LETABA LAB (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY

GEOTECHNICAL INVESTIGATION: EXTENTION OF BOLOKANANG RURAL SETTLEMENT FREE STATE PROVINCE

GIBB
ENGINEERING & SCIENCE

Letaba Lab

2014-02-26

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26 February 2014

LIST OF ABBREVIATIONS AND DEFINTIONS

CBR	**California Bearing Ratio** CBR is a penetration test for evaluation of the mechanical strength of road subgrades and base-courses. It was developed by the California Department of Transportation before World War II.
Excavation Classification	**Class A:** Hard rock excavation which may require the use of drill and blast methods to remove in-situ bedrock/boulder material to the required depth of excavation. **Class B:** Boulder or soft bedrock excavation which may require the use of heavy mechanical earth moving equipment to remove in-situ bedrock/boulder material to the required depth of excavation. **Class C:** In-situ material excavation which may require the use of light mechanical earth moving equipment or laborers through the use of a pick-and-shovel system to remove in-situ bedrock/boulder material to the required depth of excavation.
DCP	**Dynamic Cone Penetrometer** The DCP works by using a 8 kg steel mass dropping 575 mm which hits the anvil. Each stroke causes penetration of a 20mm diameter cone (60° vertex angle) which sits at the base of assembly into the soil (underlying surface). The penetration rate of the cone of the DCP is inversely proportional to the resistance level of the terrain. The DCP test is an in-situ CBR or density testing of the soil.
DPL	**Light Dynamic Penetrometer** The Light Dynamic Penetrometer (DPL) with manual driving is the one allowing dynamic penetration tests with the lightest hammer (10 kg) in the whole range of dynamic penetrometers. The apparatus, held by its handles, is maintained vertically. The constant falling heights of its hammer (50 cm) drive the rods - fitted with a standard cone - into the soil.
Excavatability	The excavatability of an earth (rock and regolith) material is a measure of the material to be excavated with conventional excavation equipment such as a bulldozer with rippers, light mechanical excavator or other grading equipment.
MOD AASHTO	**The Modified AASHTO** Soil Classification System which was developed by the American Association of State Highway and Transportation Officials, and is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes.
Pedocretes	Pedocretes are soils which have to a less or greater extent been cemented or replaced by mineral constituents such as; carbonate (calcretes), iron oxide (ferricrete) or silica (silcrete).
Residual soil	Residual soils are soils that develop from the complete weathering of their underlying parent rocks and have the same general chemistry as those rocks.
TP	**Test Pit** An excavation unit used to sample or probe a site before large-scale excavation or to check surface surveys. Typically small square trenches or holes arranged in such a way as to sample a site.
Transported Soil	Soils which form from the accumulation of material which has been transported by wind, water, ice and/or gravity.

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1 Introduction

1.1 General

A detailed geotechnical investigation was conducted for the proposed extension of the existing Bolokanang Rural Settlement to the south east of Petrusburg in the Free State Province. This investigation was undertaken in order to assess the engineering geological character of the area, focusing on the geotechnical properties which will affect the overall development potential of the site.

1.2 Terms of Reference

Letaba Lab was appointed by GIBB Engineering and Science, as confirmed by means of a Letter of Appointment dated 17/01/2014, the geotechnical investigation commenced on the 30/01/2014.

The test pit positions and quantities were specified by the client upon appointment.

1.3 Scope of the investigation

The investigation had the following aims:

- to determine and describe the succession of soil and rock materials occurring beneath and across the site
- to assess the mechanical properties of the soil material covering the study area with regard to the founding of single- and double storey structures
- to evaluate site excavatability
- to recommend measures to be implemented during design and development of the area

The development potential of the study area is assessed based on the following premises:

- Single- and double storey masonry structures will be constructed.

It must be noted that this investigation was conducted for design and construction purposes.

