ABSA DEVCO

REPORT ON THE GEOTECHNICAL INVESTIGATION FOR TOWNSHIP ESTABLISHMENT OF ZAMBEZI COUNTRY ESTATE IN PRETORIA

REPORT 50858/G1 SEPTEMBER 2002

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Report title	Report on the geotechnical investigation for township establishment of Zambezi Country Estate in Pretoria. (Montana Tuine Extension 34, 36 and 38)
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	Collapsible / Compressible soil	Expansive soil

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Location	Pretoria, RSA	
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ABSTRACT

A geotechnical site investigation was conducted in August 2002 for township establishment of Zambezi Country Estate

The investigation comprised profiling 12 test pits excavated with a backhoe and the sampling of selected soil horizons for laboratory testing. In addition, the soil profile descriptions (40 in number) from a previous investigation were interpreted and evaluated.

The soil profile comprised combinations of hillwash, alluvium, aeolian deposits, reworked residual norite as well as residual norite. Ground water seepage was not encountered in any test pits excavated at the site. Due to the presence of ferruginised layers in the soil profile, seepage can be expected in excavations at a few isolated locations during the rainy season. Machine excavatability of in situ materials for services is generally not considered problematic.

The site is zoned into four zones, which can be summarised as follows:

Zone C1: Zone characterised by collapsible/compressible soil profile with total expected movements between 5 mm and 10 mm. Development can take place provided appropriate precautions against differential settlement are implemented.

Zone H1: Zone characterised by expansive soil profile with total expected movements between 7,5 mm and 15 mm. Development can take place provided appropriate precautions against differential movement are implemented.

Zone H3: Zone characterised by expansive soil profile with expected total differential movements of >30 mm. Development can take place provided appropriate precautions against differential and total movement are implemented.

Zone P(Flooding) Zone characterised by alluvial channels and natural drainage features, seasonal or intermittent. These areas are subject to flooding and no development is permissible except for roads and bridges.

Recommendations regarding proposed development include the following:

- Founding alternatives are provided for each zone;
- Drainage precautions must be implemented; and
- Corrosiveness of the soils at the site must be investigated.

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1 INTRODUCTION

Africon was appointed by ABSA Devco to conduct a geotechnical investigation for township establishment purposes for the proposed Zambezi Country Estate development in Pretoria. The main purpose of this investigation is to classify the area in terms of the requirements of the National Home Builders Registration Council (NHBRC) and the Council for Geosciences.

The objectives of this report are to:

- Describe the investigation procedure;
- Provide an overview of the geology of the site;
- Discuss the soil profile encountered;
- Identify problematic geotechnical considerations;
- Provide a geotechnical zoning of the site.

2 AVAILABLE INFORMATION

At the time of the investigation the following information was available:

- The 1 : 50 000 scale geological map of the area (Pretoria 2528 CA).
- A 1 : 5000 scale site layout plan, showing the boundaries of the site.
- A geotechnical investigation report by Africon titled Geotechnical investigation of the remainder of Portion 44 Hartbeesfontein 324-JR - Report 50234/G1/1995, compiled in May 1995.

3 SITE LOCATION AND DESCRIPTION

The site is located on the remainder of Portion 44 Hartebeesfontein 324-JR, as indicated on the site layout plan (Drawing 50858.01/LP1).

At the time of the investigation a portion of the site was used as a centre for radio communications. A double-storey office building with associated outbuildings is located near the centre of the site and a set of buildings in the south east serve as the Telkom Laboratories. A large number of foundations for radio masts are still scattered throughout the area. In addition, large numbers of cables, no longer functional, run from the old mast positions to the central offices. The site is otherwise generally undisturbed and groundcover consists of acacia thorn trees and veld grass. A small stream and associated tributaries drain the area in a northerly direction. A dam, probably a disused quarry or borrow pit, is located in the south western corner of the area to the north of the Lapa Munnik Retirement Village. A similar, although smaller, dam is located near the south-eastern corner.

4 SITE INVESTIGATIONS

4.1 PREVIOUS INVESTIGATION

The investigation commenced with a desk study of available information, which included the 1:50 000 geological map of the area, the description of the engineering geology of the underlying geological formations and various reports on investigations carried out in the surrounding areas. An air photo interpretation was carried out using air photos at a scale of 1:10 000 with the aim of identifying the boundaries of potential geotechnical zones.

