GEOCALIBRE
GEOTECHNICAL CONSULTANCY

TECHNICAL REPORT

Pampierstad Multi Land Use Development

Portion of ERF 312- Vaal-Harts Settlement B- Phokwane Local Municipality

Phase 1 Geotechnical Site Investigation

Prepared for
GPO Boerdery (Pty) Ltd.

Date
13/12/2022

Compiled by
Kevin Coertzen (Pr.Sci.Nat)

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Technical Report

GC22/177

13 December 2022

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Project Details

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1.1. Background

This report describes the results of the Phase 1 Geotechnical Site Investigation conducted in support of the proposed establishment of a **multi land-use development** taking place across the southern portion of **ERF 312** of the **Vaal-Harts Settlement B.** The site is located between the towns of Hartswater (to the east) and Pampierstad (to the west); and entails a partially developed irregular shaped parcel of land, with a total extent of approximately **4.4 ha.**

The area in question falls within the boundaries of the Phokwane Local Municipality, which is an administrative area in the Frances Baard District of the Northern Cape Province of South Africa.

The detailed investigation was undertaken in order to assess the engineering geological character of the site; focussing on the geotechnical properties which will affect the overall development potential of the parcel of land in question.

1.2. Terms of Appointment

GeoCalibre Geotechnical Consultancy was appointed by *GPO Boerdery (Pty) Ltd.* to undertake the Phase 1 Geotechnical Site Investigation.

The information presented in this document is based on the information supplied by the Client prior to the commencement of the investigation; therefore, GeoCalibre Geotechnical Consultancy (Pty) Ltd- shall not be held liable for, and is indemnified against all actions, claims, demands, losses, liabilities, costs, damages and expenses prompted by, or in connection with, inaccurately relayed information pertaining to the site and/or the development.

1.3. GeoCalibre- Company Background and Information

GeoCalibre is a specialist geotechnical consulting firm made up of a team of qualified professional geo-practitioners. The firm was established out of a love for the industry and an urge to define a new calibre of professional consulting.

GeoCalibre uses advanced scientific methods to create accurate and reproducible geotechnical models; successfully guiding the implementation of site-specific design precautionary measures/engineering solutions. The methodology followed throughout the investigative process accounts for the nature and location of the development as well as adhering to the standards of our practice (SANS and SAICE).

Investigations undertaken by GeoCalibre are overseen by suitably qualified Engineering Geologists *professionally registered* (Pr.Sci.Nat) with the South African Council of Natural Scientific Professions (SACNASP)- in accordance with all the relevant and required procedures and legislations.

GeoCalibres employees are also members of the South African Institute for Engineering and Environmental Geologists (SAIEG).

1.4. Codes of Practise and Investigative Standard

The investigation was carried according to the following standard practice codes and guidelines:

- The NHBRC Home Building Manual (2015)
- Geotechnical Investigations for Township Developments- SANS 634 (2012)
- Guidelines for Urban Engineering Geological Investigations (SAIEG & SAICE, 1997) for urban development
- SANS 10400

1.5. Limitations of the Geotechnical Assessment

The presented geotechnical model is based on point data; with our opinions based on what was visible at the time of the investigation. The investigation has therefore attempted, through interpolation and extrapolation of known testing locations, to identify problem issues of a geotechnical nature on which this report is based. Variances in soil and rock quality and quantity from those predicted may be encountered during construction and these should be recorded.

Foundation trenches and excavations for deep services should be overseen by a competent person to identify and assess any variance in the geotechnical character exposed in these trenches (Phase 2 Investigation).

1.6. Information Sources

- **Geological Map:**
  - Geological Series Map 2724 Christiana; scale 1 : 250 000 (digital copy)
- **Hydrogeological Data:**
  - SADC Groundwater Information Portal (SADC GIP)
  - Hydrogeological Series Map 2722 Kimberley; scale 1 : 500 000 (digital copy)
  - Electronic Maps of the Water Management Areas and Drainage Regions in South Africa- DWAF [Department of Water Affairs and Forestry]- 1996 and 1999 (www.dwa.gov.za).
- **Topocadastral maps:**
  - 2724 Dc; scale 1:50 000 (digital copy)
- **Remote Sensing Information:**
  - Google Earth Pro ™
  - Elevation Heat Map; Online Resource
  - Planet GIS (Northern Cape Cadastral Land Layer)
- **Provided by the Client:**
  - Site development plan- option 4
  - Drawing No. 10963/C/M/L001
- **Available geotechnical reports:**
  - Numerous reports from the region compiled by Kevin Coertzen (Pri.Sci.Nat and MSAIEG)

1.7. Scope of the Investigation

A geotechnical site investigation was be carried out across the site in question in order to assess the mechanical nature of the underlying strata as well as model the geomorphological nature of the area as a whole. Following the detailed assessment, GeoCalibre provides recommendations on the implementation of **site-specific engineering solutions.**

The aim of the overall site investigation can be summarised as follows:

- Establishment of a **regional geological**, **geomorphological** and **geo-technical** model for the site.
- To delineate the **succession of strata** (soil and rock) underlying the site; with the identification of problematic **physical, chemical** and **mechanical** characteristics which may influence the development.
- To quantify the **in-situ mechanical properties** of the soft materials underlying the site; specifically, with regards to the proposed future developments.
- To compute the **excavatability properties** of the materials underlying the site.
- To assess shallow **groundwater** patterns.
- To evaluate the **re-usage potential** of the materials underlying the site.
- To aid the development moving forward through the formulation of an **accurate geotechnical model** for the site under investigation.

This investigation was conducted to aid the decision-making processes during the land rezoning phase of the development- and to serve as specialist input for structural design.

The investigation <u>excludes</u> the following aspects, where applicable:

- Phase 2 Investigations
- Geophysical, resistivity, or corrosion studies
- Detailed hydrological, hydropedological, hydrogeological, pedological, flood line, or wetland delineation studies
- Detailed slope stability assessment

1.8. Investigative Methodology

The investigation is undertaken in several phases in order to achieve the aims discussed above. The investigative phases are as follows:

- **Phase 1: Introduction and Regional Assessment of the Site**
- **Phase 2: Geotechnical Analysis - Engineering Geological Investigation**
- **Phase 3: Data Assessment and Report Compilation**

1.8.1. Phase 1: Introduction and Regional Assessment of the Site

The collation and evaluation of all the available topographic, geo-morphological and geological data across the investigated site and its' surroundings. This assessment is done using available regional maps and remote sensing images. This section of the report will include a description and summary of the site's nature, based on existing literature, and is supplemented with the compilation of a series of base maps.

1.8.2. Phase 2: Geotechnical Analysis- Engineering Geological Investigation

Trenching and Sampling

The field work phase of the investigation was conducted by GeoCalibre in October 2022. A total of eight (8) test pits (TP1 to TP8) were excavated using a TLB-type light mechanical excavator (JCB 3CX).

Test pits were distributed across the site; at locations chosen on merit to map and model variances in the underlying strata. This allows for data to be extrapolated between known testing points in order to create an accurate and reproducible site-specific geotechnical model.

A number of challenges arose regarding trial pit placements; however, the project team managed the risk- with the placement of trial pits in such a way so as to create an accurate and reproducible site-specific geotechnical model.

The succession of soil layers exposed within the test pits and exposures were logged by GeoCalibre and a series of detailed photographs were taken of the different soil layers.

Undisturbed, disturbed and bulk samples were taken of the material deemed to be important to the proposed development. Laboratory testing commenced on the samples collected during the field work phase of the investigation. The quantity and locations of samples were governed by the nature of the development and the in-situ characteristics of the excavated material.

Laboratory Testing

Standard foundation indicator and soil compaction tests were conducted by Letaba Lab Bloemfontein (**SANAS Accredited**) on disturbed and bulk soil samples. These tests were undertaken to determine the composition of the underlying soils (i.e.: the relative percentages of gravel, sand, silt and clay) and to evaluate the suitability of the materials for the re-use in the proposed construction.

The following tests were conducted:

I. Atterberg limits (Liquid Limit, Plasticity Index and Linear Shrinkage)- (SANS 3001: GR10/11)

II. Particle-size Distribution (SANS 3001: GR1)

III. Maximum Dry Density versus Optimum Moisture Content (SANS 3001: GR30)

IV. Californian Bearing Ratio versus Compaction Effort (MOD AASHTO method) (SANS 3001: GR40)

V. Double hydrometer as an indication of material dispersivity (chemical testing)

VI. pH and Electrical Conductivity (EC)

Specialist **undisturbed sample testing** was conducted by Steyn-Wilson Geotechnical, to quantify the in-situ mechanical properties of the soft materials underlying the site.

The following specialist tests were conducted:

I. Single- oedometers
II. Free Swell
III. Collapse potential
IV. Bulk density
V. Moisture content

1.8.3. Phase 3: Data Assessment and Report Compilation

The investigation concluded with the compilation of a technical report detailing the methodology utilised during the study and the summarised results obtained. This includes a potential geotechnical evaluation of the site as well as the associated NHBRC Site Class Designation, based on the investigative results.

1.9. Development within 1 : 100 year-flood lines

It must be noted that the National Water Act (Act 36 of 1998) states the following regarding development within the 1 : 100 year-flood lines of any stream or river (Thompson, 2006):

Section 21(c): Impeding or diverting the flow of water in watercourses (including alteration of the hydraulic characteristics of flood events) requires licensing according to the Act.

Section 21(i): Any action that may alter the bed, banks, courses, or characteristics of watercourses (including flood events) requires licensing according to the Act, including: widening or straightening of the bed or banks of a river to allow for the construction the housing development and altering the course of a river partially or completely (i.e.: river diversion) to be able to use or develop the area where the watercourse originally was.

The National Water Act does not prohibit development within 1 : 100 year-flood lines; however, the Act requires detailed analysis of the effects of the proposed development on the surrounding environment, with special reference to surface and sub-surface water flow.

The Act requires that suitable precautionary measures be implemented to limit the effect within and downstream from the proposed development.

2. Description of the Environment

2.1. Site Location and Description

The **study area** for this investigation is located across the far eastern portions of the Northern Cape Province of South Africa. On a more localised scale, the study area falls between the towns of Hartswater (to the east) and Pampierstad (to the west) (Figure 1); within the bounds of the Phokwane Local Municipality.

The **site** which forms the focal point of this investigation spans the southern portion of **ERF 312** of the **Vaal-Harts Settlement B.** This partially developed irregular shaped parcel of land exhibits a total extent of approximately **4.4 ha.** At the time of this investigation, the site was accessible via numerous gravel farm roads; however, future access is envisaged from the sealed district road which forms the sites southern boundary. Terrain accessibility/mobility is aided by a basic internal road network.

The site for this investigation is located at the following coordinates:

Latitude: 27.789628° S **Longitude:** 24.718154° E

This investigation was conducted to aid the decision-making processes during the land rezoning phase of the development and to serve as specialist input for structural design. The planned development across the surface will encompass the subdivision of this land portion into various land-use zones i.e., infrastructural units, roadways, and services etc. Each of these zones may require their own set of geotechnical assessments and associated engineering solutions.

The sites surface was seen to display a **reworked nature** attributed to past and ongoing **human activities** in the area. This reworking was predominantly in the form of surficial fills, relict canals/foundations/structures and historic agricultural practices. The exact extent of the existing/past surface and subsurface infrastructure in this region is not known. The combination of the anthropogenic processes has affected the continuity of the sites' topographic nature as well as its' inherent geotechnical characteristics. The exact extent of the existing/past surface and subsurface infrastructure in this region is not known.

The photo series below depicts the reworked surficial nature of the site.

2.2. Topography

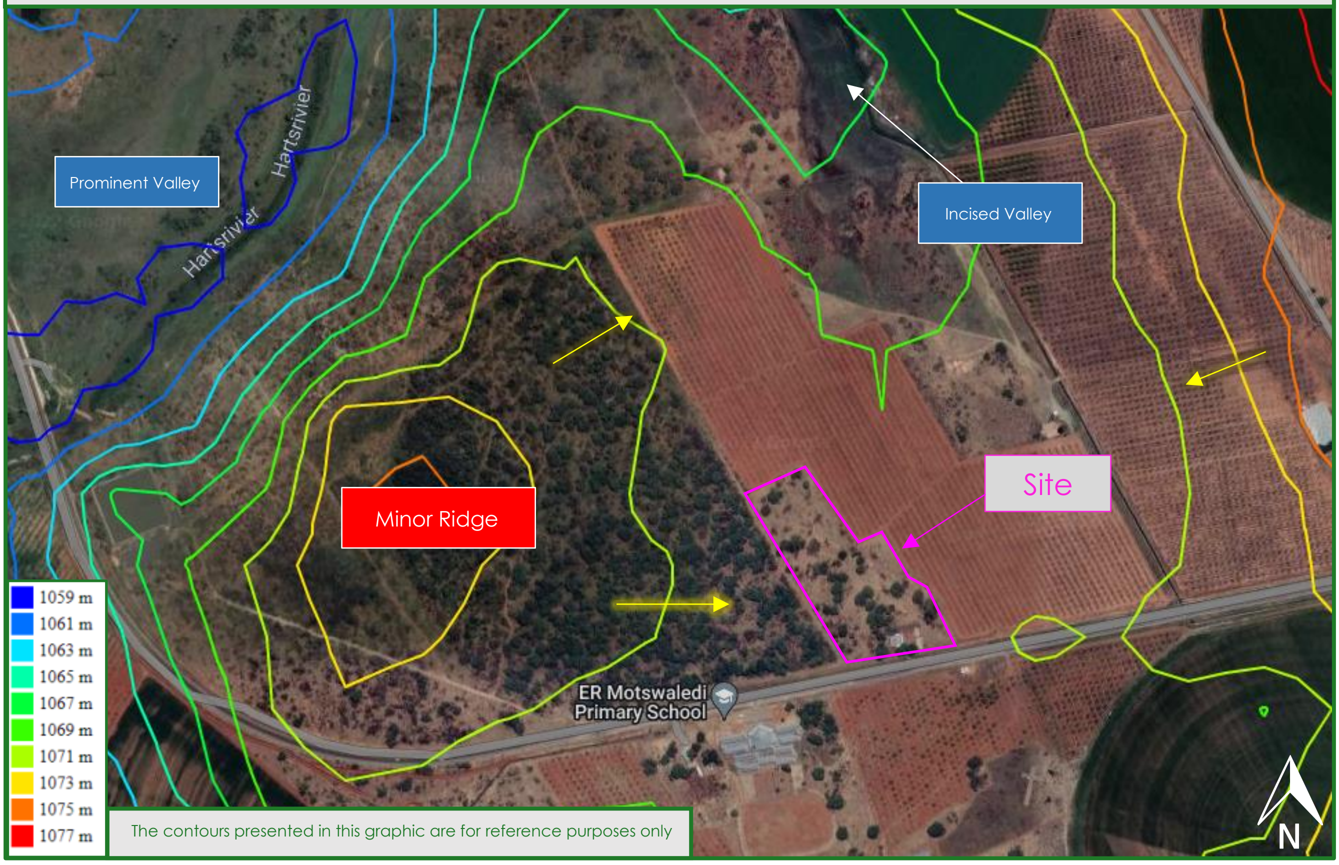
Topography is based on elevation profiles from the available remote sensing information and basic field observations. This does not substitute land survey data. Topography and regional hydrology (e.g., steep slopes, very flat slopes, defined drainage features, and rapid changes in slope) affect the distribution of ground as it affects the weathering, erosion, transport, and deposition of materials. As such, it provides a valuable indication of possible changes in subsurface ground and water conditions, but also affects the stability of slopes and the direction of surface runoff.

The regional setting is seen to display an **undulating surface morphology** with an irregular shaped **dolerite ridge,** surrounded by continuous low-lying terrain. This assortment is because of past plutonic processes. The low-lying areas- between dolerite ridges- are frequently filled over time with transported sediments of varying shapes and sizes (quaternary aged sediments).

As seen in the annotated topographic model below (Image 1); a **minor radial ridge** landform (orange and yellow contours) is seen to traverse the western to south western portion of the study area. This topographic feature forms the geographic **watershed** for the site and its immediate surrounds, with the degree of sloping decreasing with an increased distance from its crests. Furthermore, an **incised valley** meanders its way through the low-lying terrain in the east and north east.

Image 1 graphically depicts the topographic nature of the study area.

Image 1: Study Area- Annotated Topographic Model



Although the image depicts a fluctuating geomorphological environment (constant changes in colour), the range in elevation is notably low. This serves as evidence for a uniform and continuous surficial morphology.

The topographic nature of the **site** itself is similar to that observed on a regional scale. As a whole, the **natural slopes** seen to traverse the site display a **very gentle sloping nature** with a declivity of **less than 2 degrees**. The **natural slopes** display an overall **easterly to north easterly declivity.** The south western and western portions of the site are seen to display the highest elevations of approximately 1071 meters above mean sea level (MAMSL); decreasing to an elevation of approximately 1070 MAMSL in the far north eastern portions (calculated using Google Earth PRO^{tm}).

A **minor unlined canal/relict depression** traverses the south western portion of the site- oriented generally NW/SE- the canal is no longer active.

The artificial reworking of the sites surface affects the continuity and degree of **natural slopes** traversing its' footprint, impacting its' natural drainage character and resulting in the formation of **small-scale topographic anomalies**. Small scale topographic anomalies will need to be addressed individually in the engineering design and in so doing eliminating their localised effects. Please note that these processes have not only artificially diversified the topographical nature of the investigated site, but also its geotechnical character.

Based on the available information, the development will entail the **rehabilitation** of the site's surface- within and immediately surrounding the planned structures and associated services.

2.3. Drainage

The drainage nature of the site will mirror its' topographic nature as described in Section 2.2 of this report. The **ridge** landform traversing the south western portion of the study area will serve as the primary watershed for the site. The site is situated within close proximity to the watershed landform, for this reason the **local catchment area is limited**.

The developments orientation in relation to the natural slopes will impact the rate and associated energy of the overland flow. Due to the sites' overall **very gentle sloping nature**, it will drain mainly by means of **low energy surface run-off (sheet-flow);** with storm water flowing from the high-lying south western and western portions, in a general north easterly direction.

The very gentle sloping portions of the site will be subjected to elevated degrees of **surface water infiltration** into the underlying soils, rather than rapid surface water flow, accentuating **surface water ponding** and **fluctuating moisture conditions** after prolonged precipitation events. Should excessive infiltration take place across the undeveloped/open high-lying portions of the site; it is predicted that elevated volumes of shallow ground water throughflow may occur.

The natural/anthropogenic reworking of the sites surface will result in local variations of surface water flow- both rate and direction. Emphasis will need to be placed on remoulding the surface of the site, understanding that the continuity and manipulation of the topography and associated drainage plays a pivotal role in the longevity and sustainability of the development as a whole.

According to the available information (Topocadastral Maps 2724 Dc - Figure 3), there are no **natural** drainage structures traversing the investigated site. The surface runoff will be channelled away artificially due to the presence of infrastructure between the site and natural drainage systems in the area.

2.4. Climate

The climate around the site is similar to that of Christiana (situated to the south east) and is essentially a continental one, where the weather provides hot wet summers (December to February) and mild dry winters (June to August). The infrequent summer rains tend to take the form of occasional severe thunderstorms rather than prolonged soft showers. It is not unusual for winter night-time temperatures to drop below freezing.

Christiana normally receives about **320mm** of rain per year, with most rainfall occurring during **summer**. It receives the lowest rainfall (0mm) in July and the highest (63mm) in March. The average midday temperatures for Christiana range from 18°C in June to 31.8°C in January. The region is the coldest during July when the mercury drops to 0°C on average during the night.

According to *Köppen and Geiger* climate classification, the climate is classified as **Arid Climate (BSh)** and **Cold Interior** (SANS 204-2).

Climate determines the mode and rate of **weathering**. The effect of climate on the weathering process (i.e. soil formation) is determined by the climatic N value defined by Weinert, 1980.

The climatic N-value (Weinert, 1980) of the area is deemed to be between **7.5 and 10**; therefore, **physical/mechanical disintegration** of the parent rocks in the regional setting is deemed the principal mode of weathering. This mode of weathering favours the formation of an abundance of rocky fragments occurring within the soil matrix. Chemical disintegration of parent rock will take place but on a lower scale.

2.5. Vegetation and Biotic Activity

The study area is located within the **Kalahari Hardveld Bushveld Bioregion** of the *Savanna Biome* (Mucina and Rutherford, 2006).

At the time of this investigation, the vegetation across the site was comprised predominately of a dense grass cover with occasional shrubs as well as scattered groups of large trees.

Abundant organic material was exposed in the blanketing topsoil horizon, with a visible decrease in root occurrence with an increase in depth. In the areas hosting shrubs/trees- greater amounts of sub-surface vegetation is predicted to occur. The effects of the removal of trees on sites should also be considered, particularly where trees have **depressed the water table over a period**. The removal of large trees can result in the formation of highly compressible zones of voided soils. Such areas should be treated as zones of possible risk.

The degree of organic material and biotic activity was seen to decrease with an increase in depth, with **major root systems** (organic rich topsoil/aeolian sand) reaching to a depth of **approximately 0.83 m** below the existing ground level.

Many structures are likely to be near planted or self-sown trees during their useful life. In some situations, trees can adversely affect structures and induce damage. All trees should be regarded as a potential source of damage. The greatest risk of direct damage occurs close to the tree from the growth of the main trunk and roots and diminishes rapidly with distance.

The following varieties are, however, particularly prone to causing damage:

a) all eucalyptus varieties

b) London planes

c) willows (Salix) of any type

d) jacarandas.

Trees can cause direct damage by

a) the growth of roots or the base of the trunk lifting or distorting structures

b) the disruption of underground services and pipelines

c) the direct contact of branches with the superstructure

Where adequate distances are not observed, precautions, such as the reinforcement of foundations to resist lateral thrusts and the bridging over of roots to allow for future growth, should be adopted.

The site was seen to host **biological activity** in the form of localised- and somewhat scattered- biological tunnels and nests. Tunnelling- predicted to be as a result of warthogs- was more prolific in the western and north western portions of the site.

The photo series below depicts examples of the biological activity across the site:






2.6. Cemetery Sites

No mounds, suggestive of semi-formal graves, or burial sites were observed during the site investigation.

3. Regional Geological and Hydrogeological Setting

3.1. Introduction

The regional geology provides geological context to the anticipated distribution of geological material and how these can affect the distribution of lithologies (rock types) with different chemical, mineralogical, structural, and mechanical properties. Bedrock refers to the rock directly underlying the site and, when exposed to surface, is referred to as outcrop. Bedrock can be underlain by other rock types at shallow depths, and it is usually overlain by residual soils derived of its in-situ weathering and transported soils deposited from other positions.

3.2. Regional Stratigraphic Setting

According to the available geological information (geological series map: 2724 Christiana); the study area is primarily underlain by **windblown sands**- **Qw** (Quaternary aged aeolian dune sand) covering the older Karoo Supergroup sedimentary rocks (Permian Age) (Figure 2).

Quaternary sediment deposits are extensive throughout the study area- the prevalence of which can be linked to the region's geomorphology. **No** bedrock nor its weathered counterparts were encountered across the site.

Based on the available exposures, the site was seen to by display **alternating sequences** of transported sediments. These young deposits consist of **multiple cycles** of deposition resulting from varying transport mechanisms (a combination of both aeolian and colluvial). The final product is a **layered sediment deposit** with frequent in-situ variations in predominantly composition and colour.

The site is primary blanketed by a fin-grained and loose deposit of **aeolian sand.** The primary make-up of the aeolian sediment deposits include resistant quartz particles along with less resistant micas and feldspars (clays). The less resistant minerals typically weather to a clay which bridges the gaps between the more resistant minerals. These **clay bridges** give high strength to the aeolian soils under dry conditions, however very low strength under wet conditions. As such, these soils frequently undergo **collapse settlement** under an **increase in moisture conditions**.

The aeolian sediments were calcified to varying degrees at depth. Calcrete may develop as a **groundwater** or **pedogenic** types depending on whether precipitation occurred above a shallow groundwater table or if the carbonate has been carried downwards through the soil by rainwater. Calcretes also typically form in areas with rainfall below 550 mm/y. In some instances, the groundwater table occurs directly below the hardpan horizon.

The typical intercalated nature of fine soil (matrix) and calcrete particles (gravels and cobbles) results in subsoils which display an inconsistent/discontinuous geotechnical nature, amplifying the degree of anticipated **differential movement** upon loading.

3.3. Dolomitic Terrain

The study area does not reflect any risk for the formation of sinkholes or subsidence's caused by the presence of water-soluble rocks (dolomite or limestone), and as such is **not deemed "*dolomitic land*".**

3.4. Mineral Deposits

According to the geological maps and accompanied explanation **no** specific mineral deposits are present on the site.

3.5. Prominent Geological Structures

According to the available information, no geological structures are mapped to traverse the study area.

Geological mapping is based on surficial outcrops and aeromagnetic data (regional geophysical data), either of which are not feasible in a geological setting of this nature. The thick sediment deposits blanket geological structures, with their extensive nature and thickness obscuring traceable geophysical patterns and evidence.

3.6. Seismic Risk

According to Kijko et al (2003) the regional seismic hazard in the project area can be defined as **LOW**, exhibiting a 10% probability of a seismic event with a mining related peak ground acceleration of **less than 100 cm/s^2** within a period of 50 years.

3.7. Hydrogeological Setting

The findings of a detailed hydrological survey- conducted by a competent specialist- overwrites the information presented below (where applicable).

The site falls within the **Quaternary Catchment Area C33A**, which forms part of the **Harts River** Catchment Area.

