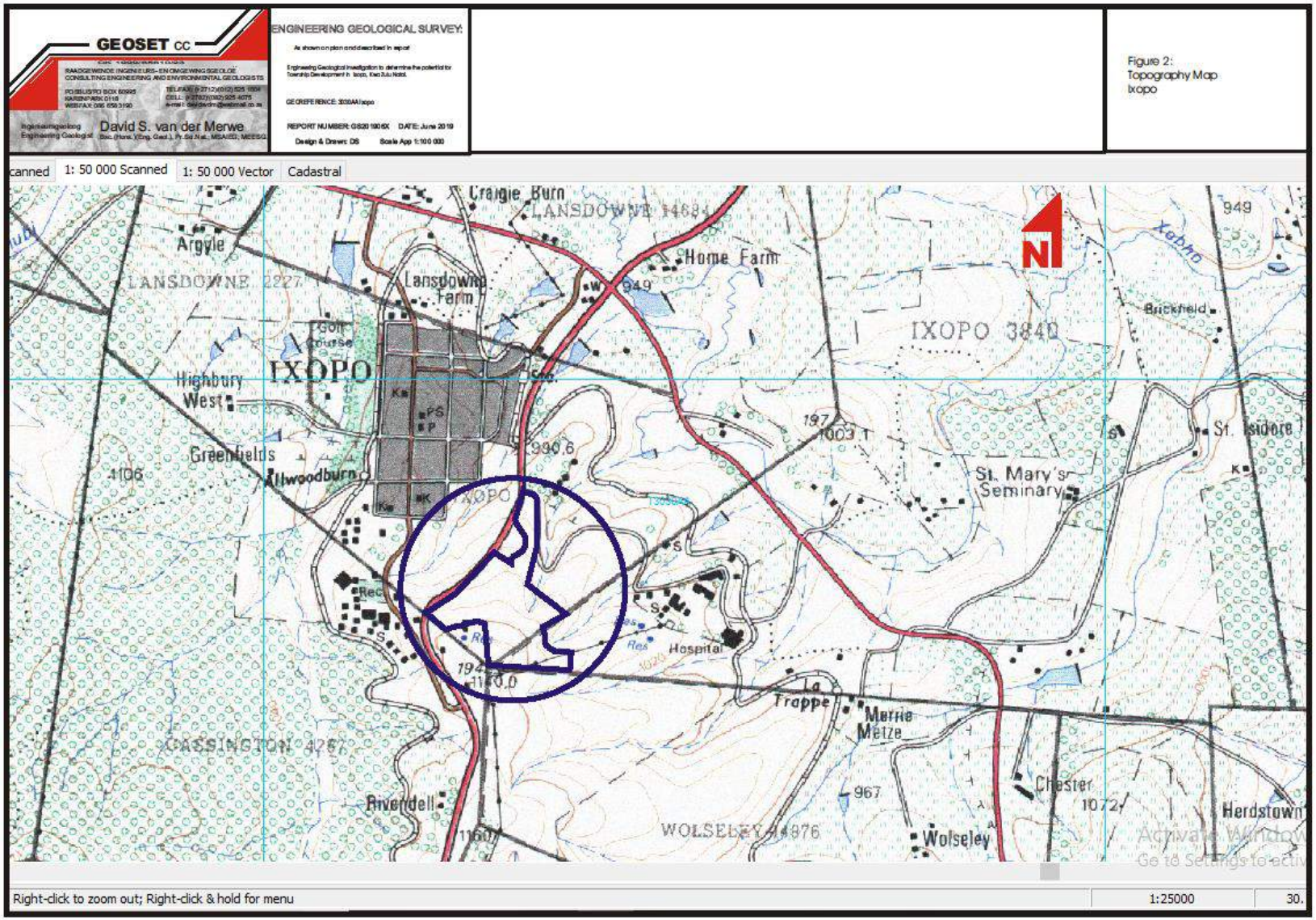
Table 1. Categories of Urban Engineering Geological Investigation

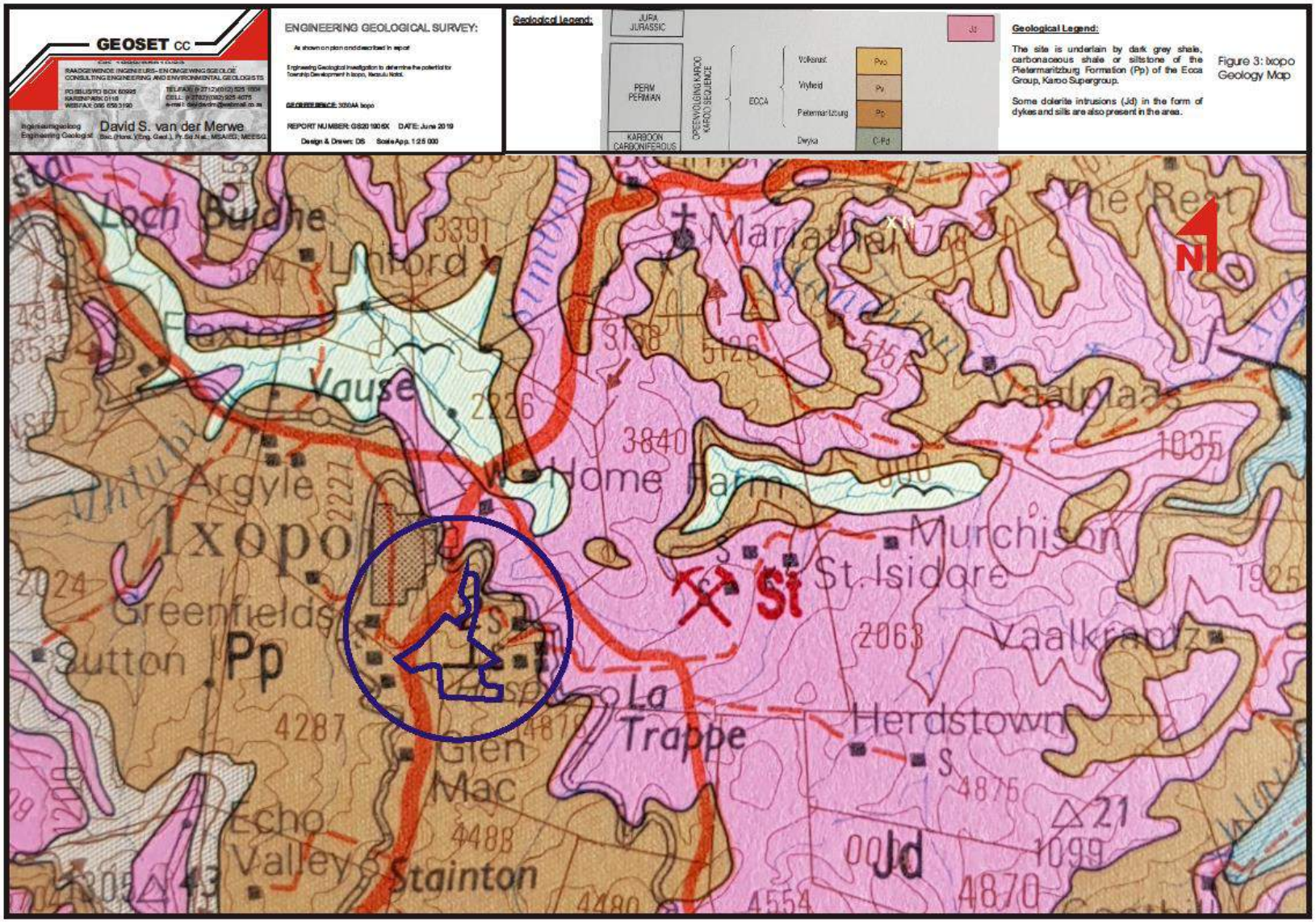
Table 2. Geotechnical Classification for Urban Development: Partridge, Wood & Brink (1993)