The zones identified in the air photo study were explored in the field by means of 40 test pits, which were excavated with a backhoe. Three of the test pits (TP1, TP2 and TP3) were excavated for the proposed Montana Gardens Extension 3 township which is located in the south eastern corner of the area. The pits are nevertheless included in this report as the results add to the analysis of the site under consideration. All the test pits were logged by an engineering geologist using the methods proposed by Jennings et al (Ref 1). A summary of the standard soil and rock profiling descriptions are included in Appendix A of this report. The locations of the pits are shown on the site layout plan, Drawing 50858.01/SLP1. The detailed soil profile descriptions are attached in Appendix B of this report.

A number of samples, representative of the various strata encountered in the field investigation, were retrieved from the test pits and submitted to a laboratory for testing.

4.2 CURRENT INVESTIGATION

An additional investigation was conducted on 14 August 2002 and comprised excavation of twelve (12) test pits (numbered TP41 to TP52) with a backhoe. The positions of the test pits are also indicated on the site layout plan, Drawing 50858.01/SPL1.

The test pits were profiled according to the standard methodology proposed by Jennings, Brink and Williams (Ref 1). All test pits were backfilled after completion of the soil profiling and sampling.

The following table gives a summary of test hole information gained during the current investigation:

Table 1 : Test hole summary

Hole no	Depth to residuum (m)	Total depth (m)	Remarks
TP41	1,8	2,5	No refusal – hole stopped due to slow progress
TP42	1,5	2,5	No refusal – hole stopped due to slow progress
TP43	0,7	1,7	No refusal – hole stopped due to slow progress
TP44	0,7	1,1	Refusal on medium hard rock gabbro-norite
TP45	1,1	2	No refusal – hole stopped due to slow progress
TP46	1,3	2,2	No refusal – hole stopped due to slow progress
TP47	0,6	1,2	Near refusal on very dense residual gabbro-norite
TP48	1	1,6	No refusal – hole stopped due to slow progress
TP49	0,4	0,8	Near refusal in very dense residual gabbro-norite.
TP50	1,5	1,9	Near refusal in very dense residual gabbro-norite.
TP51	0,6	1,8	No refusal – hole stopped due to slow progress
TP52	0,3	2,4	Refusal on medium hard rock gabbro-norite

To confirm the visual assessments of the engineering properties of the soil, a number of representative soil samples were taken and submitted for laboratory testing.

The data gained by the aforementioned activities is presented in this report as follows:

- Summary of standard soil and rock profile descriptions - Appendix A
- Soil profile descriptions from the previous investigation - Appendix B
- Soil profile descriptions from the current investigation - Appendix C
- Laboratory test results - Appendix D

5 GEOLOGY

According to the 1 : 50 000 scale geological map of Pretoria the site is underlain rocks of the Bushveld Complex. These consist of norite, quartz norite, quartz gabbro and pyroxenic norite in the southern portion of the site and hybrid rocks, similar in composition to norites, in the northern portion. A diabase dyke has intruded at the contact of the two rock types. All three rock types are treated as one unit for the purpose of this report as the weathering products and associated engineering properties are essentially the same.

6 SOIL PROFILE

The following generalised horizons were encountered on the site:

6.1 TRANSPORTED SOILS

Three different types of transported soils were encountered during the investigation and are largely responsible for defining the different geotechnical zones. The individual transported soil types are discussed below.

6.1.1 Hillwash

In the southern area, and along the eastern and western boundaries a hillwash horizon was encountered. This horizon is generally red or brown in colour and was usually profiled as a clayey sand. The consistency varied from loose to firm. In several instances the soil was profiled as having a shattered and slickensided structure which is indicative of the presence of active clays. This structure was especially noted in the area to the north of the Derdepoort Park Garden City township on the western side of the site. The horizon is 0,5 m thick on average and ranges in thickness from 0,2 m to 1,1 m.

6.1.2 Aeolian deposits

Two areas dominated by deep aeolian sands occur in the north eastern and north western corners of the site. The aeolian soil consists of a loose to medium dense clayey fine sand which is reddish brown in colour. The sand is considered to have a collapsible grain structure and the difference in consistency between moist and slightly moist was very noticeable in some cases. See the profile from TP36 for such an example. The aeolian sand is on average 1,4 m thick and ranges in thickness from 0,8 m to 1,8 m.

6.1.3 Alluvium

A large body of alluvial clay occurs stretching from north to south down the centre of the site. The clay is dark greyish brown or black in colour and has a micro shattered and slickensided structure which is indicative of the presence of expansive clays. The horizon varies in thickness from 0,8 to 1,6 m and is on average 1,1 m thick.

