Report number 0791

Report on a Phase 1 Geotechnical Site Investigation for the township Ermelo Extension 37 situated on Portion 188 and a portion of Portion 13 of the Farm Nooitgedacht 268-IT, Ermelo, Mpumalanga Province

February 2008

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1. INTRODUCTION

A Phase 1 Geotechnical Site Investigation was undertaken at the request of Tom Le Roux for the proposed township Ermelo X 37 situated on Portion 188 and a portion of Portion 13 of the Farm Nooitgedacht 268-IT, Ermelo, Mpumalanga Province.

The investigation was undertaken according to the Guidelines for Urban Engineering Geological Investigations (SAIEG & SAICE, 1997) for urban development on sites larger than 10 hectares.

The objectives of the investigation were to:

- Identify, where possible, the underlying geological formations and their near surface weathered, residual and transported soil cover.
- Delineate the site into the prescribed geotechnical zones according to the different founding conditions.
- Obtain the basic data concerning the use of in situ material for guideline purposes.
- Provide suitable foundation recommendations for the proposed development.
- To comment on the excavation characteristics of the site soils.
- To comment on site water management aspects, particularly pertaining to shallow groundwater or seepage.

2. AVAILABLE INFORMATION

At the time of the investigation the 1:250 000 geological maps 2628 East Rand and 2630 Mbabane, a site contour map, site locality map, aerial photo and a satellite image was available.

The guideline and specification documents by the South African Institute of Engineering and Environmental Geologists and South African Institution for Civil Engineers (1997), the National Department of Housing (2002) and the National Home Builders Registration Council (1999) were also consulted.

3. SITE DESCRIPTION

The investigated holding is located between West Street and President Fouche Avenue with Roberts Street as the northern boundary and Voortrekker Avenue as the southern boundary, Ermelo, Mpumalanga Province, (Figure 1, Appendix A).

The rectangular shaped investigated area comprises of a surface area of roughly 21ha of which a large portion of this is situated below the determined 1:100 year floodline. An existing drainage channel drains the surrounding area in a north to north-westerly direction through the western half of the site, parallel to the boundary of the site. The surface runoff is collected in an existing dam to the north of the site. The general slope angle is between 2° and 4° towards the channel.

There is an elevation difference of approximately 10m between the upper and lower parts of the site, which is located between 1 699m and 1 689m above mean sea level.

The site is currently undeveloped and is generally covered with natural grass and a number of small to large sized trees next to the river, generally below the 1:100 year flood line.

A municipal building is present on the northeastern corner of the site with an existing small structure on the central western portion of the site at the intersection between Strijdom Street and President Fouche Avenue.

The surrounding area is serviced by the usual municipal services.

The climatic N-value (Weinert, 1980) of the region is less than 5, which implies that chemical weathering is dominant.

4. METHOD OF INVESTIGATION

The fieldwork, entailing a site walkover, trial pitting and profile descriptions, was conducted on the 6th of December 2007. Eleven test pits were excavated using a CAT 412C TLB.

The test pits covered the accessible parts of the site and their positions are indicated on the site plan (Figure 2, Appendix A).

An Engineering Geologist inspected the test pits and recorded the soil profiles using the standard procedures as recommended by SAIEG (1997). The soil profiles are included in Appendix B.

Five disturbed soil samples were retrieved from selected layers and submitted to Soillab (Pty) Ltd. of Pretoria for testing. Foundation indicator tests were performed on the samples to determine the particle size distribution and plasticity of the soil. The material was tested for foundation purposes and therefore the grading is carried out to 0,002mm.

5. GEOLOGY

5.1 GENERAL

According to the 1:250 000 geological sheet 2630 Mbabane, the site is underlain by shale, sandstone and grid with possible coal seams of the Vryheid Formation of the Ecca Group of the Karoo Supergroup.

This site is not underlain by dolomitic bedrock and a stability investigation is therefore not required.