It is envisaged that the future development across the site will be serviced by local municipal services, for this reason, no site-specific hydraulic conductivity tests or borehole searches were undertaken. Appropriate percolation and permeability tests should be undertaken in the event that local sanitation, such as septic tank and French drains are considered (SANS 10400-P).

According to the SADC Groundwater Information Portal (SADC GIP) there are no recent boreholes drilled across or within close proximity to the study area in question. For this reason, the static rest level and chemistry of the ground water cannot be discussed. A hydro census can be conducted across the site to determine the ground water table depth, location and quality/category underlying the site.

According to the available hydrogeological information (2722 Kimberley (2003)); the study area is mainly underlain by **Fractured Aquifers** of low yield with **limited potential (B2)-** an average borehole yield class of between 0.1 and 0.5 median l/s can be expected. Enhanced groundwater recharge, and related localized seepage, may occur within the fractured bedrock surrounding geological features.

The ground water **quality** is deemed to be between **70 and 300 mS/m**. The bedrock underlying the study area at depth represents a weathered- and fractured aquifer where groundwater rest level occurs within fractures of the bedrock at depth.

According to the available information, large scale groundwater abstraction does not take place within close proximity to the site.

4. Geotechnical Evaluation

4.1. Slope Stability and Erosion

Developments of this nature typically include the rehabilitation/remoulding of the site's surface- within and immediately surrounding the planned structures.

Emphasis should be placed on surface drainage and storm water control measures to avoid both surface water ponding and concentrated water flow (erosion) across the development area. Structures constructed perpendicular to the natural slopes will result in the ponding of surface water. Furthermore, the development will influence natural infiltration and run-off rates and appropriate precautions against concentrated flow must therefore be implemented.

No natural slope instabilities were visible in these areas at the time of the investigation (basic inspection). The final layout of the development is not known but based on the limited natural slopes prior to modification (majority of the site), specialised methods for the stabilisation of cuts into the existing slopes are not deemed necessary. Due to the site gradient- cut to fill site preparation is also not expected.

The very gentle sloping nature across the vast majority of the site will aid surface water **infiltration** into the underlying soils, rather than rapid surface water flow, accentuating surface water ponding and fluctuating moisture conditions after prolonged precipitation events. Surface water ponding will be more prolific in areas hosting natural and/or anthropogenic depressions and where bulk earthworks are employed to create level platforms.

Due to the sites' natural slope, erosion will not be a major concern. The blanketing soils are deemed to be **erodible** classifying as a **SM** type material according to the USCS. In addition, the blanketing sandy soils are deemed to be dispersive. The modification of the sites' surface and the compaction of the topsoil through vehicle and/or foot traffic will result in poor drainage characteristics and the possibility of channelized/concentrated surface water flow. Erosion is predicted to be more prolific in areas where concentrated surface water flow is induced anthropogenically and where the natural vegetation is stripped.

Attention must be given to site contouring to ensure an effective gradient is achieved so that standing water does not occur, and the draining of water is efficient to minimise erosion and damage to the construction.

The anthropogenic reworking of the sites surface will result in local variations of surface water flow- both rate and direction. The continuity and manipulation of the topography and associated drainage plays a pivotal role in the longevity and sustainability of the development.

Once surveyed, small scale topographic anomalies will need to be addressed individually in the engineering design and in so doing eliminating their localised effects. Adequate drainage measures can be discussed with the project team once the design/layout of the development has been formulated.

4.2. Trenching

The field work phase of the investigation was conducted by GeoCalibre in October 2022.

Test pits were distributed across the site; at locations chosen on merit to map and model variances in the underlying strata (Figure 5). This allows for data to be extrapolated between known testing points in order to create an accurate and reproducible site-specific geotechnical model.

A number of challenges arose regarding trial pit placements; however, the project team managed the risk- with the placement of trial pits in such a way so as to create an accurate and reproducible site-specific geotechnical model.

A total of eight (8) test pits (TP1 to TP8) were excavated using a TLB-type light mechanical excavator (JCB 3CX). The succession of soil layers exposed within the test pits and exposures were logged and a series of detailed photographs were taken of the soil layers.

A Professional Engineering Geologist supervised the excavation of the trial pits. The description of soil profiles is done according to SANS 633:2012 and describes the moisture, colour, consistency, structure, (soil) texture and origin.

The soil profile is described according to the following parameters:

- **Moisture** dictates the colour and consistency of soils and indicates how and where water moves and the depth to perched water systems.
- **Colour** indicates the oxidizing or reducing state of soils and assist in the identification of minerals in completely weathered to fresh rock.
- **Consistency** is separated between cohesive and granular as the drainage and permeability affects the soil's shear strength.
- **Structure** describes any relict features from rock or soil and those that form through packing, soil and rock structures, seepage, reworking and biotic action.
- **Texture** is the abundance of different grain sizes in soils and is described by means of field test.
- **Origin** is the formation of the soil by means of transport of weathering.

Following the detailed logging, undisturbed, disturbed and bulk samples were taken of the material deemed to be important to the proposed development.

4.3. Generalized Ground Profile

Note: this description is based on field observations and does **not** reflect the results of any laboratory tests.

4.3.1. Introduction

The results of the trenching phase indicate that the vast majority of the site is blanketed by a fine-grained transported material deemed to be of an **aeolian origin.** The uppermost extent of this material was **artificially reworked** to a degree as a result of the past **anthropogenic processes** undertaken across the site.

The above defined sandy materials were underlain by **pedogenic materials** in the form of **calcified aeolian sand** and **concretionary calcrete**. Difficult excavation conditions were experience from shallow depths due to the cemented structure of these materials as well as the occurrence of boulder sized particles/decomposed calcrete.

Detailed soil profile logs are included in **Appendix A.**

Refer to Table 1 overleaf which depicts the summarised ground profile of the site. Following this table, Image 2 depicts the testing locations across the area.

Table 1: Summarised Ground Profile for the Site

Summarised Ground Profile															
Test Pit	Topsoil/Aeolian Sand			Calcified Aeolian Sand			Concretionary Calcrete			Excavation Character			Ground Water Seepage		Excavation Stability
	From	To	Thickness (m)	From	To	Thickness (m)	From	To	Thickness (m)	Test pit depth (m)	Termination Conditions	Termination Material	Seepage Depth (m)	Seepage Rate	
TP1	0,00	0,91	0,91	0,91	2,45	1,54	2,45	3,00	0,55	3,00	DE	CC	-	-	Minor Collapse
TP2	0,00	1,23	1,23	1,23	2,75	1,52	2,75	3,10	0,35	3,10	ES	CC	3,10	Very Slow	Stable
TP3	0,00	0,81	0,81	0,81	2,50	1,70	2,50	3,10	0,60	3,10	DE	CC	3,10	Slow	Minor Collapse
TP4	0,00	0,41	0,41	0,41	1,85	1,44	1,85	3,00	1,15	3,00	ES	CC	3,00	Slow	Stable
TP5	0,00	0,74	0,74	0,74	2,25	1,51	2,25	2,90	0,65	2,90	ES	CC	2,45	Moderate	Minor Collapse
TP6	0,00	0,65	0,65	0,65	2,33	1,68	2,33	3,00	0,67	3,00	ES	CC	2,33	Moderate	Stable
TP7	0,00	1,18	1,18	1,18	2,30	1,12	2,30	3,00	0,70	3,00	ES	CC	3,00	Slow	Minor Collapse
TP8	0,00	0,68	0,68	0,68	2,25	1,57	2,25	3,10	0,85	3,10	ES	CC	-	-	Minor Collapse
Data Summary	**Minimum**		0,41	0,41	1,85	1,12	1,85	2,90	0,35	2,90			2,33		
	Max		1,23	1,23	2,75	1,70	2,75	3,10	1,15	3,10			3,10		
	Average		**0,83**	0,83	2,34	**1,51**	2,34	3,03	**0,69**	**3,03**			**2,83**		
Notes:	Thickness refers to the exposed thickness of each soil horizon (meters) All depths displayed in meters (m) Horizon depths displayed in the table are average measured values Excavation conditions: R-Refusal; DE - Difficult Excavation; ES- Excavation Stopped Materials: CC- Concretionary Calcrete														

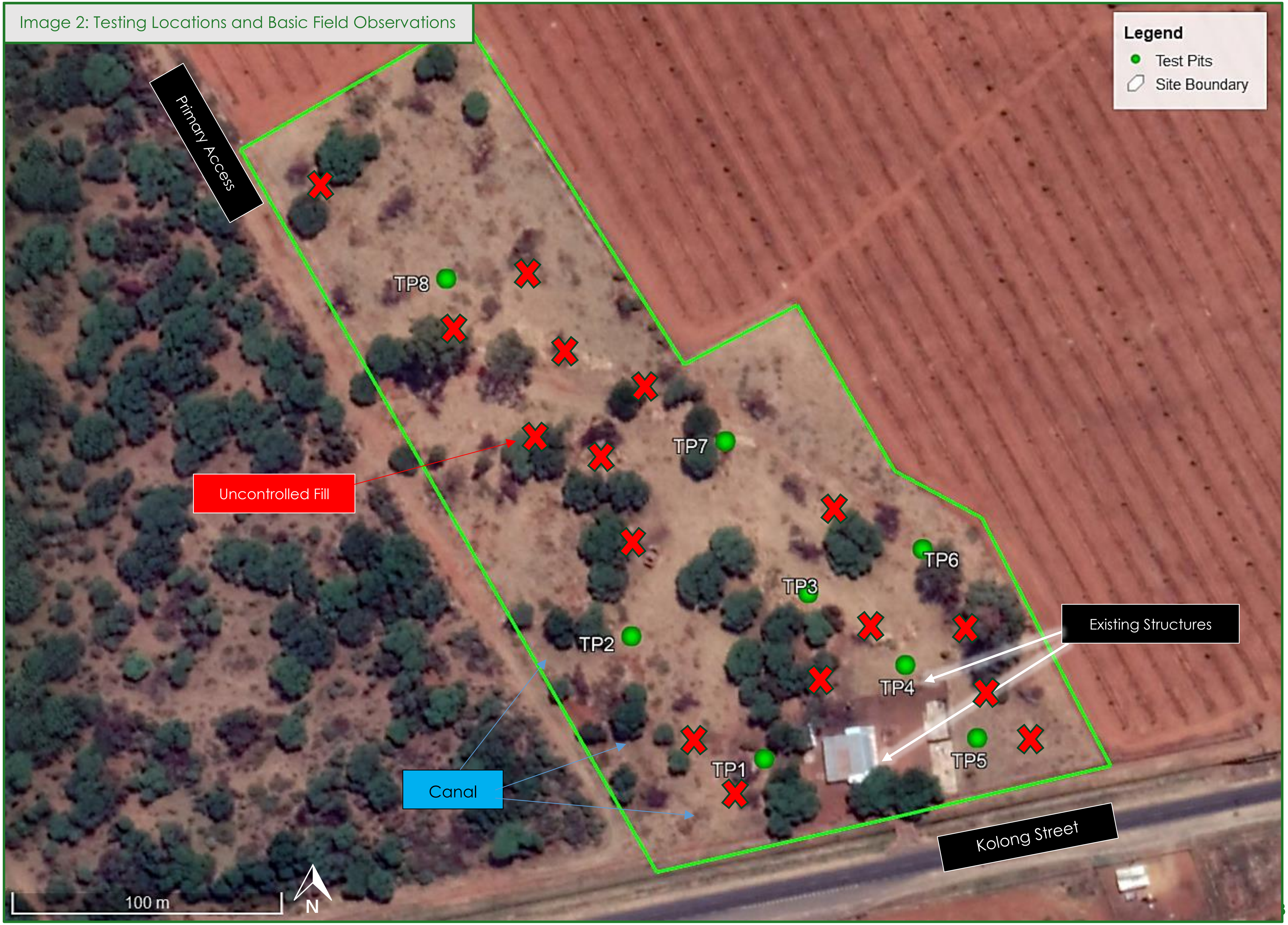


Image 2: Testing Locations and Basic Field Observations

The information presented below is based on point data. Every effort was made during the site investigation to ensure that generally accepted practices of our profession were used in the sub-surface evaluation of the site, and that the sampling and testing was representative of the soil/rock conditions observed on-site. Variances in soil quality and quantity from those predicted may be encountered during construction and these should be recorded.

The ground profiles across the site can be **generally summarised** as follows:

4.3.2. Fill Materials (Human Origin)

Surficial uncontrolled fill material and relict infrastructure/services was present across scattered portions of the site. These combined successions of fill material were dumped/reworked across the area in an **uncontrolled manner** during past anthropogenic activities.

Based on surficial exposures, this material displayed a highly variable composition (heterogenous range of particles), thickness and consistency, with the occurrence of anthropogenic contamination in the form of building rubble and waste. These parameters have resulted in subsoils which display an inconsistent/discontinuous geotechnical nature (soil mechanics).

It is predicted that this material shares a **similar composition** and **plasticity** as compared to the **natural soils** (excluding the minor artificial contamination); insinuating that the **primary make-up** of the uncontrolled fill is **backfilled natural soils**. Due to its age, it will however lack the pre-consolidation characteristics of the natural soils. This will result in consolidation and collapse settlement upon loading; with its heterogenous composition amplifying differential settlement.

The **mechanics** of these deposits are predicted to be **highly variable** as a result of the both the variable nature of the particles (rock or waste) and the variable interaction between individual particles.

Small **landfill areas** were present across scattered portions of the site (examples of which are annotated on image 2)- with these areas primarily hosting dumped natural materials (calcrete boulders etc.)- with lesser extents of domestic waste and rubble. Surficial heaps of fill ranged in shape and size sporadically.

Notable successions of reworked topsoil/fill were exposed in test pits **TP1** and **TP5**. Where encountered, this material was described as: *slightly moist; dak reddish brown, blotched white and grey, banded grey;* ***very loose****; pinholed;* ***silty sand with traces of sub-rounded calcrete cobbles****; reworked topsoil;* ***variable intercalated natural materials and rubble/waste; organic rich topsoil with minor anthropogenic contamination.***

In these test pits, this material was present from the **surface** extending to depths of between **0.74 and 0.91 m** below the existing ground level (E.G.L.).

As for the removal of relict infrastructure, it is strongly recommended that this material be **selectively mined** and **removed** from within the footprint of the proposed development (extent determined by the design engineer). The location and extent of these anomalies can be mapped by the surveyor for the amalgamation into the local earthworks model.

4.3.3. Aeolian Sand

Transported material- deemed to be of **aeolian origin** (windblown sand)- were seen to dominate the sub-terrain (foundation zone). The exposed successions of aeolian sand were seen to be slightly variable, with fluctuations in moisture content, consistency and colour across the site. The upper extent of the aeolian sand was generally **reworked** and/or **contaminated** to varying degrees as a result of past and on-going human activities in the area. Furthermore, across the undeveloped portions of the site, the uppermost extent of this material was seen to be **organic rich**, with a gradual degree in root occurrence with depth.

Due to its age and shallow occurrence- this sandy deposit may **lack** essential pre-consolidation characteristics. This will result in additional consolidation settlement upon saturation and loading.

The exposed aeolian sands were generally described as a: *predominately slightly moist with moist pockets; dark red, blotched grey and cream;* ***very loose, loose or loose with medium dense pockets****;* ***pinholed****;* ***silty sand*** *with traces of basal calcrete concretions; aeolian sand;* ***abundant fine roots with minor medium sized roots****; heterogenous composition;* ***decomposed organic.***

As a whole, the aeolian sand was seen to display a **low in-situ density**, fine-grained nature and a **voided fabric**; attributes typically associated with **potentially collapsible soils**.

This sediment was generally seen to extended from the surface to depths of between **0.41** and **1.23 m** below E.G.L.- displaying an **average exposed thickness** of **0.83 m.**

4.3.4. Pedogenic Material- Varying Grades of Calcrete

Across the entire site, the above-described sandy materials were seen to be underlain by a variable pedogenic material deemed to be **calcified aeolian sand**, followed by **concretionary calcrete** at depth.

Calcrete may develop as a groundwater or pedogenic types depending on whether precipitation occurred above a shallow groundwater table or if the carbonate has been carried downwards through the soil by rainwater. Calcretes also typically form in areas with rainfall below 550 mm/y. In some instances, the groundwater table occurs directly below the hardpan horizon.

The formation of pedocrete is linked to the morphology of the investigated area. Due to the **very gentle sloping nature** of the area, the processes of water **infiltration** and surface water ponding are favoured over surface water run-off (sheet flow). The infiltration of water, subsequent temporary perching on less permeable underlying material and evaporation has resulted in the precipitation of pedocretes and the ensuing natural reworking of the in-situ materials.

Calcified aeolian sand

The calcified aeolian sand displays **variable degrees of induration** and **calcification,** ranging from minor to abundant amounts. A general **increase in calcification** with depth was observed within the horizon. The calcified sand is characterised by a partially cemented structure and heterogenous composition.

The calcified aeolian sand was generally described as a: *slightly moist to moist at base; dark red, blotched grey and cream;* ***loose with medium dense pockets****;* ***matrix supported and partially cemented****;* ***calcrete nodules and concretions*** *in a* ***matrix of silty sand****; calcified aeolian sand;* ***minor or traces of fine roots*** *and decomposed organics; pockets of* ***variable concretionary calcrete*** *with* ***localized calcrete boulders****; traces of small calcrete boulders.*

The **calcified sediment** was encountered from below the sandy soils- extending to a depth of between **1.85 and 2.75 m** below E.G.L.- displaying an **average exposed thickness of 1.51 m.**

<u>**Concretionary calcrete**</u>

Concretionary calcrete was exposed at depth across the site. A general **gradual contact** was present between the various pedogenic materials- with the transitional zone poorly defined due to intercalated materials.

The pedogenic layer was excavatable to a degree- with alternating hard and soft zones. Boulder sized calcrete concretions at depth hampered site excavatability. The excavated material was notably gravelly and/or cobbly with a **fine-grained powdery matrix**.

The **concretionary calcrete** was generally described as a: *moist to wet at the base; light creamy or dark olive creamy brown, mottled black and blotched red or white;* ***medium dense, dense, or dense with medium dense pockets increasing with depth****;* ***intact and cemented****;* ***sub-angular calcrete nodules*** *and minor* ***cobble sized concretions*** *with a* ***matrix of powdery calcrete****; concretionary calcrete; traces of fine roots;* ***undulating extent; pockets of relict host material; friable upon exposure****; localized minor infiltration zones.*

As a whole, the calcrete was made up of hard particles- ranging from gravel to cobble sized (boulders localised)- **supported by a fine-grained matrix**. It should be noted that the geotechnical nature of this horizon will be a function of the properties of the **matrix** rather than individual hard particles.

The **concretionary calcrete** was encountered from below the calcified aeolian sands- extending to the **final excavation depths** of between **2.90 and 3.10 m** below E.G.L.- displaying an **average exposed thickness of 0.69 m.**

4.4. Groundwater and Shallow Seepage

The findings of a detailed hydrological survey- conducted by a competent specialist- overwrites the information presented below (where applicable).

This investigation was undertaken in the summer months of the year (summer rainfall region). Shallow seepage was encountered in numerous excavations undertaken across the site- as depicted in Table 2 overleaf.

Table 2- Summarised Shallow Seepage

Test Pit	Seepage Depth	Seepage Rate
TP2	3,10	Very Slow
TP3	3,10	Slow
TP4	3,00	Slow
TP5	2,45	Moderate
TP6	2,33	Moderate
TP7	3,00	Slow

Seepage was generally focused along the **base** of the test pits- predicted to be perching/flowing along the contact between concretionary calcrete and the predicted underlying hardpan calcrete at depth. This seepage is predicted to be in the form of a shallow perched water table, rather than the permanent ground water table for the area (to be defined by the hydrogeologist). Furthermore, a small **unlined canal** is present in the south western portion of the site- annotated on Image 2.

Without knowledge on the depth to permanent groundwater in the region- it is not possible to comment on the occurrence of permanent groundwater flow within/below the exposed pedocretes bedrock. Although not favourable, engineering solutions can be applied to the site to allow for future development- with the actions aligned with the applicable law of South Africa and site specific OHS protocols.

The predominant runoff will occur as sheet wash following the topography. During rainfall events the upper sandy sediments will allow **infiltration** and **lateral** ground water movement. Due to the low site gradient and artificially reworked surface morphology- surface ponding my also occur in some localities (especially following compaction).

Furthermore, should excessive infiltration take place across the high-lying portions of the site; it is predicted that elevated volumes of shallow ground water **throughflow** may occur across the investigated site. The additional influx of groundwater within the subsoils will impact their associated mechanical properties. The extent of this phenomena is predicted to reduce following development in these areas.

Across most of the site, the excavations in natural materials were seen to host **pedogenic materials at depth** (calcification). These pedogenic inclusions indicate the periodic occurrence of **fluctuating moisture conditions** after prolonged precipitation events. The evidence for fluctuating moisture conditions was encountered within the **upper 1.5 meter** of the profile.

Significant changes in moisture content may contribute to the anticipated consolidation/collapse/expansive behaviour of the site soils. Bulk excavations may need to be dewatered during construction.

Good site drainage measures, on surface and subsurface, must be implemented to prevent moisture changes, which may add to the development of perched groundwater tables. Drainage precautions are required to minimise erosion as well as limiting focused infiltration. During construction and after development, shallow perched water systems may develop yet further due to stormwater management practices, localised infiltration and site modification practices. Provisions should be made for the dewatering of deep trenches following prolonged precipitation events.

As a result of the **current seepage** and the possibility of **prolonged seepage** across the **lifetime** of the development- the implementation of a **sub-surface drainage** system is **deemed necessary**. Subsoil drains should form part of the structural configurations for the planned deep structures (i.e., subsoil tanks) in order to limit the volume of through flow beneath the structure- the nature of which is to be defined based on the requirements of the design team.

The weight of the structures on the surface may result in an increased ground water rest level. Adequate **damp-proofing** measures should be implemented beneath individual structures.

If the site or a portion thereof is situated within the 1:100-year flood lines, or have been delineated as a wetland, it is the prerogative of the Civil Engineer or other suitably experienced specialist to overwrite the geotechnical recommendations for such portions.

4.5. Rock- and/or Pedocrete Outcrops

<u>No</u> bedrock or pedocrete outcrops were encountered across the site. Intermittent dumped calcrete boulders were seen to litter the surface- prolific across the central to eastern portions. These features, coupled with relict structures/foundations/services are expected to have an impact on the overall **continuity of the excavatability** across this portion of the site. Additional shallow anomalies in these areas may be masked by vegetation**.**

It is recommended that the exact location and extent of these anomalies be modelled by the surveyor for the amalgamation into the site's earthworks model should development take place in these portions.

4.6. Site Excavatability

Excavatability is a measure of material to be excavated/dug/mined with conventional excavation equipment such as a bulldozer with rippers, mechanical excavator or other grading equipment.

The **average** excavation depth across the site was approximately **3.03 m.** Profiles were described in trenches excavated by means of TLB- type light mechanical excavator. End of hole conditions were typically due to **maximum reach** or **difficult excavation** at depth in dense calcretes.

Across the site, **no significant problems** are foreseen during the excavation of <u>**shallow foundation**</u> trenches and <u>**deep service trenches**</u> to an average depth of approximately **3.03 m** below E.G.L.- though the use of light excavation methods (i.e., TLBs). Due to the occurrence of fill materials, boulders and relict infrastructure- excavations by hand are not recommended.

The excavation type to an **average** depth of **3.03 m** below the existing ground level is deemed to be **SOFT Excavation** (SANS 10400G/SANS1200D). **Category 1 hard excavation** is estimated to be less than 10% of material to 1.5 meters below ground level (mbgl).

It should be noted that **no** intact bedrock- nor its weathered constituents- was encountered across the site. Thick interbedded successions of transported and pedogenic materials were seen to extend from the surface to depths of up to ~3m. The nature, consistency and associated excavatability of the materials at depths exceeding 3 m is not known due to the implemented excavation method.

4.7. Cutting/Trench Stability

Minor sidewall collapse was experienced in numerous test pits excavated across the site- specifically in test pits hosting fill materials. Following prolonged saturation, additional instabilities may occur due to the cohesionless nature of the subsoils.

Due to the existing natural slopes, large/extensive cuts into the slope are not expected. It is envisaged that temporary shallow trenches and/or cuttings to depths of up to 1.0 m will remain stable- the stability of which can be assessed periodically. No loading of the temporary slopes by machinery, equipment, excavated soil or materials shall be allowed. Sheet wash from stormwater or other waters shall be prevented from running over the slopes. Any excavation deeper than 1,5 mbgl must be stabilised as prescribed in the relevant act.

Based on the results of this study, ground water ingress into the bulk excavations can be expected across the vast majority of the site and will need to be dealt with accordingly. Trenches/box-cuts may need to be dewatered between and following prolonged precipitation events because of water temporarily perching upon the underlaying less permeable materials at depth.

Should the sites surface need to be extensively modified for the development, permanent cut slopes should be stabilised, or the geometry adequately modified to ensure long-term stability.

All deep excavations should be inspected by a competent person (engineer or geo-professional with relevant training and experience) periodically and following any periods of rain or any long periods where no work has taken place. It remains the responsibility of the contractor/engineer on site to ensure excavations are safe and shored in line with requirements as set down in legislature. The provisions of the Occupational Health and Safety Act of 1993 and Construction Regulations of 2014 must be followed in the excavations and workings therein.

Existing Services: damages to existing wet services and/or existing leaking services will result in surface water ponding and unstable trench sidewall conditions; drastically hampering safety, terrain mobility and site excavatability.