1.4 Available information

The following sources of information were utilized:

- Geological maps:
    - Geological Map of South Africa (Council of Geocsience)
- Topocadastral Map
    - 2925 AB (digital format)
- Site development plan
    - PLAN Number- 200372/1 Draft 1
    - Compiled by: L. Pienaar
    - Date: 11/09/2013
    - Scale 1:5000
    - DWG format
- Geotechnical site layout:
    - Google Earth
    - Google Maps

1.5 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 line 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:
>
> i. widening or straightening of the bed or banks of a river to allow for the construction of a bridge, sports ground or housing development
>
> ii. 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.

2 Description of Environment

2.1 Site location and Description

The study area is defined as an irregular shaped parcel of land, sub divided into alternating rectangular and triangular structures/land use zones. The total combined surface area of these structures is approximately 80 ha. The study area is located to the south of the existing Bolokanang Rural Settlement which is falls within close proximity of the Petrusburg Town in the Free State province, South Africa. Moreover; Petrusburg forms the mid-point between the major towns of Bloemfontein and Kimberly along the National Road 8 (N8). (Figure 1).

This investigation forms as part of the analysis for the proposed extension of this settlement towards the south. The site plan provided by the client indicates the subdivision of the site into various land-use zones i.e. residential, business and roads. Each of these zones potentially require their own set of unique geotechnical recommendations.

The existing Bolokanang Rural Settlement is located at roughly the following co-ordinates:

Latitude: 29.127191° S **Longitude:** 25.422619° E

The site for this investigation is located roughly at the following coordinate:

Latitude: 29.136979° S **Longitude:** 25.422311° E

2.2 Topography

The site is located towards the western boundary of the Free State at an elevation of between 1 256 and 1 282 m above mean sea level (mamsl). The regional area is generally flat with occasional table top hill structures.

The study area represents slopes of **less than 2º.**

The contours of the site indicate that the south eastern portions are generally higher than the areas in the north and west.

The surface of the site hosts small/localised areas where the surface morphology/topography has been altered through on-going human.

2.3 Drainage

Due to its slope, the site will drained mainly by means of slow/low energy surface run-off (sheet-flow) with storm water eventually flowing from the high raised areas in the south east towards the north west.

The gentle sloping nature in the centeral portions of the site as well as the undulating topography in the western portions of the site may lead to ponding of water on the surface after prolonged precipitation events. In area where natural vegetation is removed it can be expected that on-going erosion of surface material may lead to desertification.

Surface water may flow along artificial paths after prolonged precipitation which will alter the natural drainage pattern of the area.

2.4 Climate

Petrusburg receives about **318mm** of rain per year, with rainfall occurring mainly during summer. It receives the lowest rainfall (1mm) in July and the highest (62mm) in March. The average midday temperatures for Petrusburg ranges from 17°C in June to 30.9°C in January. The region is the coldest during July when the mercury drops to 0°C on average during the night.

The Climatic N-Value (Weinert, 1980) for the area is **between 8 and 9**; indicating that principle mode of weathering within the regional setting will be the physical/mechanical decomposition of the parent rock rather than chemical disintegration which can be expected in areas with a wetter climate.

2.5 Vegetation

The site was seen to be well covered with grasses and small shrubs. In drier periods of the year this vegetation cover is degraded and exposed soils are eroded. On-going human activity has negatively affected the vegetation density in the area. Subsistence farming has led to the exposure of in-situ material, which can lead to greater degrees of erosion.

There is an overwhelming presence of termite mounds found to cover the site. Termites can drastically alter the geotechnical properties of the in-situ soil horizons.

3 Site Geology and Groundwater Seepage

3.1 Regional stratigraphic setting

According to the available electronic geological information; the study area is underlain by strata belonging to the Dwyka and Ecca Groups, which form the oldest sedimentary deposits in the Karoo Supergroup. These sedimentary units formed from the interbedded deposition of sand, silt and mud in the Karoo Basin, within the Carboniferous Period. These groups therefore comprise of a broad spectrum of interbedded sedimentary lithologies including carbonaceous Siltstones, Mudstones, Sandstones and micro Conglomerates. (Figure 2).