According to the geological maps and accompanied explanation no specific mineral deposits are present on or in close proximity of the site.

No linear structures or any intrusive dykes are indicated on the map in the vicinity of the site.

5.2 SOIL PROFILE

A brief description of the various soil horizons encountered during this investigation is given below with a summary in Table 1 with the detailed soil profile descriptions attached in Appendix B.

5.2.1 Topsoil

A relatively thin highly organic topsoil layer covers the majority of the site. This topsoil horizon was generally described as *moist to wet, brown to dark grey, loose to medium dense, intact, clayey silty sand with an abundance of roots.*

The layer thickness varied between 0,10m and 0,50m with an average thickness of approximately 0,29m.

5.2.2 Colluvium
A loose to medium dense highly collapsible/compressible colluvium horizon underlies the organic topsoil. This horizon was generally described as *moist to wet, brownish-orange to light grey, slightly open structured, clayey silty sand.*

The colluvial material was encountered down to depths of 0,60m to 1,65m below ground level with an average thickness of 0,7m.

5.2.3 Reworked and residual sandstone
The residual material varies in appearance due to reworking and the degree of ferruginisation and was generally described as *very moist to wet, light grey to greyish-brown to orange, mottled and stained orange and dark purple-black, intact to slightly open structured, clayey silty sand with no to abundant Fe and Mn concretions.* The material consistency was generally described as loose to medium dense.

This horizon occurred from an average depth below surface of 1.1m.

5.2.4 Highly weathered sandstone
Highly weathered sandstone was encountered in TP02 at 1,30m below natural ground level. This material was described as *moist, light brown, minor stained orange, intact, silty sand* with a *dense* in situ material consistency.

5.2.5 Hardpan ferricrete
Highly ferruginised residual sandstone and hardpan ferricrete was encountered during the investigation. Refusal of the TLB was reached on ferricrete layers in test pits TP05, TP06 and TP08 at depths of 1,35m, 1,20m and 1,20m respectively.

Table 1: Test pit summary: Encountered depths of different materials (m)

Test Pit	Topsoil	Fill	Colluvium	Reworked/ residual sandstone	Ferricrete	Highly weathered sandstone	Test pit depth (m)	Test Pit NHBRC Class
TP01	0-0.10	0.10-0.5	0.50-1.00	1.00-1.90	--	--	1.90*	C2
TP02	0-0.20	--	0.20-0.80	0.80-1.30	--	1.30-1.50	1.50*	C2
TP03	0-0.20	--	0.20-2.00	2.00-2.20	--	--	2.20	C2-S2
TP04	0-0.50	--	0.50-1.10	1.10-1.90	--	--	1.90	S1-H1
TP05	0-0.40	--	0.40-1.25	--	1.25-1.35	--	1.35**	C2-S2
TP06	0-0.50	--	0.50-1.10	--	1.10-1.20	--	1.20**	C2-S2
TP07	0-0.15	--	0.15-0.60	0.60-1.50	--	--	1.50*	C1-S1
TP08	0-0.20	--	0.20-0.80	0.80-1.10	1.10-1.20	--	1.20**	C2-S2
TP09	0-0.10	0.10-0.6	0.60-1.65	1.65-1.80	--	--	1.80	C2-S2
TP10	0-0.30	--	0.30-0.70	0.70-1.60#	--	--	1.60	S1-H1
TP11	0-0.50	--	0.50-1.00	1.00-1.60#	--	--	1.60	C2-S2

*Gradual refusal of TLB; **Refusal of TLB; -- Horizon not present; # Possibly transported alluvium

5.3 GROUNDWATER
Groundwater seepage was encountered in test pits TP01, TP03, TP05, TP06, TP07 and TP08.

Shallow perched groundwater tables and/or surface seepage will be encountered throughout the majority of the site, especially during and towards the end of the rainy season.

Groundwater will flow towards the direction of the river through the upper permeable horizons.