4.8. Engineering and Material Characteristics

4.8.1. Introduction and Sampling

The engineering material properties of the various sampled soil horizons were measured in laboratory conditions as per accredited testing procedures.

Standard foundation indicator, compaction tests and soil chemistry tests were conducted by Letaba Lab Bloemfontein (**SANAS Accredited**) on disturbed and bulk soil samples. These tests were undertaken to determine the composition of the underlying soils (i.e.: the relative percentages of gravel, sand, silt and clay) and to evaluate the suitability of the materials for the re-use in the proposed construction.

Full laboratory test results are included in **Appendix B**.

The sampling which took place during this investigation was based on both the in-situ geotechnical properties of the exposed soil horizons as well as the nature of the development. Problem soil horizons were accurately sampled where encountered (i.e., collapsible/expansive soils).

This section focuses on the identification and assessment of the soil properties which will influence the proposed construction.

The sampling process **excluded** the following inclusions:

- Oversized particles
- Organic materials
- Anthropogenic contamination

4.8.2. Bulk and Disturbed Samples- Laboratory Test Results

The soil testing which was conducted across the site can be subdivided into three broad categories, as follows:

- **Foundation Indictor Tests**

  Atterberg limits (Liquid Limit, Plasticity Index and Linear Shrinkage) and Particle-size Distribution

- **Compaction Tests**

  Maximum Dry Density versus Optimum Moisture Content and Californian Bearing Ratio versus Compaction Effort (MOD AASHTO method)

- **Soil Chemistry Tests**

  pH and EC analysis (corrosivity) as well as double hydrometers as an indication of material dispersivity.

The results presented in the summaries to follow are as received from the accredited testing facility. Although the summaries have been annotated, no amendments have been made to the results themselves.

The tables to follow summarise the results of the soil tests conducted on the various sampled materials.

Table 3: Foundation Indictor Test Results

Foundation Indictor Test Results																		
Sample Number	Test Pit	Depth (m)	Sampled Material	Particle Size Distribution: Standard Sieves (Cumulative percentage passing)					Particle Size Distribution: Hydrometer Analysis (SANS 3001-GR3)			Atterberg Limits SANS 3001-GR10 (%)			Grading Modulus	Material Classification		Heave
				37,5 mm	20 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm	0,005 mm	0,002 mm	LL	PI	LS		TRB	USC	
9463/1	TP2	0,00-1,23	Aeolain Sand	-	-	99	71	13	7,6	4,9	3,7	-	NP	0,0	1,2	A-2-4	SM	**LOW**
9463/2	TP4	0,41-1,85	Calcified Aeolian Sand	91	72	46	38	21	15,1	4,5	2,9	21	4	2,0	2,0	A-1-b	SM/SC	**LOW**
9463/3	TP4	1,85-3,00	Concretionary Calcrete	93	80	46	38	26	18,1	2,5	1,8	34	8	4,1	1,9	A-2-4	SC	**LOW**
9463/4	TP5	2,25-2,90	Concretionary Calcrete	72	64	31	22	9	6,1	1,5	1,1	49	12	5,7	2,4	A-2-7	GW/GC	**LOW**
9463/5	TP6	0,65-2,33	Calcified Aeolian Sand	63	53	36	27	8	5,4	3,0	2,5	-	NP	0,0	2,3	A-2-5	GP/GM	**LOW**
9463/6	TP7	0,00-1,18	Aeolain Sand	-	100	98	72	13	7,8	5,1	3,5	-	NP	0,0	1,2	A-2-4	SM	**LOW**

Notes:
1. Atterberg Limits undertaken on material passing the <0,425 mm sieve
2. Atterberg Limits: Liquid Limit (LL), Plasticity Index weighted (PI), Linear Shrinkage (LS).
3. Heave: Potential expansiveness (acc. Van Der Merwe, 1964).

Table 4: Compaction Test Results

Compaction Test Results										
Sample Number	Test Pit	Depth (m)	Sampled Material	Compaction Test Results					Material Classification	
				MDD (kg/m^3)	OMC (%)	Interpreted CBR Values SANS 3001-GR40 Mod AASHTO Method			COLTO	Material re-usage potential
						90%	93%	100%		
9463/1	TP2	0,00-1,23	Aeolain Sand	1968	4,7	2	5	27	<G9	POOR
9463/2	TP4	0,41-1,85	Calcified Aeolian Sand	2169	7,8	16	23	54	G6	GOOD
9463/3	TP4	1,85-3,00	Concretionary Calcrete	1836	11,1	5	9	33	G9	POOR
9463/5	TP6	0,65-2,33	Calcified Aeolian Sand	2146	5,8	12	21	75	G6	GOOD
Notes:	1. Compaction Test Results; percentage compaction of MDD (MOD AASTHO Method); CBR of 13.344 kN 2. MDD- Maximum Dry Density; OMC- Optimum Moisture Content 3. Material classification and re-usage potential based on the COLTO classification system									

Table 5: Soil Chemistry Test Results

Soil Chemistry Test Results								
Sample Number	Test Pit	Depth (m)	Sampled Material	Corrosivity Indicators				Dispersivity Indicators
				Profiled In-Situ Moisture	% Clay	pH	EC (S/m)	Double Hydrometer Results (%)
9463/1	TP2	0,00-1,23	Aeolain Sand	Slightly Moist	3,7	6,4	0,022	55
9463/3	TP4	0,41-1,85	Calcified Aeolian Sand	Slightly Moist	2,9	7	0,113	77
Notes:	1. Material as per soil profile description. 2. Moisture as per soil profile description or natural moisture content. 3. Percentage clay, pH, EC (Electrical Conductivity) and double hydrometer as per laboratory results.							

4.8.3. Results Discussion

Aeolian Sand

The results from the **Aeolian Sand** indicate the following:

- The sampled soils grade as **fine sand** with a **grading modulus** of **1.2.**
- The soils exhibit a **LOW plasticity**, low linear shrinkage values and an overall **LOW potential for heave** (acc. Van Der Merwe, 1964).
- The measured **PI values** are **NP**.
- Clay percentages are low to moderate in the sites subsoil, which may be sufficient to form clay bridges between grains that are typical of a **collapsible grain structure**.
- Typical Unified Soil Classes (USC) is **SM** (silty sand).
- Typical TRB Classes are **A-2-4.**

- The sampled **sandy materials** typically displayed a **POOR reaction** to **compaction:**
  - The sampled sands classified as a **worse than G9- type** material according to the COLTO classification system.
  - The compacted sample displayed a calculated **remoulded bearing capacity** of approximately **40 kPa** @ 93 % MOD AASHTO with a Factor of Safety of 1.5.
- The material displayed a notably **low density in-situ**.
- The sandy materials on site are regarded as being suitable for bedding or Stage 1 backfill.
- Some of the soil samples were tested for pH and electrical conductivity. These results and other indicators of aggressiveness to steel and concrete (corrosivity) are shown in Table 5. Based on the measured **pH** and **EC results**; the aeolian sand blanketing the site is deemed to be **mildly corrosive.** It is advisable not to use steel pipes.
- Based on the **double hydrometer** results the sandy material blanketing the site is deemed to be **dispersive.**

Granular Calcified Materials

The results from the granular **calcified aeolian sand** and **concretionary calcrete** samples indicate the following:

- These soils grade as **coarse sand** or **gravel** with a **grading modulus** of between **1.9** and **2.4-** the range of which serves as evidence for the varying grades of induration/calcification.
- The soils exhibit a **LOW to medium plasticity**, low linear shrinkage values and an overall **LOW potential for heave** (acc. Van Der Merwe, 1964).
- Measured PI values are between **NP** and **12**.
- Typical Unified Soil Classes (USC) are **SW/SC** and **GP/GW/GM/GC.**
- Typical TRB Classes are **A-2-a, A-1-b, A-2-7 and A-2-5.**
- The sampled **granular materials** typically displayed a **VARIABLE but generally good reaction** to **compaction:**
  - The sampled granular materials classified as a **G9**- and **G6- type** material according to the COLTO classification system.
  - The compacted granular samples displayed a calculated **remoulded bearing capacity** of between approximately **69 and 155 kPa** @ 93 % MOD AASHTO with a Factor of Safety of 1.5.
  - As a whole the **calcified sediment** displayed suitable material characteristics with regards to the planned construction, with the underlying concretionary calcrete partially poorer.
- Some of the soil samples were tested for pH and electrical conductivity. These results and other indicators of aggressiveness to steel and concrete (corrosivity) are shown in Table 5. Based on the measured **pH** and **EC results**; the granular materials are deemed to be **corrosive.** It is advisable not to use steel pipes.
- Based on the **double hydrometer** results the granular materials at depth are deemed to be **potentially dispersive.**

4.8.4. Combined Material Re-usage Summary

The **blanketing transported materials** and **concretionary calcrete** at depth were seen to display **POOR** material re-usage characteristics with regards to the planned development. These materials generally classified as a **worse than G9-/G9- type material** (COLTO)- as such, these materials are deemed **NOT suitable** for the use in the proposed construction and associated engineered fill and road layer works (other than subgrade). This material should be stockpiled for future landscaping purposes.

The underlying **calcified sediment** was seen to display a **GOOD** quality- typically classifying as a **G6-** type material (COLTO 1998). These materials are therefore **suitable** for the use in the proposed construction and associated engineered fill/road layer works (suitability based on the engineer's design). It is strongly recommended that this material be selectively mined and stockpiled for future use in planned construction. Due to its **heterogenous composition** and **varying degrees of induction,** stockpiles should be continuously tested to ensure acceptable material quality (QC aligned with the engineer's design).

Caution should be taken in the zones of poor-quality material highlighted in the study. Where encountered, zones of poor-quality material should be adequately modified prior to its re-use- within the specifications of the engineer's design.

The extent of **cut-to-spoil** is dependent on the layout of the development coupled with the design of the planned light structures.

Where encountered, the poor materials could, however, be **modified** both **mechanically**, by importing G6 quality material from the commercial/ borrow pit source, and/or **chemically**, by blending in a certain percentage of **cement/lime**. These modification methods will attempt to increase the CBR value. These forms of modification could be considered when attempting to improve the quality of material from say G9 to G7 (as an example).

Should blending (mechanical modification) or chemical stabilisation be investigated for the localised problem areas; the ratio of in-situ vs imported material OR percentage cement/lime required to improve the quality can be determined in the laboratory by doing various blends/mix designs.

Should additional materials be required, it is recommended that material be imported from a local borrow area or certified/registered commercial source for the use in controlled layers in the proposed construction.

4.9. In-Situ Mechanical Assessment

4.9.1. Introduction

The soils underlying the site have been examined and tested to determine their suitability as founding horizons for the proposed development according to the following criteria:

- **Bearing capacities** of the founding materials determined from estimated field consistencies and inferred from tabulated strength values.
- **Compressibility**, where applicable.
- **Collapse potential,** where applicable.
- Potential **heave**, where applicable.
- Predicted **displacements** (settlement/collapse/heave) from the above factors.

The **uncontrolled fill materials** have been omitted from the analysis to follow.

The interbedded successions of **aeolian sand** and the variable upper extent of the **calcified sediments** form the materials of primary concern across the site. Caution must be taken when dealing with these fine-grained and potentially **collapsible/compressible** soils- in the design of structures and services.

4.9.2. Undisturbed Sampling

TWO (2) undisturbed samples were extracted from the **aeolian sand** underlying the site, in order to determine the in-situ mechanical properties of these materials. The samples were extracted in areas and at depths deemed suitable for the analysis of the geotechnical conditions as to assist with foundation design.

It should be noted that the extraction of block samples changes the samples natural state (unloading of in-situ stresses); and as such, the test is only an indication of the in-situ material properties.

Specialist **undisturbed sample testing** was conducted by Steyn-Wilson Geotechnical, to quantify the in-situ mechanical properties of the soft materials underlying the site.

The following specialist tests were conducted:

I. Single- oedometers
II. Free Swell
III. Collapse potential
IV. Bulk density
V. Moisture content

The calculated values presented in the sections to follow are based on estimated foundation configurations. Once figurations have been decided upon the calculations can be modified.

Detailed soil test results for the undisturbed samples are included in **Appendix C.**

The table overleaf summarises the results from the undisturbed testing.

Table 6: Undisturbed Samples- Test Results

Summarised Undisturbed Sample Results																
Sample Details				Initial Conditions				Swell Indicators				Calculated Settlement (mm) Consolidation Test Results			Collapse Potential Analysis	
Sample Number	Location	Depth (m)	Sampled Material	Average Dry Density (Mg/m^3)	Moisture Content (%)	Particle Density (Mg/m^3)	Void Ratio	Plasticity Index (PI)	Potential Heave (Van der Merwe 1964)	Swell Pressure (kPa)	Swell Percentage (%)	50 kPa	100 kPa	150 kPa	Measured Collapse Potential (%)	Severity Classification (Jennings and Knight 1975)
SWG00446/1	TP2	1,00-1,20	Aeolain Sand	1,61	5,0	2,64	0,641	NP	LOW	0,0	0,0	20 - 29	27 - 38	31 - 44	-	-
SWG00446/2	TP7	0,80-1,00	Aeolain Sand	1,67	3,9	2,65	0,584	NP	LOW	-	-	-	-	-	5,4	TROUBLE

Notes:

1. Results presented as received from Steyn-Wilson Geotechnical.
2. No Factor of Safety has been applied to all of the settlement ranges presented above, so as to account for sample bias and any disturbances induced during sampling and testing.
3. A strip footing with a width of 0,6 m was used during settlement calculations.
4. Heave: Potential expansiveness (acc. Van Der Merwe, 1964).
5. The settlement range presented above assumes a depth of influence factor of 1.5 times the presented foundation width.

4.9.3. Inferred Material Properties Unified Soil Classification System

As part of this assessment several engineering material properties can be **inferred**- to be confirmed/measured in follow-up studies where required. Inferred figures are extracted from the data base available on geotechdata.info.

The Unified Soil Classification System (USCS) is a soil classification system used in engineering and geology to describe the texture and grain size of a soil. The classification system can be applied to most unconsolidated materials and is represented by a two-letter symbol. The demarcated result can be used to infer a wide range of soil properties and characteristics.

The materials across the site classify as SW/SC and GP/GW/GM/GC.

The following inferred paraments/attributes can be used in **preliminary designs**:

1. Typical values of **soil friction angle (degrees)**
   a. SC Soils: 30 to 40
   b. SM Soils: 27 to 34
   c. GM Soils: 30 to 40
   d. GW Soils: 33 to 40
   e. GP Soils: 32 to 44
   f. GC Soils: 28 to 35
2. Typical values of **soil cohesion (kPa)**
   a. SC Soils: 5
   b. SM Soil: 20 to 50
   c. GP/GW/GM Soils: 0
   d. GC Soils: 20
3. Typical values of **soil permeability (m/s)**
   a. SC Soils: $5.5x10^{-9}$ to $5.5x10^{-6}$
   b. SM Soils: $1x10^{-8}$ to $5x10^{-6}$
   c. GW/GP Soils: $5.0x10^{-4}$ to $5.0x10^{-2}$
   d. GM Soils: $5.0x10^{-8}$ to $5.0x10^{-6}$
   e. GC Soils: $5.0x10^{-9}$ to $5.0x10^{-6}$

Numerous additional inferences can be made based on the available laboratory test results and associated data bank of information. Additional properties can be presented on the request of the project team.

4.9.4. Bearing Capacity and Soil Shear Strength

Bearing capacity is defined as the pressure which would cause **shear failure** of the supporting soil immediately below and adjacent to a foundation.

The estimated presumed bearing values of the foundation materials are only an empirical guide to the maximum load that can be placed on the soil/weathered rock particular to this site without shear failure, and as such are not an indicator of the possible settlement/heave that may occur at foundation pressures up to the bearing capacity of the soil.

The allowable bearing pressures imposed on the material is a function of both the soils shear strength (ultimate limit state) and its' settlement characteristics (serviceability limit state). The presumptive bearing capacity figures disregard the effect of soil moisture changes that may induce settlement or collapse. Taking the additional movements due to soil compressibility into account will imply that foundation improvements will be necessary for light structures.

The presumed bearing values above are based on the materials exposed in situ in the test pits and ignore any improvement, which may be obtained by compacting, or treating the site soils.

Calculations are based on the geometry of the foundation. GeoCalibre is open to ongoing discussions regarding these calculations using data from exact depths and known structural configurations.

Aeolian Sand

As a whole, the aeolian sand was seen to display a low in-situ density, fine-grained nature and a voided fabric; attributes typically associated with **potentially collapsible soils**.

Where the aeolian sand was not modified it was typically **loose** or **very loose** in-situ. **Loose** consistencies in these sandy materials may be roughly correlated to a presumed bearing value of **30 - 80 kPa** (Look, 2014). This may not be adequate for the typical pressure from a light masonry structure and disregards the effect of soil moisture changes that may induce **settlement** or **collapse**.

The sampled sandy materials typically displayed POOR reaction to compaction- classifying as a worse than G9- type material according to the COLTO classification system. The compacted sample displayed a calculated remoulded bearing capacity of approximately **40 kPa** @ 93 % MOD AASHTO with a Factor of Safety of 1.5.

This aeolian sand was present from the **surface** extending to average depths of between **0.41 and 1.23 m** below the existing ground level (E.G.L.)- displaying an average exposed thickness of **0.83 m**. Due to the vast lateral and vertical extent of these materials, it is recommended that the bearing capacity ranges, and discussion points presented above be considered when designing the planned surficial light structures.

Calcified Aeolian Sand and Concretionary Calcrete

The materials underlying the aeolian sand displayed a **granular nature** and an overall **loose** to **medium dense** consistency- becoming dense at depth.

Loose to medium dense consistencies may be roughly correlated to a presumed bearing value of **30 - 230 kPa.** Other sources list presumptive bearing capacity of sandy/gravelly soils to 95 – 150 kPa (Alemdag et al, 2017; BS8004-1986; Builders Engineer 27 October 2012).

The compacted **calcified aeolian sand** displayed a calculated remoulded bearing capacity of between approximately **145 and 155 kPa** @ 93 % MOD AASHTO with a Factor of Safety of 1.5- this attribute is expected to decrease when mixed with the underlying concretionary calcrete (G9).

The applied load from a single storey masonry structure may be assumed to be between 30 kPa and 50 kPa, which will fall well within the bearing capacity limit of these horizons.

4.9.5. Heave Characteristics

Expansive soils are soils that undergo changes in volume due to changes in moisture content, swelling when the moisture content increases and shrinking when the moisture content decreases. The natural wetting up of the soil profile below the central portions of a structure typically leads to the development of a domed profile under the building in the long term, known as the "central doming" mode of deformation.

In the short term, ingress of water into the soil around the perimeter of the structure can lead to heave around the perimeter of the building resulting in the "edge heave" mode of deformation.

According to the **free swell test,** the sampled **aeolian sand** materials exhibit a **percentage swell** of **0.0%,** with a **measured swell pressure of 0.0 kPa.**

Based on the disturbed and undisturbed sample results from the on-site materials it was noted that these soils exhibit a **low to medium** plasticity, low linear shrinkage values and an overall **LOW potential for heave** (acc. Van Der Merwe, 1964). These combined results indicate that soil heave will <u>not</u> be a dominant design/geotechnical factor across the site.

4.9.6. Collapse Settlement Characteristics of the In-Situ Soils

Collapsible soils are open-textured (high void ratio) soils that are stiff when dry but lose their stiffness when they become wet. This can lead to sudden, large settlements taking place when the moisture content of the soils below a foundation increase, even many years after construction.

The vast majority of the sampled materials displayed a **low liquid limit** (typically <35) and **low in-situ density** (aeolian sand); these attributes are typically associated with **collapsible fabrics**. Clay percentages are low to moderate in the sites subsoil, which may be sufficient to form clay bridges between grains that are typical of a collapsible grain texture.

Collapse potential testing was conducted on the **aeolian sand** exposed in test pit TP7. The **aeolian sand** exhibits a measured **collapse potential** of **5.4%-** with this severity class indicating "*TROUBLE*" according to the *Jennings and Knight* severity of collapse classification system.

In accordance with the in-situ material properties profiled during the fieldwork phase of the investigation- the aeolian sand and the uppermost extent of the calcified aeolian sand are deemed to have a potentially **collapsible nature**, with their inherent variability amplifying the predicted degree of **differential settlement**.

Differential settlement is amplified across the site due to heterogenous composition of the site's subsoils at depth.

The voided nature of the upper soil horizons may in addition to the settlement also cause larger than normal settlements due to collapse under loading and saturation of these voids.

The use of impact rolling, dynamic compaction or over excavation, sorting and re-compaction (in controlled layers) of these soils will result in the **destruction** of their non-favourable in-situ soil properties (i.e., collapsible fabric). The extent of this modification is based on the engineer's design at that point.

Due to the potential of collapse settlement in the road bed; it is recommended that the road bed be adequately treated through pre-soaking and the implementation of vibratory compaction methods (to engineer's design).

4.9.7. Settlement Characteristics of the In-Situ Soils

Compressible soils are soils of low stiffness that settle significantly when loaded. In free-draining soils (e.g., sands), this settlement occurs during and shortly after loading. In low permeability soils (e.g., clays), this settlement occurs over a period of time as the pore pressures set up during loading dissipate.

According to the **single oedometer tests**, the consolidation settlement within the **sandy sediments** across the site will range between **20 and 29 mm** assuming a foundation pressure of **50 kPa** with a foundation width of **0.60 m** (normally consolidated material). Thereafter, at a foundation pressure of **100 kPa**, a settlement range of between **27 and 38 mm** can be expected.

The settlement measured in the transported soils was seen to **exponentially increase** with an increased foundation load.

Considering the material characteristics measured in lab conditions and observed within the soil profiles; the soft materials underlying the site are deemed to display a **compressible nature** at foundation loads of 50 kPa.

The degree of expected soil consolidation upon loading is expected to decrease with depth due to the overall medium dense to dense state of the underlying pedocretes.

5. Geotechnical Site Classification

5.1. Introduction and Discussion

This report describes the results of the Phase 1 Geotechnical Site Investigation conducted in support of the proposed establishment of a **multi land-use development** taking place across the southern portion of **ERF 312** of the **Vaal-Harts Settlement B.** The site is located between the towns of Hartswater (to the east) and Pampierstad (to the west); and entails a partially developed irregular shaped parcel of land, with a total extent of approximately **4.4 ha.**

The sites surface was seen to display a **reworked nature** attributed to past and ongoing **human activities** in the area. This reworking was predominantly in the form of surficial fills, relict canals/foundations/structures and historic agricultural practices. The exact extent of the existing/past surface and subsurface infrastructure in this region is not known. The combination of the anthropogenic processes has affected the continuity of the sites' topographic nature as well as its' inherent geotechnical characteristics. The exact extent of the existing/past surface and subsurface infrastructure in this region is not known.

This investigation was conducted to aid the decision-making processes during the land rezoning phase of the development and to serve as specialist input for structural design. The planned development across the surface will encompass the subdivision of this land portion into various land-use zones i.e., infrastructural units, roadways, and services etc. Each of these zones may require their own set of geotechnical assessments and associated engineering solutions.

The field work phase of the investigation was conducted by GeoCalibre in October 2022. Test pits were distributed across the designated site (Figure 5), at locations deemed safe for excavations and free of subsurface infrastructure. The placement of trial pits was undertaken in such a way so as to create an accurate and reproducible site-specific geotechnical model.

The presented geotechnical model is based on a data base of available information and available on-site exposures. Parcels of land within the developmental area which are free of excavations are modelled using on-site observations and surrounding exposures.

5.2. Impact of the Geotechnical Constraints on Housing Developments

The impact of the geotechnical constraints on urban development (single and double storey masonry structures) may be evaluated according to Table 8-Appendix D at the end of this report- 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.

The main expected geotechnical constraints for this site are:

- Occurrence of surficial uncontrolled fill materials, relict infrastructure and anthropogenic reworking: **P** $^{\textbf{Infrastructure and fills}}$
- Highly compressible soil horizons with expected larger than acceptable differential movements: **3D**
- Collapsible horizons with a combined thickness exceeding 750 mm: **2A**

- Localised and variable shallow perched groundwater tables and/or shallow throughflow during high intensity precipitation events: **2B**
- The surficial sandy soils are expected to have an intermediate risk for erosion in areas subjected to artificial channelised/concentrated surface water flow: **2E**
- Very gentle slopes of less than 2 degrees, with an artificially induced variable surface morphology accentuating surface water ponding: **2I**
- Materials deemed to be potentially **corrosive** and **slightly dispersive**

5.3. Site Class Designations

The site is underlain by a variable sequence of materials; with most of the soft material deemed to be **compressible** and **slightly collapsible.** The degree of collapse and compressibility is predicted to decrease with an increase in depth.

These soil parameters require that structures be adequately strengthened, or the underlying soils be adequately modified to prevent structural damage due to total and differential settlement beneath foundations. Due to the **potentially slightly collapsible nature** of the underlying soils, elevated degrees of differential settlement (75%) are predicted **under fluctuating moisture conditions.**

The entire site has been classified into **ONE (1) Site Class Designation Zone** (Figure 6), based on the above constraints and the criteria as set out in the NHBRC Home Building Manual (2015) guideline document of which the appropriate tables have been included at the end of this report.

