ABSTRACT

A Phase I Geotechnical Investigation has been conducted for the proposed township establishment and related high-density residential development on **PORTIONS OF THE FARMS LEEUWPOORT 283-JS & TWEEDAM 377-JS**. This proposed township is located within the area of jurisdiction of the Emalahleni Local Municipality in the Mpumalanga Province.

The objectives of the investigation may be summarised as follows:

- To determine the geology and relevant mechanical properties of the soil and rock horizons underlying the site.
- To determine the different geotechnical zones present on the site according to the NHBRC classification.
- To provide general foundation recommendations for the proposed development.
- To comment on the excavation characteristics of the materials underlying the site for the installation of services.
- To comment on the potential usage of the materials for use in layer works in paving and roads.
- To comment on site water management aspects particularly pertaining to shallow groundwater or seepage.

The geotechnical evaluation is based on the observations and interpretations on site as well as on the results of the laboratory tests. The site was tentatively divided into ninegeotechnical zones as indicated on the **Geotechnical Map (V14/003/2P)** in **Appendix A**.

- **Zone A:**The central northern portion of the site consist of this zone that is characterized by sandstone sub-outcrop, minor outcrop and boulders on surface. This zone is classified as **Class R** with sub-zones of **C/R**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. Class **R** indicate "hard excavation" for the excavation of the bulk of foundation but all service trenches. Class **C/R** indicates that total settlement of less than 5mm is estimated.

  Structures may be founded utilizing one of the following solutions:
  - Normal construction (strip footings or slab-on-the-ground-foundations).
  - Good site drainage.
  - **The areas of sub-outcrop and outcrop as delineated should be excluded from development.**

  It should be borne in mind that due to rock on surface and/or shallow rock natural "springs" might be present in this zone during the wet season. The small "excavation" observed close to test pit SP26 should be rehabilitated prior to development by means of backfilling with suitable inert material compacted in controlled layers.

- **Zone B:**A small section of the central northern portion, the central eastern portion as well as a section of the south-eastern portion of the site consists of this zone where a layer **(0,9m thick on average)** of potentially moderately collapsible soil underlain by shallow very soft to soft rock sandstone or ferricrete was encountered. This zone is classified as **Class C1/R**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 5 to 10mm is estimated with differential settlement assumed to equal 75% of the estimated total. Class **R** indicates that "intermediate to hard excavation" is expected for the excavation of service trenches.

  Structures may be founded utilizing one of the following solutions:
  - Modified normal construction.
  - Deep strip foundations.

  Structures should be articulated and reinforcement incorporated in masonry and site drainage with service and plumbing precautions implemented. It should be borne in mind that due to the presence of shallow rock natural "springs" or a shallow perched water table might be present in this zone during the wet season. The installation of sub-surface drainage systems should be considered to prevent saturation of the foundation soils. The drainage ditch in this zone should be rehabilitated prior to development.

- **Zone C:**The central western portion, the central southern portion, two small sections in the southern portion as well as the central eastern portion of the site consists of this zone where a layer **(1,0m thick on average)** of potentially moderately collapsible and compressible soil was encountered. This zone is classified as **Class C1/S**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10mm is estimated with differential settlement assumed to equal 75% of the estimated total.

  Structures may be founded utilizing one of the following solutions:
  - Modified normal construction.
  - Deep strip foundations.

  Structures should be articulated and reinforcement incorporated in masonry and site drainage with service and plumbing precautions implemented.The drainage ditch in the southern portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The excavations in the central eastern portion where sand has been removed for building purposes should be treated similarly.

- **Zone D:**The north-western portion and the central south-western portion as well as a small section in the central northern portion of the site consists of this zone where a layer **(1,15m thick on average)** of potentially moderately to highly compressible and collapsible soil was encountered. This zone is classified as **Class S1/C**according to the

National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10 to 20mm is estimated with differential settlement assumed to equal 50% of the estimated total. Shallow soft to hard rock sandstone was encountered in isolated spots within this zone that would lead to "hard excavation" for the excavation of service trenches.

Structures may be founded utilizing one of the following solutions:

- Modified normal construction.
- Compaction of soil below footings.
- Deep strip foundations.

Structures should be articulated and reinforcement incorporated in masonry and site drainage with service and plumbing precautions implemented. The drainage ditch that runs alongside the tar and gravel roads as well as through the central south-western portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development.

- **Zone E:**The extreme western portion of the site consists of this zone where a layer **(0,95m thick on average)** of potentially moderately to highly compressible and collapsible soil underlain by shallow very soft rock grit stone was encountered. This zone is classified as **Class S1/C/R**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10 to 20mm is estimated with differential settlement assumed to equal 50% of the estimated total. **Class R** indicates that "hard excavation" is expected within 1,5m of surface.

  Structures may be founded utilizing one of the following solutions:

  - Modified normal construction.
  - Compaction of soil below footings.
  - Deep strip foundations.

  Structures should be articulated and reinforcement incorporated in masonry and site drainage with service and plumbing precautions implemented. It should be borne in mind that due to the presence of shallow rock a shallow perched water table might be present in this zone during the wet season. The installation of sub-surface drainage systems should be considered to prevent the saturation of foundation soils.

- **Zone F:**The central south-western portion, the bulk of the central and southern portions as well as a section in the central south-eastern portion of the site consist of this zone where a thick layer **(2,0m thick on average)** of potentially highly compressible and moderately to highly collapsible soil was encountered. This zone is classified as **Class S2/C1**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of more than 20mm is estimated with differential settlement assumed to equal 50% of the estimated total.

Structures may be founded utilizing one of the following solutions:

- Stiffened concrete or cellular rafts.
- Compaction of soil below footings.
- Pad and pier foundations.
- Soil raft.

Structures should be articulated and reinforcement incorporated in masonry and site drainage with service and plumbing precautions implemented. The man-made drainage ditch in the central and southern portions of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The excavations created by the mine in the south-western corner of this zone should be rehabilitated as described above. The "contours" and shallow ditches created by the land owner during cultivation should be treated similarly. A natural drainage gulley runs through the central south-western portion of this zone and the 1:100 year flood line, if applicable, should be determined with no development permitted below it. The gulley itself should be excluded from residential development.

- **Zone G:**The southern portion, a section of the central portion as well as a section in the central south-eastern portion of the site consist of this zone where a thick layer **(1,8m thick on average)** of potentially moderately to highly collapsible and compressible soil was encountered. This zone is classified as **Class C2/S1**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10 to 20mm is estimated with differential settlement assumed to equal 75% of the estimated total.