Furthermore, the Karoo sediments are extensively intruded by Doleritic dykes and sills. These igneous bodies intrude through weaknesses and discontinuities found within the older sedimentary units. These intrusions usually form the highest points in the regional landscape due to their greater resistance to weathering and erosion as compared to the older sedimentary strata. Although these bodies were not seen to transgress the site, micro structures such as hydrothermal veins, feeder dykes and micro folds can be expected.

No outcrops were observed, the study area is generally soil covered.

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

3.2 Prominent geological structures

The available geological information indicates the presence of large geological structures, namely geological contacts and igneous intrusions, within close proximity to the site. However, no evidence of such structures was noted on the site due to shallow depths of excavation and the absence of rock outcrops. It must be noted, as mentioned above, that the localised presence of igneous intrusions can lead to the formation of micro-structures which could transgress the site i.e. feeder dykes and hydrothermal veins. These structures can affect the geotechnical properties of the in-situ bedrock.

3.3 Groundwater occurrences

Significant groundwater seepage was **not** encountered in the test pits.

4 Nature of the investigation

4.1 Desk study

The investigation commenced with the conducting of the following actions:

- the collation and evaluation of available geological and geotechnical information
- the compilation of a base map showing the regional geological setting
- the planning and distribution of field testing locations

4.2 Field work

The field work phase was done by Letaba Lab Bloemfontein on the 30th of January 2014. Test pits and DPL tests were placed throughout the study area in such a way as to accurately describe the general soil conditions occurring within the boundaries of the study area. The succession of soil and rock layers exposed within the test pits was logged and a series of detailed photographs were taken of the different soil layers. Samples were taken of the soil and rock material deemed to be important to the proposed development.

4.3 Laboratory testing

The following tests were conducted on soil samples taken during the field work phase by the soils laboratory:

- Standard **foundation indicator tests** were conducted by Letaba Lab Bloemfontein on disturbed soil samples in order to determine its composition (i.e.: the relative percentages of gravel, sand, silt and clay present within each sample), to evaluate the heave and compressibility potential of these soils, and to calculate the maximum heave and/or differential settlement that can be expected. The following tests were conducted:
    i. Atterberg Limits (Liquid Limit and Plasticity Index) and Linear Shrinkage
    ii. Particle-size distribution
    iii. pH and EC tests
- Standard **road indicator tests** were conducted by Letaba Lab Bloemfontein on bulk soil samples in order to determine its composition, and to evaluate the suitability of the materials for use in the construction of access roads and parking areas. The following additional tests were conducted:
    i. Maximum Dry Density versus Optimum Moisture Content

ii. Californian Bearing Ratio versus Compaction Effort (MOD AASHTO method)

4.4 Reporting

The investigation concluded with the compilation of a technical report detailing all methodology utilised during the study and all results obtained. This report includes a detailed potential evaluation of the site in terms of the proposed development, based on the results of the geotechnical investigation, with recommendations regarding foundation design and construction and excavatability.

5 Geotechnical Setting

5.1 Trenching

5.1.1 Excavation of test pits

A total of eight test pits, numbered TP1 to TP8, were excavated by means of a TLB-type light mechanical excavator (TLB model- Bell Turbo 4x4, series 315 SJ, 2011), at which time the exposed soil layers were profiled and sampled.

The test pit positions and quantities were specified by the client.

Test pit layout can be viewed in Figure 4

5.1.2 Generalised engineering geological parameters

The following **general** engineering geological characteristics were noted:

- Excavatability

  The TLB- type light mechanical excavator generally did **not** experience any trouble excavating test pits to a depth of 1.15 m below the natural ground level. Excavatability in the north portion of the site is notably worse than the southern and western portions of the site.

  Test pits were excavated to a point at which refusal or maximum reach of the TLB-type light mechanical excavator was accomplished.

- Rock- and/or pedocrete outcrops

  Bedrock outcrop was **not** encountered within the study area.