6.2 PEDOGENIC HORIZON

A poorly developed pedogenic horizon occurs sporadically across the site. A nodular and in one or two cases a hardpan ferricrete horizon has generally developed at the base of the aeolian sands mentioned above. In the more clayey horizons the ferricrete is generally absent or only present as scattered nodules. Powder or nodular calcrete was often noted at the base of the alluvial clay horizon.

6.3 RESIDUAL SOILS

The residual soils are derived from the weathering of basic igneous rocks, i.e. norite, diabase and hybrid rocks similar to norite. In general, in this area, basic igneous rocks weather to form clayey soils. The type of clay dominating the profile depends to some extent on the topography, drainage, thickness and type of transported soil occurring in the area. In the higher lying, better drained areas the residual profile is usually red or yellow in colour and the dominant clay type is kaolin which is the least active of the clay family. In more poorly drained, lower lying areas the dominant clay mineral type is montmorillonite which is the most active of the clay mineral family.

The residual profile can generally be divided into two distinct zones. The lower residual soil is distinguished by the presence of structural features inherited from the parent rock such as joint patterns and mineral boundaries. The lower residual soil horizon is generally a clayey or sandy silt which grades with depth into a sand or gravel and then into weathered rock. The upper or reworked horizon is devoid of these structures and is more clayey. The reworked horizon is often expansive although the activity of the horizon will be determined by the dominant clay type which in turn is dependant on the factors discussed in the paragraph above.

In the higher lying, better drained areas, the reworked residual horizon is generally reddish brown or yellowish brown in colour with the structure varying from intact to shattered and slickensided. In the lower lying areas the reworked horizon is very similar to the alluvial clay in appearance, being both dark grey in colour and having a micro-shattered and slickensided structure. In the western half of the site, the reworked horizon is expected to contain predominantly active clays as in the alluvial areas. The thickness of the reworked residual soil horizon varies from 0,9 m to 1,2 m and is on average 1 m thick.

In all areas of the site the lower lying residual soil profile is generally yellow in colour, and as noted earlier, is a silt which grades into rock with depth. The structure of the lower residual soil horizon indicates that it is generally fairly inactive and is not likely to be more than moderately expansive. The consistency of the residual soil horizon is generally stiff or better. Very little outcrop occurs in the area under consideration. A small, but prominent area of outcrop was noted on the western boundary as indicated on the site plan. Smaller areas of outcrop were also noted. The survey plan has some areas shown as outcrop near the eastern boundary. These could not be found in the field. This area is underlain by diabase and it is likely that sporadic boulder outcrop will occur.

7 GROUND WATER

No ground water was encountered during the field investigation. It is expected that a shallow water table will exist in the alluvial clay areas close to the streams, especially during wet seasons.

8 LABORATORY TEST RESULTS

8.1 INDICATOR TESTS

Representative samples of the various soil horizons were taken and submitted for foundation indicator tests. The results of these tests can be summarised as follows:

Table 2: Indicator test results

Hole no	Depth (m)	Material type	Soil composition				GM	Atterberg limits			Activity
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	PI (%)	LS (%)	
TP3	0,8	Reworked residual norite	32	33	33	2	0,52	42	17	9	Medium
TP6	0,5	Reworked residual norite	45	34	21	0	0,32	64	39	16	Very high
TP7	0,5	Hillwash	30	18	52	0	0,63	28	12	6	Low to medium
TP10	1,0	Reworked residual norite	27	27	35	1	0,46	49	21	11	Medium
TP14	0,5	Reworked residual norite	17	21	28	34	1,49	51	14	11	Medium
TP27	0,5	Reworked residual norite	45	18	35	2	0,46	57	35	15	Very High
TP30	0,5	Hillwash	7	59	27	7	0,57	42	17	10	Low to medium
TP38	1,2	Aeolian deposits	7	40	50	3	0,62	26	9	5	Low
TP41	1,0	Alluvium	22	23	55	0	0,69	51	17	9	Medium
TP44	0,6	Alluvium	25	32	37	7	0.65	62	22	13	Medium
TP48	1,1	Reworked residual norite	30	37	32	1	0,31	54	24	13	High
TP50	1,0	Alluvium	35	39	25	1	0,24	101	48	18	Very high

Legend
GM = Grading modulus
LL = Liquid Limit
PI = Weighted Plasticity Index
LS = Linear Shrinkage
Activity = Activity of the soil according to Van der Merwe's method

Table 2 indicates that:

- The **reworked residual norite** generally has moderate to high grading moduli varying between 0,69 and 1,49. The liquid limits of this material are high and vary between 49 % and 64 %. The weighted plasticity indices (PI) are moderate to very high (14 % to 39 %) with corresponding moderate to high linear shrinkage values of between 9 % and 16%. In conjunction with the high clay content of this material the soil is considered to be moderately to highly expansive.