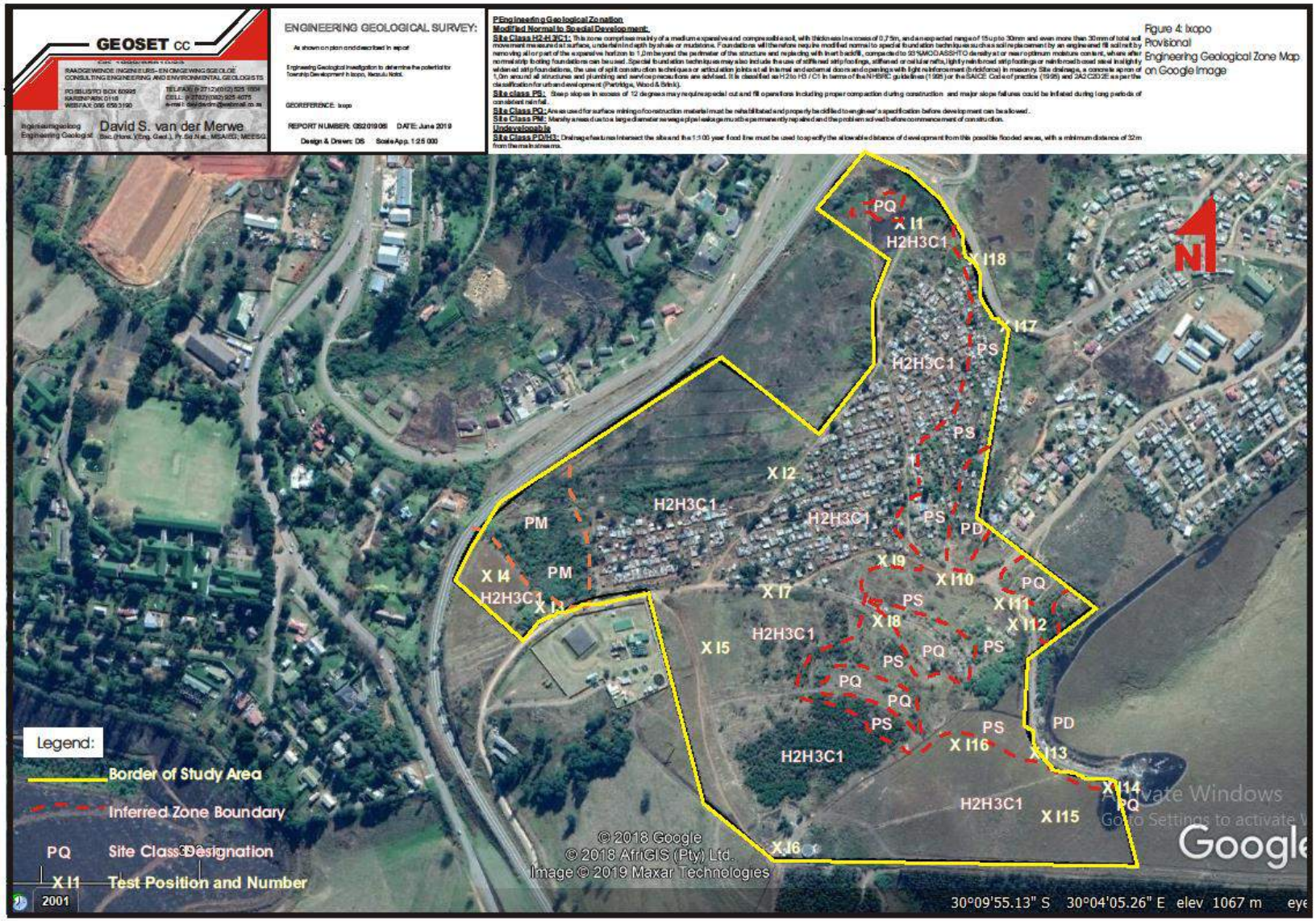
Table 3. Residential Site Class Designations: SAICE, SAIEG & NHBRC (1995)

APPENDIX A: FIGURES


GEOSET CC
ENGINEERING GEOLOGICAL SURVEY:
David S. van der Merwe
Figure 1:
Regional Locality Map
Ixopo
1: 50 000 Scanned
1: 50 000 Vector
Cadastral
Ixopo
Chibini
Avonmore
The Glen
Klaera
The Rest
Dawn Valley
Doringplaas
Kelston
Springvale Mission
Glentin
Lincoldale
Langton
Manathal Mission
Vaalplaas
Craigie Burn
Flaxton
Homelands
Watervale
Domingo
Waterfall
Caskie Ben
Murchison
Vaalkrantz
Sweet Waters
Downside
Waverley
Smithfield
Herdstown
Chester
Gold Cliff
Arundel
Eland
Rockside
Ramald
Rockvale
Erskine
Cawood
CAWOOD
Crofton
Kingsholm
Eersteling
Echo Valley
Sutton
SUTTON PLANTATION
Landing Strip
Hosp
Old Railroute
Penhalonga
I X O P O
1: 100000


GEOSET CC
ENGINEERING GEOLOGICAL SURVEY:
David S. van der Merwe
Figure 2:
Topography Map
Ixopo
canned
1: 50 000 Scanned
1: 50 000 Vector
Cadastral
Craigie Burn
LANSDOWNE 14684
Argyle
LANSDOWNE 2227
Lansdowne Farm
Home Farm
949
Golf Course
IXOPO
IXOPO 3840
Highbury West
Greenfields
Allwoodburn
1106
990.6
197
1003.1
St. Isidore
St. Mary's Seminary
Brickfield
Hospital
La Trappe
Merrie Metze
CASSINGTON 4267
Riverdell
1160
967
1072
Chester
Herdstown
WOLSELEY 14876
Wolseley
Right-click to zoom out; Right-click & hold for menu
1:25000
30.


GEOSET CC
ENGINEERING GEOLOGICAL SURVEY:
David S. van der Merwe
Geological Legend:
JURA
JURASSIC
PERM
PERMIAN
KAROO SEQUENCE
ECCA
Volksrust
Vryheid
Pietermaritzburg
Dwyka
Jd
Pvo
Pv
Pp
C-Pd
Geological Legend:
The site is underlain by dark grey shale, carbonaceous shale or siltstone of the Pietermaritzburg Formation (Pp) of the Ecca Group, Karoo Supergroup.
Some dolerite intrusions (Jd) in the form of dykes and sills are also present in the area.
Figure 3: Ixopo Geology Map
Loch Buidhe
Lynford
Mariathal
Vause
Argyle
Ixopo
Home Farm
Murchison
St. Isidore
Greenfields
Sutton
Pp
La Trappe
Vaalkrantz
Herdstown
Glen Mac
Echo Valley
Stainton
Jd
N


GEOSET CC
ENGINEERING GEOLOGICAL SURVEY:
David S. van der Merwe
Engineering Geologist
Pr.Sci.Nat.; MSAIEG; MEESG
REPORT NUMBER: GS2019/08 DATE: June 2019
Design & Drawn: DS Scale App. 1:25 000
Figure 4: Ixopo Provisional Engineering Geological Zone Map on Google Image
PQ
X I1
H2H3C1
X I18
X I17
PS
X I2
PM
X I4
X I3
X I5
X I7
X I8
X I9
X I10
X I11
X I12
X I13
X I14
X I15
X I16
X I6
PD
N
Legend:
Border of Study Area
Inferred Zone Boundary
Site Class Designation
Test Position and Number
© 2018 Google
© 2018 AfriGIS (Pty) Ltd.
Image © 2019 Maxar Technologies
Google
30°09'55.13" S 30°04'05.26" E elev 1067 m