Site Classification: S2/C2 and P ^{fill} with **3D, 2ABEI.**

Please note the following regarding these site class designations:

- The site class designation is specific as suggested in the Home Builders Manual (2015), Part 4, 4.2 and derived from an estimation of the expected range of soil volume change in single- and double-storey structures constructed of masonry walls with soil pressures not exceeding 50 kPa.
- The classification and foundation recommendations are based on results from this and proximate investigations.
- The mechanical properties of the sites' subsoils are inferred based on the exposed soil profiles (soil consistency, composition and structure) and associated laboratory test results.
- Site class designations are based on the existing ground level, prior to any earthworks. Upon the removal of the problematic aeolian sand the site class can be reduced drastically.
- Localised phenomena such as anthropogenic depressions/canals, biological tunnelling, heaps of fill and relict infrastructure have been omitted form the primary site classification.
- Although not investigated, developed portions of the site have been included into the zonation. The geotechnical nature of these areas can be confirmed during the construction phase/Phase 2 Investigations following demolition and rehabilitation.

6. Development Recommendations

6.1. Introduction

The results of this geotechnical analysis models that the whole site exhibits geotechnical characteristics that may require the implementation of design and/or precautionary measures to reduce the risk of structural damage due to adverse geotechnical characteristics. However, these characteristics do **not** disqualify the site from being used for the development, but rather require the implementation of site-specific precautionary **engineering measures.**

Based on the results of the investigation, the in-situ soils display a moderate shear strength (ultimate limit state), however, display a **compressible and potentially slightly collapsible nature** (serviceability limit state).

Variable founding conditions and materials are expected to be encountered. This variability includes soils of different age, composition and associated pre-consolidation pressures.

Uniform heave, shrinkage, collapse settlements or consolidation settlements generally do not cause damage to structures but might detrimentally affect service (water and sewer) pipe entries at the perimeter of structures. Non-uniform or differential movements can cause structural distress, deformations and overstressing of structural components, resulting in damage to the building.

The general site conditions with regards the geotechnical considerations are such that any light structure placed on the compressible and potentially collapsible materials occurring on site will need special precautionary measures to prevent serious damage to the structure. Additional foundation modifications to prevent damage to single-storey structures due to differential settlements may be necessary.

Structural solutions shall improve the flexibility and strength of the structure to enable the building to tolerate potential soil movements so that the resulting response to actions is within the limits specified in SANS 10400-B. Due to the variable founding conditions across the site it is recommended that the structure be adequately jointed and/or strengthened to allow for the predicted differential settlement. Please consult a qualified/competent engineer for additional options and final designs.

GeoCalibre is open to ongoing discussions with consulting civil engineers surrounding suitable foundation configurations for the planned structures, considering the variable geotechnical nature of the site.

6.2. Foundation Options

The foundation recommendations are according to the Joint Structural Division (SAICE, 1995) Code of Practice for single and double storey masonry structures founded below the loose upper horizons with foundation pressures limited to 50 kPa (Appendix D- Tables 9 and 10).

This does not exclude any other structures or development including higher foundation pressures, but additional site investigation and foundation measures will be necessary to prevent damage to such structures.

It is recommended that the structural engineers calculate the best economical foundation option for the proposed development based on the type of structure and the different available construction methods to remedy the negative effects of the geotechnical constraints.

The final layout of the development is not known at this stage. Discussions surrounding suitable founding depths and methods can be discussed at length with the project team once final structural configurations are known.

It is recommended that foundation be place on a uniform founding medium (i.e. bedrock) so as to limit the degree of differential settlement. Foundations should not span from soil and/or engineered fill to rock so as to limit differential settlement.

As for the removal of relict infrastructure, it is strongly recommended that fill materials be selectively mined and removed from within the footprint of the proposed development (to a depth deemed suitable by the design engineer).

Following the rehabilitation of the area, either of the foundation configurations presented below can be implemented, depending on the layout of the structures (based on engineer's design). Considering the mechanical properties of the in-situ soils underlying the site, in conjunction with the nature of the development, there are **three main options** for the mitigation of the deleterious effects of the compressible/collapsible soils:

1. <u>**Compaction of in-situ soils below individual footings:**</u>

The **first option** entails the destruction of unfavourable soil characteristics underlying the foundations/pads, through over-excavation, replacement and compaction of the in-situ material directly below the reinforced footings in controlled layers; and in so doing creating a **uniform earth mattress.**

The competent engineer is to define the nature of the fill including the required material quality (strength) as well as the possibility of material improvement (chemical or mechanical). The suitability of the founding medium will be a function of the predicted design loads imposed by the structure at depth. Horizon depths and corresponding mechanical properties pre- and post-modification are presented in the report.

The engineered fill should be constructed/designed in such a way as to dissipate the load of the structure- ensuring that excessive loads are not transferred into the underlying compressible/collapsible natural soils. Remove in-situ material below foundations to a depth and width of 1.5 times the foundation width- or to weathered bedrock- and replace with suitable material compacted to at least 93% MOD AASHTO density at -1% to +2% of optimum moisture content.

The width and thickness of the earth mattress relates directly to the required increase in surface area for the reduction in load so as to minimise the effects of soil movement/failure.

The load transfer should be done in such a way so as to spread the load equally in order to eliminate both total and differential settlement.

The engineered mattress should be separated from the existing soils using a bidim type liner so as to mitigate contamination.

Removal/modification of the problem soils below surface beds and drainage requirements (surface and sub-surface).

The temporary flanks of bulk excavations for box cuts and/or service trenches will need to be stabilised, or the geometry adequately modified to ensure stability.

Trenches/bulk excavations will need to be dewatered.

The created soil raft should be kept as dry as possible, saturation with result in a reduction of shear strength.

Adequate subsurface drainage measures should be included into the foundation designs. Rockfill can be implemented as a pioneer layer to improve drainage below the structure/raft.

Essential that backfilled material is of sufficient quality and compacted in controlled layers (material quality/required density as per engineer's design).

The blanketing transported materials and concretionary calcrete at depth were seen to display POOR material re-usage characteristics with regards to the planned development. These materials generally classified as a worse than G9-/G9- type material (COLTO)- as such, these materials are deemed NOT suitable for the use in the proposed construction and associated engineered fill and road layer works (other than subgrade). This material should be stockpiled for future landscaping purposes.

The underlying calcified sediment was seen to display a GOOD quality- typically classifying as a G6- type material (COLTO 1998). These materials are therefore suitable for the use in the proposed construction and associated engineered fill/road layer works (suitability based on the engineer's design). It is strongly recommended that this material be selectively mined and stockpiled for future use in planned construction. Due to its heterogenous composition and varying degrees of induction, stockpiles should be continuously tested to ensure acceptable material quality (QC aligned with the engineer's design).

Should additional materials be required, it is recommended that material be imported from a local borrow area or certified/registered commercial source for the use in controlled layers in the proposed construction.

Normal construction with lightly reinforced footings and light reinforcement in masonry.

2. **Reinforced concrete foundations:**

This option entails shallow foundations with the **reinforcement** of the foundations to the point at which they can withstand the expected total and differential movements. Foundation configurations generally in the form of stiffened strip footings/pads or stiffened/cellular rafts.

Bearing capacity values (pre-or-post compaction) and corresponding settlement tolerances presented in this report can be used as a reference for the sizing of the foundations in relation to the planned structural loads.

3. **Deep foundations:**

The third option entails **deep foundations**- either strip footings or pads. Founding on **dense pedocretes** below problematic soft materials. Due to the predicted depths of these materials (average ~2.34 m)- this option may not be feasible for the planned light surficial structures.

If this foundation option is considered by the design team- additional discussions between the team and GeoCalibre can commence.

All foundation trenches should be inspected and approved by a competent person to ensure that the footing design is appropriate for the actual ground conditions encountered. Deep founding will be required if any currently unidentified buried material or structure is encountered in the excavations for the footings (i.e., soft materials below pedocretes).

Groundwater is anticipated to perch/flow along the soil-rock interface, periodically inundating the foundations. As such, deep excavations will need to be dewatered during construction and adequate subsurface drainage measures should be included into the foundation designs.

4. **General:**

Below are typical foundation recommendations for structures of this nature, taking into account the geotechnical characteristics of the investigated site SAICE 1995). It is recommended that EITHER of the following foundation designs be utilised for structures to be placed across the site:

Table 7: NHBRC Site Classification Designations linked to Construction Types Home Builders Manual, 2015 (SAICE, 1995)

Site Class designation	Typical founding material	Character of founding material	Single storey masonry house construction type
R	Rock	Stable	Normal
H	Clays, silty clays, clayey silts and sandy clays.	Expansive soils	Normal
H1			Modified normal / soil raft
H2			Stiffened or cellular raft / piled or split construction / soil raft.
H3			Stiffened or cellular raft / piled or split construction / soil raft.
C	Silty sands, sands, sandy and gravelly soils.	Compressible and potentially collapsible soils	Normal
C1			Modified normal / compaction of in-situ soils below individual footings / deep strip foundations / soil rafts.
C2			Stiffened strip footings, stiffened or cellular raft / deep strip foundations / compaction of in-situ soil below individual footings / piled or pier foundations / soil raft.

P	Contaminated soils, controlled fill, dolomitic areas, landslip, landfill, marshy areas, mine waste fill, mining subsidence, reclaimed areas, uncontrolled fill, very soft silts / silty clays.	Variable.	Variable.
S	Clayey silts, clayey sands of low plasticity, sands, sandy and gravelly soils	Compressible soils	Normal
S1			Modified normal / compaction of in-situ soil below individual footings / deep strip foundations/ soil raft
S2			Stiffened strip footings, stiffened or cellular raft / deep strip foundations / compaction of in-situ soil below individual footings / piled or pier foundations / soil raft.

6.3. Design Considerations and Summarised Geotechnical Site Constraints

The diverse geotechnical attributes of the site have been discussed at length in the preceding sections of this report. There are geotechnical attributes of the site which are not ideally suited for the planned development (delineated in this report)- for this reason, **advanced engineering solutions** will be required to ensure the stability and longevity of the development.

The following **primary concerns** need to be addressed in the design phase:

- Rehabilitation of the sites surface- including earthworks to create stable working levels, surficial drainage measures, removal of fills, relict infrastructure and vegetation.
- Site topography/drainage- attributes discussed in Section 2.2/2.3 and 4.1.
- Generalised ground profile depicting the variability of the underlying materials- discussed in Section 4.3.
- Shallow seepage and fluctuating/temporary perched ground water tables- discussed in Section 4.4.
- Site excavatability and trench stability- discussed in Section 4.6/4.7.
- Summarised engineering material characteristics- discussed in Section 4.8.
- Compressible and potentially collapsible soft materials with predicted poor to moderate strength characteristics- discussed in Section 4.9 (mechanics).
- Combined geotechnical site classification- discussed in Section 5.
- Discissions surrounding suitable foundation configurations and development recommendations- discussed in Section 6

GeoCalibre is open to discussions with the project team surrounding suitable engineering solutions for these adverse conditions once final structural configurations are known.

The following general notes are applicable to the design phase of the development and where applicable can form part of the contract/tender documentation:

- The sites surface was seen to display a reworked nature attributed to past and ongoing human activities in the area. Based on the available information, the development will entail the rehabilitation of the site's surface- within and immediately surrounding the planned structures.
- A maintenance regime should be put in place to periodically assess the nature of the development for a set period following the construction phase of the development. Areas showing visible deformation should be modified accordingly, in order to avoid further deformation or permanent damage.
- At the time of this investigation, the vegetation across the site was comprised predominately of a dense grass cover with occasional shrubs as well as scattered groups of large trees.
    - In the areas hosting shrubs/trees- greater amounts of sub-surface vegetation is predicted to occur. The effects of the removal of trees on sites should also be considered, particularly where trees have depressed the water table over a period. The removal of large trees can result in the formation of highly compressible zones of voided soils. Such areas should be treated as zones of possible risk.
    - The degree of organic material and biotic activity was seen to decrease with an increase in depth, with major root systems (organic rich topsoil/aeolian sand) reaching to a depth of approximately 0.83 m below the existing ground level.
    - The site was seen to host biological activity in the form of localised- and somewhat scattered- biological tunnels and nests. Tunnelling- predicted to be as a result of warthogs- was more prolific in the western and north western portions of the site.
- Emphasis should be placed on surface drainage and storm water control measures to avoid both surface water ponding and concentrated water flow (erosion) across the development area. Structures constructed perpendicular to the natural slopes will result in the ponding of surface water. Furthermore, the development will influence natural infiltration and run-off rates and appropriate precautions against concentrated flow must therefore be implemented.
- No natural slope instabilities were visible in these areas at the time of the investigation (basic inspection). The final layout of the development is not known but based on the limited natural slopes prior to modification (majority of the site), specialised methods for the stabilisation of cuts into the existing slopes are not deemed necessary. Due to the site gradient- cut to fill site preparation is also not expected.
- The very gentle sloping nature across the vast majority of the site will aid surface water infiltration into the underlying soils, rather than rapid surface water flow, accentuating surface water ponding and fluctuating moisture conditions after prolonged precipitation events. Surface water ponding will be more prolific in areas hosting natural and/or anthropogenic depressions and where bulk earthworks are employed to create level platforms.
- Attention must be given to site contouring to ensure an effective gradient is achieved so that standing water does not occur, and the draining of water is efficient to minimise erosion and damage to the construction.

- The continuity and manipulation of the topography and associated drainage plays a pivotal role in the longevity and sustainability of the development. Topographic anomalies identified/ measured during the professional survey can be addressed individually in the design.
- Surficial uncontrolled fill material and relict infrastructure/services was present across scattered portions of the site. These combined successions of fill material were dumped/reworked across the area in an uncontrolled manner during past anthropogenic activities.
  - Small landfill areas were present across scattered portions of the site (examples of which are annotated on image 2)- with these areas primarily hosting dumped natural materials (calcrete boulders etc.)- with lesser extents of domestic waste and rubble. Surficial heaps of fill ranged in shape and size sporadically.
  - As for the removal of relict infrastructure, it is strongly recommended that this material be selectively mined and removed from within the footprint of the proposed development (extent determined by the design engineer). The location and extent of these anomalies can be mapped by the surveyor for the amalgamation into the local earthworks model.
- Transported material- deemed to be of aeolian origin (windblown sand)- were seen to dominate the sub-terrain (foundation zone). The exposed successions of aeolian sand were seen to be slightly variable, with fluctuations in moisture content, consistency and colour across the site.
  - The upper extent of the aeolian sand was generally reworked and/or contaminated to varying degrees as a result of past and on-going human activities in the area. Furthermore, across the undeveloped portions of the site, the uppermost extent of this material was seen to be organic rich, with a gradual degree in root occurrence with depth.
  - Due to its age and shallow occurrence- this sandy deposit may lack essential pre-consolidation characteristics. This will result in additional consolidation settlement upon saturation and loading.
  - As a whole, the aeolian sand was seen to display a low in-situ density, fine-grained nature and a voided fabric; attributes typically associated with potentially collapsible soils.
  - This sediment was generally seen to extended from the surface to depths of between 0.41 and 1.23 m below E.G.L.- displaying an average exposed thickness of 0.83 m.
- Across the entire site, the above-described sandy materials were seen to be underlain by a variable pedogenic material deemed to be calcified aeolian sand, followed by concretionary calcrete at depth.
  - The formation of pedocrete is linked to the morphology of the investigated area. Due to the very gentle sloping nature of the area, the processes of water infiltration and surface water ponding are favoured over surface water run-off (sheet flow). The infiltration of water, subsequent temporary perching on less permeable underlying material and evaporation has resulted in the precipitation of pedocretes and the ensuing natural reworking of the in-situ materials.

- The calcified aeolian sand displays variable degrees of induration and calcification, ranging from minor to abundant amounts. A general increase in calcification with depth was observed within the horizon.
    - The calcified sand is characterised by a partially cemented structure and heterogenous composition.
    - The calcified sediment was encountered from below the sandy soils- extending to a depth of between 1.85 and 2.75 m below E.G.L.- displaying an average exposed thickness of 1.51 m.
- Concretionary calcrete was exposed at depth across the site. A general gradual contact was present between the various pedogenic materials- with the transitional zone poorly defined due to intercalated materials.
    - The pedogenic layer was excavatable to a degree- with alternating hard and soft zones. Boulder sized calcrete concretions at depth hampered site excavatability. The excavated material was notably gravelly and/or cobbly with a fine-grained powdery matrix.
    - As a whole, the calcrete was made up of hard particles- ranging from gravel to cobble sized (boulders localised)- supported by a fine-grained matrix. It should be noted that the geotechnical nature of this horizon will be a function of the properties of the matrix rather than individual hard particles.
    - The concretionary calcrete was encountered from below the calcified aeolian sands- extending to the final excavation depths of between 2.90 and 3.10 m below E.G.L.- displaying an average exposed thickness of 0.69 m.
- Shallow seepage was encountered in numerous excavations undertaken across the site.
    - Seepage was generally focused along the base of the test pits- predicted to be perching/flowing along the contact between concretionary calcrete and the predicted underlying hardpan calcrete at depth.
    - This seepage is predicted to be in the form of a shallow perched water table, rather than the permanent ground water table for the area (to be defined by the hydrogeologist).
    - Should excessive infiltration take place across the high-lying portions of the site; it is predicted that elevated volumes of shallow ground water throughflow may occur across the investigated site. The additional influx of groundwater within the subsoils will impact their associated mechanical properties. The extent of this phenomena is predicted to reduce following development in these areas.
    - Significant changes in moisture content may contribute to the anticipated consolidation/collapse/expansive behaviour of the site soils. Bulk excavations may need to be dewatered during construction.
    - Good site drainage measures, on surface and subsurface, must be implemented to prevent moisture changes, which may add to the development of perched groundwater tables.

- As a result of the current seepage and the possibility of prolonged seepage across the lifetime of the development- the implementation of a sub-surface drainage system is deemed necessary. Subsoil drains should form part of the structural configurations for the planned deep structures (i.e., subsoil tanks) in order to limit the volume of through flow beneath the structure- the nature of which is to be defined based on the requirements of the design team.
- The weight of the structures on the surface may result in an increased ground water rest level. Adequate damp-proofing measures should be implemented beneath individual structures.

- No bedrock or pedocrete outcrops were encountered across the site. Intermittent dumped calcrete boulders were seen to litter the surface- prolific across the central to eastern portions. These features, coupled with relict structures/foundations/services are expected to have an impact on the overall continuity of the excavatability across this portion of the site. Additional shallow anomalies in these areas may be masked by vegetation.
- The average excavation depth across the site was approximately 3.03 m. Profiles were described in trenches excavated by means of TLB- type light mechanical excavator. End of hole conditions were typically due to maximum reach or difficult excavation at depth in dense calcretes.
  - It should be noted that no intact bedrock- nor its weathered constituents- was encountered across the site. Thick interbedded successions of transported and pedogenic materials were seen to extend from the surface to depths of up to ~3m. The nature, consistency and associated excavatability of the materials at depths exceeding 3 m is not known due to the implemented excavation method.
- Minor sidewall collapse was experienced in numerous test pits excavated across the site- specifically in test pits hosting fill materials. Following prolonged saturation, additional instabilities may occur due to the cohesionless nature of the subsoils.
  - Due to the existing natural slopes, large/extensive cuts into the slope are not expected. It is envisaged that temporary shallow trenches and/or cuttings to depths of up to 1.0 m will remain stable- the stability of which can be assessed periodically.
  - No loading of the temporary slopes by machinery, equipment, excavated soil or materials shall be allowed. Sheet wash from stormwater or other waters shall be prevented from running over the slopes.
  - Based on the results of this study, ground water ingress into the bulk excavations can be expected across the vast majority of the site and will need to be dealt with accordingly. Trenches/box-cuts may need to be dewatered between and following prolonged precipitation events because of water temporarily perching upon the underlaying less permeable materials at depth.
  - Should the sites surface need to be extensively modified for the development, permanent cut slopes should be stabilised, or the geometry adequately modified to ensure long-term stability.

- The allowable bearing pressures imposed on the material is a function of both the soils shear strength (ultimate limit state) and its' settlement characteristics (serviceability limit state). The presumptive bearing capacity figures disregard the effect of soil moisture changes that may induce settlement or collapse. Taking the additional movements due to soil compressibility into account will imply that foundation improvements will be necessary for light structures.
- In accordance with the in-situ material properties profiled during the fieldwork phase of the investigation- the aeolian sand and the uppermost extent of the calcified aeolian sand are deemed to have a potentially collapsible nature, with their inherent variability amplifying the predicted degree of differential settlement.
  - Differential settlement is amplified across the site due to heterogenous composition of the site's subsoils at depth.
  - The use of impact rolling, dynamic compaction or over excavation, sorting and re-compaction (in controlled layers) of these soils will result in the destruction of their non-favourable in-situ soil properties (i.e., collapsible fabric). The extent of this modification is based on the engineer's design at that point.
  - Due to the potential of collapse settlement in the road bed; it is recommended that the road bed be adequately treated through pre-soaking and the implementation of vibratory compaction methods (to engineer's design).
- Considering the material characteristics measured in lab conditions and observed within the soil profiles; the soft materials underlying the site are deemed to display a compressible nature at foundation loads of 50 kPa. The degree of expected soil consolidation upon loading is expected to decrease with depth due to the overall medium dense to dense state of the underlying pedocretes.
- It is recommended that foundations be placed on a uniform founding medium so as to limit the degree of differential settlement. Foundations should not span from soil and/or engineered fill to rock.
- Areas subjected to extensive fills need to be adequately modified/ compacted to limit soil movement over time (i.e., fill creep).
- Based on the measured EC results; the material underlying the site is deemed to be potentially corrosive. It is advisable not to use steel pipes.
- Special attention must be given to the selection of the correct material to be used for the bedding, fill material and the general backfill in the construction of pavement layers as well as foundations.
  - The blanketing transported materials and concretionary calcrete at depth were seen to display POOR material re-usage characteristics with regards to the planned development.
  - These materials generally classified as a worse than G9-/G9- type material (COLTO)- as such, these materials are deemed NOT suitable for the use in the proposed construction and associated engineered fill and road layer works (other than subgrade).

- This material should be stockpiled for future landscaping purposes.
- The underlying calcified sediment was seen to display a GOOD quality- typically classifying as a G6- type material (COLTO 1998). These materials are therefore suitable for the use in the proposed construction and associated engineered fill/road layer works (suitability based on the engineer's design). It is strongly recommended that this material be selectively mined and stockpiled for future use in planned construction. Due to its heterogenous composition and varying degrees of induction, stockpiles should be continuously tested to ensure acceptable material quality (QC aligned with the engineer's design).
- Caution should be taken in the zones of poor-quality material highlighted in the study. Where encountered, zones of poor-quality material should be adequately modified prior to its re-use- within the specifications of the engineer's design.
- The extent of cut-to-spoil is dependent on the layout of the development coupled with the design of the planned light structures.

- Plumbing and service precautions will be necessary to prevent pipe rupture or joint leakages due to soil movement.
- All earthworks should be carried out in a manner to promote stable development of the site.
  - It is recommended that earthworks be carried out along the guidelines given in SABS 1200/SANS 10400 (current version).
  - Placement of fill layers should be undertaken in layers not exceeding 200mm thick when placed loose and compacted using suitable compaction plant to achieve 93% Modified AASHTO maximum dry density at ±2% optimum moisture content.
  - Boulders larger than 2 /3 of the layer thickness must not be included in the fill material.
  - A carefully engineered fill embankment should not settle more than 0.5% of its height due to self-weight. Density control of placed fill material should be undertaken at regular intervals during fill construction.
  - Engineered fill slopes should be over constructed and thereafter trimmed back to the required position. Cut and fill heights greater than 2 metres would need to be inspected and approved by an engineering geologist or geotechnical engineer.
  - The imported material should be placed in layers not exceeding 200 mm in thickness and compacted to a minimum of 93% Modified AASHTO maximum dry density.
- Test pits were not compacted in layers when backfilled and differential settlements may occur across these features.
- Quality control testing should be undertaken by an accredited laboratory where possible.

7. Report Provisions

The investigation was conducted according to the accepted proposal and the scope of works and literature references provided in this document. Field work and reporting were conducted and/ or overseen by professionally registered scientists with the South African Council for Natural Scientific Professions.

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.

The design and implementation of the planned thick fills remains the responsibility of the consulting engineers- with GeoCalibre and its' employees carrying no liability in this regard. Adequate design and associated quality control measures should be implemented to ensure the longevity of the development as a whole.

The presented geotechnical model is based on a data base of available information and available on-site exposures. Parcels of land within the developmental area which are free of excavations are modelled using on-site observations and surrounding exposures.

The present site zoning is based on the Phase 1 geotechnical investigation results referred to in the Home Building Manual with the guideline site class designation specifically for single or double storey masonry residential units. This does not exclude any other development for which additional site investigations will be necessary.

The determination of flood lines and delineation of wetland areas were not part of this investigation scope and should be addressed by suitably competent professionals prior to the final site development plan is compiled, if deemed necessary. If the site or a portion thereof is situated within the 1:100-year flood line, or has been delineated as a wetland, it is the prerogative of the Civil Engineer or other suitably experienced specialist to overwrite the recommendations for such portions.

In view of the variability inherent in natural materials, a competent person must inspect all service trenches excavations at the time of construction to ensure that the materials are adequate for the proposed structure and that they are in accordance with the recommendations stated in this report. The placement of engineered fill must be controlled with suitable field tests to ensure that the required densities are achieved during compaction, and that the quality of the fill material is within specification.

Although not anticipated at this site, it should be noted that this investigation did not include the assessment of any potential environmental hazards, or groundwater impacts that may be present, or ensue from the construction of the proposed structures.

GeoCalibre is open to ongoing discussions with all the parties involved in order to elaborate on the methodology implemented during this assessment and its associated findings/ground models.