- The **hillwash** has moderate grading moduli varying between 0,57 and 0,63. The liquid limits of this material are moderate and vary between from 28 % and 42 %. The weighted plasticity indices are very moderate (12% to 17%) with corresponding moderate linear shrinkage values of between 6% and 10%. In conjunction with the low to high clay content of this material the soil is expected to display a low to moderate potential expansiveness.

- The **alluvium** has low to moderate grading moduli varying between 0,24 and 0,69. The liquid limits of this material are high to very high and vary between 51 % to 101%. The weighted plasticity indices are moderate to very high (17 to 48%) with moderate linear shrinkage values of between 9 % and 18%. In conjunction with the high clay content of this material the soil is considered to be moderately to highly expansive.

- The sample of the **aeolian deposits** has a moderate grading modulus of 0,62 and a moderate liquid limit of 26 %. The weighted plasticity index of the material is low (9 %) with a corresponding low linear shrinkage value of 5%. In conjunction with the low clay content of this material the soil is considered to be non-expansive.

8.2 COLLAPSE POTENTIAL TESTS

A collapsible fabric may occur in any open textured silty or sandy soil that has a high void ratio (low dry density) and yet has a relatively high shear strength at a low moisture content due to colloidal or other coatings around the individual grains. In the South African context this is common in many transported soils and also in areas where quartz rich rocks such as granite or feldspathic sandstone have undergone chemical weathering to produce intensely leached residual soils.

The hillwash and aeolian sand was generally found to be of loose consistency. Undisturbed samples of these materials were taken and subjected to standard collapse potential tests (i.e. soaked at 200 kPa). The test results are summarised as follows.

Table 3: Collapse potential tests

Hole no	Depth (m)	Material type	DD (kg/m^3)	MC (%)	CP (%)
TP7	0,5	Hillwash	1580	17,45	0,87
TP38	1,2	Aeolian sand	1283	11,96	14,6

Legend DD = In situ dry density
MC = In situ moisture content
CP = Collapse potential (soaked at 200 kPa)

A density of 1 600 kg/m^3 is regarded as a guideline density below which collapse settlement can be expected. Furthermore, Jennings and Knight (Ref 3) suggested the following guideline values of collapse potential:

Table 4: Guideline values for collapse potential

Collapse Potential	Severity of the problem
0 % - 1 %	No problem
1 % - 5 %	Moderate trouble
5 % - 10 %	Trouble
10 % - 20 %	Severe trouble
> 20 %	Very severe trouble

It must be emphasised that the **Collapse Potential is not a design parameter but is an index figure providing a guideline to the collapse situation** and whether there is justification for further investigation or specific founding measures. Under certain conditions a low Collapse Potential index does not necessarily mean that the soil is not compressible.

From the results in Table 3 and the guidelines for interpretation of the results it is evident that:

- The collapse potential of the red hillwash overlying the norites has proved to be in the "No problem" category of the Jennings Knight classification system. This low figure should, however, be approached with some caution, especially where the hillwash meets the aeolian sands as the boundary between these two units is gradational and not easily distinguished.
- The aeolian sand in the north eastern and north western corner of the site have a very high collapse potential. Using the classification system proposed by Jennings and Knight(4) a collapse potential of 14,6% for the aeolian sands places this horizon into the severely troublesome category. In addition the indicator and grading tests show that the aeolian sands have a low potential expansiveness.

It must be borne in mind that the potential settlements resulting from a collapsible soil stratum is a function of the collapse potential, the magnitude of compression prior to collapse, as well as the thickness of the compressible/collapsible layer below founding level of the structures.

8.3 LUMP TESTS

The lump test involves determination of dry density and the corresponding moisture content of samples that have been allowed to dry out or wet up for different periods of time. The 'volume characteristic' (relationship between the dry density and the moisture content) of the soil can be determined from the test results. This can then be used to calculate the potential one and three dimensional swell of the soil.

Before the volumetric change of the soil can be determined a choice of the initial and final moisture content must be made. These should correspond to the limiting values of moisture content likely to occur in situ for the particular soil. The test results can be summarised as follows:

Table 5: Lump test results

Hole no	Depth (m)	Material type	Moisture Content (%)		Expected swell (%)	
			Estimated Initial	Estimated Final	One dimensional	Three dimensional
TP 41	1	Alluvium	10	25	18	6
TP 44	0,6	Alluvium	10	25	19	6
TP 48	1,1	Reworked residual norite	10	25	17	5
TP 50	1	Alluvium	10	25	14	5

The test results in Table 5 indicate that the alluvium and the reworked residual norite encountered at the site is highly expansive.