APPENDIX B: SOIL PROFILES

Profiles with photographs

	Test Pit Nr		Samples Depth m	Hillwash Depth 0m to m	Residual shale Depth to m	Site Class	Remarks	GPS Coordinates X Coord	GPS Coordinates Y Coord		Test Pit Nr
I	1		0,3&0,8	0,4&1,0	1,5&2,3+	H3C1	Near refusal on shale	30˚09'30,32" S	30˚03'54,60" E	I	1
I	2			0,4&0,8	2,3+	H3C1	Near refusal on shale	30˚09'38,96" S	30˚03'50,27" E	I	2
I	3			0,4&1,0	1,5&2,3+	H3C1	Near refusal on shale	30˚09'44,37" S	30˚03'38,67" E	I	3
I	4		0,3&0,8	0,6&1,2	1,4&2,2+	H3C1	Near refusal on shale	30˚09'43,45" S	30˚03'36,37" E	I	4
I	5			0,4&1,0	1,5&2,3+	H3C1	Near refusal on shale	30˚09'46,55" S	30˚03'46,67" E	I	5
I	6			0,6	1,8&2,2+	H3C1	Near refusal on shale	30˚09'53,36" S	30˚03'49,26" E	I	6
I	7			1,0	1,0+	H3C1	Road cutting in hillwash	30˚09'44,15" S	30˚03'49,27" E	I	7
I	8		1,4&2,0	0,8	1,6&3,8+	H3C1	Near refusal on shale	30˚09'45,72" S	30˚03'54,60" E	I	8
I	9			0,9	1,8&2,5+	H3C1	Road cutting in hillwash	30˚09'42,93" S	30˚03'54,31" E	I	9
I	10			0,5	1,5&2,5+	H3C1	Road cutting in hillwash	30˚09'44,00" S	30˚03'56,76" E	I	10
I	11			0,3	1,2&2,2+	H3C1	Road cutting in hillwash	30˚09'44,62" S	30˚03'59,27" E	I	11
I	12			0,2	1,8+	H3C1	Road cutting in hillwash	30˚09'45,44" S	30˚04'00,01" E	I	12
I	13			0,2	2,1+	H3C1	Road cutting in hillwash	30˚09'49,40" S	30˚04'00,08" E	I	13
I	14			0,6	1,8&2,2+	H3C1	Near refusal on shale	30˚09'51,68" S	30˚04'03,19" E	I	14
I	15			0,3	0,9&2,2+	H3C1	Near refusal on shale	30˚09'52,77" S	30˚03'58,63" E	I	15
I	16			0,6	1,8&2,2+	H3C1	Near refusal on shale	30˚09'50,12" S	30˚03'56,53" E	I	16
I	17					H3C1	Development on steep slopes	30˚09'34,20" S	30˚04'00,01" E	I	17
I	18					H3C1	Road cutting in hillwash	30˚09'30,87" S	30˚03'58,08" E	I	18

6 Samples

No water was encountered in any test pit

A competent CAT 428E 4X4 TLB was supplied by Fynn Construction.

All the test pits were dug to the refusal depth or reach of the TLB, usually in shale.

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

The hillwash usually consisted of clayey sand and gravel.

The consistency of the soil increased with increasing depth and was described as loose to dense with near refusal on shale

Transported material comprized sandy to gravelly soil with quartz and hematite pebbles with a loose to dense consistency.

Soil Profile Nr: I1

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

GEOSET CC
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			
0.2		I1-0,3	Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3		●	
0.4			
0.5			
0.6			
0.7			Slightly moist, reddish brown, soft, intact silty clay. Hillwash.
0.8		●	
0.9		I1-0,8	
1.0			
1.1			
1.2			
1.3			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.4			Residual highly weathered shale.
1.5			
1.6			
1.7			
1.8			
1.9			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.0			Moderalety to highly weathered shale.
2.1			
2.2			
2.3			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. ● Disturbed samples I1-0,3 & 0,8.

Lat/long	X Coord:	30°09'30,32" S
WGS84 datum	Y Coord:	30°03'54,60" E

Soil Profile Nr: I1

Soil Profile Nr: I2

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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	I:I:I:I:I:I:I:I		
0.2	I:I:I:I:I:I:I:I		Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3	I:I:I:I:I:I:I:I		
0.4	I:I:I:I:I:I:I:I		
0.5	I:I:I:I:I:I:I:I		
0.6	I:I:I:I:I:I:I:I		
0.7	I:I:I:I:I:I:I:I		Slightly moist, reddish brown, soft, intact silty clay. Hillwash.
0.8	I:I:I:I:I:I:I:I		
0.9			
1.0			
1.1			
1.2			
1.3			
1.4			
1.5			Slightly moist, khaki orange stained red, soft, laminated silty clay.
1.6			Moderalety to highly weathered shale.
1.7			
1.8			
1.9			
2.0			
2.1			
2.2			
2.3			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'38,96" S
WGS84 datum	Y Coord:	30˚03'50,27" E

Soil Profile Nr: I2

Soil Profile Nr: I3

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			
0.2			Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3			
0.4			
0.5			
0.6			
0.7			Slightly moist, reddish brown, soft, intact silty clay. Hillwash.
0.8			
0.9			
1.0			
1.1			
1.2			
1.3			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.4			Residual highly weathered shale.
1.5			
1.6			
1.7			
1.8			
1.9			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.0			Moderalety to highly weathered shale.
2.1			
2.2			
2.3			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30°09'44,37" S
WGS84 datum	Y Coord:	30°03'38,67" E

Soil Profile Nr: I3

Soil Profile Nr: I4

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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		I4-0,3	Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3		●	
0.4			
0.5			
0.6			
0.7			Slightly moist, reddish brown, soft, intact silty clay. Hillwash.
0.8		●	
0.9		I4-0,8	
1.0			
1.1			
1.2			
1.3			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.4			Residual highly weathered shale.
1.5			
1.6			
1.7			
1.8			
1.9			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.0			Moderalety to highly weathered shale.
2.1			
2.2			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. ● Disturbed samples I4-0,3 & 0,8.

Lat/long	X Coord:	30°09'43,45" S
WGS84 datum	Y Coord:	30°03'36,37" E

Soil Profile Nr: I4

Soil Profile Nr: I5

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			
0.2			Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3			
0.4			
0.5			
0.6			
0.7			Slightly moist, reddish brown, soft, intact silty clay. Hillwash.
0.8			
0.9			
1.0			
1.1			
1.2			
1.3			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.4			Residual highly weathered shale.
1.5			
1.6			
1.7			
1.8			
1.9			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.0			Moderalety to highly weathered shale.
2.1			
2.2			
2.3			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30°09'46,55" S
WGS84 datum	Y Coord:	30°03'46,67" E

Soil Profile Nr: I5

Soil Profile Nr: I6

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			
1.1			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.2			Residual highly weathered shale.
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			
2.0			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.1			Moderalety to highly weathered shale.
2.2			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'53,36" S
WGS84 datum	Y Coord:	30˚03'49,26" E

Soil Profile Nr: I6

Soil Profile Nr: I7

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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	I:I:I:I:I:I:I:I		
0.2	I:I:I:I:I:I:I:I		
0.3	I:I:I:I:I:I:I:I		
0.4	I:I:I:I:I:I:I:I		
0.5	I:I:I:I:I:I:I:I		Slightly moist, dark brown becoming orange, loose to dense, intact sandy clay.
0.6	I:I:I:I:I:I:I:I		Hillwash.
0.7	I:I:I:I:I:I:I:I		
0.8	I:I:I:I:I:I:I:I		
0.9	I:I:I:I:I:I:I:I		
1.0	I:I:I:I:I:I:I:I		