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Layout Maps

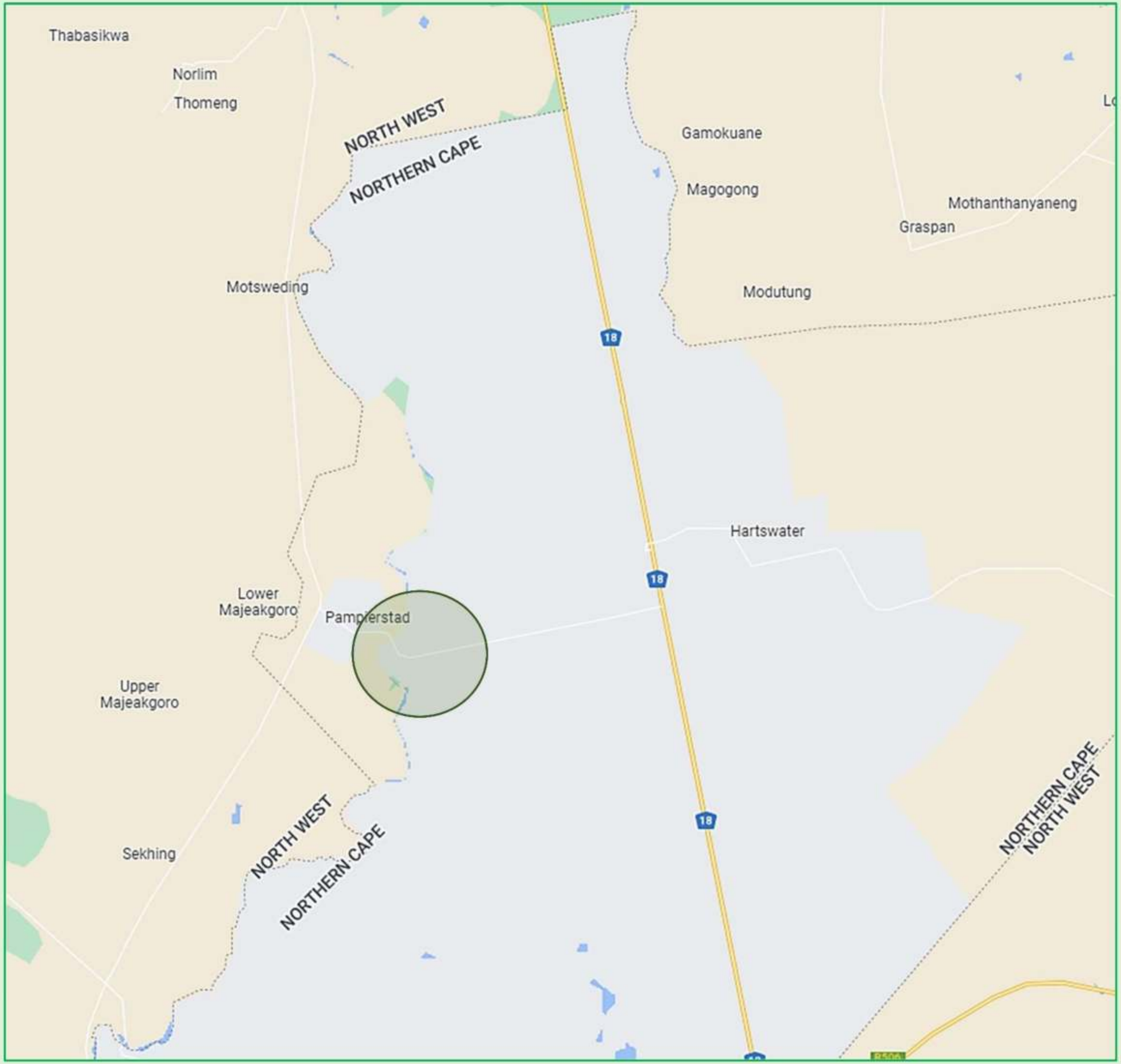

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Figure 1

Study Area Location

LEGEND

Study Area

N

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PO Box 12493
Nelspruit
1200

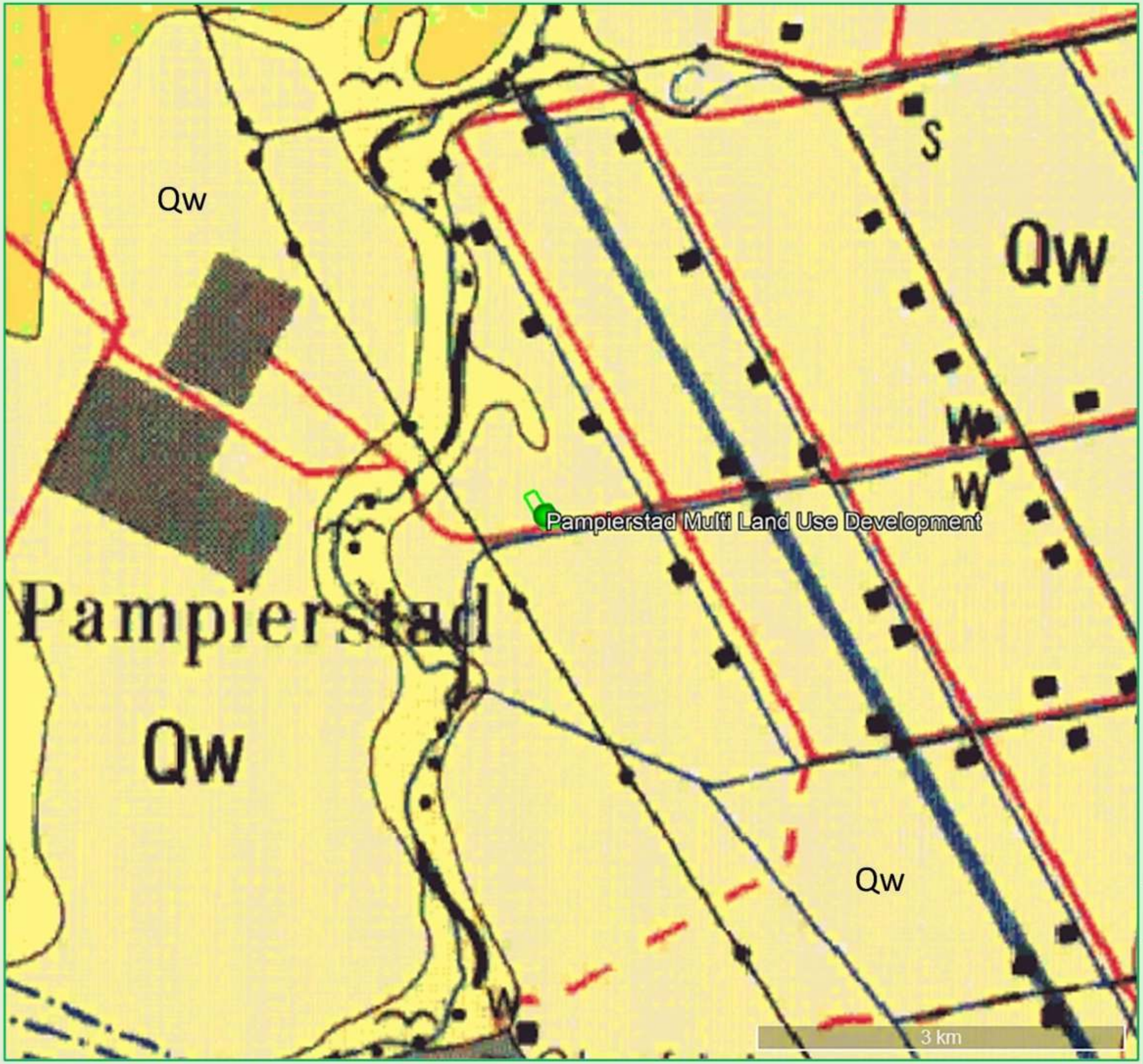

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Figure 2

Regional Geology Map

LEGEND

Qw	Windblown Sand- Quaternary Aged

Geological Series Map:
2724 Christiana; Scale 1 : 250 000

N

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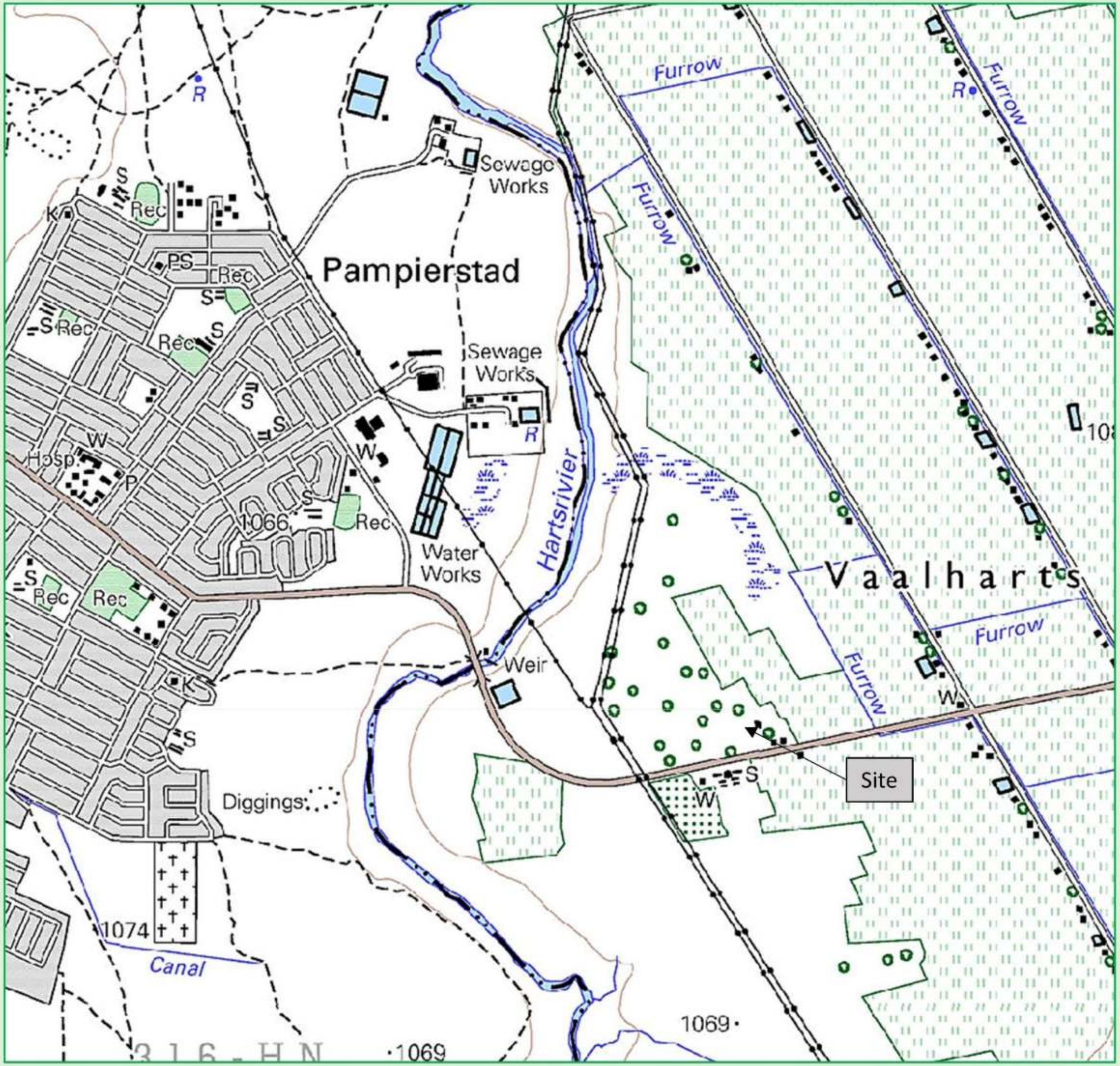

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Figure 3

Topocadastral Map

Topocadastral Maps:
2724 Dc; Scale 1 : 15 000

N

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Figure 4

Site Location- Aerial View

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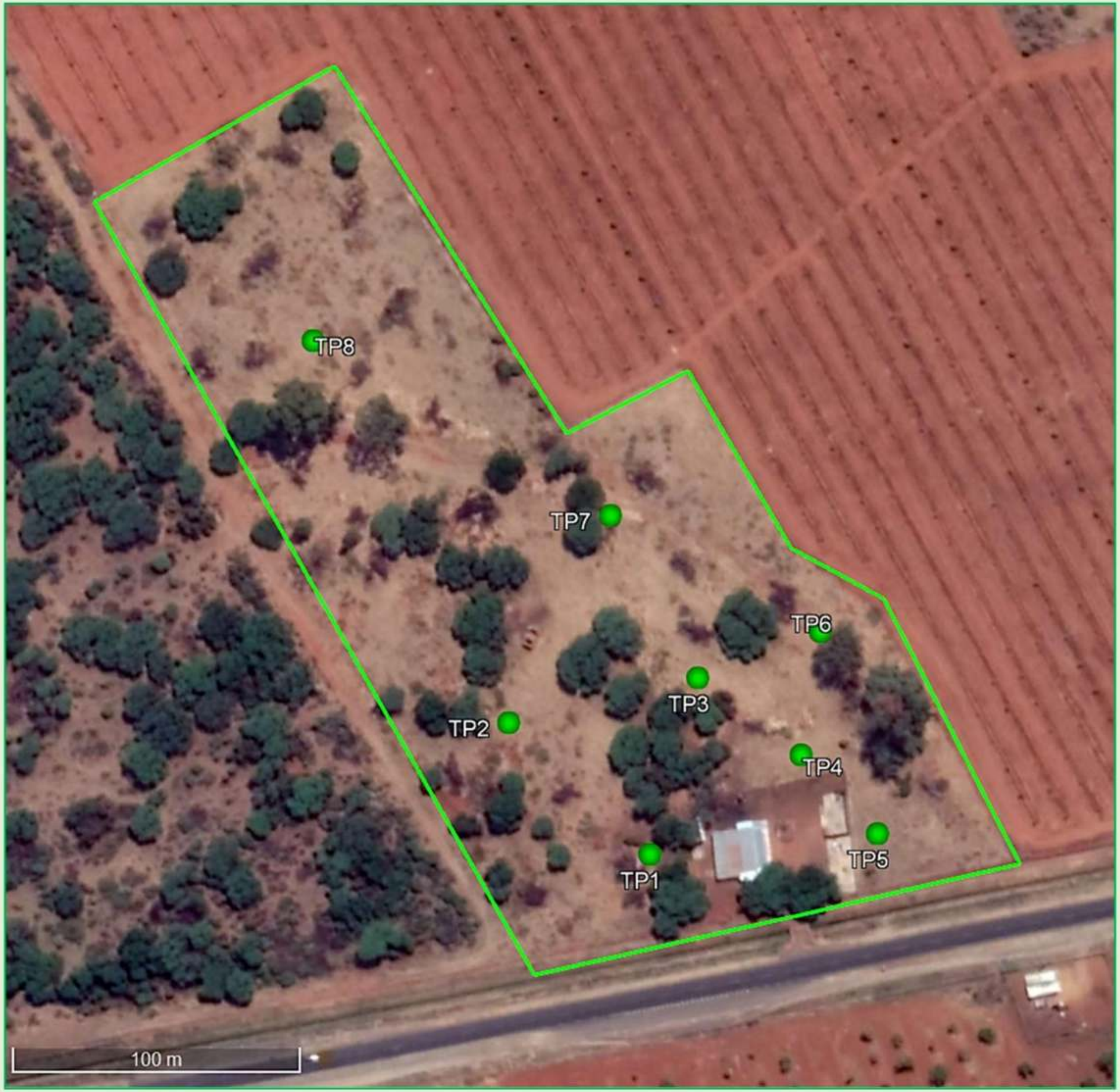

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Figure 5

Testing Locations

LEGEND

Test Pit

Site Boundary

N

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Figure 6

Site Zonation

LEGEND

Zone A- S2/C2 and P ^{fill} with 3D, 2ABEI

N

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Testing Locations

GC-22-177

Pampierstad Multi Land Use Development

GPO Boerdery (Pty) Ltd

Test Pit Locations

Test Pit Number	Location		Elevation (meters above mean sea level)	Final Excavation Depth with TLB (m)
	Latitude (South)	Longitude (East)		
TP1	27.790019	24.717940	1071	3,00
TP2	27.789614	24.717442	1071	3,10
TP3	27.789471	24.718105	1071	3,10
TP4	27.789708	24.718469	1071	3,00
TP5	27.789951	24.718740	1071	2,90
TP6	27.789325	24.718536	1070	3,10
TP7	27.788967	24.717795	1071	3,00
TP8	27.788429	24.716747	1071	3,10

Please note that all GPS co-ordinates are extracted from Garmin Oregon 600 tm and elevation data from Google Earth PRO

Appendix Index

Pampierstad Multi Land Use Development

INDEX

Appendix A

Soil Profiles

GEOCALIBRE
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Test Pit TP1

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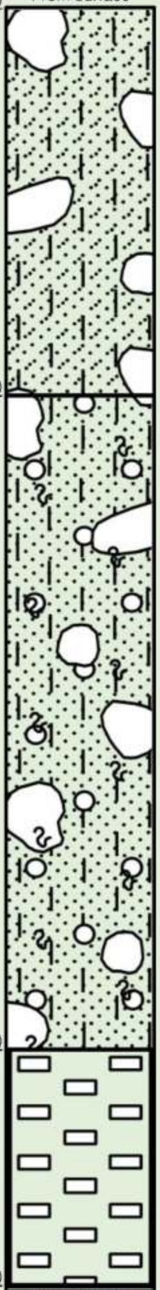
Soil Profile for Test Pit TP1

0 From surface



slightly MOIST; dak reddish BROWN, blotched white and grey, banded grey; very LOOSE; PINHOLED; silty SAND with traces of sub-rounded calcrete cobbles; reworked TOPSOIL; variable intercalated natural materials and rubble/waste; organic rich topsoil with minor anthropogenic contamination thickening to the west; Not Sampled.

-910 ~Undulating contact (880 to 940)

slightly MOIST to moist at base; dark RED, blotched grey and cream; LOOSE with medium dense pockets; MATRIX SUPPORTED and partially cemented; calcrete nodules and concretions in a matrix of silty SAND; calcified AEOLIAN sand; minor fine roots and decomposed organics; pockets of variable concretionary calcrete; heterogenous composition; Not Sampled.

-2450 Gradual contact

slightly MOIST; light creamy BROWN, mottled black; DENSE with medium dense pockets increasing with depth; INTACT and CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; traces of fine roots; undulating extent; pockets of relict host material; friable upon exposure; Not Sampled.

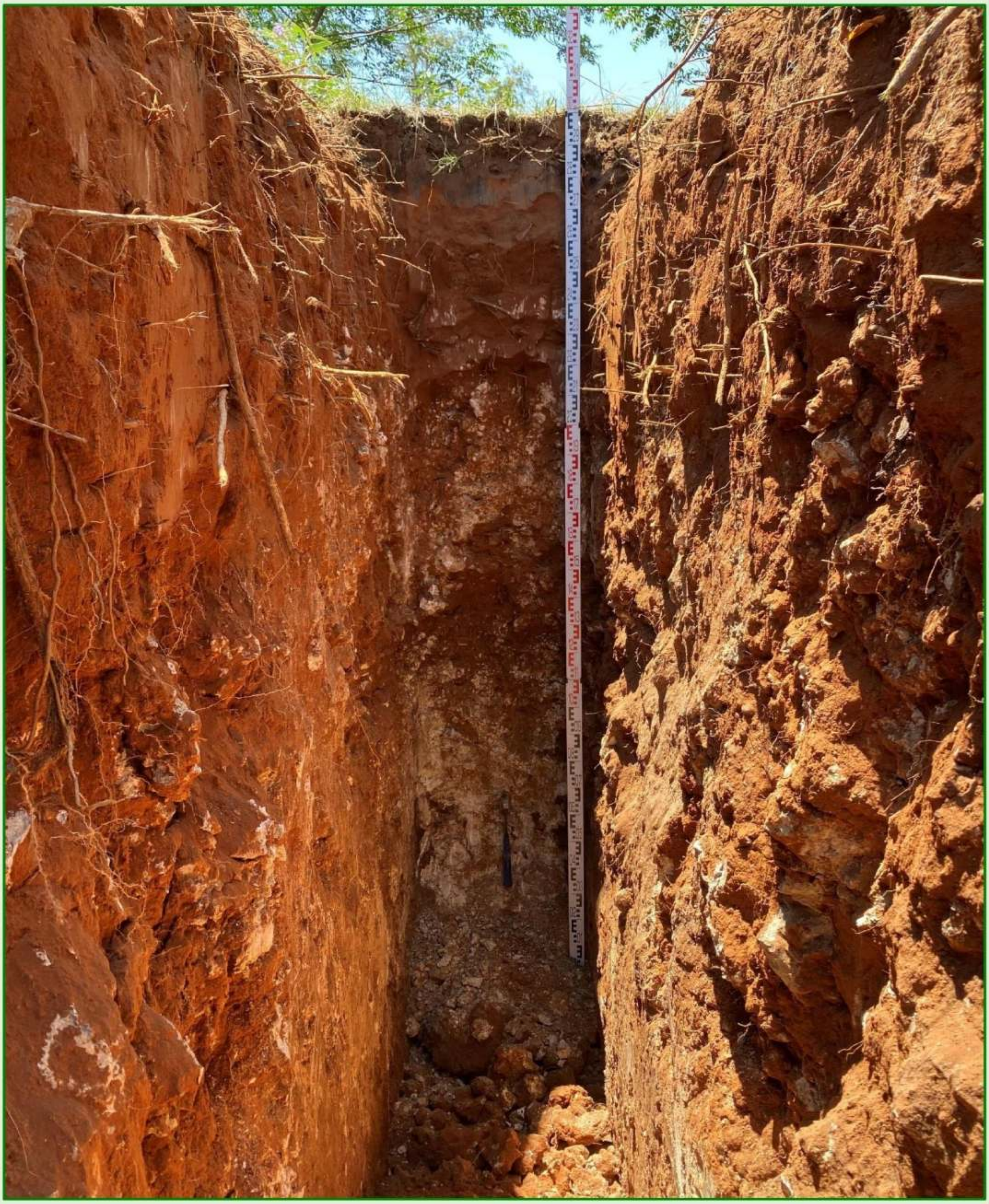
-3000

DIFFICULT EXCAVATION

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	No seepage	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Minor sidewall collapse	Excavation Character:	Difficult excavation due to dense calcrete at the base
Samples Extracted:	N/A	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.790019°S 24.717940°E

GEOCALIBRE GEOTECHNICAL CONSULTANCY	GC-22-177 Pampierstad Multi Land Use Development

Profile Photo: TP1



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Material Present in Test Pit: TP1

Surroundings of Test Pit: TP1

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Test Pit TP2

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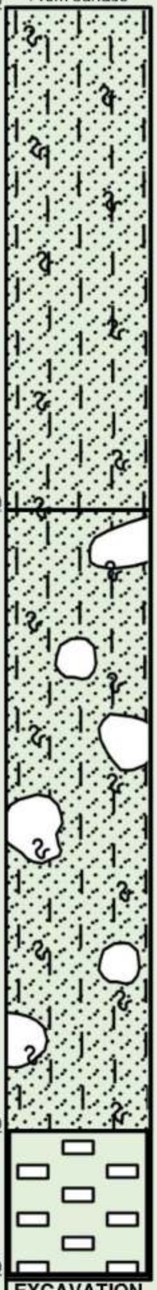
Soil Profile for Test Pit TP2

0 From surface



slightly MOIST; dark RED; LOOSE; PINHOLED; silty SAND with traces of basal calcrete concretions; AEOLIAN sand; abundant fine roots with minor medium sized roots; decomposed organics; Bulk Sample No. 1; Undisturbed Sample No. 1.

-1230 ~Undulating contact

slightly MOIST with moist pockets; dark RED, blotched grey and cream; LOOSE with medium dense pockets; MATRIX SUPPORTED and partially cemented; calcrete nodules and concretions in a matrix of silty SAND; calcified AEOLIAN sand; minor fine roots; traces of variable concretionary calcrete; heterogenous composition; Not Sampled.

-2750 Gradual contact

MOIST to wet at the base; light creamy BROWN, mottled black and blotched red; DENSE; CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; traces of fine roots; undulating extent; pockets of relict host material; friable upon exposure; Not Sampled.

-3100 Very slow seepage at base

EXCAVATION STOPPED

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	Very slow seepage at 3,10 m	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Sidewalls stable	Excavation Character:	Excavation Stopped due to maximum reach
Samples Extracted:	1 Bulk Sample, 1 Undisturbed Sample	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.789614°S 24.717442°E

Profile Photo: TP2

Material Present in Test Pit: TP2

Surroundings of Test Pit: TP2

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Test Pit TP3

GC-22-177

Pampierstad Multi Land Use Development

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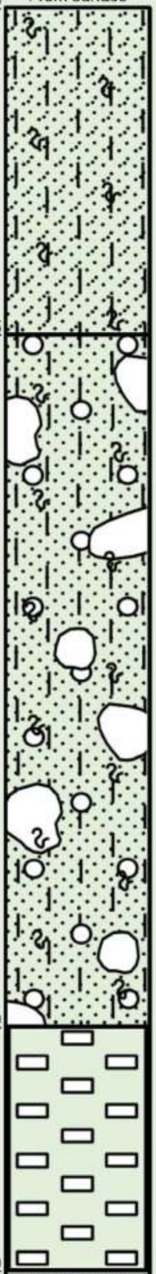
Soil Profile for Test Pit TP3

0 From surface



slightly MOIST; dark RED; LOOSE; PINHOLED; silty SAND with traces of basal calcrete concretions; AEOLIAN sand; abundant fine roots with minor medium sized roots; decomposed organics; highly undulating extent due to calcrete boulders at the base; Not Sampled.