8.4 CORROSIVENESS TESTS

Three disturbed samples were subjected to tests with the aim of establishing the conductivity and acidity of the materials. These tests give an indication of the corrosiveness of the soils to buried metals

The corrosiveness of soil towards buried metals depends on a number of factors. These are basically as follows:

- The soil's electrical conductivity,
- The heterogeneity of the soil,
- The ability of the soil to support sulphate-reducing bacteria and
- Chemical properties of the soil.

The tests carried out to assess the corrosiveness of the soils to steel are indicator tests and give an idea of whether the soil is likely to be a problem or not. Table 6.1.2 below provides a guide to interpreting the conductivity test results listed in Table 6.1.1.

Table 6: Relationship soil conductivity and corrosiveness of soils (Ref. 6)

Conductivity (mS/cm)	Corrosiveness
greater than 0,5	Very corrosive
0,5 to 0,2	Corrosive
0,2 to 0,1	Mildly corrosive
less than 0,1	Generally not corrosive

Using the above as a guide it can be seen that the black clays should be considered to be very corrosive to steel, the red or yellow reworked clays should be considered corrosive and the red aeolian sands to be not corrosive. The low conductivity results may, however, be as a result of the presence of soluble salts and further testing may be required to confirm the presence of the type of salt.

Particular attention should be paid to the presence of soluble chlorides and sulphates as these two are particularly aggressive to metals. Where metal pipes pass from one soil type to another, particularly from clayey soils to sandy soils, electrochemical cells are set up due to the different rates of oxygen diffusion of the soils. There are a number of such boundaries on this site.

Sulphate reducing bacteria usually prosper under anaerobic conditions, typically waterlogged clays. The alluvial clays are likely to meet this condition in areas close to drainage channels. These areas are generally restricted to the areas between the flood lines and this mechanism for corrosion of metals is thus not likely to be applicable to this site except where services cross the stream channels.

Full chemical testing for the presence of sulphates and chlorides has not been carried out. However, the pH of the soil gives an indication of potential problems related to acidity. Where soils have a pH of less than 6,0 they should be considered a corrosion problem and where the pH is lower than 4,5 this becomes more serious. The pH indicator tests show that the aeolian sands and red reworked residual norite should be considered problematic while the alluvial clays may be considered non-corrosive. The two tests are to some extent contradictory and it is advisable that further testing be carried out before measures to be adopted against corrosion are decided upon.

9 GEOTECHNICAL CONSIDERATIONS

The purpose of the investigation is to provide a broad overview and classification of the suitability of the land for the proposed development and outline obvious constraints to the development of the area. The following constraints, as proposed by Partridge, Wood and Brink (Ref 8), have to be considered for the evaluation of the sites for urban development (see Appendix D for a summary of the constraints):

- Collapsible / compressible soil profile;
- Shallow seepage or groundwater level;
- Expansive soil profile;
- Erodibility of the soil profile;
- Excavatibility;
- Undermined ground;
- Instability of areas of soluble rock;
- Steep slopes;
- Unstable natural slopes;
- Seismic activity; and
- Areas subject to flooding

Each of the above-mentioned constraints and its applicability to this specific site are discussed in the sections that follow.

9.1 COLLAPSIBLE / COMPRESSIBLE SOIL PROFILE

The north-east corner of the site (indicated as **Zone C1** on the site layout plan) is characterised by the presence of collapsible sands considered to be of aeolian origin. A collapsible grain structure essentially consists of an open voided structure where clay bridges span the gaps between sand particles. The soil appears to be competent when dry but when saturated loses its apparent strength. This frequently results in sudden and dramatic settlement occurring with consequent damage to the structure.

9.2 SHALLOW SEEPAGE OR GROUND WATER LEVEL

Ground water seepage was not encountered in any of the test holes. The presence of ferruginisation in some of the test pits indicate that shallow perched water tables can be expected from time to time in the rainy season. Seepage into excavations in some areas can therefore be expected in the rainy season.

9.3 EXPANSIVE SOIL PROFILE

Almost the entire site is characterised by the presence of expansive material which overlie the residual norite. Signs of potential expansive soil horizons, such as micro-shattering and

slickensided structure, were observed in the soil profile. The presence of the expansive soil profile was confirmend by the laboratory test results.

The south-eastern half of the site is characterised by the presence of silty clay or clayey sands and silts which overlie residual norite. Using Van der Merwe's method of predicting heave (Ref. 5) it is calculated that total heave of between 7,5 mm and 15 mm can be expected in the area indicated as **Zone H1** on the site layout drawing.