Notes:
1. Road cutting in hillwash.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30°09'44,15" S
WGS84 datum	Y Coord:	30°03'49,27" E

Soil Profile Nr: I7

Soil Profile Nr: I8

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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	I		
0.2	I		
0.3	I		
0.4	I		
0.0	I		
0.1	I		Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.2	I		
0.3	I		
0.4	I		
0.5	I		
0.6	I		
0.7	I		
0.8	I		
0.9	I		
1.0	I		
1.1			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.2			Residual highly weathered shale.
1.3		I8-1,4	
1.4		●	
1.5			
1.6			
1.7			
1.8			
1.9			
2.0		●	
2.1		I8-2,0	
2.2			
2.3			
2.4			
2.5			
2.6			
2.7			
2.8			Slightly moist, khaki orange stained red becoming pink, soft, laminated silty clay.
2.9			Moderalety to highly weathered shale.
3.0			
3.1			
3.2			
3.3			
3.4			
3.5			Notes: 1. Near refusal on pinkish shale.
3.6			2. No groundwater was intersected.
3.7			3. ● Disturbed samples I8-1,4 & 2,0.
3.8			

Lat/long	X Coord:	30˚09'45,72" S
WGS84 datum	Y Coord:	30˚03'54,60" E

Soil Profile Nr: I8

Soil Profile Nr: I9

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

GEOSET CC
Consulting Engineering & Environmental Geologists
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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	I:I:I:I:I:I:I:I		
0.2	I:I:I:I:I:I:I:I		
0.3	I:I:I:I:I:I:I:I		
0.4	I:I:I:I:I:I:I:I		
0.5	I:I:I:I:I:I:I:I		Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.6	I:I:I:I:I:I:I:I		
0.7	I:I:I:I:I:I:I:I		
0.8	I:I:I:I:I:I:I:I		
0.9	I:I:I:I:I:I:I:I		
1.0	I		
1.1	I		
1.2	I		
1.3	I		Slightly moist, orange to reddish brown, soft, intact silty clay.
1.4	I		Residual highly weathered shale.
1.5	I		
1.6			
1.7			
1.8			
1.9			
2.0			
2.1			
2.2			Slightly moist, orange stained red becoming white grey, soft, laminated silty clay.
2.3			Moderalety to highly weathered shale.
2.4			
2.5			

Notes:
1. Road cutting in shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'42,93" S
WGS84 datum	Y Coord:	30˚03'54,31" E

Soil Profile Nr: I9

Soil Profile Nr: I10

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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	I		
0.2	I		
0.3	I		Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.4	I		
0.5	I		
0.6	I		
0.7	I		
0.8	I		
0.9	I		
1.0	I		Slightly moist, orange to reddish brown, soft, intact silty clay.
1.1	I		Residual highly weathered shale.
1.2	I		
1.3	I		
1.4	I		
1.5	I		
1.6			
1.7			
1.8			
1.9			
2.0			Slightly moist, orange stained red becoming white grey, soft, laminated silty clay.
2.1			Moderalety to highly weathered shale.
2.2			
2.3			
2.4			
2.5			

Notes:
1. Road cutting in shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'44,00" S
WGS84 datum	Y Coord:	30˚03'56,76" E

Soil Profile Nr: I10

Soil Profile Nr: I11

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3			
0.4			
0.5			
0.6			
0.7			Slightly moist, orange to reddish brown, soft, intact silty clay.
0.8			Residual highly weathered shale.
0.9			
1.0			
1.1			
1.2			
1.3			
1.4			
1.5			
1.6			
1.7			Slightly moist, orange stained red becoming white grey, soft, laminated silty clay.
1.8			Moderalety weathered shale.
1.9			
2.0			
2.1			
2.2			

Notes:
1. Road cutting in shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'44,62" S
WGS84 datum	Y Coord:	30˚03'59,27" E

Soil Profile Nr: I11

Soil Profile Nr: I12

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			Slightly moist, orange to reddish brown, soft, intact silty clay.
0.2			Residual highly weathered shale.
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			Slightly moist, kaki orange stained red becoming white grey, soft, laminated silty clay.
1.1			Slightly weathered shale.
1.2			
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			

Notes:
1. Road cutting in shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'45,44" S
WGS84 datum	Y Coord:	30˚04'00,01" E

Soil Profile Nr: I12

Soil Profile Nr: I13

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			Slightly moist, orange to reddish brown, soft, intact silty clay.
0.2			Residual highly weathered shale.
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			Slightly moist, kaki orange stained red becoming white grey, soft, laminated silty clay.
1.1			Slightly weathered shale.
1.2			
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			
2.0			
2.1			

Notes:
1. Road cutting in shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'49,40" S
WGS84 datum	Y Coord:	30˚04'00,08" E

Soil Profile Nr: I13

Soil Profile Nr: I14

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			
0.2			
0.3			Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			
1.1			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.2			Residual highly weathered shale.
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			
2.0			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.1			Moderalety to highly weathered shale.
2.2			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'51,68" S
WGS84 datum	Y Coord:	30˚04'03,19" E

Soil Profile Nr: I14

Soil Profile Nr: I15

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			Slightly moist, dark brown, dense, intact sandy clay. Hillwash.
0.3			
0.4			
0.5			
0.6			Slightly moist, kaki orange to reddish brown, soft, intact silty clay.
0.7			Residual highly weathered shale.
0.8			
0.9			
1.0			
1.1			
1.2			
1.3			
1.4			
1.5			Slightly moist, khaki orange stained red, soft, laminated silty clay.
1.6			Moderalety to highly weathered shale.
1.7			
1.8			
1.9			
2.0			
2.1			
2.2			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'52,77" S
WGS84 datum	Y Coord:	30˚03'58,63" E

Soil Profile Nr: I15

Soil Profile Nr: I16

DATE: 28 June 2019
JOB NR: GS201906I
PROJECT NAME: Ixopo
TOWN: Ixopo
CLIENT: Maxim Planning
TLB Contractor: Fynn Construction
TLB Machine: CAT 428E 4X4
TLB Operator: Simon

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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			Slightly moist, dark brown to grey, dense, intact sandy clay. Hillwash.
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1.0			
1.1			Slightly moist, orange to reddish brown, soft, intact silty clay.
1.2			Residual highly weathered shale.
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			
2.0			Slightly moist, khaki orange stained red, soft, laminated silty clay.
2.1			Moderalety to highly weathered shale.
2.2			

Notes:
1. Near refusal on shale.
2. No groundwater was intersected.
3. No samples.

Lat/long	X Coord:	30˚09'50,12" S
WGS84 datum	Y Coord:	30˚03'56,53" E

Soil Profile Nr: I16

APPENDIX C: LABORATORY RESULTS

Indicator tests

Table A Summary of Laboratory Results

Stats		Depth	Material Description		Classification		% Linear	Plasticity	Liquid	Expan-
6	Nr	m	and Origin	Clay %	Unified	PRA	Shrinkage	Index	Limit	siveness
1	I1	0,3	Sandy silty clay	38	CL	A-7-6	12,5	22	48	M
2	I1	0,8	Sandy silty clay	45	CL	A-7-6	8	17	44	L
3	I4	0,3	Sandy silty clay	34	CL	A-7-6	12,5	23	52	M/H
4	I4	0,8	Sandy silty clay	55	CH	A-7-6	10,5	22	51	M
5	I8	1,4	Sandy silty clay	47	CH	A-7-5	11,5	21	51	M
6	I8	2,0	Sandy clayey silt	36	MH	A-7-5	8	17	50	M
Material possibly expansive if value:				>12%			>8%	>12	>30	Exp?