-805 ~Undulating contact (500 to 1110)

slightly MOIST to moist at the base; dark RED, blotched cream; LOOSE with medium dense pockets; MATRIX SUPPORTED and partially cemented; calcrete nodules and boulder-sized concretions in a matrix of silty SAND; calcified AEOLIAN sand; highly variable exposure with calcrete boulders followed by pockets of sand; traces of fine roots; Not Sampled.

-2500 Gradual contact

MOIST to wet at the base; light creamy BROWN, blotched red; DENSE; CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; traces of fine roots; undulating extent; pockets of relict host material; Not Sampled.

-3100 Seepage at base

DIFFICULT EXCAVATION

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	Slow seepage at 3,10 m	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Minor sidewall collapse- boulders	Excavation Character:	Difficult excavation due to calcrete boulders
Samples Extracted:	N/A	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.789471°S 24.718105°E

Profile Photo: TP3

Material Present in Test Pit: TP3

Surroundings of Test Pit: TP3

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

Test Pit TP4

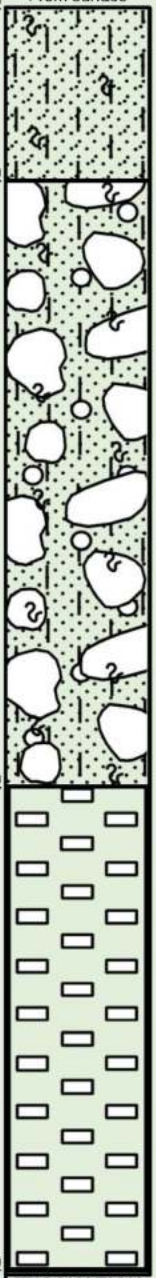
GC-22-177

Pampierstad Multi Land Use Development

GPO Boerdery (Pty) Ltd

Soil Profile for Test Pit TP4

0 From surface



slightly MOIST; dark RED; very LOOSE; PINHOLED; silty SAND with traces of basal calcrete concretions; AEOLIAN sand; abundant fine roots; decomposed organics; Not Sampled.

-410 ~Undulating contact

slightly MOIST; dark RED, blotched grey and cream; LOOSE with medium dense pockets; MATRIX SUPPORTED and partially cemented; calcrete nodules and concretions in a matrix of silty SAND; calcified AEOLIAN sand; minor fine roots; traces of variable concretionary calcrete; heterogenous composition; Bulk Sample No. 2.

-1850 Gradual contact

MOIST to wet at the base; light creamy BROWN, blotched red and dark olive; medium DENSE; CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; friable upon exposure; Bulk Sample No. 3.

-3000 Slow seepage at base

EXCAVATION STOPPED

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	Slow seepage at 3,0 m	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Sidewalls stable	Excavation Character:	Excavation stopped due to maximum reach
Samples Extracted:	2 Bulk Samples	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.789708°S 24.718469°E

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

GC-22-177

Pampierstad Multi Land Use Development

Profile Photo: TP4

Material Present in Test Pit: TP4

Surroundings of Test Pit: TP4

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

Test Pit TP5

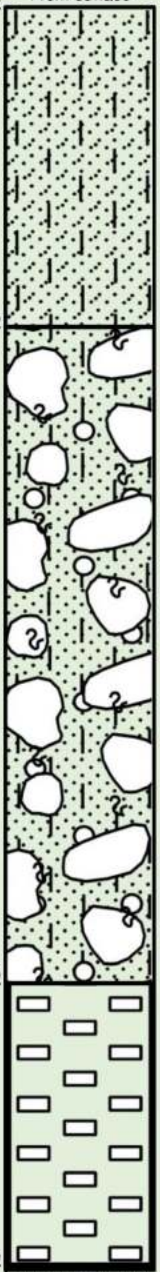
GC-22-177

Pampierstad Multi Land Use Development

GPO Boerdery (Pty) Ltd

Soil Profile for Test Pit TP5

0 From surface



slightly MOIST; dak reddish BROWN, blotched white and grey, banded grey; very LOOSE; PINHOLED; silty SAND with traces of sub-rounded calcrete cobbles; reworked TOPSOIL; variable intercalated natural materials and rubble/waste; organic rich topsoil; Not Sampled.

-740 ~Undulating contact

MOIST; dark RED, blotched grey and cream; LOOSE; MATRIX SUPPORTED and partially cemented; calcrete nodules and concretions in a matrix of silty SAND; calcified AEOLIAN sand; minor fine roots and decomposed organics; pockets of variable concretionary calcrete with traces of small calcrete boulders; heterogenous composition; Not Sampled.

-2250 Gradual contact

MOIST to wet; dark olive creamy BROWN, banded and blotched white; medium DENSE; INTACT and CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete with minor clay lenses; friable upon exposure; traces of fine roots; Disturbed Sample No. 4.

Moderate seepage at 2.45 m

-2900

-3000 EXCAVATION STOPPED

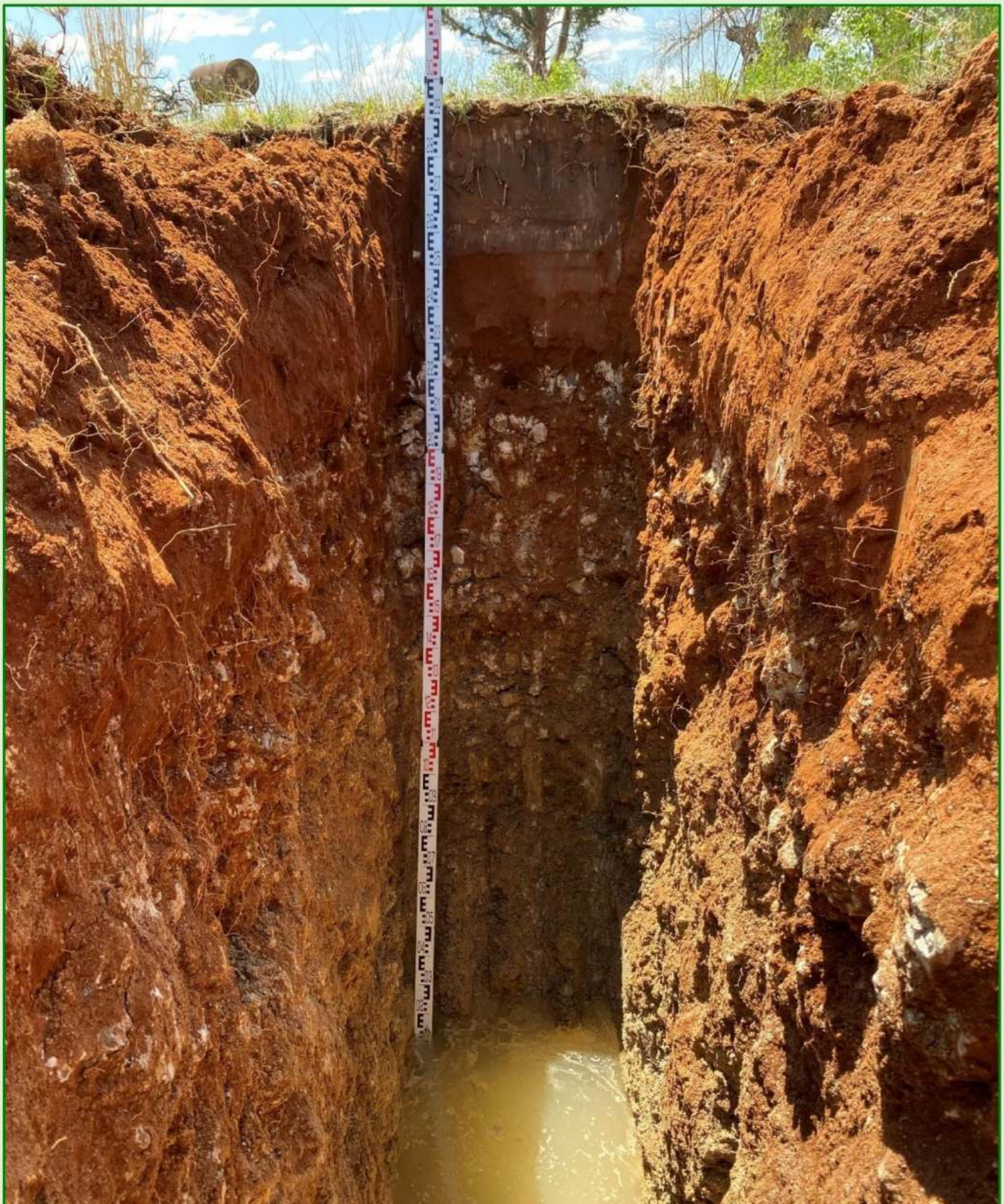
Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	Moderate seepage at 2,45m	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Minor sidewall collapse- not safe to enter	Excavation Character:	Excavation stopped due to seepage
Samples Extracted:	1 Disturbed Sample	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.789951°S 24.718740°E

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

GC-22-177

Pampierstad Multi Land Use Development

Profile Photo: TP5



GEOCALIBRE
GEOTECHNICAL CONSULTANCY

GC-22-177

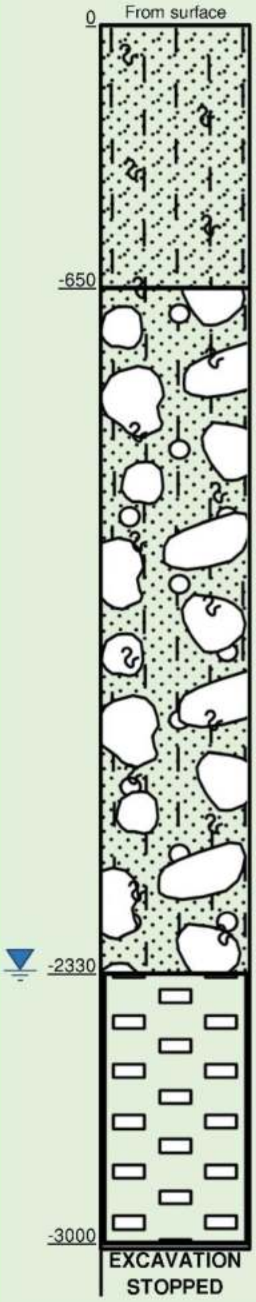
Pampierstad Multi Land Use Development

Material Present in Test Pit: TP5

Surroundings of Test Pit: TP5

GEOCALIBRE GEOTECHNICAL CONSULTANCY	**Test Pit TP6** GC-22-177 Pampierstad Multi Land Use Development GPO Boerdery (Pty) Ltd

Soil Profile for Test Pit TP6



MOIST; dark RED; LOOSE with very loose pockets; PINHOLED; silty SAND with traces of basal calcrete concretions; AEOLIAN sand; abundant fine roots with minor medium sized roots; decomposed organics; Not Sampled.

~Undulating contact

slightly MOIST with moist pockets; dark RED, blotched grey and cream; LOOSE; MATRIX SUPPORTED and partially cemented; calcrete nodules and concretions in a matrix of silty SAND; calcified AEOLIAN sand; minor fine roots; traces of variable concretionary calcrete; heterogenous composition; Bulk Sample No. 5.

Moderate seepage at 2.33 m

WET; dark olive creamy BROWN, blotched and banded white; medium DENSE; CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; pockets of relict host material; friable upon exposure; Not Sampled.

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	**Contractor:**	Client Supply
Groundwater Seepage:	Moderate seepage at 2,33m	**Machine:**	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Sidewalls stable	**Excavation Character:**	Excavation Stopped due to maximum reach
Samples Extracted:	1 Bulk Sample	**Date Profiled:**	27/10/2022
Elevation (MAMSL):	1070	**Coordinates:**	27.789325°S 24.718536°E

Profile Photo: TP6

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

GC-22-177

Pampierstad Multi Land Use Development

Material Present in Test Pit: TP6

Surroundings of Test Pit: TP6

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

Test Pit TP7

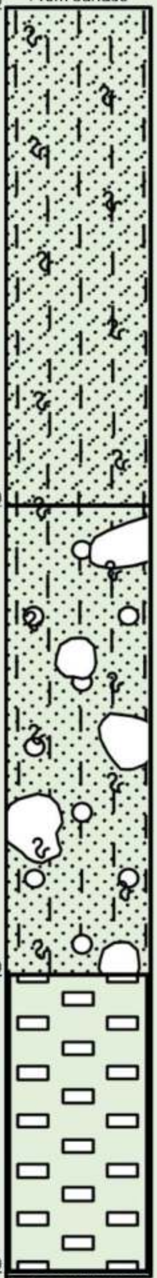
GC-22-177

Pampierstad Multi Land Use Development

GPO Boerdery (Pty) Ltd

Soil Profile for Test Pit TP7

0 From surface



slightly MOIST; dark RED; LOOSE; PINHOLED; silty SAND; AEOLIAN sand; abundant fine roots; decomposed organics; biological tunnelling; Bulk Sample No. 6; Undisturbed Sample No. 2.

-1180 ~Undulating contact

MOIST; dark RED, blotched orange and cream; medium DENSE with loose pockets; MATRIX SUPPORTED and partially cemented; calcrete nodules and concretions in a matrix of silty SAND; calcified AEOLIAN sand; minor fine roots; traces of variable concretionary calcrete; heterogenous composition; Not Sampled.

-2300 Gradual contact

MOIST to wet at the base; light creamy BROWN, mottled black and blotched red; DENSE; CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; minor infiltration zones; traces of fine roots; undulating extent; pockets of relict host material; Not Sampled.

-3000 Slow seepage at base

EXCAVATION STOPPED

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	Slow seepage at 3,0 m	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Minor sidewall collapse	Excavation Character:	Excavation stopped due to maximum reach
Samples Extracted:	1 Bulk Sample, 1 Undisturbed Sample	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.788967°S 24.717795°E

GC-22-177

Pampierstad Multi Land Use Development

Profile Photo: TP7

Material Present in Test Pit: TP7

Surroundings of Test Pit: TP7

GEOCALIBRE GEOTECHNICAL CONSULTANCY

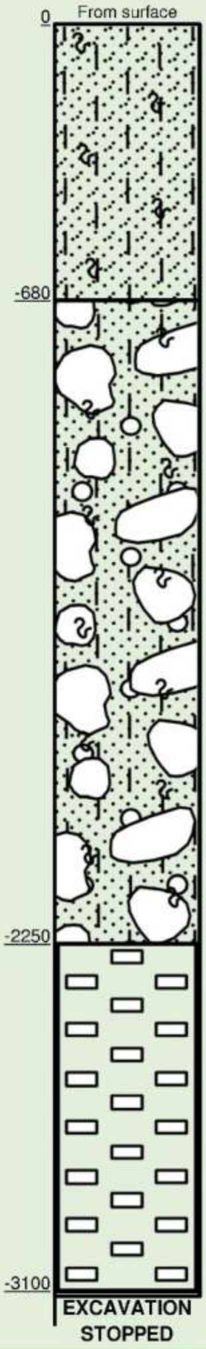
Test Pit TP8

GC-22-177

Pampierstad Multi Land Use Development

GPO Boerdery (Pty) Ltd

Soil Profile for Test Pit TP8



slightly MOIST; dark RED; LOOSE; PINHOLED; silty SAND; AEOLIAN sand; abundant fine roots with minor medium sized roots; highly undulating extent due to calcrete boulders at the base; Not Sampled.

~Undulating contact (420 to 940)

slightly MOIST to moist at the base; dark RED, blotched cream and olive; LOOSE with medium dense pockets; MATRIX SUPPORTED and partially cemented; calcrete nodules and boulder-sized concretions in a matrix of silty SAND; calcified AEOLIAN sand; highly variable exposure with calcrete boulders followed by pockets of sand; traces of fine roots; Not Sampled.

Gradual contact

slightly MOIST; dark olive creamy BROWN, banded and blotched white; medium DENSE; INTACT and CEMENTED; sub-angular calcrete nodules and minor cobble sized concretions with a matrix of powdery CALCRETE; CONCRETIONARY calcrete; friable upon exposure; traces of fine roots; Not Sampled.

Profile Notes		Excavation Description	
Profiled by:	KS Coertzen (Pri.Sci.Nat)	Contractor:	Client Supply
Groundwater Seepage:	No seepage	Machine:	TLB Type Light Mechanical Excavator-JCB 3CX
Excavation Stability:	Minor sidewall collapse	Excavation Character:	Excavation stopped due to maximum reach
Samples Extracted:	N/A	Date Profiled:	27/10/2022
Elevation (MAMSL):	1071	Coordinates:	27.788429°S 24.716747°E

Profile Photo: TP8

GEOCALIBRE
GEOTECHNICAL CONSULTANCY

GC-22-177

Pampierstad Multi Land Use Development

Material Present in Test Pit: TP8

Surroundings of Test Pit: TP8

Appendix B

Laboratory Test Results

Bulk and Disturbed Samples

LETABA LABORATORIES
AND SURVEYORS (Pty)
CIVIL ENGINEERING MATERIALS LABORATORY

6 Gruis Street, Hilton
Bloemfontein, 9301
P.O Box 22874,
Exton Road, 9313

ilac-MRA sanas Testing Laboratory T0864

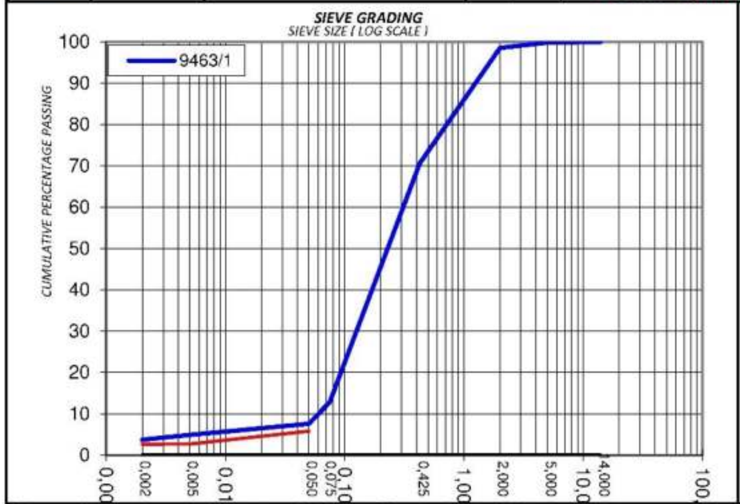
Tel. No: 087 285 0816 e-mail : letaba@letabalab.co.za www.letabalab.co.za

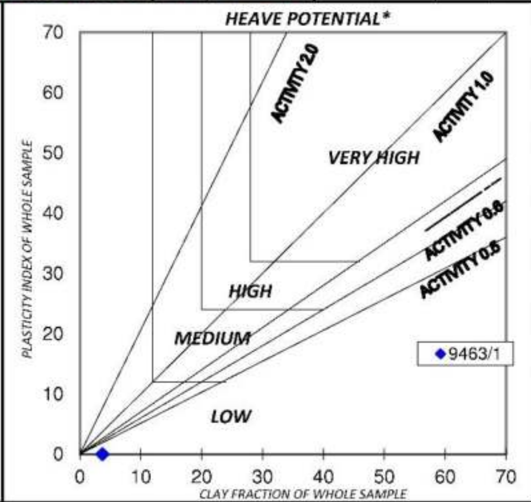
GRAVEL, SOIL AND SAND ANALYSIS : FOUNDATION INDICATOR TEST REPORT

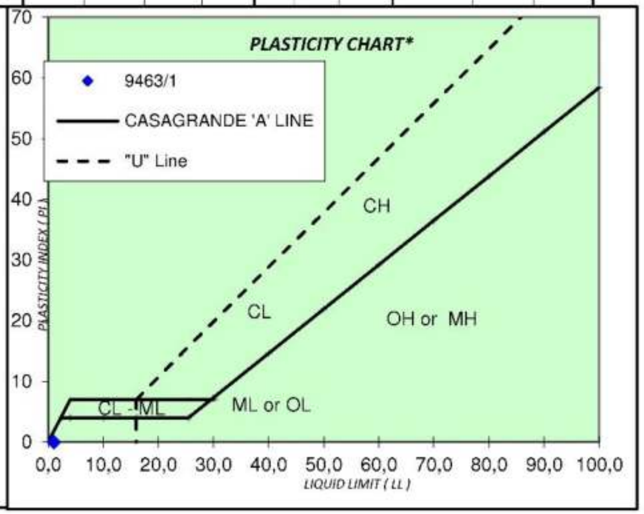
SANS 3001 Methods GR1, GR3, GR5, GR10, GR20, GR30 & GR40

Client : **Geocalibre (Pty) Ltd**	Address: 33 Denne Avenue, Donegal SH, Bainsvlei, Bloemfontein, 9301	**Date Sampled: 27-Oct-22**
Contract : **Pampierstad Filling Station**		**Doc No:** 9463/1(i)
Description : **TP 2 (P1) from 0.00 - 1.23 m below existing ground level - uncrushed material**		**Date Tested: 10-Nov-22**

Depth (m)	Sample No.	Description (Unified Soil Classification - ASTM D2487*)	Sieve analysis Cumulative percentage passing: 50,0 mm	37,5 mm	28.0 mm	20,0 mm	14.0 mm	5.0 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse sand <2,0 >0,425mm	Fine sand <0,425 >0,075mm	Silt <0,05 >0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.00 - 1.23	9463/1	lt Red. Orange Silty sand					100	100	99	71	13	7,6	4,9	3,7	28,3	58,6	2,7	5,0	0,060	5	0,8	1,2		NP	0,0	SM(d)	<G9	A-2-4	0
		*Double Hydrometer Values:										5,8	2,7	2,7															







Remarks: ** tests done at Bloemfontein branch

The Shrinkage Product of this material was 0

***DOUBLE HYDROMETER RESULT : 55 %** If Double Hydrometer result is above 40%, the material is considered to be dispersive.