The largest portion of the site (indicated as **Zone H3** on the site layout drawing) is underlain by black clays that comprise either transported materials (alluvium) or reworked residual norite. Both these materials are on average 1 m thick and there is very little difference in appearance or their engineering properties. Observations in the field and the laboratory test results indicate that these materials are highly expansive and that heave in excess of 30 mm can be expected.

9.4 EXCAVATIBILITY

Excavations to depths of 1,5m should generally be feasible at the site, although shallow rock may occur in small areas at the site. Precautions against collapse of side walls may have to be taken in excavations deeper than 1,5m.

9.5 UNDERMINED GROUND

No indication of the presence of undermined areas was found during the desk study or field investigation.

9.6 INSTABILITY OF AREAS OF SOLUBLE ROCK

No indication of the presence of soluble rock formations was found during the desk study or field investigation.

9.7 STEEP SLOPES

The site has a gentle slope to the north and areas with steep slopes are not present at the site.

9.8 UNSTABLE NATURAL SLOPES

No indication of the presence of unstable natural slopes was found during the desk study or the field investigation.

9.9 SEISMIC ACTIVITY

According to Fernandez and Guzman (Ref 6), the area investigated is classified as having a seismic intensity of between V and VI on the modified Mercalli scale (MMS) with a 90% probability of not being exceeded during a 100 year recurrence period.

An earthquake with an intensity of V on the MMS is described as having the following characteristics:

- It can be felt outdoors and its direction estimated;
- Sleepers are awakened;
- Liquids are disturbed and some are spilled;
- Small unstable objects are displaced or upset;
- Doors swing, close or open;
- Shutters and pictures move; and
- Pendulum clocks stop, start or change rate.

An earthquake of VI on the MMS is described as follows:

- All people, in- and outdoors feel it;
- Windows, dishes and glassware are broken;
- Pictures and books fall of walls and shelves;
- Furniture is moved and overturned; and
- Weak plaster and poorly constructed masonry structures crack.

The expected peak ground acceleration values associated with these magnitudes of earthquake are:

- Horizontal acceleration: 32 to 56 cm/s^2
- Vertical acceleration: 9 to 18 cm/s^2

The peak ground acceleration values indicate low intensity of seismic activity. No special seismic design measures are therefore required.

9.10 AREAS SUBJECT TO FLOODING

The 1:50 year floodline has been determined prior to the layout planning. It is therefore unlikely that any development that has occurred within the previously demarcated areas will be subject to flooding except possibly during abnormal rainfall events that result in stream levels appreciably higher than the 1 : 50 year flood levels.

10 ENGINEERING GEOLOGICAL ZONES

For urban planning purposes the site is classified according to the classification system described in the NHBRC's Home Building Manual, Part 1 & 2 (Ref 7).

The site is zoned into four geotechnical zones or residential site classes, as indicated on Drawing 50858.01/SPL1. The descriptions of the zones are as follows:

Zone C1: Zone characterised by collapsible/compressible soil profile with total expected movements between 5 mm and 10 mm. Development can take place provided appropriate precautions against differential settlement are implemented.

Zone H1: Zone characterised by expansive soil profile with total expected movements between 7,5 mm and 15 mm. Development can take place provided appropriate precautions against differential movement are implemented.

Zone H3: Zone characterised by expansive soil profile with expected total differential movements of >30 mm. Development can take place provided appropriate precautions against differential and total movement are implemented.

Zone P(Flooding) Zone characterised by alluvial channels and natural drainage features, seasonal or intermittent. These areas are subject to flooding and no development is permissible except for roads and bridges.

11 RECOMMENDATIONS

Recommendations are provided regarding the following:

- Development in general;
- Founding of light structures;
- The use of in situ soils as construction material; and
- Drainage measures.

11.1 DEVELOPMENT

It is recommended that township development proceeds subject to the following preconditions:

- Special founding solutions must be implemented for single and double storey structures in zones (indicated on Drawing 50843.02/SPL1) that have the symbol **C1, H1** or **H3** in their zone classification code.
- Detailed geotechnical investigations must be conducted for all high-rise structures, i.e. structures exceeding conventional double-storey height.