  Structures may be founded utilizing one of the following solutions:

  - Stiffened concrete or cellular rafts.
  - Compaction of soil below footings.
  - Pad and pier foundations.
  - Soil raft.

  Structures should be articulated and reinforcement incorporated in masonry and site drainage with service and plumbing precautions implemented. The drainage ditch that runs alongside the tar road and the one in the southern portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The excavations in the south-eastern corner and in the central south-eastern portion where sand has been removed for building purposes should be treated similarly.

- **Zone H:**This zone consists of the three prominent old borrow pits that have most probably been established during construction of the R544 tar road. This zone is classified as **Class P(excavations)**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. The following procedure is recommended prior to development.

- Rehabilitate the borrow pits by backfilling with suitable inert material compacted in controlled layers.
- Backfill in bulk (thick layers) with suitable inert material and compact the fill by means of dynamic compaction procedures.
- Test the backfill method to determine that any potential settlement is acceptable for the anticipated development.
- Design structures accordingly.
- Good site drainage with service and plumbing precautions.

- **Zone I:**This zone consists of the high-lying ground (koppie) present in the north-eastern portion of the site. This is characterized by extensive sandstone outcrop, sub-outcrop and steep slopes.

  - This zone should be excluded from the development and reserved as open space.

The mining rights for the site investigated belongs to Eyethu Coal who operates the Leeupoort open cast coal mine that bound the site on the south-west. Eyethu Coal prospected in this area and indicated the site is not underlain by economically exploitable coal reserves. The site investigated is not undermined.

In a letter dated 20 January 2014, Eyethu Coal indicated that they have no objection to the establishment of the proposed township provided that the development adheres to the 500m blasting limit around the present operations. Due to blasting being conducted on a regular basis the developer should take cognizance of the "*shock clause"*. "*As this site (erf, stand, parcel of land) forms part or are located in close proximity of land which may be undermined, or are currently being mined, and are potentially liable to subsidence, settlement, shock and/or cracking due to mining operations past, present or future, the owner/developer (applicant, grantee, as the case may be) thereof accept all liability for any damage thereto or to any structure thereon which may result from such subsidence, settlement, shock and/or cracking"*. All potential buyers/investors of stands/structures in the proposed development should be made aware of this clause.

The site is considered suitable for the proposed township establishment and related commercialdevelopment provided that the recommendations made in this report are adhered too.

Table of Contents

1 INTRODUCTION 7
2 AVAILABLE INFORMATION 7
3 SITE DESCRIPTION 7
4 GEOLOGY 8
5 INVESTIGATION PROCEDURE 9
5.1 Fieldwork 9
5.2 Laboratory Testing 9
6 GEOTECHNICAL EVALUATION 9
6.1 Collapsible/Compressible Soil 9
6.1.1 Collapse Settlement 9
6.1.2 Normal (consolidation) Settlement 10
6.2 Expansive Soil 10
6.3 Foundations 10
6.4 Material Usage 21
6.5 Shallow Seepage 22
6.6 Excavation Characteristics 22
6.7 Stability of Excavations 25
6.8 Undermined Ground 26
6.9 Slope Instability 26
6.10 Erodability of the Soil Profile 26
6.11 Steep Slopes 26
7 GENERAL 26
8 REFERENCES 28

TABLES

Table 1: Summary of Excavation Depths…..……...……..23

APPENDICES

Appendix A Maps

Appendix B Soil Profiles

PHASE I GEOTECHNICAL INVESTIGATION FOR TOWNSHIP ESTABLISHMENT :PORTIONS OF THE FARMS LEEUWPOORT 283-JS & TWEEDAM 377-JS

1. INTRODUCTION

At the request of the developer, **VIPCON (PT) LTD)**, the undersigned conducted a Phase I Geotechnical Investigation for the proposed township establishment and related high-density residential development on**PORTIONS OF THE FARMSLEEUWPOORT 283-JS & TWEEDAM 377-JS**. This proposed township is located within the area of jurisdiction of the EmalahleniLocal Municipality in the Mpumalanga Province.

The objectives of the investigation may be summarized as follows:

- To determine the geology and relevant mechanical properties of the soil and rock horizons underlying the site.
- To determine the different geotechnical zones present on the site according to the NHBRC classification.
- To provide general foundation recommendations for the proposed development.
- To comment on the excavation characteristics of the materials underlying the site for the installation of services.
- To comment on the potential usage of the materials for use in layer works in paving and roads.
- To comment on site water management aspects particularly pertaining to shallow groundwater or seepage.

2. AVAILABLE INFORMATION

The following sources were consulted in the evaluation of the site.

- Geological Map sheet 2528 Pretoria at a scale of 1:250,000.
- Topographical Map sheet 2529CC Witbank at a scale of 1:50,000.
- Stereo pair air photos supplied by AZUR Aerial Photography & Mapping at a scale of 1:6,000.
- Sitelayout provided by the town planner.

3. SITE DESCRIPTION

The site is located on portions of the Farms Leeuwpoort283-JS &Tweedam 377-JS north-west of the Emalahleni CBD along the R544 provincial road. This road bisects the site and runs in a north-west south-east direction. The northern and north-western portions of the site is located on high ground with the remainder on gentle to moderate slopes. The north-eastern portion of the site has moderate to steep slopes in an easterly direction. An opencast coal mine

operated by Eyethu Coal is present along the south-western boundary. Smaller portions of the farm Leeuwpoort bound the site on the north.

The northern portion of the site is characterized by extensive sandstone outcrop and sub-outcrop whilst the southern portion has more deeply weathered soils. A large blue gum bush occupies the south-eastern corner of the site. Two dams with related wet areasare present in the central eastern portion of the site. A stream below the lowest dam flows towards the BlesbokSpruit.

The northern portion of the site is covered with sour veld grass species and Highveld shrubs whilst the southern portion has been cultivated in the past and is presently covered by grass and weeds. An overhead powerline runs through the western portion of the site with a second one running parallel with the tar road. Several shallow drainage ditches were observed, but is most probably man-made to assist with surface drainage to prevent erosion of the crops.

Three borrow pits is present in the central western portion of the site and was most probably been established during the construction of the R544 road. Several shallow excavations are present in the central eastern and south-eastern portions of the site where sand has been removed by the locals for building purposes. A natural drainage gulley is present in the central south-western portion of the site.

The site covers an area of approximately 600 hectares and the exact locality is indicated on the **Locality Map**(V14/003/1) in Appendix A.