***pH =6.4 , *Electrical Conductivity =0.022 S/m, tested on the whole sample**

Date Issued: 5/Dec/22

Technical signatory (Name) : **O. Bodumele**

Signature: Digitally signed by Obakeng Bodumele Date: 2022.12.05 15:28:03 +02'00'

LETABA LABORATORIES AND SURVEYORS (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY

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Exton Road, 9313

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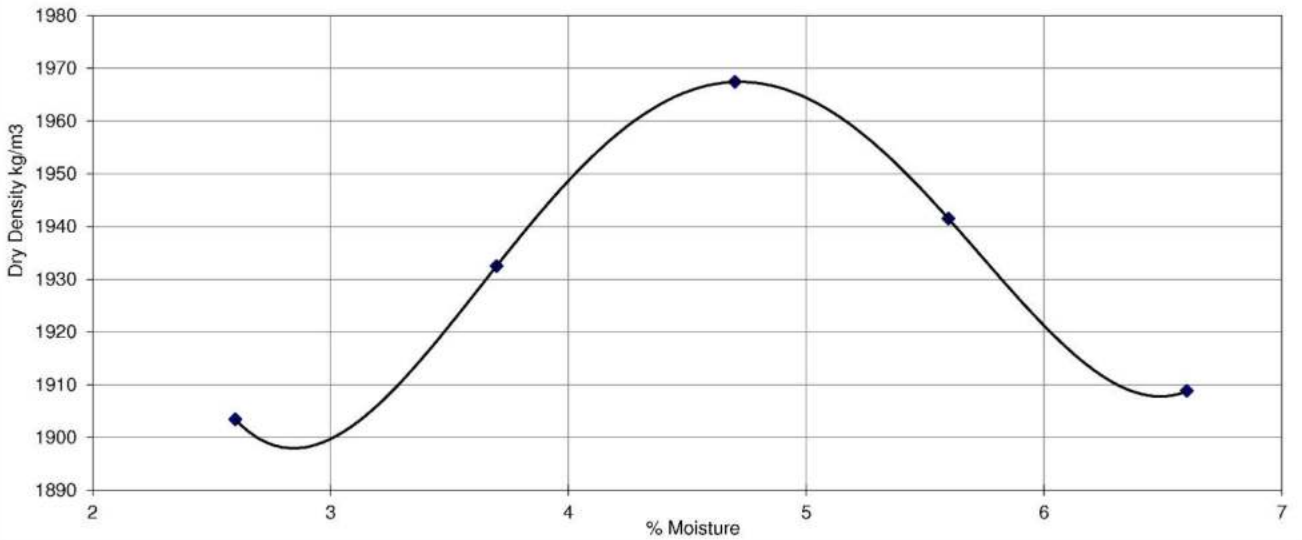
Tel. No: 087 285 0816 e-mail : letaba@letabalab.co.za www.letabalab.co.za

CBR and Maximum Dry Density Test Report

SANS 3001 Methods GR20, GR30 & GR40

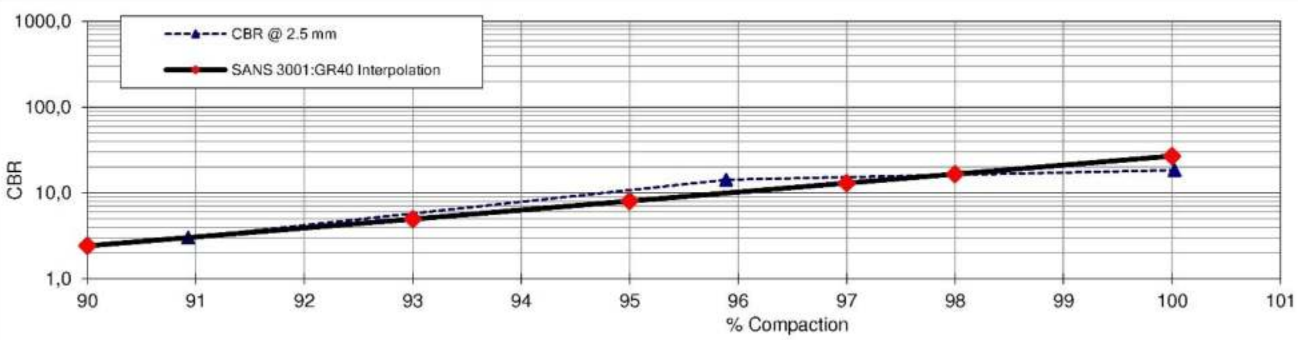
Client:	Geocalibre (Pty) Ltd	Date tested:	10-Nov-22
Contract :	Pampierstad Filling Station	Date Sampled:	27-Oct-22
Description:	TP 2 (P1) from 0.00 - 1.23 m below existing ground level - uncrushed material	Sample No.	9463/1
		Doc no:	9463/1(II)

*Maximum Dry Density =	1968	kg/m³
Optimum moisture content =	4,7	%



California Bearing Ratio

* This sample was prepared for compaction by using the Scalping method



% Compaction	100	98	97	95	93	90
CBR of 13.3 kN	27	17	13	8	5	2

** tests done at Bloemfontein branch

REMARKS

Briquette Information			
Compaction (%)	100,0	95,9	90,9
Dry Density (kg/m³)	1968	1887	1789
Compaction Moisture (%)	4,6	4,5	4,5
% Swell	0,13	0,28	0,51

Date Issued: 05-Dec-22 Technical signatory (Name) : **O. Bodumele** Signature:

Digitally signed by Obakeng Bodumele Date: 2022.12.05 15:28:56 +02'00'

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Exton Road, 9313

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Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

GRAVEL, SOIL AND SAND ANALYSIS : FOUNDATION INDICATOR TEST REPORT

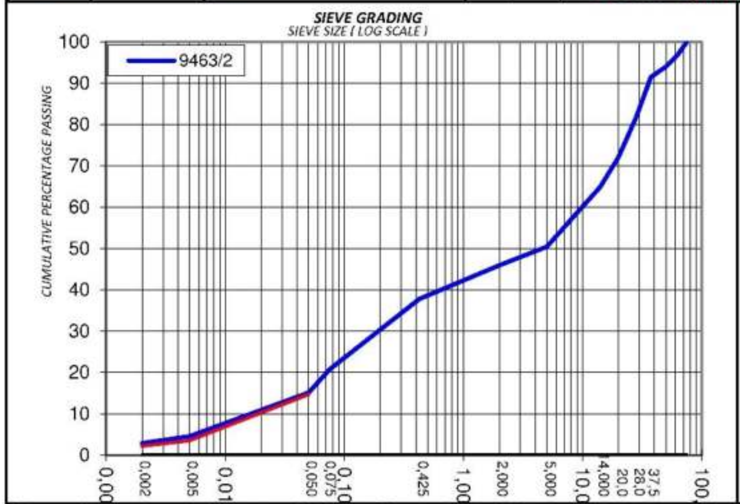
SANS 3001 Methods GR1, GR3, GR5, GR10, GR20, GR30 & GR40

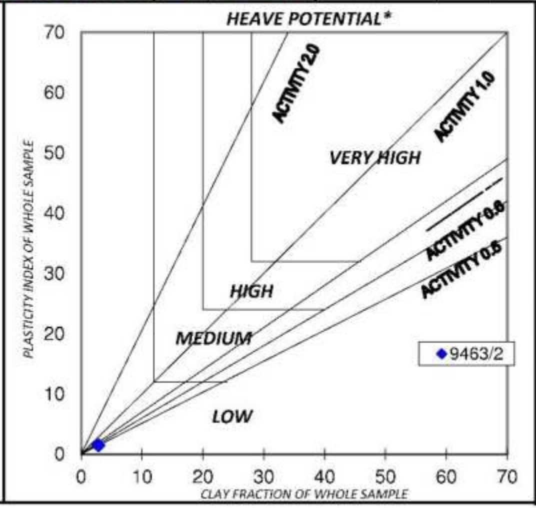
Client : **Geocalibre (Pty) Ltd** Address: 33 Denne Avenue, Donegal SH, Bainsvlei, Bloemfontein, 9301 **Date Sampled: 27-Oct-22**

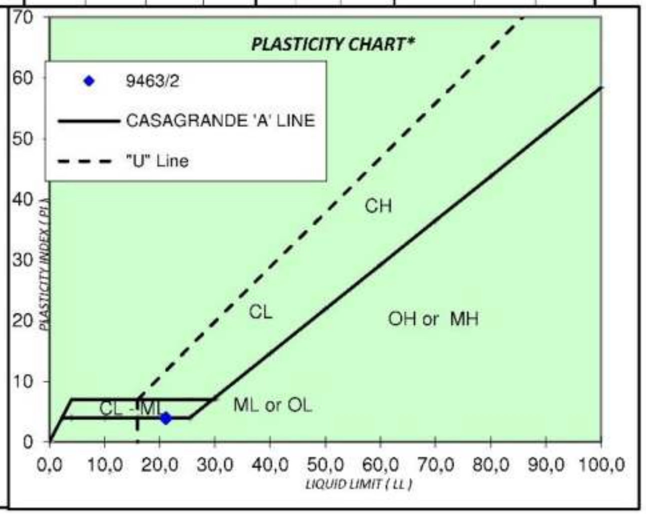
Contract : **Pampierstad Filling Station** **Doc No:** 9463/2(i)

Description : **TP 4 (P2) from 0.41 - 1.85 m below existing ground level - uncrushed material** **Date Tested: 10-Nov-22**

Depth (m)	Sample No.	Description (Unified Soil Classification - ASTM D2487*)	Sieve analysis Cumulative percentage passing: 50,0 mm	37,5 mm	28.0 mm	20,0 mm	14.0 mm	5.0 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0,005 mm*	0,002 mm*	Soil Mortar Analysis % of mat. <2,00 mm*: Coarse sand <2,0 >0,425mm	Fine sand <0,425 >0,075mm	Silt <0,05 >0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications*: Unified Soil	COLTO	US.Highway	Group Index
0.41 - 1.85	9463/2	drk Yel. Orange Silty/clayey sand	94	91	82	72	65	50	46	38	21	15,1	4,5	2,9	17,8	37,1	23,1	9,8	0,016	600	0,2	2,0	21	4	2,0	sm/sc	G6	A-1-b	0
					*Double Hydrometer Values:					14,7	3,5	2,2																







Remarks: ** tests done at Bloemfontein branch

The Shrinkage Product of this material was 76

***DOUBLE HYDROMETER RESULT : 77 %** If Double Hydrometer result is above 40%, the material is considered to be dispersive.

***pH =7 , *Electrical Conductivity =0.113 S/m, tested on the -5mm fraction**

Date Issued: 5/Dec/22 Technical signatory (Name) : **O. Bodumele** Signature:

Digitally signed by Obakeng Bodumele Date: 2022.12.05 15:56:06 +02'00'

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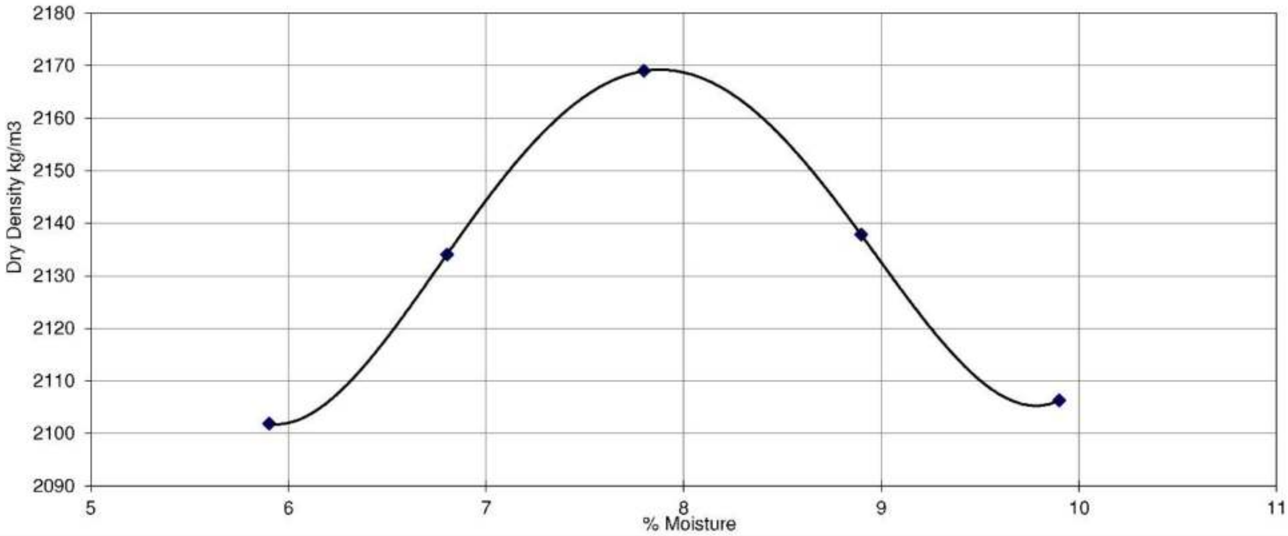
Tel. No: 087 285 0816 e-mail : letaba@letabalab.co.za www.letabalab.co.za

CBR and Maximum Dry Density Test Report

SANS 3001 Methods GR20, GR30 & GR40

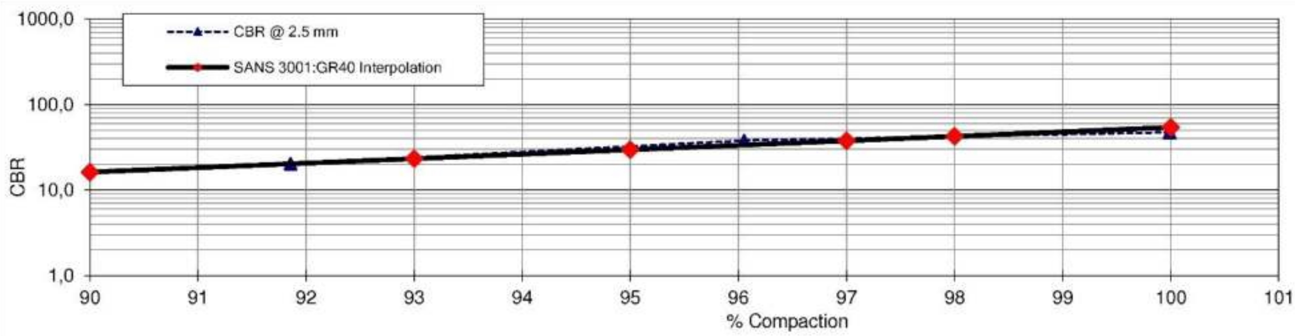
Client:	Geocalibre (Pty) Ltd	Date tested:	10-Nov-22
Contract :	Pampierstad Filling Station	Date Sampled:	27-Oct-22
Description:	TP 4 (P2) from 0.41 - 1.85 m below existing ground level - uncrushed material	Sample No.	9463/2
		Doc no:	9463/2(ii)

*Maximum Dry Density =	2169	kg/m³
Optimum moisture content =	7,8	%



California Bearing Ratio

* This sample was prepared for compaction by using the Scalping method



% Compaction	100	98	97	95	93	90
CBR of 13.3 kN	54	43	38	30	23	16

** tests done at Bloemfontein branch

REMARKS

Briquette Information			
Compaction (%)	100,0	96,1	91,9
Dry Density (kg/m³)	2169	2084	1993
Compaction Moisture (%)	7,7	7,7	7,6
% Swell	0,06	0,16	0,24

Date Issued: 05-Dec-22 Technical signatory (Name) : O. Bodumele Signature:

Digitally signed by Obakeng Bodumele Date: 2022.12.05 15:56:25 +02'00'

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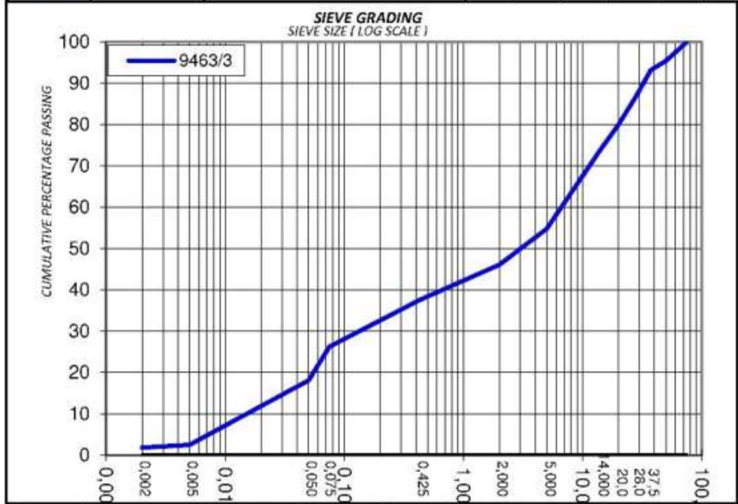
Tel. No: 087 285 0816 e-mail : letaba@letabalab.co.za www.letabalab.co.za

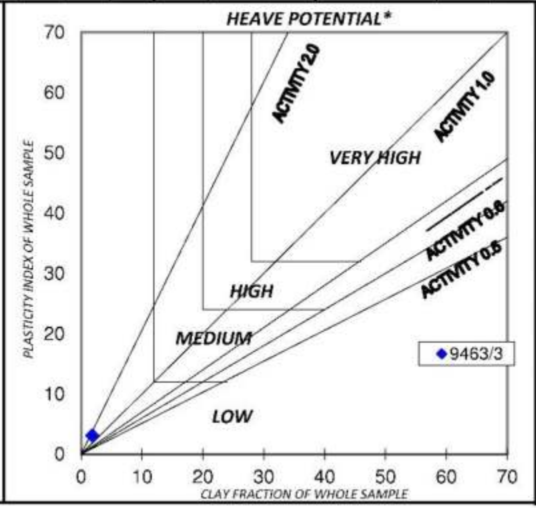
GRAVEL, SOIL AND SAND ANALYSIS : FOUNDATION INDICATOR TEST REPORT

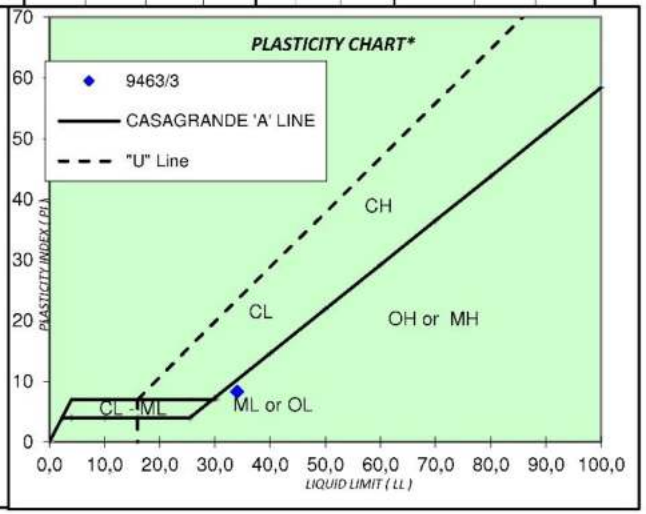
SANS 3001 Methods GR1, GR3, GR5, GR10, GR20, GR30 & GR40

Client : **Geocalibre (Pty) Ltd** Address: 33 Denne Avenue, Donegal SH, Bainsvlei, Bloemfontein, 9301	**Date Sampled: 27-Oct-22**
Contract : **Pampierstad Filling Station**	**Doc No:** 9463/3(i)
Description : **TP 4 (P3) from 1.85 - 3.00 m below existing ground level - uncrushed material**	**Date Tested: 10-Nov-22**

Depth (m)	Sample No.	Description (Unified Soil Classification - ASTM D2487*)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm*				Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits			Classifications*			
			50,0 mm	37,5 mm	28.0 mm	20,0 mm	14.0 mm	5.0 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0,002 mm*	Coarse sand <2,0 >0,425mm	Fine sand <0,425 >0,075mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	COLTO	US.Highway	Group Index
1.85 - 3.00	9463/3	lt Yel. Orange Clayey sand	95	93	87	80	74	55	46	38	26	18,1	2,5	1,8	18,5	24,5	33,9	5,4	0,015	439	0,2	1,9	34	8	4,1	SC	G9	A-2-4	0







Remarks: ** tests done at Bloemfontein branch

The Shrinkage Product of this material was 154

Date Issued: 6/Dec/22 Technical signatory (Name) : **O. Bodumele** Signature:

Digitally signed by Obakeng Bodumele
Date: 2022.12.06 08:19:52 +02'00'

LETABA LABORATORIES
AND SURVEYORS (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY

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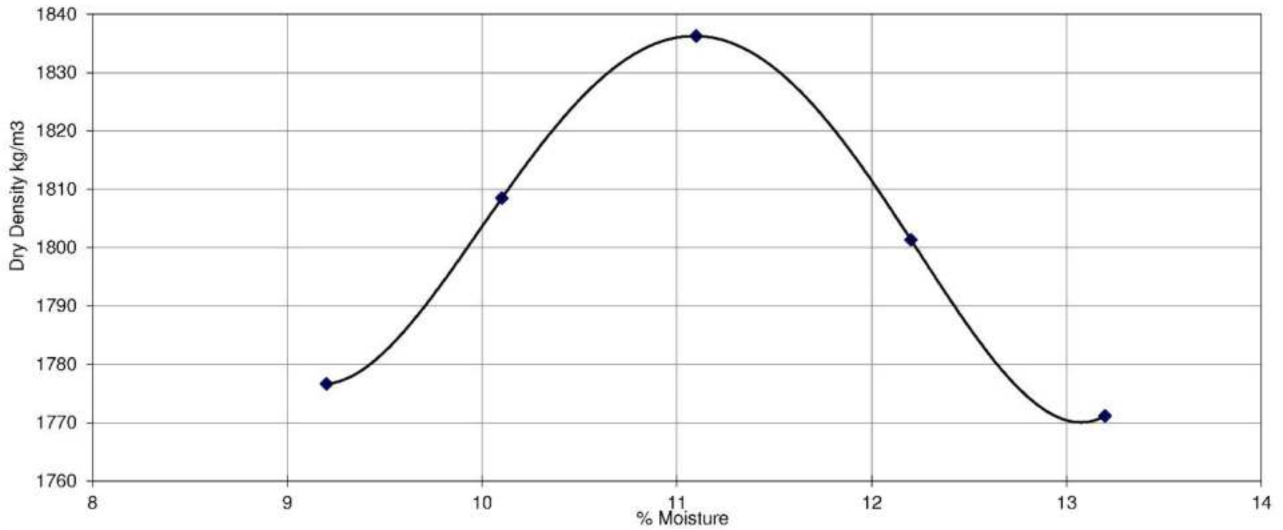
CBR and Maximum Dry Density Test Report

SANS 3001 Methods
GR20, GR30 & GR40

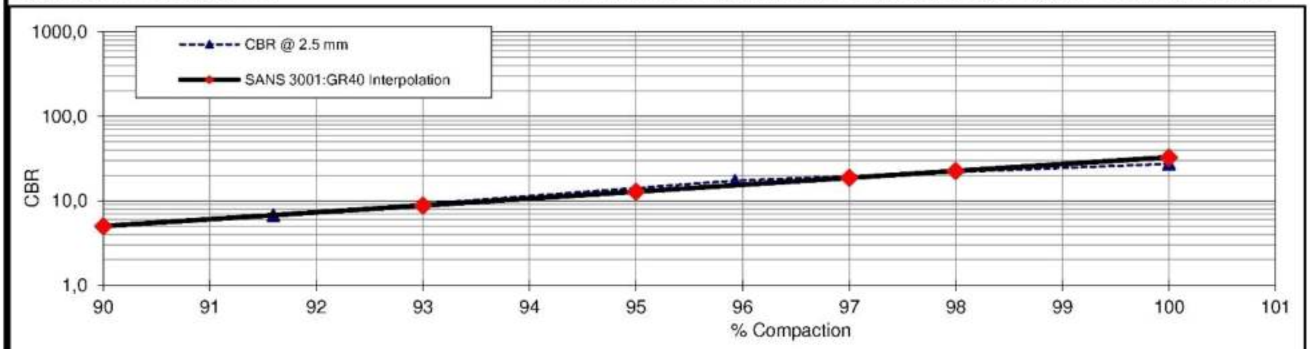
Client:	Geocalibre (Pty) Ltd	Date tested:	10-Nov-22
Contract :	Pampierstad Filling Station	Date Sampled:	27-Oct-22
Description:	TP 4 (P3) from 1.85 - 3.00 m below existing ground level - uncrushed material	Sample No.	9463/3
		Doc no:	9463/3(ii)

*Maximum Dry Density =	1836	kg/m³
Optimum moisture content =	11,1	%



California Bearing Ratio

* This sample was prepared for compaction by using the Scalping method



% Compaction	100	98	97	95	93	90
CBR of 13.3 kN	33	23	19	13	9	5

** tests done at Bloemfontein branch

REMARKS

Briquette Information			
Compaction (%)	100,0	95,9	91,6
Dry Density (kg/m³)	1836	1761	1682
Compaction Moisture (%)	11,0	11,0	10,9
% Swell	0,09	0,27	0,61

Date Issued: 06-Dec-22 Technical signatory (Name) : O. Bodumele Signature:

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LETABA LABORATORIES
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ilac-MRA sanas Testing Laboratory T0864

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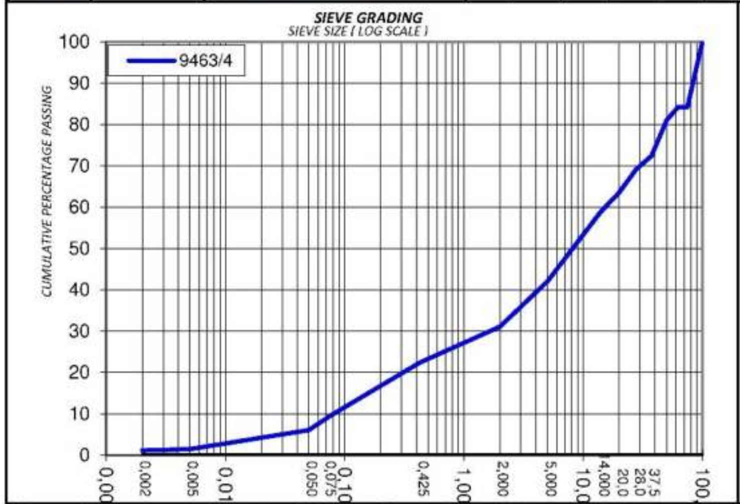
GRAVEL, SOIL AND SAND ANALYSIS : FOUNDATION INDICATOR TEST REPORT

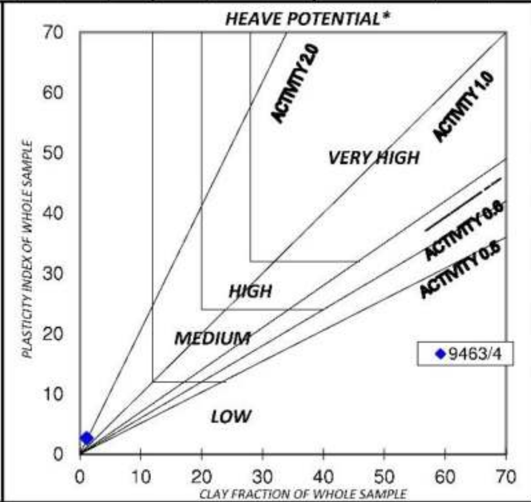
SANS 3001 Methods GR1, GR3, GR5, GR10, GR20, GR30 & GR40

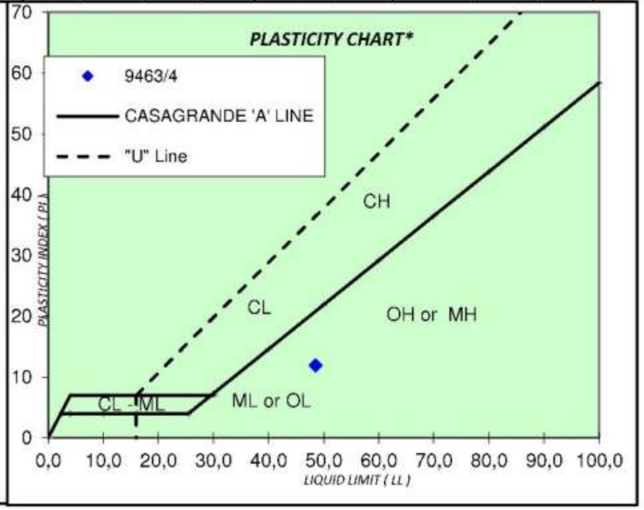
Client : **Geocalibre (Pty) Ltd** Address: 33 Denne Avenue, Donegal SH, Bainsvlei, Bloemfontein, 9301
Contract : **Pampierstad Filling Station**
Description : **TP 5 (P4) from 2.25 - 2.90 m below existing ground level - uncrushed material**