A number of stormwater outlets or catch pits are present that flows from the site boundaries towards the river channel. These outlets are mainly at the road intersections resulting in additional concentrated water runoff onto the site.

The regional groundwater in this area occurs in intergranular and fractured aquifers with an average depth to the groundwater table of between 10 and 30m.

6. GEOTECHNICAL EVALUATION

The geotechnical appraisal is based on the field observations, local knowledge of the area, interpretations made on site and laboratory test results obtained during this investigation.

6.1 ENGINEERING AND MATERIAL CHARACTERISTICS

The foundation indicator test results conducted on the bulk samples selectively retrieved from the various soil horizons are summarised in Table 2.

Table 2: Indicator test results

Test pit	Depth (m)	Description	Soil composition				Atterberg Limits		LS %	GM	Activity	AASHO / Unified classification
			Clay %	Silt %	Sand %	Gravel %	LL %	PI %				
TP03	0.5-1.0	Colluvium	0	9	91	0	--	NP	0.0	1.17	Low	A-2-4 (0) / SP & SC
TP07	0-0.15	Topsoil	3	23	47	0	16	4	1.5	0.84	Low	A-2-4 (0) / SC & SM
TP07	0.15-0.6	Colluvium	10	21	69	0	19	7	3.5	0.77	Low	A-4 (1) / SC & SM
TP07	0.6-1.4	Residual sandstone	14	16	71	0	27	11	5.0	0.80	Low	A-2-6 (0) / SC
TP10	0.7-1.6	Transported	25	15	59	1	44	20	8.5	0.70	Medium	A-7-6 (6) / SC

LL - Liquid limit; PI - Plasticity index; LS - Linear shrinkage; GM - grading modulus;

The test results on the soil samples indicate the following:

- The **colluvial** material retrieved from test pit TP03 consists mainly of sand with a low percentage of silt. The material is non-plastic, has low to moderate grading modulus and a low soil heave potential.
- The **topsoil, colluvium and residual sandstone** retrieved from test pit TP07 mainly consist of sand with minor amounts of silt and clay. The material has low plasticity (Burmister, 1949), low to moderate liquid limit, low grading modulus and low soil heave potential.
- The **transported material** retrieved from test pit TP10 consists of silty clayey sand with moderate to high liquid limit, medium plasticity, low grading modulus and medium soil heave potential.
- According to the Unified Soil Classification and the PRA classification the topsoil, colluvial and residual sandstone generally classifies as "SC" and will be fair for use as subgrade, poor for use as subbase and not suitable for base course in roads. The material will be impervious when compacted. The in situ material may have medium in-situ compressibility with a low compressibility and good to fair shear strength when compacted. The material will be reasonably stable embankment material when compacted with good workability and good to fair compaction characteristics. The transported material has the same characteristics as above, but with medium soil heave potential.

The upper soil horizons mainly consist of loose to medium dense slightly open structured sand with low percentages of clay and silt. The topsoil and colluvium have low bearing capacity with moderate to high soil collapse and compressibility. Where practically possible it is recommended that the foundations be placed below the transported horizons on the more competent residuum or highly weathered sandstone.

The site soils will be mildly corrosive to steel pipes.

6.2 SLOPE STABILITY AND EROSION

No steep slopes are present within the proposed development areas and no natural slope instabilities will occur. Steep slopes are however present next to the river channel, although these slopes will not have an effect on the proposed development.

Due to the site gradient levelling of building sites may involve cut-to-fill preparation. To prevent differential settlements over the cut and fill parts controlled compaction should be implemented in especially the fills.

Due to the slope angle and the sandy nature of the colluvium covering the site, good water management practice must be employed to prevent erosion, especially after the vegetation has been cleared.

6.3 EXCAVATION CLASSIFICATION WITH RESPECT TO SERVICES

No rock outcrop was encountered during the field walkover survey. Excavation difficulty was experienced in trial pits TP05, TP06, TP07 and TP08 at depths of less than 1,5m below natural ground level on highly ferruginised material or hardpan ferricrete. Based on excavation conditions in the trial holes and field observations minor excavation difficulty is expected down to 1,5m below natural ground level.