Table A Legend

Unified

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

2 CH: Inorganic clay of high plasticity, fat clay.

1 MH: Inorganic silt, micaceous or fine sandy or silty soil, elastic silt.

3 CL: Inorganic clay of low to medium plasticity, gravelly, sandy or silty clay, lean clay.

PRA / AASHTO

6 "Public Roads Classification" (Brink, Partridge & Williams).

2 A-7-5: High compressibility silty clay.

4 A-7-6: High compressibility high volume change clay.

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

1 L: Low

1 L/M: Low to medium expansiveness

4 M: Medium

0 H: High

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

6 a clay content greater than 12 percent,

6 a linear shrinkage of more than 8 percent,

6 a plasticity index of more than 12, and

6 a liquid limit of more than 30 percent

0 NP: Not plastic: sandy material with no cohesion

0 SP: Slightly plastic: material with little cohesion

0 ND: not determined

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Client Name: Geoset
Project Name: Ixopo
Job Number: DVM-85
Date: 23-Aug-19
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	I1	I1	I4	I4	I8	I8		
Depth (m)	0.3	0.8	0.3	0.8	1.4	2.0		
Lab No	DVM-85-820	DVM-85-821	DVM-85-822	DVM-85-823	DVM-85-824	DVM-85-825		
53.0	100	100	100	100	100	100		
37.5	100	100	100	100	100	100		
26.5	100	100	100	100	100	100		
19.0	100	100	100	100	100	100		
13.2	100	100	100	100	100	100		
9.5	100	100	100	100	100	100		
6.7	99	100	100	100	100	100		
4.75	99	99	100	100	99	100		
2.00	93	89	99	94	90	98		
1.00	88	84	98	92	85	97		
0.425	86	83	96	90	85	96		
0.250	85	82	95	90	84	96		
0.150	84	81	94	89	83	95		
0.075	83	80	77	88	82	93		
0.060	76	78	70	86	80	90		
0.050	74	76	68	84	79	87		
0.035	70	73	63	82	77	82		
0.020	64	67	57	77	71	74		
0.006	50	57	47	66	58	56		
0.002	38	45	34	55	47	36		
GM	0.38	0.48	0.28	0.28	0.43	0.13		

Atterberg Limits

LL (%)	48	44	52	51	51	50		
PI (%)	22	17	23	22	21	17		
LS (%)	12.5	8.0	12.5	10.5	11.5	8.0		

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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www.stlab.co.za

Client Name: Geoset
Project Name: Ixopo
Job Number: DVM-85
Date: 2019-08-23
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	I1	I1	I4	Sample	I1	I1	I4
Depth (m)	0.3	0.8	0.3	Depth (m)	0.3	0.8	0.3
Lab No	DVM-85-820	DVM-85-821	DVM-85-822	Lab No	DVM-85-820	DVM-85-821	DVM-85-822
53.0	100	100	100	Liquid Limit (%)	48	44	52
37.5	100	100	100	Plastic Limit (%)	26	27	29
26.5	100	100	100	Plasticity Index (%)	22	17	23
19.0	100	100	100	Linear Shrinkage (%)	12.5	8.0	12.5
13.2	100	100	100	PI of whole sample	19	14	22
9.5	100	100	100				
6.7	99	100	100	% Gravel	7	11	1
4.75	99	99	100	% Sand	17	11	29
2.00	93	89	99	% Silt	38	33	36
1.00	88	84	98	% Clay	38	45	34
0.425	86	83	96	Activity	0.6	0.4	0.7
0.250	85	82	95				
0.150	84	81	94	% Soil Mortar	93	89	99
0.075	83	80	77				
0.060	76	78	70	Grading Modulus	0.38	0.48	0.28
0.050	74	76	68	Moisture Content (%)	N / T	N / T	N / T
0.035	70	73	63	Relative Density (SG)*	2.65	2.65	2.65
0.020	64	67	57				
0.006	50	57	47	Unified (ASTM D2487)	CL	CL	CH
0.002	38	45	34	AASHTO (M145-91)	A - 7 - 6	A - 7 - 6	A - 7 - 6

Remarks: *: Assumed
N / T: Not Tested

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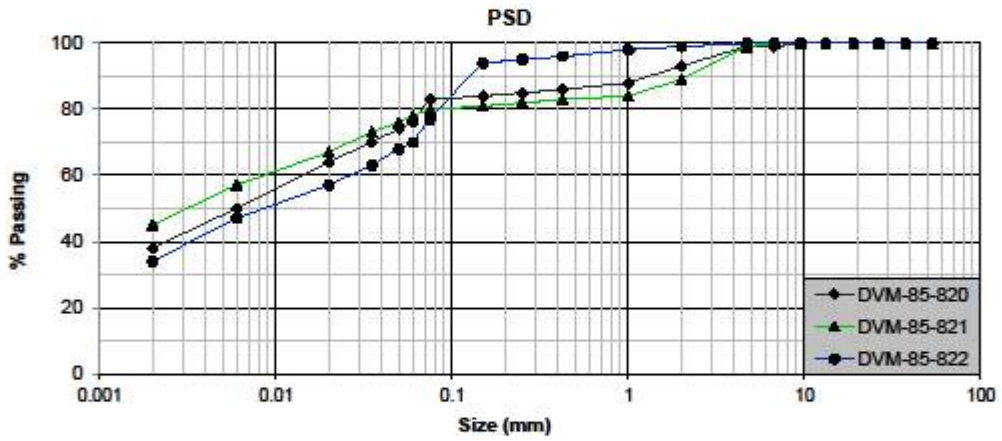
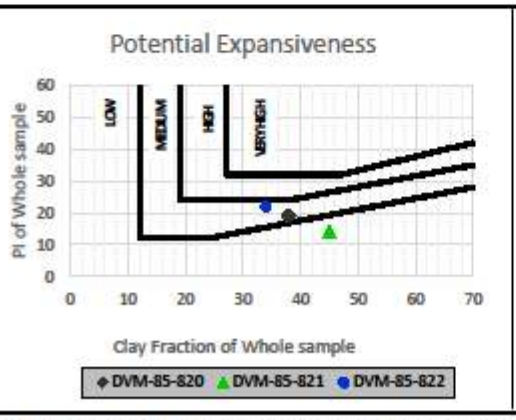
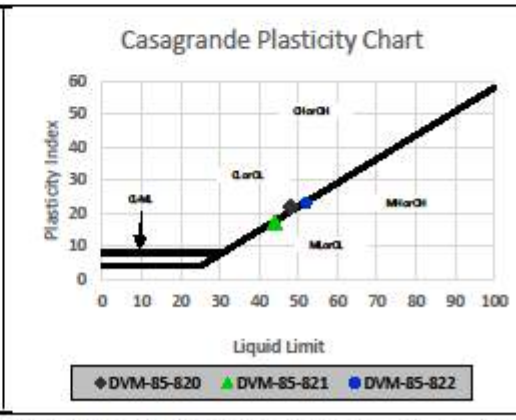
Gerie | 082 309 4448 | gerie@stlab.co.za
www.stlab.co.za

Client Name:	Geoset
Project Name:	Ixopo
Job Number:	DVM-85
Date:	2019-08-23
Method:	SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR







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Client Name: Geoset
Project Name: Ixopo
Job Number: DVM-85
Date: 2019-08-23
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	I4	I8	I8	Sample	I4	I8	I8
Depth (m)	0.8	1.4	2.0	Depth (m)	0.8	1.4	2.0
Lab No	DVM-85-823	DVM-85-824	DVM-85-825	Lab No	DVM-85-823	DVM-85-824	DVM-85-825
53.0	100	100	100	Liquid Limit (%)	51	51	50
37.5	100	100	100	Plastic Limit (%)	29	30	33
26.5	100	100	100	Plasticity Index (%)	22	21	17
19.0	100	100	100	Linear Shrinkage (%)	10.5	11.5	8.0
13.2	100	100	100	PI of whole sample	20	18	16
9.5	100	100	100				
6.7	100	100	100	% Gravel	6	10	2
4.75	100	99	100	% Sand	8	10	8
2.00	94	90	98	% Silt	31	33	54
1.00	92	85	97	% Clay	55	47	36
0.425	90	85	96	Activity	0.4	0.5	0.5
0.250	90	84	96				
0.150	89	83	95	% Soil Mortar	94	90	98
0.075	88	82	93				
0.060	86	80	90	Grading Modulus	0.28	0.43	0.13
0.050	84	79	87	Moisture Content (%)	N / T	N / T	N / T
0.035	82	77	82	Relative Density (SG)*	2.65	2.65	2.65
0.020	77	71	74				
0.006	66	58	56	Unified (ASTM D2487)	CH	CH	MH
0.002	55	47	36	AASHTO (M145-91)	A - 7 - 6	A - 7 - 5	A - 7 - 5

Remarks: *: Assumed
N / T: Not Tested

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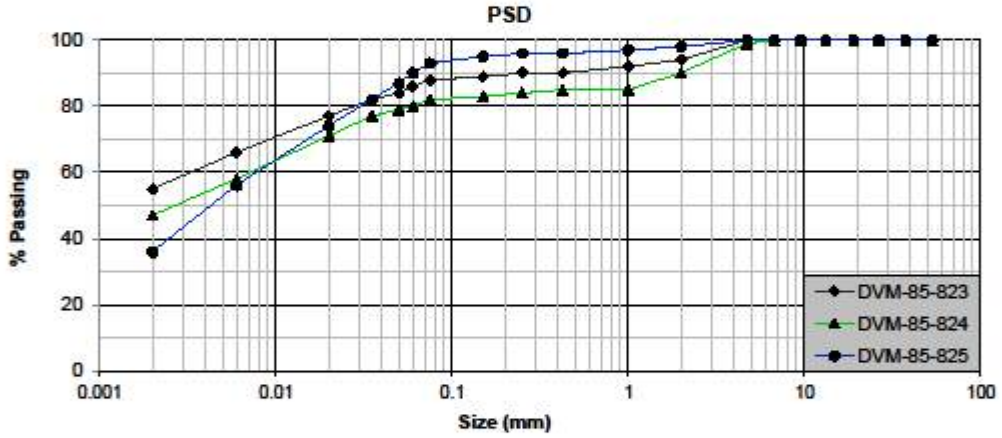
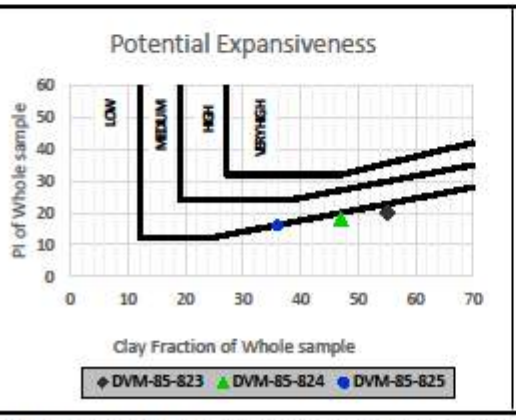
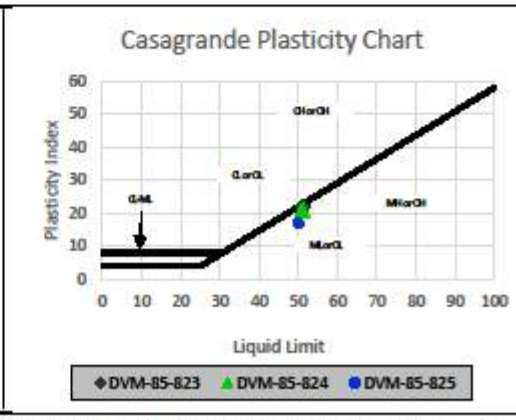
Client Name:	Geoset
Project Name:	Ixopo
Job Number:	DVM-85
Date:	2019-08-23
Method:	SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR







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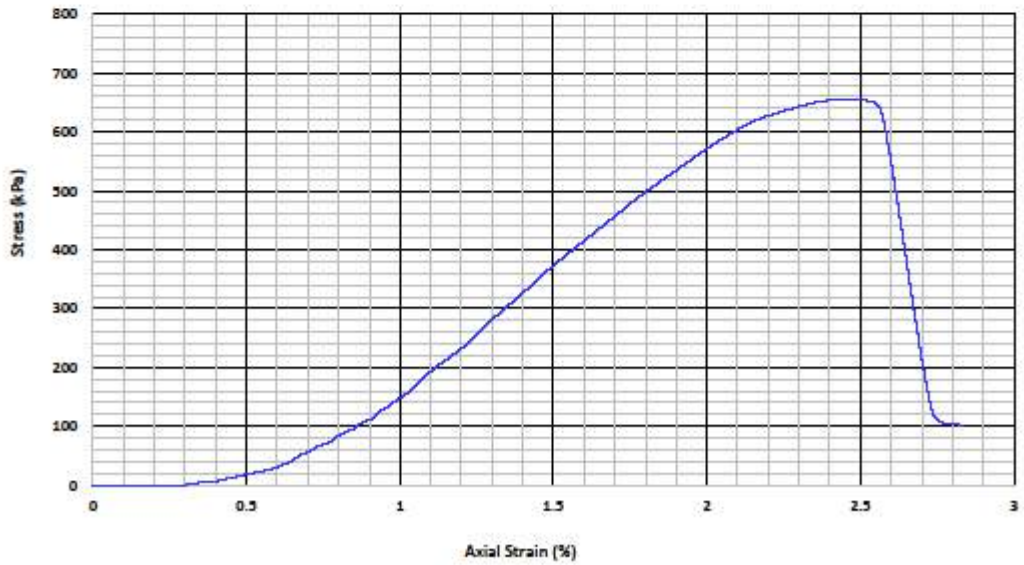
Client Name:	**Geoset**	**Job Number:**	**DVM-85**
Project Name:	**Ixopo**	**Lab Number:**	**DVM-85-821**
Sample:	**I1**	**Date:**	**23/08/2019**
Depth: (m)	**0.8**	**Method:**	**ASTM D2166**

UNCONFINED COMPRESSIVE STRENGTH OF REMOULDED SOIL SAMPLE

Initial Specimen Details		
Diameter	mm	50.0
Length	mm	100.7
Volume	cm^3	197.7
Length-to-Diameter ratio	-	2.01
Moisture Content	%	24.3
Dry Density	g/cm^3	1.566
Void Ratio	-	0.770
Degree of Saturation	%	87.4
Particle Density (SG)	-	2.771 - Determined

Test Parameters		
Rate of Strain	%/min	0.83
Axial Strain at max. σ_c	%	2.48
q_u	kPa	654



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Client Name:	**Geoset**	**Job Number:**	**DVM-85**
Project Name:	**Ixopo**	**Lab Number:**	**DVM-85-825**
Sample:	**IB**	**Date:**	**23/08/2019**
Depth: (m)	**2.0**	**Method:**	**BS 1377 Part 8**

CONSOLIDATED UNDRAINED TRIAXIAL TEST

General Test Data	
Type of Test:	Saturated, Consolidated Undrained with Pore Water Pressure Measurements
Type of Sample:	Undisturbed
Side Drains:	Yes
Drainage:	To One End
Comments:	-