11.2 FOUNDING OF LIGHT STRUCTURES

11.2.1 Zone C1

Founding alternatives for lightly loaded single and double-storey structures constructed in this zone include the following:

- Compacted in situ material below individual footings
- Deep strip or pad footings
- Construction of soil rafts
- Deep compaction of the footprint of the structure

11.2.2 Zone H1

Founding alternatives for lightly loaded single and double-storey structures constructed in this zone include the following:

- Modified normal construction (Reinforcement in masonry and strip footings, articulation joints in structure and drainage precautions)
- Construction of soil rafts

11.2.3 Zone H3

Founding alternatives for lightly loaded single and double-storey structures constructed in this zone include the following:

- Stiffened or cellular rafts
- Piled construction
- Construction of soil rafts

11.2.4 Zone P (Flooding)

It is recommended that no development be contemplated for this zone.

11.3 DRAINAGE MEASURES

The following drainage measures must be implemented:

- No accumulation of surface water is permitted and the entire development must be properly drained.
- All trenches and excavation works must be properly backfilled and compacted in order prevent them from functioning as French drains. Backfilling should be done in 150 mm thick layers and compacted to 90% of modified AASHTO density.

11.4 CORROSIVENESS

The reworked residual norite and residual soils are considered to be mildly corrosive. The test results for the clay and the aeolian sand are contradictory and further testing is recommended before measures against corrosion are adopted.

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for AFRICON

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APPENDIX A

SUMMARY OF THE SOIL AND ROCK PROFILE SCRIPTIONS

STANDARD DESCRIPTIONS USED IN SOIL PROFILING

1. MOISTURE CONDITION	
Term	Description
Dry	
Slightly moist	Requires addition of water to reach optimum moisture content for compaction
Moist	Near optimum content
Very Moist	Requires drying to attain optimum content
Wet	Fully saturated and generally below water table

2. COLOUR

The Predominant colours or colour combinations are described including secondary coloration described as banded, streaked, blotched, mottled, speckled or stained.

3. CONSISTENCY

3.1 Non-Cohesive Soils

Term	Description
Very Loose	Crumbles very easily when scraped with geological pick
Loose	Small resistance to penetration by sharp end of geological pick
Medium Dense	Considerable resistance to penetration by sharp end of geological pick
Dense	Very high resistance to penetration to sharp end of geological pick. Requires many blows of hand pick for excavation.
Very Dense	High resistance to repeated blows of geological pick. Requires power tools for excavation

3.2 Cohesive Soils

Term	Description
Very soft	Easily penetrated by thumb. Sharp end of pick can be pushed in 30 - 40mm. Easily moulded by fingers.
Soft	Pick head can easily be pushed into the shaft of handle. Moulded by fingers with some pressure.
Firm	Indented by thumb with effort. Sharp end of pick can be pushed in up to 10mm. Can just be penetrated with an ordinary spade.
Stiff	Penetrated by thumbnail. Slight indentation produced by pushing pick point into soil. Cannot be moulded by fingers. Requires hand pick for excavation.
Very Stiff	Indented by thumbnail. Slight indentation produced by blow of pick point. Requires power tools for excavation.

4. STRUCTURE

Term	Description
Intact	Absence of fissures or joints
Fissured	Presence of closed joints
Shattered	Presence of closely spaced air filled joints giving cubical fragments
Micro-shattered	Small scale shattering with shattered fragments the size of sand grains
Slickensided	Polished planar surfaces representing shear movement in soil
Bedded Folitated	Many residual soils show structures of parent rock.

5. SOIL TYPE

5.1 Particle Size

Term	Size (mm)
Boulder	>200
Pebbles	60 – 200
Gravel	60 – 2
Sand	2 – 0,06
Silt	0,06 – 0,002
Clay	<0,002

6. ORIGIN

6.1 Transported Soils

Term	Agency of Transportation
Colluvium	Gravity deposits
Talus	Scree or coarse colluvium
Hillwash	Fine colluvium
Alluvial	River deposits
Aeolian	Wind deposits
Litoral	Beach deposits
Estuarine	Tidal – river deposits
Lacustine	Lake deposits

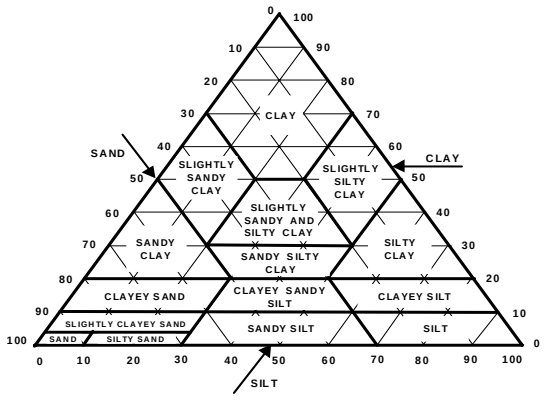
6.2 Residual soils

These are products of in-situ weathering of rocks and are described as e.g. Residual Shale

6.3 Pedocretes

Formed in transported and residual soils etc. calcrete, silcrete, manganocrete and ferricrete.