4. GEOLOGY

The site is underlain by sandstone and shale with coal beds at the bottom of the sedimentary succession of the Vryheid Formation as well as by diamictite with sub-ordinate shale of the Dwyka Formation both belonging to the Karoo Sequence. Dolerite in the form of dykes and sills has intruded into the host rock along planes of weakness and are often encountered within the sedimentary succession. The site is covered with Recent Deposits in the form of silty and sandy hillwash. Ferricrete, classed as pedogenic material, was encountered as either abundant concretions within the site soils or as a well-developed layer at the base of the colluvium.

The sandstone encountered vary from a fine-grained to a coarse-grained variety (gritstone). A pebble marker horizon was encountered sporadically across the site and this represents the most recent major geological unconformity in the soil profile and occurs at the base of the transported soil. This is generally a zone of high permeability as it contains abundant gravel.

Diamictite is an essence a matrix supported conglomerate, i.e. gravel and cobbles of mixed origin cemented in a fine grained matrix deposited by the melting of ice-sheets.

5. SITE INVESTIGATION

5.1 Fieldwork

The site investigation was carried out during February2014 and comprised the excavation of hundred and twenty eighttest pits with a Cukurova 883 TLB supplied by a contractor from Witbank. The test pits were set out by means of a handheld GPS on the WGS 84 coordinate system to cover the entire site to satisfy the objectives outlined above. An engineering geologist inspected the test pits and recorded soil profiles using standard procedures. The positions of the test pits are indicated on the **Geotechnical Map (V14/003/2)**in **Appendix A** whilst the soil profiles are included in **Appendix B.**

5.2 Laboratory Testing

Small and bulk disturbed samples as well as undisturbed samples (block samples) representative of the soils encountered were retrieved from the test pits and submitted to a commercial soils laboratory for testing. The following tests were performed in order to determine the mechanical properties of the different soil horizons.

- **Indicator Tests**
  These were carried out to determine the particle distribution and plasticity of the soils. The soil was fine grained and therefore the grading was carried out to 0,002mm in order to determine the clay percentage in the soil and hence potential activity.
- **Collapse Potential Tests**
  Several collapse potential tests was conducted on the hillwashto determine the amount of collapse and consolidation settlement that could be expected.
- **Mod & CBR Tests**
  The hillwash was tested for use in layer works and the modified AASHTO moisture density relationship and CBR tests were conducted to determine compaction and strength characteristics.

The depth of the samples is indicated on the relevant profile sheets in **Appendix B.** The test results are not yet available.

6. GEOTECHNICAL EVALUATION

6.1 Collapsible/Compressible Soil

6.1.1 Collapse Settlement

The southern portion of the site is blanketed with a thick layer of hillwash whilst the remainder is generally blanketed by a layer of variable thickness. The hillwash is considered to exhibit a collapsible grain structure and should therefore be regarded as being potentially

collapsible and/or compressible. Soils with a collapsible grain structure consist of sand grains held apart by clay bridges that form an open, honeycomb type structure. When dry, these soils appear to have a high strength, however when subjected to simultaneous loading and saturation the clay bridges lose strength and the soil collapses into a denser state resulting in sudden settlement.

Sixundisturbed samples of the hillwash were retrieved and submitted to collapse potential testing according to the method as advocated by Jennings 1975. The test results are not yet available but from a visual assessment the hillwash is considered to be potentially moderately to highly compressible and slightly too moderately collapsible, depending on the in-situ moisture content.The pebble marker and top portion of the residual profile of loose to medium dense/soft consistency are also considered to be potentially collapsible and/or compressible.Thesesoilsare therefore not considered an adequate founding medium in their natural state and appropriate foundation recommendations are provided in section 6.3.

6.1.2 Normal (consolidation) Settlement

Excessive normal settlement is likely to occur where a thick layer of hillwash is encountered particularly if this soil has a high moisture content (**S_r>30%**) as was the case during the investigation. Normal settlement generally does not pose a serious problem if the settlement is not excessive, is uniform and takes place during construction. Problems also occur when the settlement is uneven when structures are founded partly on competent and partly on soft foundation soils. This uneven settlement known as differential settlement, results in structural distress.

6.2 Expansive Soil

The hillwash is sandy and silty with a low to moderateclay content whilst both the residual shaleand diamictite consists of a sandy silt. The residual sandstone is generally coarse-grained with a clay content of < 2%. From a visual assessment no problems with regards to potentially expansive soils are anticipated.

6.3 Foundations

Foundation recommendations for the proposed high-density residential development are provided in this section. This is based on the observations and interpretations on site as well as on the results of the laboratory tests. The site was tentatively divided into nine geotechnical zones as indicated on the **Geotechnical Map (V14/003/2)**in **Appendix A**.

- **ZONE A**

  The central northern portion of the site consist of this zone that is characterized by sandstone sub-outcrop, minor outcrop and boulders on surface. Twenty six test pits have been excavated to delineate this zone and shallow refusal on soft to hard rock sandstone were encountered at an average depth of **0,5m** below existing ground level.Refusal occurred from surface to a depth of 1,2m below ground level.

This zone is classified as **Class R**with sub-zones of **C/R**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. Class **R**indicate "hard excavation" for the excavation of the bulk of foundation but all service trenches. Class **C/R** indicates that total settlement of less than 5mm is estimated.

The following foundation recommendations may be considered for lightly loaded single and double storey structures.

Normal Construction

- Normal construction (strip footings or slab-on-the-ground-foundations).
- Good site drainage.
- The areas of sub-outcrop and outcrop as delineated should be excluded from development.

It should be borne in mind that due to rock on surface and/or shallow rock natural "springs" might be present in this zone during the wet season. Foundations should be designed in accordance and under supervision of a civil or structural engineer and the NHBRC recommendations given above should be verified during construction. The small "excavation" observed close to test pit SP26 should be rehabilitated prior to development by means of backfilling with suitable inert material compacted in controlled layers.

- **ZONE B**

A small section of the central northern portion, the central eastern portion as well as a section of the south-eastern portion of the site consists of this zone where a layer **(0,9m thick on average)**of potentially moderately collapsible soil underlain by shallow very soft to soft rock sandstone or ferricrete was encountered. This zone is classified as **Class C1/R**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 5 to 10mm is estimated with differential settlement assumed to equal 75% of the estimated total. Class **R** indicatesthat "intermediate to hard excavation" is expected for the excavation of service trenches.

The following foundation recommendations may be considered for lightly loaded single and double storey structures utilizing a maximum permissible bearing pressure of **50** to **150kPa** depending on the solution adopted.