Initial Specimen Details				
		Specimen 1	Specimen 2	Specimen 3
Diameter	mm	50.0	50.0	50.0
Length	mm	100.0	100.0	100.0
Volume	cm^3	196.3	196.3	196.3
Moisture Content	%	35.5	33.7	34.1
Dry Density	g/cm^3	1.324	1.354	1.358
Void Ratio	-	1.093	1.047	1.041
Degree of Saturation	%	89.9	89.2	90.9
Particle Density (SG)	-		2.771	

End of Saturation Phase				
Method:		Increments of Cell- and Backpressure		
		Specimen 1	Specimen 2	Specimen 3
Cell Pressure	kPa	250	300	250
Back Pressure	kPa	240	290	240
B Value	-	0.96	0.98	0.96

Consolidation Phase				
		Specimen 1	Specimen 2	Specimen 3
Cell Pressure	kPa	290	390	440
Back Pressure	kPa	240	290	240
Pore Pressure (Initial)	kPa	276.8	380.3	425.0
Pore Pressure (Final)	kPa	238.2	289.2	241.2
Volumetric Strain	%	1.3	2.3	4.1
Effective Stress *	kPa	49.0	96.2	197.6

*: At commencement of Shear

End of Shear Phase				
Failure Criterion:		Maximum Deviator Stress		
Rate of Strain		1.0 %/hour		
		Specimen 1	Specimen 2	Specimen 3
Corrected Deviator Stress	kPa	167.4	214.6	316.5
at Axial Strain	%	15.0	4.3	14.1
Principal Stresses $\sigma 1'$	kPa	233	283	443
Principal Stresses $\sigma 3'$	kPa	66	69	126

Final Specimen Details				
Moisture Content	%	41.1	36.8	36.2
Dry Density	g/cm^3	1.341	1.386	1.415
Void Ratio	-	1.067	0.999	0.958

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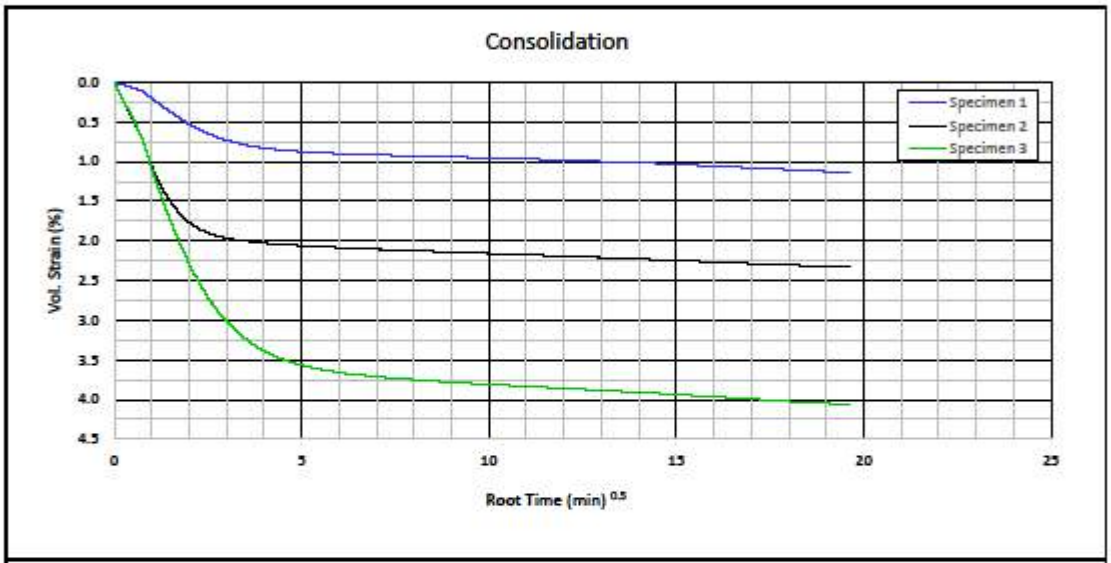
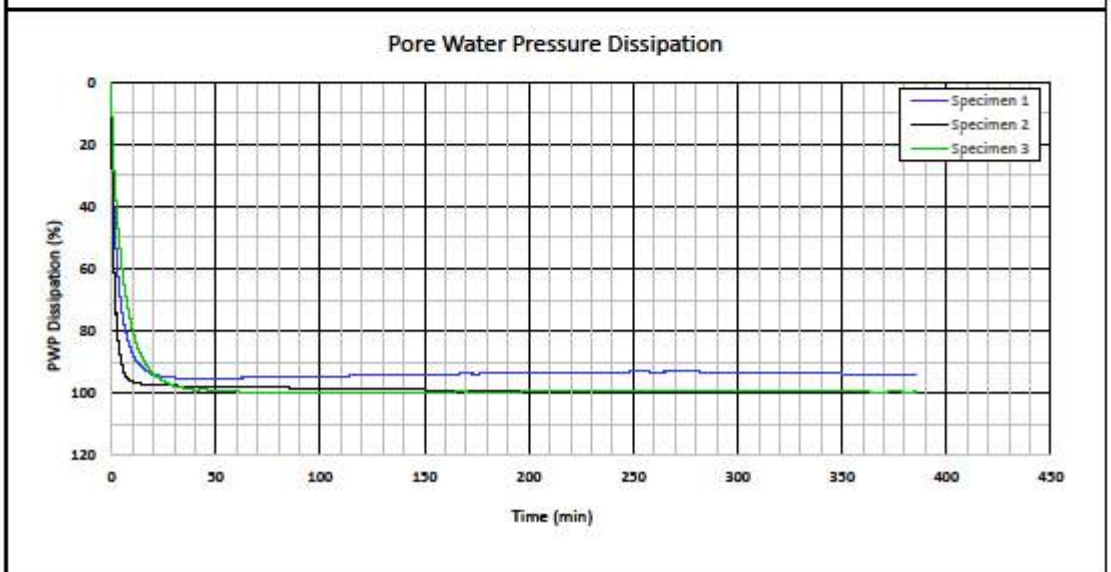
Client Name:	**Geoset**	**Job Number:**	**DVM-85**
Project Name:	**Ixopo**	**Lab Number:**	**DVM-85-825**
Sample:	**I8**	**Date:**	**23/08/2019**
Depth: (m)	**2.0**	**Method:**	**BS 1377 Part 8**