- Sidewall stability

  The excavation sidewalls generally remained stable for a period of at least 1 hour with little or no over-break or collapse occurring.

- Groundwater seepage

  Significant groundwater seepage was **not** encountered in the test pits.

5.2 Generalized soil profile

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

The results of the trenching phase indicate that the study area is covered by a variable thickness of topsoil, comprising of transported material followed by a soil horizon comprised of residual material and highly weathered bedrock.

Soil profiles are included as Appendix A.

- Transported Material

The uppermost soil horizon encountered across the site has formed a top soil cover with the presence of medium dense root structures and extensive biological activity (i.e animal burrows and insect tunnels). This top soil horizon was comprised of dusky reddish brown transported material deemed to be of alluvial origin with a loose to medium dense consistency. This soil was further classified as slightly moist silty sand.

In the northern portion of the site this transported horizon was notably thin stretching from the surface to depths of between 0.40 and 1.20 m below the natural ground level.

In the southern and western portions of the site this horizon was notably thick, stretching from the surface to depths of between 1.80 and 2.90 m below the natural ground level.

- Residual Material

The above mention transported horizon was underlain by a soil horizon deemed to be comprised of residual material which has formed from the physical and chemical disintegration of the in-situ bedrock. This horizon displays a gradational change in colour, moisture, and consistency observed with depth. These gradational changes link directly to the variable amount and type of weathering of the in-situ bedrock. The residua is generally present as dry, very dense sub-angular silty gravels often with a light yellowish-orange colour. This horizons hosts a mixture of residual material, completely weathered bedrock and highly weathered bedrock fragments.

The presence of mottled and stained structures on the rocks within this horizon indicates the presence of ground water circulation and possible perched water tables after prolonged/heavy precipitation events.

This residual material occurred from depths of between 0.40 and 1.9 m and was seen to have a maximum thickness of up to 1.20 m thick.

It was within this horizon where refusal to excavation by the TLB-type light mechanical excavator took place within the very dense material and on highly weathered bedrock.

5.3 Light Dynamic Penetrometer Tests

DPL tests were carried out across the site to assess the consistency of the in-situ subsoils and provide an indication of the founding conditions and depth to bedrock beneath the site.

DPL tests were performed at natural moisture conditions and thus the values vary greatly from the CBR results measured under controlled conditions within the laboratory. This variation is mainly due to the lab specimens being analysed under saturated conditions. It should be noted that the strength of the in-situ soil changes greatly with change in moisture conditions. DPL test should therefore only be used as indicative statistics for the site.

It must be noted that the results of the DPL tests completed across the site were relatively uniform with few discrepancies. DPL results are seen to display an increase in bearing capacity/layer strength with depth.

DPL tests refused (in very dense material) at depths of between 0.60 and 3.60 m below natural ground level. DPL results are seen to mirror the occurrence of highly weathered bedrock fragments.

The presence of abundant gravel-and cobble- and boulder sized particles within soil horizons as well as the moisture content within each horizon may have had a detrimental effect on the accuracy of the DPL results.

Full DPL results can be viewed in Appendix C.

5.4 Engineering- and material characteristics

5.4.1 Sampling

The following samples were taken:

Disturbed Samples	:	7 x Residual
		8 x Transported
Bulk samples	:	6 x Residual
		2 x Transported

Detailed soil test results for both the disturbed and bulk samples are included in Appendix B.

5.4.2 Soil test results: Transported Material

In the light of the soil test results and visual observations, the geotechnical characteristics of the transported horizons can be as follows:

- This material is deemed **compressible and potentially collapsible**, with a calculated **total settlement** in excess of **20 mm.**
- With reference to the results from the pH and EC tests completed for the samples it can be noted that this material is **slightly basic** and is therefore **non corrosive** to concrete and steel.