Modified Normal Construction

- Structures may be placed on reinforced strip footings at a depth of **0,5m** below surface after thorough compaction of the base of the foundation trench utilizing a maximum allowable bearing pressure of **50kPa**.
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Structures should be articulated at strategic points as determined by a structural engineer to cater for differential settlement.

- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Deep Strip Foundations

- Structures may be placed on conventional footings at an average depth of **0,9m** below surface on dense or better residual sandstone utilizing a maximum allowable bearing pressure of **150kPa**.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Foundations should be designed according to accepted engineering practice and the NHBRC recommendations should be verified during construction. Strict quality control is necessary during the compaction procedure to ensure that the desired result is achieved. Densities and stiffness of the compacted soils must be controlled with suitable field tests. The design of first floor slabs should take the estimated settlement into account.

It should be borne in mind that due to the presence of shallow rock natural “springs” or a shallow perched water table might be present in this zone during the wet season. The installation of sub-surface drainage systems should be considered to prevent the saturation of foundation soils.

The drainage ditch in the south-eastern portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The “contours” created by the land owner during cultivation should be treated similarly.

- **ZONE C**

The central western portion, the central southern portion, two small sections in the southern portion as well as the central eastern portion of the site consists of this zone where a layer **(1,0m thick on average)** of potentially moderately collapsible and

compressible soil was encountered. This zone is classified as **Class C1/S**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10mm is estimated with differential settlement assumed to equal 75% of the estimated total.

The following foundation recommendations may be considered for lightly loaded single and double storey structures utilizing a maximum permissible bearing pressure of **50** to **150kPa** depending on the solution adopted.

Modified Normal Construction

- Structures may be placed on reinforced strip footings at a depth of **0,6m** below surface after thorough compaction of the base of the foundation trench utilizing a maximum allowable bearing pressure of **50kPa**.
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Structures should be articulated at strategic points as determined by a structural engineer to cater for differential settlement.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Deep Strip Foundations

- Structures may be placed on conventional footings at an average depth of **1,3m** below surface on dense residual grit stoneor diamictite utilizing a maximum allowable bearing pressure of **150kPa**.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Foundations should be designed according to accepted engineering practice and the NHBRC recommendations should be verified during construction. Strict quality control is necessary during the compaction procedure to ensure that the desired result is achieved.

Densities and stiffness of the compacted soils must be controlled with suitable field tests. The design of first floor slabs should take the estimated settlement into account.

The drainage ditch in the southern portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The excavations in the central eastern portion where sand has been removed for building purposes should be treated similarly.

- **ZONE D**

The north-western portion and the central south-western portionas well as a small section in the central northern portion of the site consists of this zone where a layer **(1,15m thick on average)** of potentially moderately to highly compressible and collapsible soil was encountered. This zone is classified as **Class S1/C**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10 to 20mm is estimated with differential settlement assumed to equal 50% of the estimated total. Shallow soft to hard rock sandstone was encountered in isolated spots within this zone that would lead to "hard excavation" for the excavation of service trenches.

The following foundation recommendations may be considered for lightly loaded single and double storey structures utilizing a maximum permissible bearing pressure of **50** to **150kPa** depending on the solution adopted.

Modified Normal Construction

- Structures may be placed on reinforced strip footings at a depth of **0,7m** below surface after thorough compaction of the base of the foundation trench utilizing a maximum allowable bearing pressure of **50kPa**.
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Structures should be articulated at strategic points as determined by a structural engineer to cater for differential settlement.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Compaction of Soil Below Individual Footings

- Remove the in-situ material below foundations to a depth and width of 1,5 times the widest foundation or to a competent horizon. Compact the base of the foundation

trench before replacing the excavated material in lifts of 150mm compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content. Minimum foundation width assumed to be 0,6m.

- Structures may be founded on reinforced strip footings on this compacted material utilizing a maximum permissible bearing pressure of **75kPa**.
- Structures should be articulated at strategic points to cater for any differential movement (some internal and all external doors).
- All layers of brickwork in the plinth should be reinforced with brickforce and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at -1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

Deep Strip Foundations

- Structures may be placed on conventional footings at an average depth of **1,15m** below surface on dense residual sandstone or ferricrete utilizing a maximum allowable bearing pressure of **150kPa**.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Foundations should be designed according to accepted engineering practice and the NHBRC recommendations should be verified during construction. Strict quality control is necessary during the compaction procedure to ensure that the desired result is achieved. Densities and stiffness of the compacted soils must be controlled with suitable field tests. The design of first floor slabs should take the estimated settlement into account.

The drainage ditch that runs alongside the tar and gravel roads as well as through the central south-western portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development.

- **ZONE E**

The extreme western portion of the site consists of this zone where a layer **(0,95m thick on average)** of potentially moderately to highly compressible and collapsible soil underlain by shallow very soft rock grit stone was encountered. This zone is classified as

Class S1/C/Raccording to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10 to 20mm is estimated with differential settlement assumed to equal 50% of the estimated total. **Class R** indicates that "hard excavation" is expected within 1,5m of surface.

The following foundation recommendations may be considered for lightly loaded single and double storey structures utilizing a maximum permissible bearing pressure of **50** to **150kPa** depending on the solution adopted.

Modified Normal Construction

- Structures may be placed on reinforced strip footings at a depth of **0,6m** below surface after thorough compaction of the base of the foundation trench utilizing a maximum allowable bearing pressure of **50kPa**.
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Structures should be articulated at strategic points as determined by a structural engineer to cater for differential settlement.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Compaction of Soil Below Individual Footings

- Remove the in-situ material below foundations to a depth and width of 1,5 times the widest foundation or to a competent horizon. Compact the base of the foundation trench before replacing the excavated material in lifts of 150mm compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content. Minimum foundation width assumed to be 0,6m.
- Structures may be founded on reinforced strip footings on this compacted material utilizing a maximum permissible bearing pressure of **75kPa**.
- Structures should be articulated at strategic points to cater for any differential movement (some internal and all external doors).
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at -1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

Deep Strip Foundations

- Structures may be placed on conventional footings at an average depth of **0,95m** below surface on dense residual grit stone utilizing a maximum allowable bearing pressure of **150kPa**.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Foundations should be designed according to accepted engineering practice and the NHBRC recommendations should be verified during construction. Strict quality control is necessary during the compaction procedure to ensure that the desired result is achieved. Densities and stiffness of the compacted soils must be controlled with suitable field tests. The design of first floor slabs should take the estimated settlement into account.