5.2 Soil Classification



SUMMARY OF DESCRIPTIONS USED IN ROCK CORE LOGGING

1. WEATHERING

Term	Symbol	Diagnostic Features
Residual Soil	W5	Rock is discoloured and completely changed to a soil in which original rock fabric is completely destroyed. There is a large change in volume.
Completely Weathered	W5	Rock is discoloured and changed to a soil but original fabric is mainly preserved. There may be occasional small corestones.
Highly Weathered	W4	Rock is discoloured, discontinuities may be open and have discoloured surfaces, and the original fabric of the rock near the discontinuities may be altered; alternation penetrates deeply inwards, but corestones are still present.
Moderately Weathered	W3	Rock is discoloured, discontinuities may be open and will have discoloured surfaces with alteration starting to penetrate inwards, intact rock is noticeably weaker than the fresh rock.
Slightly Weathered	W2	Rock may be slightly discoloured, particularly adjacent to discontinuities, which may be open and will have slightly discoloured surfaces, the intact rock is not noticeably weaker than the fresh rock.
Unweathered	W1	Parent rock showing no discolouration, loss of strength or any other weathering effects.

2. HARDNESS

Classification	Field Test	Compressive Strength Range MPa
Extremely Soft Rock	Easily peeled with a knife	<1
Very Soft Rock	Can be peeled with a knife. Material crumbles under firm blows with the sharp end of a geological pick.	1 to 3
Soft Rock	Can be scraped with a knife, indentation of 2 to 4 mm with firm blows of the pick point.	3 to 10
Medium Hard Rock	Cannot be scraped or peeled with a knife. Hand held specimen breaks with firm blows of the pick.	10 to 25
Hard Rock	Point load tests must be carried out in order to distinguish between these classifications	25 - 70
Very Hard Rock	These results may be verified by uniaxial compressive strength tests on selected samples.	70 - 200
Extremely Hard Rock		>200

3. COLOUR

The predominant colours or colour combination are described including secondary colouration described as banded, streaked, blotched, mottled, speckled or stained.

4. FABRIC

4.1 Grain Size		4.2 Discontinuity Spacing		
Term	Size (mm)	Description for: Bedding, foliation, laminations	Spacing (mm)	Descriptions for joints, faults, etc.
Very Coarse	>2,0	Very Thickly Bedded	> 1000	Very Widely
Coarse	0,6 – 2,0	Thickly Bedded	300 – 1000	Widely
Medium	0,2 – 0,6	Medium Bedded	100 – 300	Medium
Fine	0,06 – 0,2	Thinly Bedded	10 – 30	Closely
Very Fine	< 0,06	Laminated	3 – 10	Very closely
		Thinly Laminated	<3	

5. ROCK NAME

Classified in terms of origin:

IGNEOUS	Granite, Diorite, Gabbro, Syenite, Diabase, Dolerite, Trachyte, Andesite, Basalt.
METAMORPHIC	Slate, Quartzite, Gneiss, Cheroot, Sandstone
SEDIMENTARY	Shale, Mudstone, Siltstone, Sandstone, Dolomite, Conglomerate, Tillite, Quartzite, Limestone.

6. STRATIGRAPHIC HORIZON

Identification of rock type in terms of stratigraphic horizons.

APPENDIX B

SOIL PROFILE DESCRIPTIONS

APPENDIX C

LABORATORY TEST RESULTS

APPENDIX D

GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT

(after Partridge, Wood and Brink 1993)

APPENDIX E

RESIDENTIAL SITE CLASS DESIGNATIONS

(NHBRC Home Building Manual, Revision 1, February 1999

TYPICAL FOUNDATION MATERIAL	CHARACTER OF 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 5 - 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	> 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 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. Cl/H2 or Sl 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/Sl 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-Hl-H2 or Cl-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 Sl 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)-Cl.
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.

DRAWINGS

	CONSTRAINT	Most Favourable (1)	Intermediate (2)	Least favourable (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750mm in thickness.*	Any collapsible horizon or consecutive horizons with a depth of more than 750mm in thickness.	A least favourable situation for this constraint does not occur.
B	Seepage	Permanent or perched water table more than 1,5m below ground surface	Permanent or perched water table less than 1,5m 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 1,5m 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 100m below surface (except where total extraction mining has not occurred).	Old undermined areas to a depth of 100m below surface where stope closure has ceased	Mining within less than 100m 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 than 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 occurrence of the constraint may arise.