The results of road indicator test conducted on the bulk samples of this material can be summarized as follows:

- This material is deemed be to be slightly too moderately- plastic.
- This material classifies as **a worse than G9-** type material according to the COLTO-classification system.
- The results of these tests indicate that this material reacts well to compaction, with CBR-values of between 27 and 36 at a compaction effort of 90% MOD AASHTO increasing to between 46 and 57 at 100% MOD AASHTO. This translates to a calculated bearing capacity value of between 215 and 300 kPa at 93% MOD AASHTO, allowing for a Factor of Safety of 1.5.

5.4.3 Soil test results: Residual Material

In the light of the soil test results and visual observations, the geotechnical characteristics of the residual horizons can be as follows:

- This material is deemed **compressible**, with a calculated **total settlement** of between **10 and 20 mm.**
- With reference to the results from the pH and EC tests completed for the samples it can be noted that this material is **slightly acidic** and is therefore **mildly corrosive** to concrete and steel.
- The residual material was seen to exhibit highly variable mechanical properties.

The results of road indicator test conducted on the bulk samples of this material can be summarized as follows:

- This material is deemed be to be slightly too moderately- plastic.
- This material classifies as **a G5-, G6-, G7-, G8-, G9 and worse than G9-** type material according to the COLTO-classification system.
- The results of these tests indicate that this material reacts variably to compaction, with CBR-values of between 6 and 46 at a compaction effort of 90% MOD AASHTO increasing to between 21 and 68 at 100% MOD AASHTO. This translates to a calculated bearing capacity value of between 70 and 300 kPa at 93% MOD AASHTO, allowing for a Factor of Safety of 1.5.

5.5 Slope stability

In the light of the **gentle slopes** (less than 2^{o}) present across the site, specialised methods for the stabilisation of cuts into the natural slopes are not deemed necessary.

5.6 Excavation classification

Significant problems **are not** foreseen during the excavation of **shallow foundation trenches** to a depth of 1.15 m through the use of a TLB-type light mechanical excavator. Thereafter, significant problems **are** foreseen during the excavation of **deep service trenches.**

It must be noted that the conditions of the site can vary over short distances due to the presence of a very dense residual material and varying weathering horizons; therefore excavatability should be accessed on-site accordingly.

The following additional comments on excavation of service trenches apply:

- Trenches near the non-perennial streams may have to be dewatered, especially after heavy precipitation events.
- The side walls of deep excavations should preferably be shored to prevent injury or death due to side wall failure.

5.7 Impact of geotechnical character on development

The geotechnical characteristics exhibited by the soil material covering the study area is deemed to have the following effects with regard to development:

1. Seepage / groundwater

   = Not applicable.

2. Erodability of soil

   The average slope across the area is less than 1 : 7.5 and some of the material (transported horizons) classifies as SM and SC according to the Unified Soil Classification.

   = Not applicable.

3. Difficulty of servicing of land due to slopes

   Type 1 site: The average slopes across the site is steeper than 1 : 100 but is flatter than 1 : 20.

   = Difficulties associated with the provision of waterborne sanitation, drainage of site and provision of pump stations.

4. Difficulty of excavation due to slopes

   Average slope measured across the erf in any direction is flatter than 1 : 10 and material to a depth of 1.5 m below pre-development level is classified as hard excavation.

   = Additional cost if trench excavation.

5. Precautionary measures in sites underlain by dolomite / limestone

   The study area is not deemed dolomitic land.

   = Not applicable.

6 Site Classification

6.1 General

The results of this study reveal that the whole site exhibits geological characteristics that may require the implementation of specific design and/or precautionary measures to reduce the risk of structural damage due to adverse geotechnical characteristics.

These include (in order of importance):

- The difficulty of servicing due to poor excavatability in the northern portion of the site.
- The presence of gentle slopes (less than 2°).
- The occurrence of compressible and potentially collapsible soil material throughout the study area

However, these characteristics do not disqualify the site from being used for the proposed settlement, but rather require the implementation of site-specific precautionary measures.