It should be borne in mind that due to the presence of shallow rock a shallow perched water table might be present in this zone during the wet season. The installation of sub-surface drainage systems should be considered to prevent the saturation of foundationsoils.

❖ **ZONE F**

The central south-western portion, the bulk of the central and southern portions as well as a section in the central south-eastern portion of the site consist of this zone where a thick layer **(2,0m thick on average)** of potentially highly compressibleand moderately to highly collapsible soil was encountered. This zone is classified as **Class S2/C1**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of more than 20mm is estimated with differential settlement assumed to equal 50% of the estimated total.

The following foundation recommendations may be considered for lightly loaded single and double storey structures utilizing a maximum permissible bearing pressure of **50** to **200kPa** depending on the solution adopted.

Stiffened Concrete or Cellular Rafts

- Structures may be placed on stiffened concrete or cellular raft foundations at shallow depth designed to accommodate the estimated settlement.
- Bearing pressure should not exceed of **50kPa**.

- Structures should be articulated at strategic points as determined by a structural engineer with reinforced masonry.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Compaction of Soil Below Individual Footings

- Remove the in-situ material below foundations to a depth and width of 1,5 times the widest foundation or to a competent horizon. Compact the base of the foundation trench before replacing the excavated material in lifts of 150mm compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content. Minimum foundation width assumed to be 0,6m.
- Structures may be founded on reinforced strip footings on this compacted material utilizing a maximum permissible bearing pressure of **75kPa**.
- Structures should be articulated at strategic points to cater for any differential movement (some internal and all external doors).
- All layers of brickwork in the plinth should be reinforced with brickforce and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at -1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

Pad and Pier Foundations

- Structures may be founded on reinforced concrete ground beams supported on pad and pier foundations placed at an average depth of **2,2m** below surface on dense/firm residual grit stone/diamictite/shale.
- A maximum permissible bearing pressure of **150kPa** may be utilized.
- Soil below floor slabs should be removed to a depth of 0,6m and be replaced as described above.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- Alternatively ground floor slabs could be designed as suspended slabs.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

Soil Raft

- Remove the in-situ material to 1,0m beyond perimeter of structures and to a depth of 1m below founding level. Compact the base of the excavation before replacing the

excavated material in lifts of 150mm compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.

- Structures may be founded on reinforced footings at shallow depth within the soil raft utilizing a maximum permissible bearing pressure of **200kPa**. Structures should be articulated to cater for any differential movement.
- All layers of brickwork in the plinth should be reinforced with brickforce and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- For every 300mm thickness of raft the density and stiffness should be confirmed using sand replacement methods and plate bearing tests respectively. The density of the compacted layers should be modified accordingly. Plate bearing tests are specified to confirm that settlements are acceptable for the structures.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

The design of raft foundations (whether soil or concrete) should be done in accordance and under supervision of a civil or structural engineer and the NHBRC recommendations given above should be verified during construction. Strict quality control is necessary during the compaction procedure to ensure that the desired result is achieved. Densities and stiffness of the compacted soils must be controlled with suitable field tests. The design of first floor slabs should take the estimated settlement into account.

The man-made drainage ditch in the central and southern portions of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The excavations created by the mine in the south-western corner of this zone should be rehabilitated as described above. The “contours” and shallow ditches created by the land owner during cultivation should be treated similarly. A natural drainage gulley runs through the central south-western portion of this zone and the 1:100 year flood line, if applicable, should be determined with no development permitted below it. The gulley itself should be excluded from residential development.

- **ZONE G**

The southern portion, a section of the central portion as well as a section in the central south-eastern portion of the site consist of this zone where a thick layer **(1,8m thick on average)** of potentially moderately to highly collapsible and compressible soil was encountered. This zone is classified as **Class C2/S1**according to the National Home Builders Registration Council’s Standards and Guidelines (NHBRC) of 1999. This classification indicates that total settlement of 10 to 20mm is estimated with differential settlement assumed to equal 75% of the estimated total.

The following foundation recommendations may be considered for lightly loaded single and double storey structures utilizing a maximum permissible bearing pressure of **50** to **200kPa** depending on the solution adopted.

Stiffened Concrete or Cellular Rafts

- Structures may be placed on stiffened concrete or cellular raft foundations at shallow depth designed to accommodate the estimated settlement.
- Bearing and fabric pressure should not exceed of **50kPa**.
- Structures should be articulated at strategic points as determined by a structural engineer with reinforced masonry.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- All wet services should be flexible in design to accommodate movement where entering or leaving structures.
- Storm water should be effectively captured and led well away from all structures.
- No ponding of surface water should be allowed to occur adjacent to foundations both during as well as after construction.

Compaction of Soil Below Individual Footings

- Remove the in-situ material below foundations to a depth and width of 1,5 times the widest foundation or to a competent horizon. Compact the base of the foundation trench before replacing the excavated material in lifts of 150mm compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content. Minimum foundation width assumed to be 0,6m.
- Structures may be founded on reinforced strip footings on this compacted material utilizing a maximum permissible bearing pressure of **75kPa**.
- Structures should be articulated at strategic points to cater for any differential movement (some internal and all external doors).
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Material below floor slabs should be removed to a depth of 0,6m and replaced in 150mm layers compacted to 95% Mod AASHTO density at -1% to +2% of optimum moisture content.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

Pad and Pier Foundations

- Structures may be founded on reinforced concrete ground beams supported on pad and pier foundations placed at an average depth of **1,9m** below surface on dense/firm residual grit stone/sandstone or firm shale.
- A maximum permissible bearing pressure of **150kPa** may be utilized.
- Soil below floor slabs should be removed to a depth of 0,6m and be replaced as described above.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- Alternatively ground floor slabs could be designed as suspended slabs.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

Soil Raft

- Remove the in-situ material to 1,0m beyond perimeter of structures and to a depth of 1m below founding level. Compact the base of the excavation before replacing the excavated material in lifts of 150mm compacted to 95% Mod AASHTO density at –1% to +2% of optimum moisture content.
- Structures may be founded on reinforced footings at shallow depth within the soil raft utilizing a maximum permissible bearing pressure of **200kPa**. Structures should be articulated to cater for any differential movement.
- All layers of brickwork in the plinth should be reinforced with brick force and thereafter every fourth course to at least four reinforced courses above all openings such as doors and windows.
- Floor slabs should be mesh reinforced and isolated from the main structure.
- For every 300mm thickness of raft the density and stiffness should be confirmed using sand replacement methods and plate bearing tests respectively. The density of the compacted layers should be modified accordingly. Plate bearing tests are specified to confirm that settlements are acceptable for the structures.
- A 1,5m wide paved strip must be placed around the entire structure.
- All yard walls, steps etc. should be isolated from the main structure to allow independent movement.
- Site drainage with service and plumbing precautions as described above.