A larger excavator may be required for the installation of services.

The material on site may therefore be classified as being soft with localised areas of medium excavation (SANS 1200D, 1988).

The colluvium and residuum may be suitable as backfill and bedding for pipelines if the pebbles are removed. The material will be suitable as fill material for construction of platforms and earth mattresses. Potentially expansive clayey material will however not be suitable for fill, backfill and bedding material for pipelines. These expansive materials are recognisable by high clay content.

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

The impact of the geotechnical constraints on housing development may be evaluated according to Table 3, which is a summary of the general geotechnical constraints relevant to urban development (Partridge, Wood and Brink, 1993). The Class column indicates the severity of the specific constraints for this site.

Table 3. Geological classification for urban development

	CONSTRAINT	SITE CONDITION	CLASS
A	Collapsible soil	Any collapsible horizon or consecutive horizons with a depth of less than 750 mm in thickness.	2
B	Seepage	Permanent or perched water table less than 1,5 m below ground surface	2
C	Active soil	Localised areas of moderate soil heave potential expected.	2
D	Compressible soil	Moderate soil compressibility expected.	2
E	Erodability of soil	Intermediate erodability of surface soils	2
F	Difficulty of excavation to 1,5m depth	Localised areas of excavation difficulty expected.	2
G	Undermined ground	No known undermined areas	1
H	Instability in areas of soluble rock	Soluble rocks not present	1
I	Steep slopes	Slopes between 2 and 6 degrees.	1
J	Areas of unstable natural slopes	Low risk.	1
K	Areas subject to seismic activity	10% probability of an event less than 100 cm/s^2 within 50 years	1
L	Areas subject to flooding	Areas within a known drainage channel or floodplain.	2

Class: 1 - Most favourable, 2 - Intermediate, 3 - Least favourable

The main expected geotechnical constraints for this site are:

- Medium to highly compressible and collapsible soil horizons.
- Medium soil heave potential expected in localised areas.
- Seasonal perched groundwater tables and/or surface seepage and water ponding.

- Intermediate erodability of surface soils.
- Localised areas of minor excavation difficulty.
- Areas subject to flooding.

7. SITE CLASSIFICATION AND FOUNDATION RECOMMENDATIONS

The site has been classified into two Site Class Designation zones (Figures 3 and 4, Appendix A), based on the above constraints and the criteria as set out in the NHBRC (1999) guideline document of which the appropriate tables have been included in Appendix A. The classification and foundation recommendations are based on the fieldwork, field observations and laboratory test results.

Zone I: Site Class Designation C2-S2/2ABD
High soil collapse and compressibility is expected due to the loose consistency and open soil structure of the upper horizons. Shallow perched water tables of less than 1,50m are expected throughout the majority of the site. Localised areas of minor excavation difficulty are expected on relatively shallow ferricrete and possible shallow very dense highly to moderately weathered sandstone.

One of the following foundation options is recommended depending on the type of structure to be erected on site and the founding depth (SAICE, 1995):

Compaction of in situ soils below individual footings (not suitable where soil heave is expected)
Stiffened strip footings, stiffened or cellular raft
Soil raft
Deep strip foundations

The foundation type will depend on the foundation depth and underlying material properties at each structure. In some localities foundations may be placed on shallow competent material where modified normal construction may be appropriate. These areas should be delineated during the phase II geotechnical site investigation.

Zone II: Site Class Designation P(flooding)-C2-S2/2ABD3L
This zone is below the 1:100year floodline and occasional flooding is anticipated.
The soil conditions will include high soil collapse and compressibility is expected due to the loose consistency and open soil structure of the upper horizons. Shallow perched water tables of less than 1,50m are expected. Localised areas of minor excavation difficulty are expected on relatively shallow ferricrete and possible shallow very dense highly to moderately weathered sandstone.