6.2 Site Classification

In the light of the results of this study, the study area can be divided into the following development potential zones (Figure 5):

- **Zone A**

The central to southern portions of the study area is deemed the most suitable for the proposed development, provided due cognisance is given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material** with an expected **settlement** in **excess of 20 mm**, that will require specialised foundation design and construction methods.
- Average slopes of less than 2º; localised ponding probable as well as difficulty of servicing.

Zone A classifies as Site Class **S2/C1** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2A** Collapsible material with a thickness of more than 750 mm, **2I** slopes of less than 2 degrees type site according to the classification system proposed by Partridge, Wood and Brink (1993).

- **Zone B**

The northern portion of the study area is deemed to be suitable for the proposed development, and requires that due cognisance be given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material** with an expected **settlement** in **excess of 20 mm**, that will require specialised foundation design and construction methods.
- Difficulty of excavation due to very dense material forming between 10 and 40 % of the total volume up to depths of 1.5 m below ground level.
- Slopes in the northern and eastern portions less than 2º, localised ponding probable as well as difficulty of servicing.

Zone B classifies as Site Class **S2/C1** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2F** Difficulty of excavation due to very dense material forming between 10 and 40 % of the total volume up to depths of 1.5 m, **2A** Collapsible material with a thickness of more than 750 mm, **2I** slopes of less than 2 degrees type site according to the classification system proposed by Partridge, Wood and Brink (1993).

6.3 Detailed Site Suitability evaluation

6.3.1 Soil excavatability

- **Zone A**

It should be possible to excavate to a depth of up to 1.90 m with the use of a TLB-type light mechanical excavator without serious difficulty.

- **Zone B**

It should be possible to excavate to a depth of 1.15 m with the use of a TLB-type light mechanical excavator without serious difficulty, after which the very dense material in the area may require the use of power tools or a heavy mechanical excavator to excavate.

6.4 Slope stability

All Zones

In the light of the very gentle slopes present throughout the study area, specialised methods for the stabilisation of the natural slopes are not deemed necessary.

The sidewalls of deep trenches must preferably be supported to prevent injury or loss of life through sidewall collapse.

7 Foundation Recommendations and Solutions

7.1 Zones A and B

The results of this investigation reveal that the soils covering the study area may undergo a degree of **consolidation and collapse** (i.e.: loss of volume) under loading or when saturated, requiring that structures be adequately strengthened to prevent structural damage due to **settlement/collapse** beneath foundations.

It is thus recommended that EITHER of the following foundation designs be utilised for structures to be placed within this zone:

OPTION 1

Stiffened strip footings or cellular raft

- Stiffened or cellular raft with articulation joints or lightly reinforced masonry.
- Site drainage and plumbing/service precautions
- Bearing pressures not to exceed 50 kPa
- Fabric pressure not to exceed 50 kPa

OPTION 2

Deep strip foundations

- Normal construction with drainage requirements
- Founding on a competent horizon below problem horizon
- Fabric re-enforcement in floor slabs

OPTION 3

Soil raft:

- Remove in-situ material to 1.0 m beyond the perimeter of the structure to a depth of 1.5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content.
- Normal construction with lightly reinforced strip footings and light reinforcement in masonry
- Site drainage and plumbing/service precautions.

It must be noted that differential settlement is assumed to equal 75% of the total settlement. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage. Furthermore these are merely recommendations. Please consult a qualified professional for additional options and final designs.

8 Drainage

8.1 Surface Drainage

It is recommended that an efficient surface drainage system be installed around all structures and along all roads throughout the study area in order to:

- prevent the ponding of water next to structures directly after heavy precipitation events, this may lead to differential settlement as the saturated material undergoes densification
- prevent large-scale changes in soil moisture beneath the structures on a seasonal basis
- prevent the seasonal formation of perched water tables (i.e.: short-term groundwater seepage) within the soil material at shallow depth
- prevent the possible lateral movement of liquids within the upper soil horizons

The precautionary measures should ideally include:

- the sealing of open ground surfaces by means of either of the following:
    a. the cultivation of a natural soil cover (e.g.: grass)
    b. compaction of the soil surface
    c. bitumen or concrete paving
- the removal of surface water to a distance of at least 1 m beyond structures by means of watertight paving
- the removal of surface run-off by means of an efficient surface drainage system
- roads should preferably be constructed parallel to the natural surface elevation contours rather than perpendicular to it, in order to reduce run-off velocities

8.2 Sub Surface Drainage

The seasonal occurrence of perched water tables at relatively shallow depth within the study area may lead to structural damage due to rising damp.