The design of raft foundations (whether soil or concrete) should be done in accordance and under supervision of a civil or structural engineer and the NHBRC recommendations given above should be verified during construction. Strict quality control is necessary during the compaction procedure to ensure that the desired result is achieved. Densities and stiffness of the compacted soils must be controlled with suitable field tests. The design of first floor slabs should take the estimated settlement into account.

The drainage ditch that runs alongside the tar road and the one in the southern portion of the site should be backfilled with suitable inert material and compacted in controlled layers prior to development. The excavations in the south-eastern corner and in the central south-eastern portion where sand has been removed for building purposes should be treated similarly.

❖ **ZONE H**

This zone consists of the three prominent old borrow pits that have most probably been established during construction of the R544 tar road. This zone is classified as **Class P(excavations)**according to the National Home Builders Registration Council's Standards and Guidelines (NHBRC) of 1999. The following procedure is recommended prior to development.

- Rehabilitate the borrow pits by backfilling with suitable inert material compacted in controlled layers.
- Backfill in bulk (thick layers) with suitable inert material and compact the fill by means of dynamic compaction procedures.
- Test the backfill method to determine that any potential settlement is acceptable for the anticipated development.
- Design structures accordingly.
- Good site drainage with service and plumbing precautions.

- **ZONE I**

  This zone consists of the high-lying ground (koppie) present in the north-eastern portion of the site. This is characterized by extensive sandstone outcrop, sub-outcrop and steep slopes.

  - This zone should be excluded from the development and reserved as open space.

6.4 Material Usage

Two bulk disturbed samples of the top portion of the hillwash were retrieved and tested for use in layer works. The test results are not yet available but from a visual assessment this material is considered to be potentially suitable for bulk fill and lower sub-grade. The material strength could be improvedwith the addition of cement. These comments need to be confirmed with the relevant compaction and strength tests (Mod, CBR & UCS).

The roads and paved areas should be designed according to the anticipated traffic and storage/axle loads bearing the estimated settlement of the roadbed into account. Adequate drainage should be provided to ensure that ponding of surface water on and in the vicinity of the roadbed is prevented. This would ensure that ingress water does not impact negatively on the strength of layer works. This is particularly important if interlocking paving blocks are used. No trees should be planted close to the road surface.

6.5 Shallow Seepage

Water seepage associated with the presence of a shallow perched water table was encountered in test pits SP56, SP59 & SP61 at depths of 1,8m, 2,7m and 1,5m respectively excavated in the central south-western portion of the site. SP 61 is located within Zone D whilst SP56 & SP59 are located in Zone F in close proximity to the natural drainage gulley.

The presence of ferruginous concretions and ferricrete in the soil profile as well as the cemented nature and gleyed texture observed in the residual soils is an indication of a seasonal fluctuating water table. The north-western corner, south-western corner, the north-eastern corner as well as the area adjacent to the flood line in the central eastern portion are the lowest-lying portions of the site and problems with ponding of surface water could be experienced during the wet season especially after periods of heavy or prolonged rains.

The presence of rock on surface and/or shallow rock natural “springs” and a shallow perched water table might be present in Zones A, B & E during the wet season.

The developer should take cognizance of this and ensure that the necessary precautions are taken to prevent problems both during as well as after construction. In any case the necessary damp proofing precautions should be taken underneath all structures and provision will have to be made to prevent ingress of water beneath foundations.

6.6 Excavation Characteristics

The excavation characteristics of the different soil horizons encountered have been evaluated according to the South African Bureau of Standards standardised 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.

A summary of the excavation/refusal depths as encountered in the test pits is provided below in **Table 1** but for detailed excavation characteristics refer to the soil profiles in **Appendix B**. It is anticipated that for "soft to intermediate excavation" conventional earth moving equipment would suffice for the excavation of foundation and service trenches. The use of pneumatic equipment and/or blasting would be required for the excavation of foundation and service trenches in the areas described/inferred as "hard excavation".

Table 1: Summary of Excavation/Refusal Depths

TP	Maximum/Refusal Depth (m)	Material Description	Excavation Class	Zone
SP1	1.8 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP2	1.3 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP3	0.3 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP4	0.6 – refusal.	Soft rock sandstone.	Hard.	A
SP5	0.2 – refusal.	Soft rock sandstone.	Hard.	A
SP6	1.3 – refusal.	Soft to hard rock sandstone.	Hard.	D
SP7	1.7 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP8	1.6 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP9	1.5 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP10	1.5 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP11	1.1 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP12	0.4 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP13	1.5 – refusal.	Very soft to soft rock sandstone.	Intermediateto hard.	D
SP14	1.6 – refusal.	Soft rock sandstone.	Hard.	D
SP15	0.6 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP16	0.7 – refusal.	Hard rock sandstone.	Hard.	A
SP17	0.2 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP18	0.4 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP19	0.2 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP20	0.4 – refusal.	Very soft to soft rock sandstone.	Intermediate.	A