Date Sampled: 27-Oct-22
Doc No: 9463/4(i)
Date Tested: 04-Nov-22

Depth (m)	Sample No.	Description (Unified Soil Classification - ASTM D2487*)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm*				Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits			Classifications*			
			50,0 mm	37,5 mm	28.0 mm	20,0 mm	14.0 mm	5.0 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Coarse sand <2,0 >0,425mm	Fine sand <0,425 >0,075mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	COLTO	US.Highway	Group Index
2.25 - 2.90	9463/4	lt Brown Well graded gravel with clay and sand	81	72	69	64	59	42	31	22	9	6,1	1,5	1,1	27,9	41,7	14,8	4,7	0,081	189	2,2	2,4	49	12	5,7	GW/GC	N/A	A-2-7	0







Remarks: ** tests done at Bloemfontein branch
The Shrinkage Product of this material was 128

Date Issued: 6/Dec/22 Technical signatory (Name) : **O. Bodumele** Signature:

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Date: 2022.12.06 08:50:23 +02'00'

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Tel. No: 087 285 0816 **e-mail :** letaba@letabalab.co.za www.letabalab.co.za

GRAVEL, SOIL AND SAND ANALYSIS : FOUNDATION INDICATOR TEST REPORT

SANS 3001 Methods GR1, GR3, GR5, GR10, GR20, GR30 & GR40

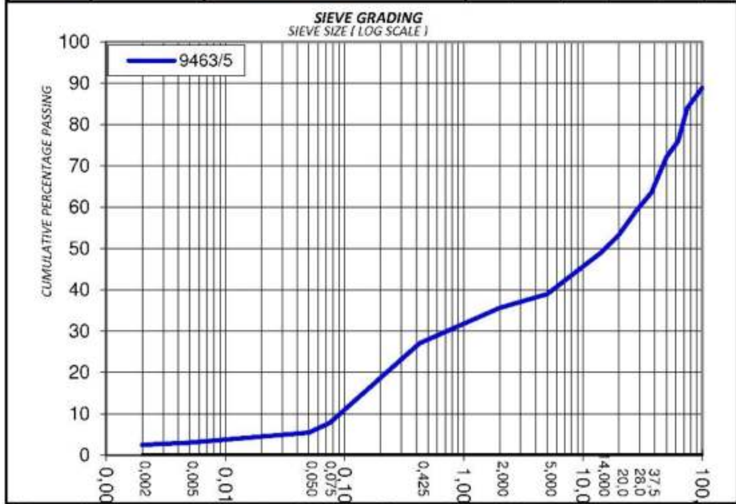
Client : **Geocalibre (Pty) Ltd** Address: 33 Denne Avenue, Donegal SH, Bainsvlei, Bloemfontein, 9301

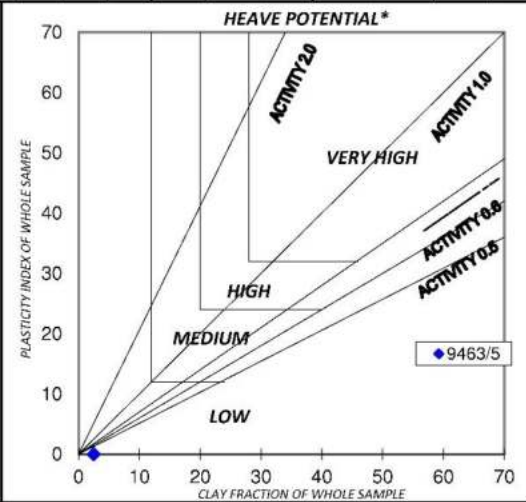
Contract : **Pampierstad Filling Station**

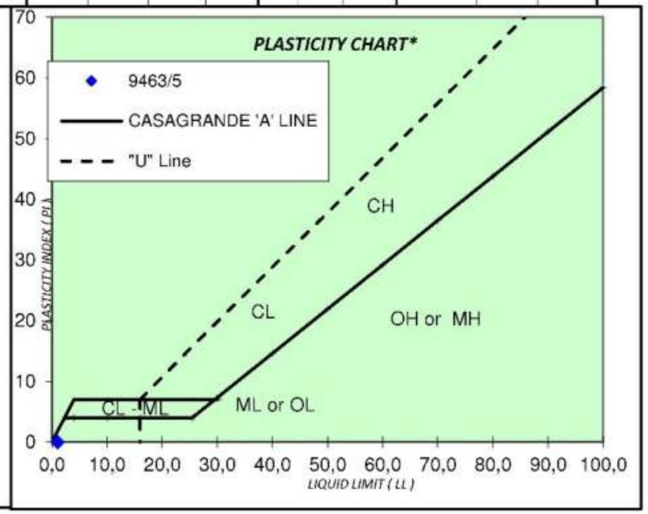
Description : **TP 6 (P5) from 0.65 - 2.33 m below existing ground level - uncrushed material**

Date Sampled: 27-Oct-22
Doc No: 9463/5(i)
Date Tested: 10-Nov-22

Depth (m)	Sample No.	Description (Unified Soil Classification - ASTM D2487*)	Sieve analysis Cumulative percentage passing 50,0 mm	37,5 mm	28.0 mm	20,0 mm	14.0 mm	5,0 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Soil Mortar Analysis % of mat. <2,00 mm* Coarse sand <2,0 >0,425mm	Fine sand <0,425 >0,075mm	Silt <0,05 >0,005mm	Clay <0,005 mm	Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications* Unified Soil	COLTO	US.Highway	Group Index
0.65 - 2.33	9463/5	lt Red Poorly graded gravel with silt and sand	72	63	59	53	49	39	36	27	8	5,4	3,0	2,5	24,2	53,9	6,7	8,4	0,091	325	0,2	2,3		NP	0,0	GP/GM	G6	A-2-5	0







Remarks: ** tests done at Bloemfontein branch

The Shrinkage Product of this material was 0

Please note that test results are only relevant to the sample delivered to the lab, and based on information and/or instructions provided by the client. Any results may only be reproduced in their entirety with the written consent of LETABA LABORATORIES AND SURVEYORS (Pty) Ltd, and any opinions and interpretations expressed,or results marked *, fall outside our Scope of Accreditation.

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Date: 2022.12.06 09:31:32 +02'00'

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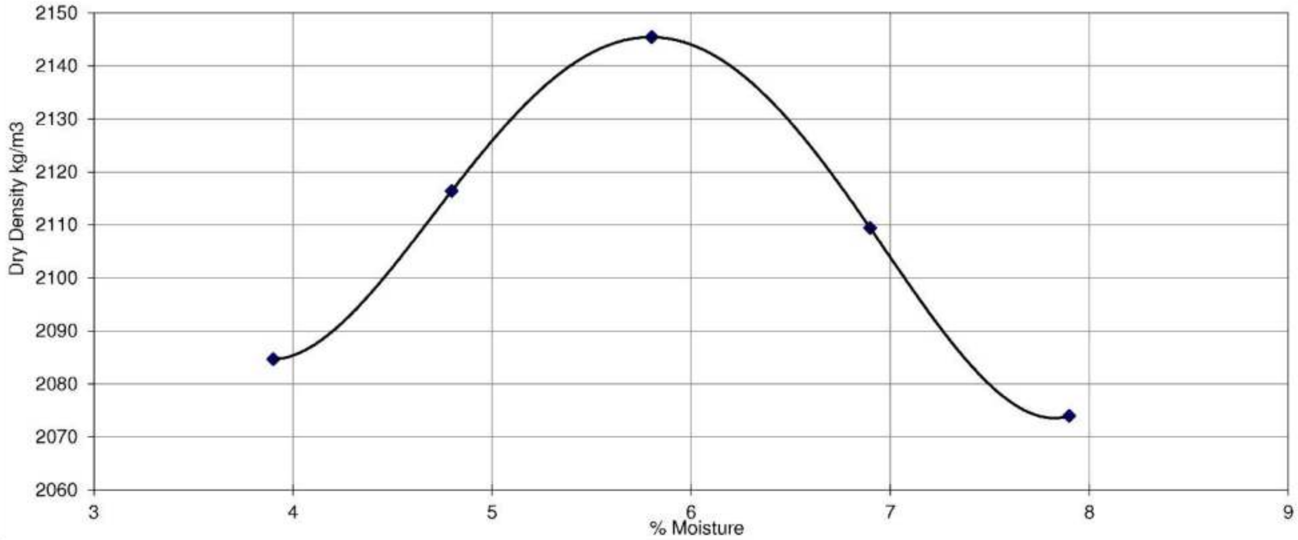
CBR and Maximum Dry Density Test Report

SANS 3001 Methods GR20, GR30 & GR40

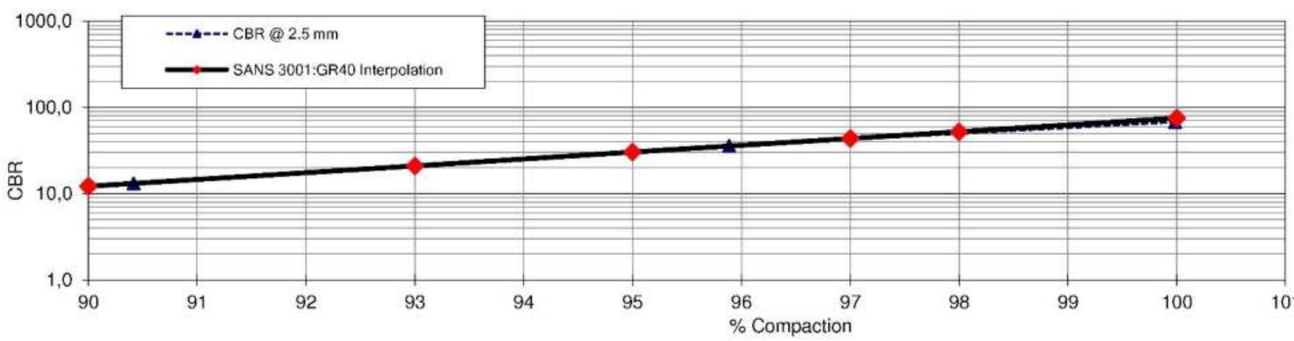
Client:	Geocalibre (Pty) Ltd	Date tested:	10-Nov-22
Contract :	Pampierstad Filling Station	Date Sampled:	27-Oct-22
Description:	TP 6 (P5) from 0.65 - 2.33 m below existing ground level - uncrushed material	Sample No.	9463/5
		Doc no:	9463/5(ii)

*Maximum Dry Density =	2146	kg/m³
Optimum moisture content =	5,8	%



California Bearing Ratio

* This sample was prepared for compaction by using the Scalping method



% Compaction	100	98	97	95	93	90
CBR of 13.3 kN	75	52	43	30	21	12

** tests done at Bloemfontein branch

REMARKS

Briquette Information			
Compaction (%)	100,0	95,9	90,4
Dry Density (kg/m³)	2146	2058	1940
Compaction Moisture (%)	5,7	5,7	5,6
% Swell	0,08	0,13	0,23

Date Issued: 06-Dec-22 Technical signatory (Name) : O. Bodumele Signature:

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GRAVEL, SOIL AND SAND ANALYSIS : FOUNDATION INDICATOR TEST REPORT

SANS 3001 Methods GR1, GR3, GR5, GR10, GR20, GR30 & GR40

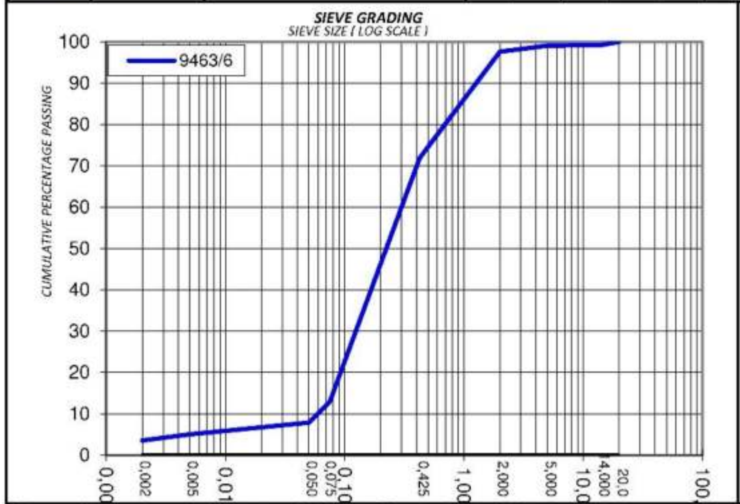
Client : **Geocalibre (Pty) Ltd** Address: 33 Denne Avenue, Donegal SH, Bainsvlei, Bloemfontein, 9301

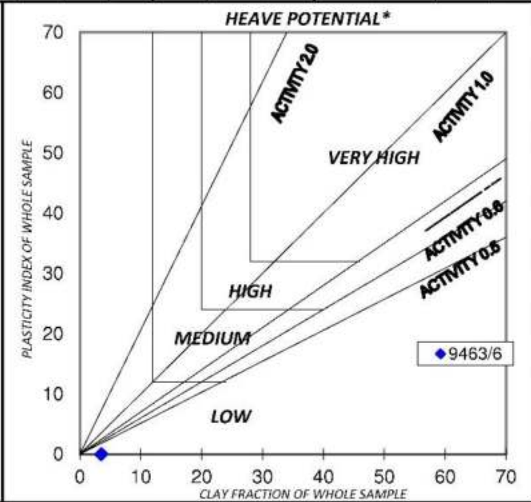
Contract : **Pampierstad Filling Station**

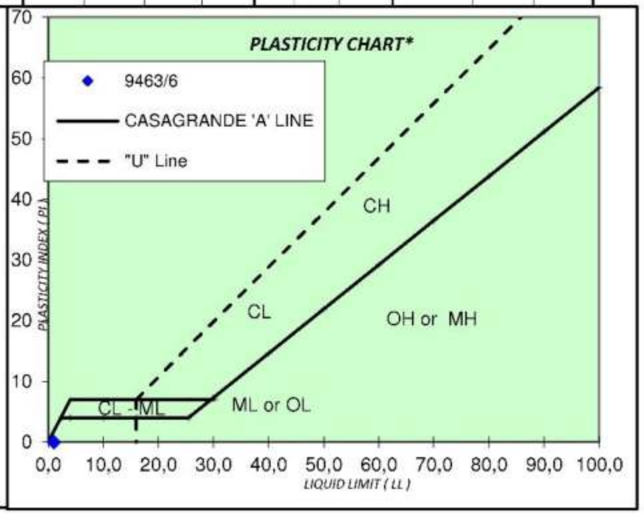
Description : **TP 7 (P6) from 0.00 - 1.18 m below existing ground level - uncrushed material**

Date Sampled: 27-Oct-22
Doc No: 9463/6(i)
Date Tested: 09-Nov-22

Depth (m)	Sample No.	Description (Unified Soil Classification - ASTM D2487*)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm*				Effective size*	Uniformity - coef.*	Curvature coef.*	Grading modulus*	Atterberg Limits			Classifications*			
			50,0 mm	37,5 mm	28.0 mm	20,0 mm	14.0 mm	5.0 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm*	0.005 mm*	0.002 mm*	Coarse sand <2,0 >0,425mm	Fine sand <0,425 >0,075mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	COLTO	US.Highway	Group Index
0.00 - 1.18	9463/6	drk Red Silty sand				100	99	99	98	72	13	7,8	5,1	3,5	26,4	60,4	2,8	5,2	0,059	5	0,9	1,2		NP	0,0	SM(d)	N/A	A-2-4	0







Remarks: ** tests done at Bloemfontein branch

The Shrinkage Product of this material was 0

Date Issued: 6/Dec/22 Technical signatory (Name) : **O. Bodumele** Signature:

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Date: 2022.12.06 09:18:40 +02'00'

Appendix C

Laboratory Test Results

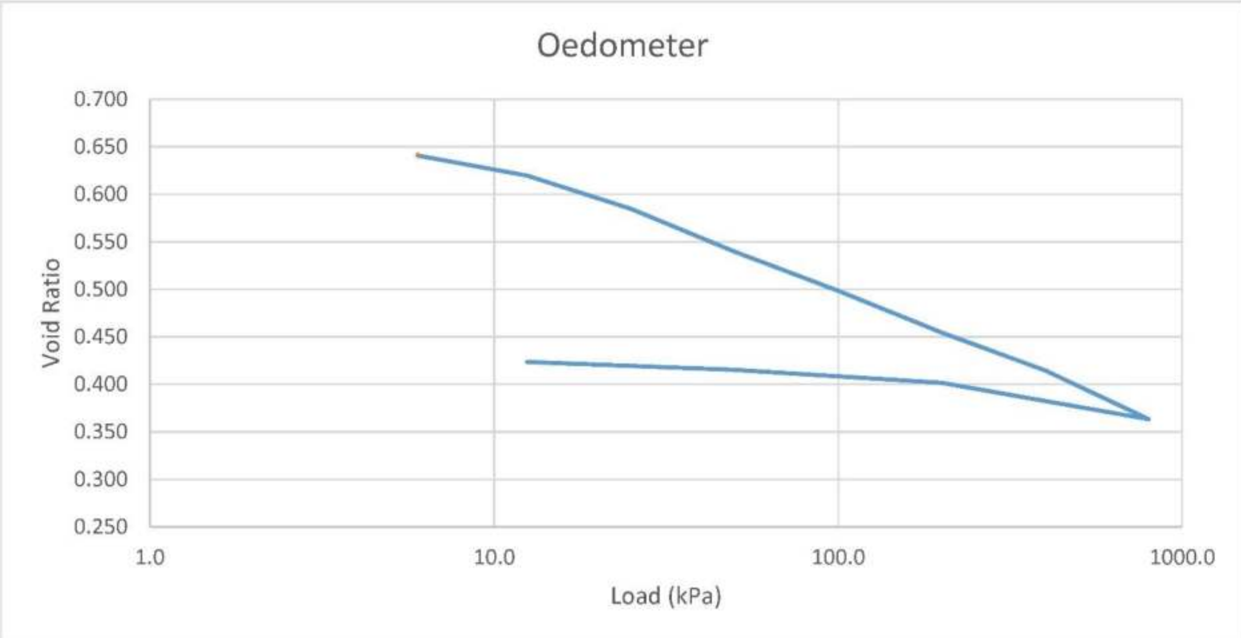
Undisturbed Test Results

Oedometer Swell Test

Sample Detail		Initial	Final
Height	(mm)	20.2	17.5
Diameter	(mm)	63.2	63.2
Weight	(g)	107.0	119.4
Moisture	(%)	5.0	15.5
Dry Density	(Mg/m^3)	1.61	1.88
Bulk Density	(Mg/m^3)	1.69	2.17
Void Ratio		0.641	0.423
Particle Density	(Mg/m^3)	2.64	
Disturbed/Undisturbed		Undisturbed	
Remoulded Density	(Mg/m^3)	-	

Load (kPa)	Height (mm)	Void Ratio
6.0	20.17	0.641
6.0	20.16	0.641
12.5	19.90	0.619
25	19.47	0.585
50	18.92	0.540
100	18.41	0.498
200	17.87	0.454
400	17.38	0.414
800	16.75	0.363
200	17.22	0.401
50	17.39	0.415
12.5	17.49	0.423

Swell Results		
Swell Percentage	0.0	%
Swell Pressure	0	kPa



STEYN-WILSON GEOTECHNICAL
sanas

Project	Pampierstad Filling Station		
Sample	PAP1-TP2_1.00-1.20m		
Client	Geocalibre	Test Method	BS1377 - 5: 1990
Jobfile	SWG00446	Test Date	30/11/2022

Oedometer Collapse Test

Sample Detail		Initial	Final
Height	(mm)	20.2	16.4
Diameter	(mm)	63.3	63.3
Weight	(g)	110.1	119.8
Moisture	(%)	3.9	15.7
Dry Density	(Mg/m^3)	1.67	2.01
Bulk Density	(Mg/m^3)	1.74	2.33
Void Ratio		0.584	0.286
Particle Density	(Mg/m^3)	2.65	
Disturbed/Undisturbed		Undisturbed	
Remoulded Density	(Mg/m^3)	-	

Load (kPa)	Height (mm)	Void Ratio
3.0	20.160	0.584
12.5	20.060	0.576
25.0	19.860	0.561
50.0	19.560	0.537
100.0	19.160	0.506
200.0	18.660	0.466
200.0	17.660	0.388
400.0	16.360	0.286

Collapse Results	
Collapse Potential	5.4 %

STEYN-WILSON GEOTECHNICAL

Project	**Pampierstad Filling Station**		
Sample	**PAP2_TP7_0.80-1.00m**		
Client	Geocalibre	Test Method	BS1377 - 5: 1990
Jobfile	SWG00446	Test Date	30/11/2022

Appendix D

Site Classification Reference Tables

Table 8. Geotechnical Constraints in Urban Development (SANS 634:2012)

CONSTRAINT		**DESCRIPTOR**		
DESCRIPTION		**1 (most favourable)**	**2 (intermediate)**	**3 (least favourable)**
A	Collapsible soil	Any collapsible horizon or consecutive horizons totalling depth of less than 750 mm in thickness	Any collapsible horizon or consecutive horizons totalling depth of more than 750 mm in thickness	n/a
B	Seepage	Permanent or perched water table more than 1.5 m below ground surface	Permanent or perched water table less than 1.5 m below ground surface	Swamps and marshes
C	Active soil	Low soil-heave potential anticipated	Moderate soil-heave potential anticipated	High soil-heave potential anticipated
D	Highly compressible soil	Low soil compressibility anticipated	Moderate soil compressibility anticipated	High soil compressibility anticipated
E	Erodibility of soil	Low	Intermediate	High
F	Difficulty of excavation to 1.5 m depth	Scattered or occasional boulders less than 10% of total volume	Rock or hardpan pedocretes between 10% and 40% of total volume	Rock or hardpan pedocretes more than 40% of total volume
G	Undermined ground	Undermining at a depth greater than 200 m below surface	Old, undermined areas to a depth of 200 m below surface	Mining within less than 200 m of surface with total extraction
H	Stability (dolomite land)	Possibly stable	Potentially instable	Known sinkholes and dolines
I	Steep slopes	2-6 degrees	< 2 degrees or 6-18 degrees	> 18 degrees
J	Unstable natural slopes	Low risk	Intermediate risk	High risk
K	Seismic activity	10% probability of an event less than 100 cm/s^2 in 50 years	Mining-induced seismicity > 100 cm/s^2	Natural seismicity > 100 cm/s^2
L	Flooding	n/a	Adjacent to known drainage or channel with slope < 1%	Areas within drainage channel or floodplain

(After Partridge, Wood & Brink, 1993)

Table 9. Residential Site Class Designations (SAICE, 1995)

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

NOTES:

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

Table 10. NHBRC Site Classification Designations Linked to Construction Types (Home Builders Manual, 2015) (SAICE, 1995)

Site Class designation	Typical founding material	Character of founding material	Single storey masonry house construction type
R	Rock	Stable	Normal
H	Clays, silty clays, clayey silts and sandy clays.	Expansive soils	Normal
H1			Modified normal / soil raft
H2			Stiffened or cellular raft / piled or split construction / soil raft.
H3			Stiffened or cellular raft / piled or split construction / soil raft.
C	Silty sands, sands, sandy and gravelly soils.	Compressible and potentially collapsible soils	Normal
C1			Modified normal / compaction of in-situ soils below individual footings / deep strip foundations / soil rafts.
C2			Stiffened strip footings, stiffened or cellular raft / deep strip foundations / compaction of in-situ soil below individual footings / piled or pier foundations / soil raft.
P	Contaminated soils, controlled fill, dolomitic areas, landslip, landfill, marshy areas, mine waste fill, mining subsidence, reclaimed areas, uncontrolled fill, very soft silts / silty clays.	Variable.	Variable.
S	Clayey silts, clayey sands of low plasticity, sands, sandy and gravelly soils	Compressible soils	Normal
S1			Modified normal / compaction of in-situ soil below individual footings / deep strip foundations/ soil raft
S2			Stiffened strip footings, stiffened or cellular raft / deep strip foundations / compaction of in-situ soil below individual footings / piled or pier foundations / soil raft.

Appendix E

Site Layout Plan

NOTE/NOTA :

NO DIMENSIONS ARE TO BE SCALED OFF ANY DRAWINGS. ALL DIMENSIONS ARE TO BE RATIFIED ON SITE PRIOR TO ANY CONSTRUCTION.

GEEN AFMETINGS MAG VAN TEKENINGE GESKAAL WORD NIE. ALLE AFMETINGS MOET OP TERREIN NAGEGAAN WORD VOOR KONSTRUKSIE.

A BEFORE CONTRACT COMMENCES. VOOR KONTRAK IN AANVANG NEEM.
A1 AFTER CONTRACT HAS COMMENCED. NA KONTRAK IN AANVANG GENEEM HET.

NO. NR.	DATE DATUM	AMENDMENTS WYSIGINGS

MVD Kalahari
Consulting Engineers and Town Planning/Raadgewende Ingenieurs en Stadsbeplanning.
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CESA

DESIGN ONTWERP	W. Karsten	
DRAWN GETEKEN	X. Magau	
CHECKED NAGEGAAN	W. Karsten	
CLIENT KLIENT	------	
DATE DATUM	June 2022	

PROJECT/PROJEK

PAMPIERSTAD PROPOSED FILLING STATION

CLIENT/KLIENT

G.P OLIVIER

DRAWING DESCRIPTION/TEKENING BESKRYWING

SITE DEVELOPMENT PLAN OPTION 4

PAPER SIZE/PAPIER GROOTTE	SCALE/SKAAL	DRAWING No./TEKENING Nr.	REV No.
A1	1:500	10963/C/M/L/001	--

DRAFT