- However, implementation of a sub-surface drainage system is not deemed necessary if adequate damp-proofing measures are taken beneath individual structures and the above-mentioned surface drainage system is implemented.

9 Conclusions and recommendations

1. A detailed geotechnical investigation was conducted for the proposed extension of the existing Bolokanang Rural Settlement to the south east of Petrusburg in the Free State Province. This investigation was undertaken in order to assess the engineering geological character of the area, focusing on the geotechnical properties which will affect the overall development potential of the site.

2. In the light of the results of this study, it can be stated that the natural soil underlying the study area exhibit some adverse geotechnical characteristics that may require the implementation of specific design and/or precautionary measures to reduce the risk of structural damage, or may hamper the development of certain areas. However, these characteristics do not disqualify the site from being used for the proposed development, but rather require the implementation of site-specific precautionary measures during the design and construction phases of the development.

   The whole study area is deemed suitable for development, but will require that due cognisance be given to the following adverse geotechnical characteristics:

   - This material is deemed **compressible and potentially collapsible soils** with a calculated total **settlement** in **excess of 20 mm**.
   - The study area classifies as **Site Class S2/C1** (NHBRC, 1999).

3. The site can be further classified in development potential zones according to the system proposed by Partridge, Wood and Brink (1993). Each zone requires that due cognisance be given to the unique adverse geotechnical characteristics.

   - **Zone A**

   The central to southern portions of the study area is deemed the most suitable for the proposed development, provided due cognisance is given to the following characteristics during the design and construction phases of the development:

   - The presence of **compressible and potentially collapsible material** with an expected **settlement** in **excess of 20 mm**, that will require specialised foundation design and construction methods.
   - Average slopes of less than 2º; localised ponding probable as well as difficulty of servicing.

Zone A classifies as Site Class **S2/C1** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2A** Collapsible material with a thickness of more than 750 mm, **2I** slopes of less than 2 degrees type site according to the classification system proposed by Partridge, Wood and Brink (1993).

- **Zone B**

The northern portion of the study area is deemed to be suitable for the proposed development, and requires that due cognisance be given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material** with an expected **settlement** in **excess of 20 mm**, that will require specialised foundation design and construction methods.
- Difficulty of excavation due to very dense material forming between 10 and 40 % of the total volume up to depths of 1.5 m below ground level.
- Slopes in the northern and eastern portions less than 2º, localised ponding probable as well as difficulty of servicing.

Zone B classifies as Site Class **S2/C1** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2F** Difficulty of excavation due to very dense material forming between 10 and 40 % of the total volume up to depths of 1.5 m, **2A** Collapsible material with a thickness of more than 750 mm, **2I** slopes of less than 2 degrees type site according to the classification system proposed by Partridge, Wood and Brink (1993).

4. Significant problems are not foreseen during the excavation of **shallow foundation trenches** as well as **deep service trenches to a depth of 1.90 m** within **Zone A** through the use of a TLB-type light mechanical excavator.
5. Significant problems are not foreseen during the excavation of **shallow foundation trenches** to a depth 1.15 m within **Zone B** through the use of a TLB-type light mechanical excavator. Significant problems are foreseen during the excavation of **deep service trenches** within **Zone B** through the use of a TLB-type light mechanical excavator.
6. In the light of the results of this investigation, it is recommended that foundation- and service trenches be inspected by an engineering geologist or geotechnical engineer in order to identify and assess any variance in the geotechnical character exposed in these trenches.