TP	Maximum/Refusal Depth (m)	Material Description	Excavation Class	Zone
SP21	1.2 – refusal.	Very soft to soft rock sandstone.	Intermediate.	B
SP22	1.2 – refusal.	Soft rock sandstone.	Hard.	B
SP23	0.55 – refusal.	Soft rock sandstone.	Hard.	A
SP24	1.0 – refusal.	Soft rock sandstone.	Hard.	A
SP25	0.5 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP26	0.4 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP27	1.1 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP28	0.5 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP29	0.7 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP30	1.1 – refusal.	Soft rock sandstone.	Hard.	B
SP31	0.45 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP32	1.3 – refusal.	Soft rock sandstone.	Hard.	B
SP33	0.4 – refusal.	Soft to hard rock sandstone.	Hard.	A
SP34	0.2 – refusal.	Soft to hard rock sandstone.	Hard.	I
SP35	1.1 – refusal.	Very soft to soft rock sandstone.	Intermediate to hard.	A
SP36	1.0 – refusal.	Very soft to soft rock sandstone.	Intermediate to hard.	B
SP37	1.4 – refusal.	Very soft rock sandstone.	Intermediate.	B
SP38	1.3 – refusal.	Soft to hard rock sandstone.	Hard.	B
SP39	1.8 – refusal.	Soft rock sandstone.	Hard.	B
SP40	3.3 – maximum.	Firm shale.	Soft.	F
SP41	2.8 – maximum.	Firm shale.	Soft.	F
SP42	1.7 – refusal.	Soft rock sandstone.	Hard.	F
SP43	0.3 – refusal.	Soft rock sandstone.	Hard.	A
SP44	0.4 – refusal.	Soft rock sandstone.	Hard.	A
SP45	0.3 – refusal.	Soft rock sandstone.	Hard.	A
SP46	2.1 – slow progress.	Very dense gritstone.	Intermediate.	C
SP47	1.8 – slow progress.	Very dense gritstone.	Intermediate.	C
SP48	1.0 – refusal.	Very soft rock gritstone.	Intermediate.	E
SP49	2.1 – slow progress.	Very dense to very soft rock gritstone.	Intermediate.	E
SP50	1.0 – refusal.	Very soft rock gritstone.	Intermediate.	E
SP51	2.5 – maximum.	Loose gritstone.	Soft.	F
SP52	2.6 – maximum.	Medium dense gritstone.	Soft.	F
SP53	1.9 – slow progress.	Very dense to very soft rock gritstone.	Intermediate.	F
SP54	2.0 – slow progress.	Very dense sandstone.	Intermediate.	C
SP55	1.8 – slow progress.	Very dense to very soft rock conglomerate.	Intermediate.	C
SP56	1.9 –refusal.	Soft rock gritstone.	Hard.	F
SP57	2.2 – refusal.	Soft rock ferricrete.	Hard.	F
SP58	2.7 – maximum.	Firm sandstone.	Soft.	F
SP59	2.7 – maximum.	Firm shale.	Soft.	F
SP60	1.3 – slow progress.	Very dense gritstone.	Intermediate.	D
SP61	1.6 – refusal.	Soft rock ferricrete.	Hard.	D
SP62	2.7 – maximum.	Firm sandstone.	Soft.	G
SP63	2.3 – slow progress.	Dense to very dense sandstone.	Intermediate.	G
SP64	2.7 – slow progress.	Dense to very dense sandstone.	Intermediate.	G
SP65	2.8 – maximum.	Dense sandstone.	Soft.	F

TP	Maximum/Refusal Depth (m)	Material Description	Excavation Class	Zone
SP66	1.6 – maximum.	Medium dense gritstone.	Soft.	G
SP67	2.8 – maximum.	Firm sandstone.	Soft.	F
SP68	2.9 – maximum.	Firm shale.	Soft.	F
SP69	2.8 – maximum.	Firm shale.	Soft.	F
SP70	2.7 – maximum.	Medium dense shale.	Soft.	F
SP71	2.5 – slow progress.	Very dense sandstone.	Intermediate.	G
SP72	2.0 – slow progress.	Very dense gritstone.	Intermediate.	G
SP73	1.4 – slow progress.	Very dense sandstone.	Intermediate.	F
SP74	2.2 – slow progress.	Very dense gritstone.	Intermediate.	F
SP75	2.7 – maximum.	Firm shale.	Soft.	F
SP76	2.8 – slow progress.	Very stiff diamictite.	Intermediate.	F
SP77	2.8 – maximum.	Firm shale.	Soft.	G
SP78	2.6 – maximum.	Firm shale.	Soft.	F
SP79	1.9 – refusal.	Soft rock gritstone.	Hard.	F
SP80	1.7 – slow progress.	Very dense to very soft rock gritstone.	Intermediate.	F
SP81	1.4 – slow progress.	Very dense ferricrete.	Intermediate.	C
SP82	2.4 – maximum.	Medium dense gritstone.	Soft.	F
SP83	1.6 – slow progress.	Very dense gritstone.	Intermediate.	C
SP84	1.6 – slow progress.	Very dense gritstone.	Intermediate.	C
SP85	1.5 – refusal.	Very soft rock gritstone.	Intermediate.	C
SP86	2.8 – maximum.	Firm shale.	Soft.	F
SP87	2.8 – maximum.	Firm shale.	Soft.	F
SP88	2.3 – slow progress.	Very stiff shale.	Intermediate.	C
SP89	0.7 – refusal.	Very soft to soft rock ferricrete.	Intermediate to hard.	B
SP90	2.8 – maximum.	Firm shale.	Soft.	F
SP91	2.8 – maximum.	Firm diamictite.	Soft.	F
SP92	1.05 – refusal.	Soft rock ferricrete.	Hard.	B
SP93	2.8 – maximum.	Firm shale.	Soft.	F
SP94	2.5 – maximum.	Dense diamictite.	Soft.	C
SP95	1.6 – slow progress.	Very dense gritstone.	Intermediate.	C
SP96	2.6 – slow progress.	Very dense gritstone.	Intermediate.	F
SP97	1.5 – refusal.	Soft rock gritstone.	Hard.	C
SP98	2.4 – slow progress.	Very dense gritstone.	Intermediate.	G
SP99	2.7 – maximum.	Medium dense gritstone.	Soft.	G
SP100	2.4 – slow progress.	Very dense sandstone.	Intermediate.	G
SP101	2.6 – maximum.	Firm sandstone.	Soft.	G
SP102	1.6 – slow progress.	Very dense sandstone.	Intermediate.	C
SP103	2.4 – slow progress.	Very dense sandstone.	Intermediate.	G
SP104	2.6 – maximum.	Medium dense gritstone.	Soft.	G
SP105	2.0 – refusal.	Soft rock sandstone.	Hard.	G
SP106	1.9 – slow progress.	Very stiff diamictite.	Intermediate.	C
SP107	2.7 – maximum.	Stiff diamictite.	Soft.	F
SP108	1.0 – refusal.	Soft rock sandstone.	Hard.	B
SP109	1.5 – slow progress.	Very stiff shale.	Intermediate.	F
SP110	2.6 – maximum.	Soft shale.	Soft.	F
SP111	2.7 – maximum.	Firm shale.	Soft.	F
SP112	2.7 – slow progress.	Very dense sandstone.	Intermediate.	G
SP113	2.6 – maximum.	Stiff shale.	Soft.	F
SP114	2.7 – slow progress.	Very dense sandstone.	Intermediate.	G
SP115	2.0 – slow progress.	Very dense sandstone.	Intermediate.	G