CONSOLIDATED UNDRAINED TRIAXIAL TEST





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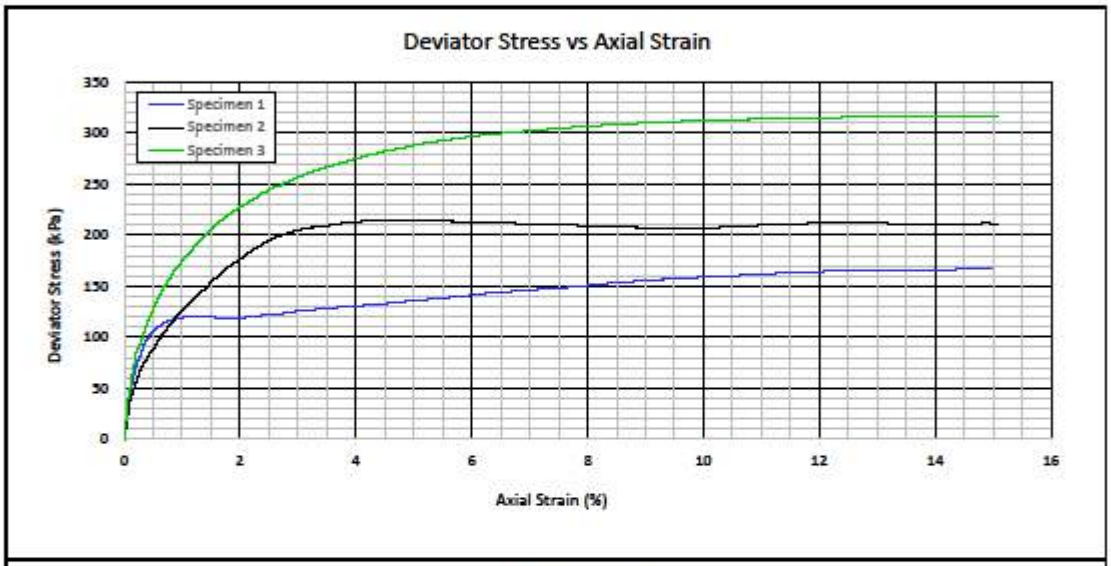
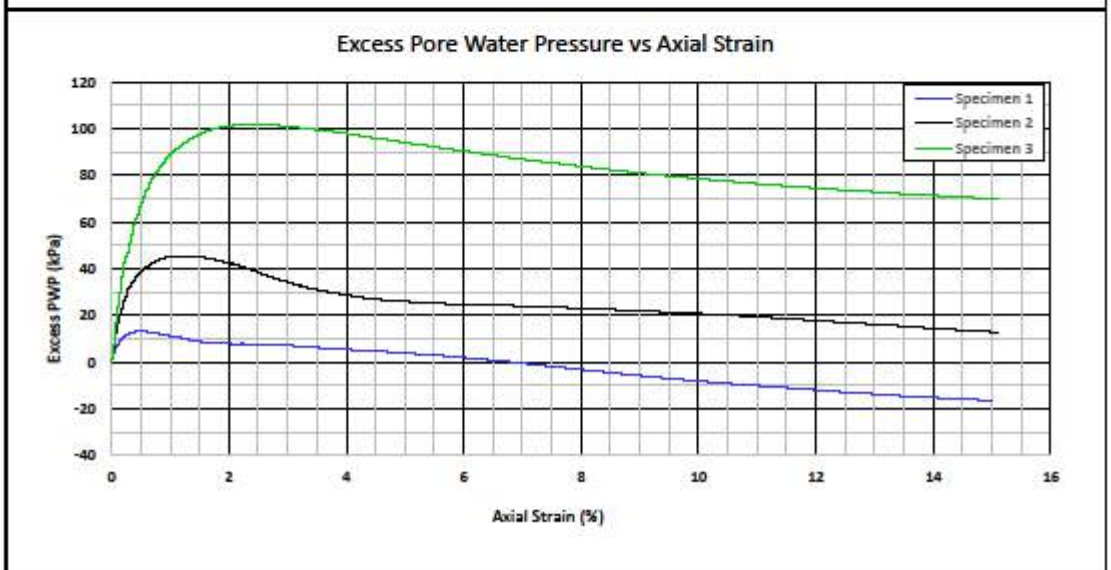
Client Name:	**Geoset**	**Job Number:**	**DVM-85**
Project Name:	**Ixopo**	**Lab Number:**	**DVM-85-825**
Sample:	**I8**	**Date:**	**23/08/2019**
Depth: (m)	**2.0**	**Method:**	**BS 1377 Part 8**

CONSOLIDATED UNDRAINED TRIAXIAL TEST





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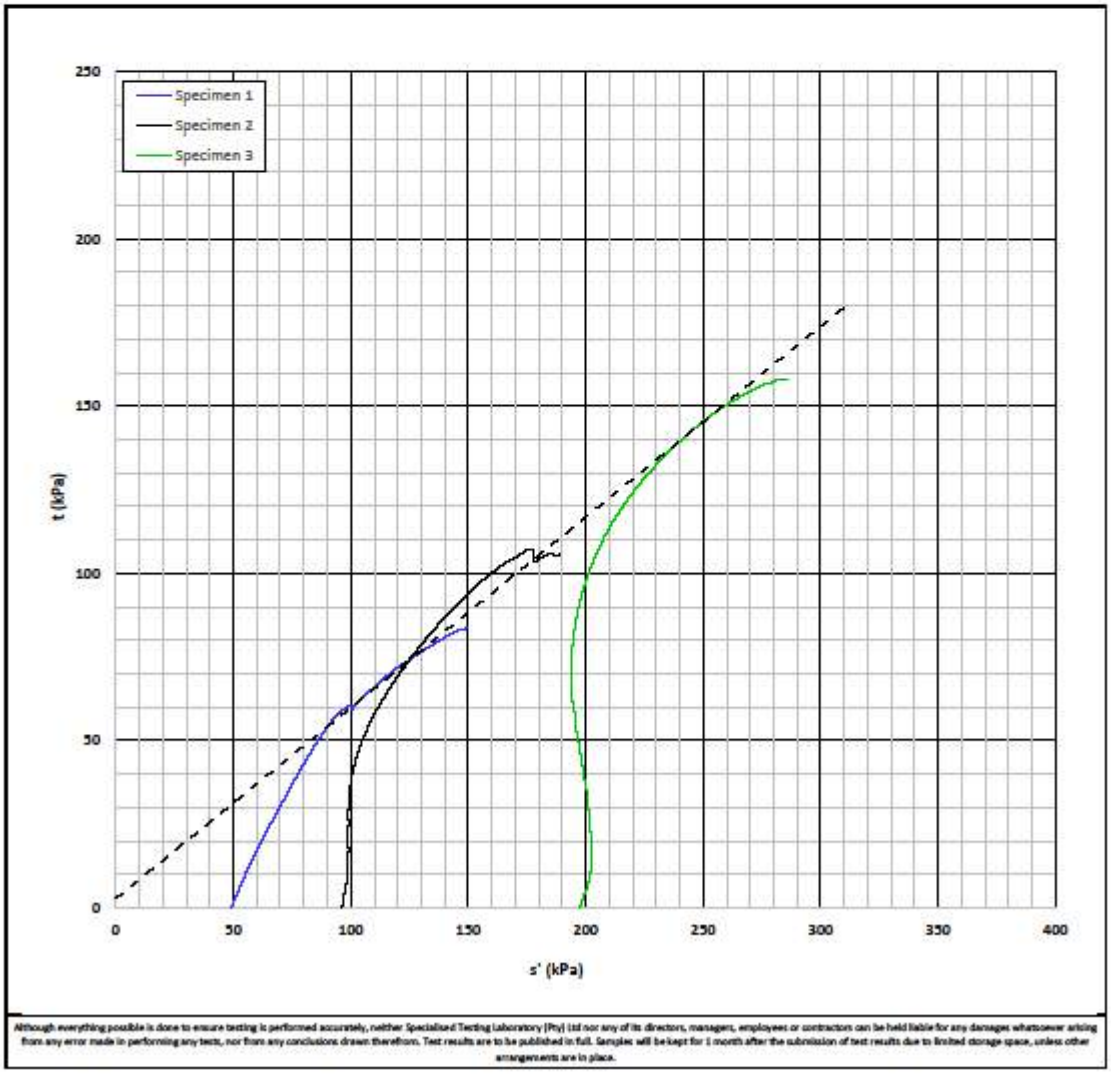
Client Name:	**Geoset**	**Job Number:**	**DVM-85**
Project Name:	**Ixopo**	**Lab Number:**	**DVM-85-825**
Sample:	**I8**	**Date:**	**23/08/2019**
Depth: (m)	**2.0**	**Method:**	**BS 1377 Part 8**

CONSOLIDATED UNDRAINED TRIAXIAL TEST

ϕ'	**Deg.**	**35**
c'	**kPa**	**3**



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/s^2 within 50 years.	Mining-induced seismic activity more 100 cm/s^2.	Natural seismic activity more than 100 cm/s^2.
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.