No development below the 1:100 year floodline

The flood lines as indicated in the report by the civil engineer should take preference over the indicated geotechnical zones in this report.

The foundation recommendations are according to the NHBRC Home Builders Manual (1999) for single storey masonry structures (Table 4, Table 5, Table 6 and Table 7, Appendix A).

The recommended foundation precautionary measures will be essential to limit damage to the proposed structures. Good site drainage and damp proofing will be necessary.

It is recommended that the structural engineers calculate the best economical foundation option for the proposed development based on the type of development and the different available construction methods.

It is recommended that the excavation of service trenches and installation of ground services be conducted during the dry season as shallow groundwater and surface seepage will cause difficulties such as flooded trenches and trench instabilities.

8. SPECIAL PRECAUTIONARY MEASURES

Good site drainage will be necessary as the occurrence of a perched water table and surface seepage will be a reality. This will cause problems with dampness in surface structures and with installation of services. The saturation of the soil profile will also need special site drainage methods as this may lead to additional differential movement/settlement under load.
The stormwater entering the site from the adjacent street runoff should be managed to limit infiltration.
Localised areas of more clayey material with a medium soil heave potential are present as encountered in test pits TP04 and TP10.

Areas of termite and other biotic activity are present and additional foundation modifications to prevent damage to single-storey structures due to differential settlements may be necessary across these features. The biotic activity is generally limited to the upper soil horizons.

The test pits were positioned to cover the accessible parts in order to zone the site. The pits were backfilled by the TLB without proper compaction in layers. If structures are to be positioned over or across these pits proper compaction must be executed to prevent differential settlements from taking place. The same will apply to development across existing foundations, waste pits, root areas of removed medium to large trees and septic tanks.

It is assumed that the development will be serviced by the usual municipal services and no recommendations are made on on-site sanitation, waste disposal, cemetery and stormwater reticulation services.

The corrosiveness of these soils is usually mild and it will be good practice to use plastic pipes rather than steel pipes for services.

9. CONCLUSIONS

The site will be suitable for development if the appropriate foundation design and building procedures are implemented as listed in this report and the NHBRC Home Builders Manual.

The major geological factors that may influence residential development are the following:

- Medium to highly compressible and collapsible soil horizons.
- Medium soil heave potential expected in localised areas.
- Seasonal perched groundwater tables and/or surface seepage and water ponding.
- Localised areas of minor excavation difficulty.
- Areas subject to flooding.

The colluvium and residuum will exhibit additional settlements, especially on the saturation of the soil profiles. Special foundation and drainage measures will be necessary to prevent damage to structures. Shallow groundwater and surface seepage are expected throughout the site, especially towards the lower lying areas. Special precautionary measures need to be implemented.

The upper soil horizons will be suitable for construction of platforms, lower road pavement layers and backfill. The potentially expansive material (Test pit TP10) will not be suitable.

The site soils will be corrosive to steel pipes.

Based on the trial pits only localised areas of minor excavation difficulty are expected. A larger excavator may be required for the installation of services in these areas.

10. REPORT PROVISIONS

While every effort is made during the fieldwork phase to identify the different soil horizons, areas subject to a perched water table, areas of poor drainage, areas underlain by hard rock and to estimate their distribution, it is impossible to guarantee that isolated zones of poorer foundation

materials, or harder rock have not been missed.

For this reason this investigation has sought to highlight areas of potential foundation, groundwater and excavation problems, to provide prior warning to the developer.

A competent person should inspect foundation excavations for future structures at the time of construction or the open service trenches, to determine the variance from the above assessment of the site.

NHBRC enrolment of the site can only be completed once this Phase II Geotechnical Site Investigation has been executed.

The present site zonation is based on the NHBRC Manual with the guideline site class designation specifically for single-storey masonry residential units.

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APPENDIX A: FIGURES AND REFERENCE TABLES