TP	Maximum/Refusal Depth (m)	Material Description	Excavation Class	Zone
SP116	1.9 – slow progress.	Very dense sandstone.	Intermediate.	C
SP117	2.7 – maximum.	Firm sandstone.	Soft.	C
SP118	3.0 – maximum.	Firm shale.	Soft.	F
SP119	2.9 – maximum.	Firm shale.	Soft.	F
SP120	2.0 – slow progress.	Very stiff diamictite.	Intermediate.	F
SP121	2.8 – maximum.	Firm sandstone.	Soft.	F
SP122	1.4 – refusal.	Very soft to soft rock sandstone.	Intermediate to hard.	B
SP123	2.6 – maximum.	Stiff shale.	Soft.	B
SP124	0.6 – refusal.	Soft rock sandstone.	Hard.	A
SP125	1.2 – refusal.	Very soft to soft rock sandstone.	Intermediate to hard.	A
SP126	0.4 – refusal.	Soft rock sandstone.	Hard.	A
SP127	1.8 – slow progress.	Very dense to very soft rock sandstone.	Intermediate.	B
SP128	0.4 – refusal.	Very soft to soft rock sandstone.	Intermediate to hard.	B

6.7 Stability of Excavations

The sides of test pits SP52, SP56, SP59 & SP61 collapsed during the investigation due to the loose consistency and high moisture content. In general terms it is envisaged that stability to temporary excavation faces could be provided by either lateral support or by battering the excavation back to a suitable (stable) slope angle. Stability of battered slopes and lateral support measures should be designed and constructed by a specialist geotechnical contractor and the contractor should be made responsible for the final selection of slopes and lateral support measures to ensure a safe working environment. Seepage may result in the destabilizing of the soils above the seepage and special precautions may be required.

It is recommended that all constructed embankments exceeding 1,5m or as deemed necessary by the design engineers be stabilized/protected by means of retaining walls. Embankments should be adequately compacted and protected from erosion.

6.8 Undermined Ground

The Vryheid Formation generally contains coal beds near the bottom of the succession, but coal layers also occur at shallow depth throughout the formation. The mining rights for the site investigated belongs to Eyethu Coal who operates the Leeupoortopen cast coal mine that bound the site on the south-west. Eyethu Coal prospected in this area and indicated the site is not underlain by economically exploitable coal reserves. The site investigated is not undermined.

In a letter dated 20 January 2014, Eyethu Coal indicated that they have no objection to the establishment of the proposed township provided that the development adheres to the 500m blasting limit around the present operations.Due to blasting being conducted on a regular basis the developer should take cognizance of the *"shock clause"*.*"As this site (erf, stand, parcel of land) forms part or are located in close proximity of land which may be undermined, or are currently being mined, and are potentially liable to subsidence,*

settlement, shock and/or cracking due to mining operations past, present or future, the owner/developer (applicant, grantee, as the case may be) thereof accept all liability for any damage thereto or to any structure thereon which may result from such subsidence, settlement, shock and/or cracking". All potential buyers/investors of stands/structures in the proposed development should be made aware of this clause.

6.9 Slope Instability

No potential unstable natural slopes occur on or in close proximity to the site.

6.10Erodability of the Soil Profile

The soil in the upper reaches of the profile is probably erodible if subjected to high water velocity, as it is generally cohesion less. Several small erosion "channels/gullies" were observed on site during the investigation in the areas with no or little vegetation.

6.11 Steep Slopes

Steep slope are present in the eastern portion of the site on the edge of the high ground (koppie). The remainder of the site has gentle to moderate slopes (2° to 6°).

7. GENERAL

Although every effort has been made to ensure the accuracy of the information contained in this report, the results are based upon fieldwork and limited laboratory testing only. It is thus possible that localised soil conditions at variance to those described in the report may be encountered.

It is recommended that the foundation excavations for each structure be inspected by a competent person during construction in order to verify that the materials thus exposed are not at variance with those described in the report and that it meets design criteria.

The NHBRC recommendations should be verified during construction. The placement of fill must be controlled with suitable field tests to confirm that the required densities and stiffness are achieved during compaction and that the quality of fill material is within specification.

The man-made drainage ditches, excavations where sand has been removed for building purposes, the existing borrow pits and other excavations as described should be rehabilitated prior to development. This would entail backfilling with suitable inert material compacted in controlled layers.

According to the latest NHBRC regulations a Phase II Geotechnical Investigation is required before enrolment of the site can be completed. This involves inter alia the inspection of service trenches in order to verify the soil classification for individual stands etc. It remains the responsibility of the developer to obtain the latest requirements for enrolment of the site from the NHBRC prior to construction.

The mining rights for the site investigated belongs to Eyethu Coal who operates the Leeupoort open cast coal mine that bound the site on the south-west. Eyethu Coal prospected in this area and indicated the site is not underlain by economically exploitable coal reserves. The site investigated is not undermined.

In a letter dated 20 January 2014, Eyethu Coal indicated that they have no objection to the establishment of the proposed township provided that the development adheres to the 500m blasting limit around the present operations. Due to blasting being conducted on a regular basis the developer should take cognizance of the "*shock clause"*. *"As this site (erf, stand, parcel of land) forms part or are located in close proximity of land which may be undermined, or are currently being mined, and are potentially liable to subsidence, settlement, shock and/or cracking due to mining operations past, present or future, the owner/developer (applicant, grantee, as the case may be) thereof accept all liability for any damage thereto or to any structure thereon which may result from such subsidence, settlement, shock and/or cracking"*. All potential buyers/investors of stands/structures in the proposed development should be made aware of this clause.

The site is considered suitable for the proposed township establishment and high-density residentialdevelopment provided that the recommendations made in this report are adhered too.

M.J. van der Walt (Pr.Sci.Nat.)
Engineering Geologist

8. REFERENCES

1. Guidelines for Urban Engineering Geological Investigations 1995. Published by SAIEG & SAICE.
2. National Home Builders Registration Council (NHBRC). HomeBuilding Manual, part 1 & 2, first revision February 1999.
3. Revised Guide to Soil Profiling for Civil Engineering Purposes in Southern Africa. Jennings, Brink & Williams. The Civil Engineer in SA, January 1973.
4. A Guide to Construction on or with Materials Exhibiting Additional Settlement Due to Collapse of Grain Structure. Jennings & Knight 1975.
5. The Prediction of Heave From the Plasticity Index and Percentage Clay Fraction of Soils. D.H. van der Merwe. The Civil Engineer in South Africa, June 1964.
6. Engineering Geology of Southern Africa. A.B.A. Brink.
7. Soil Survey for Engineering. Brink Partridge & Williams.
8. The Natural Road Construction Materials of Southern Africa. H.H. Weinert.
9. SABS 1200. Standardised Excavation Classification for Earthworks.
10. Technical Recommendations for Highways, TRH 14 of 1985.