10 Bibliography

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MAPS

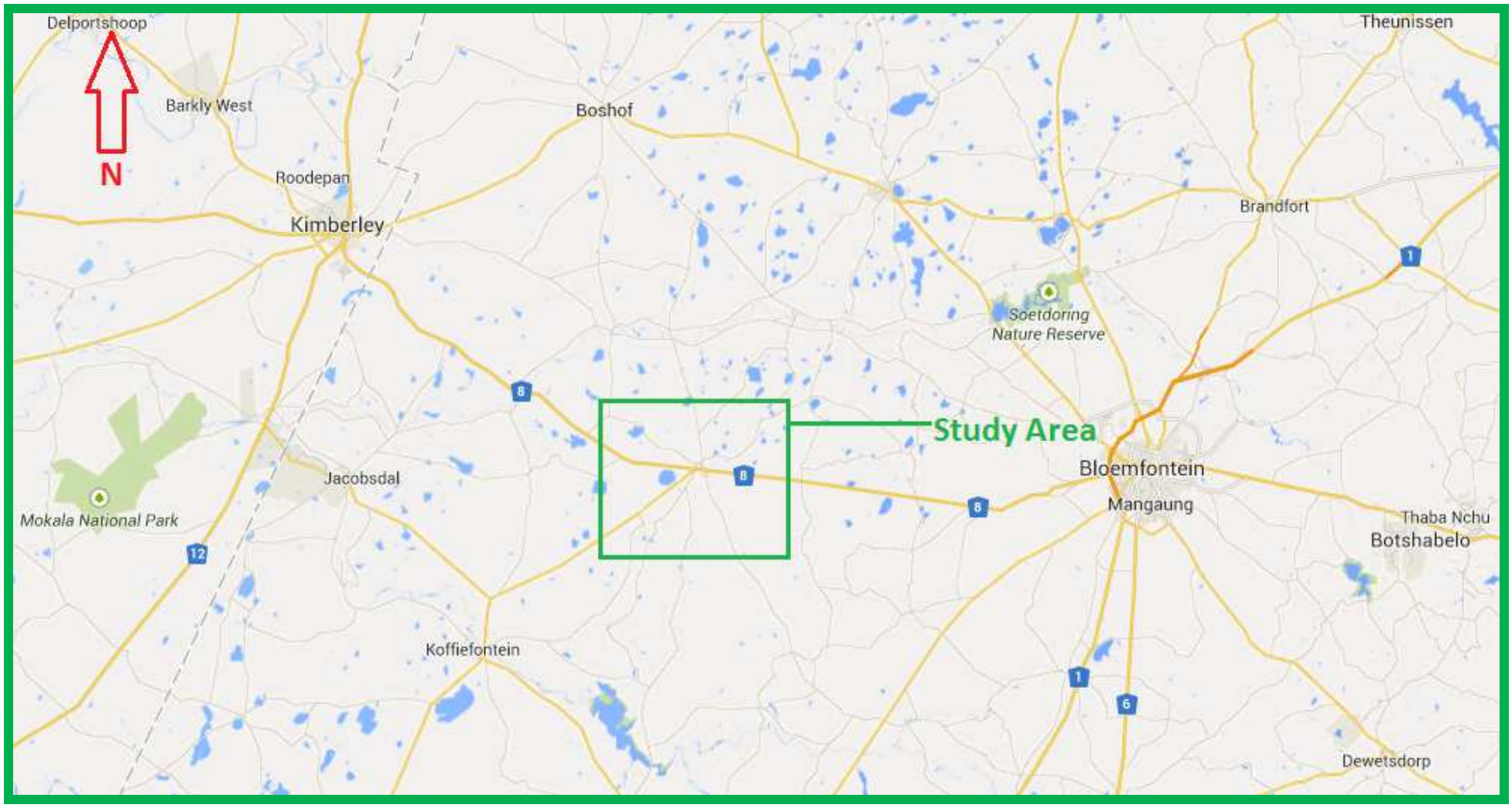


Figure 1: Study Area Location

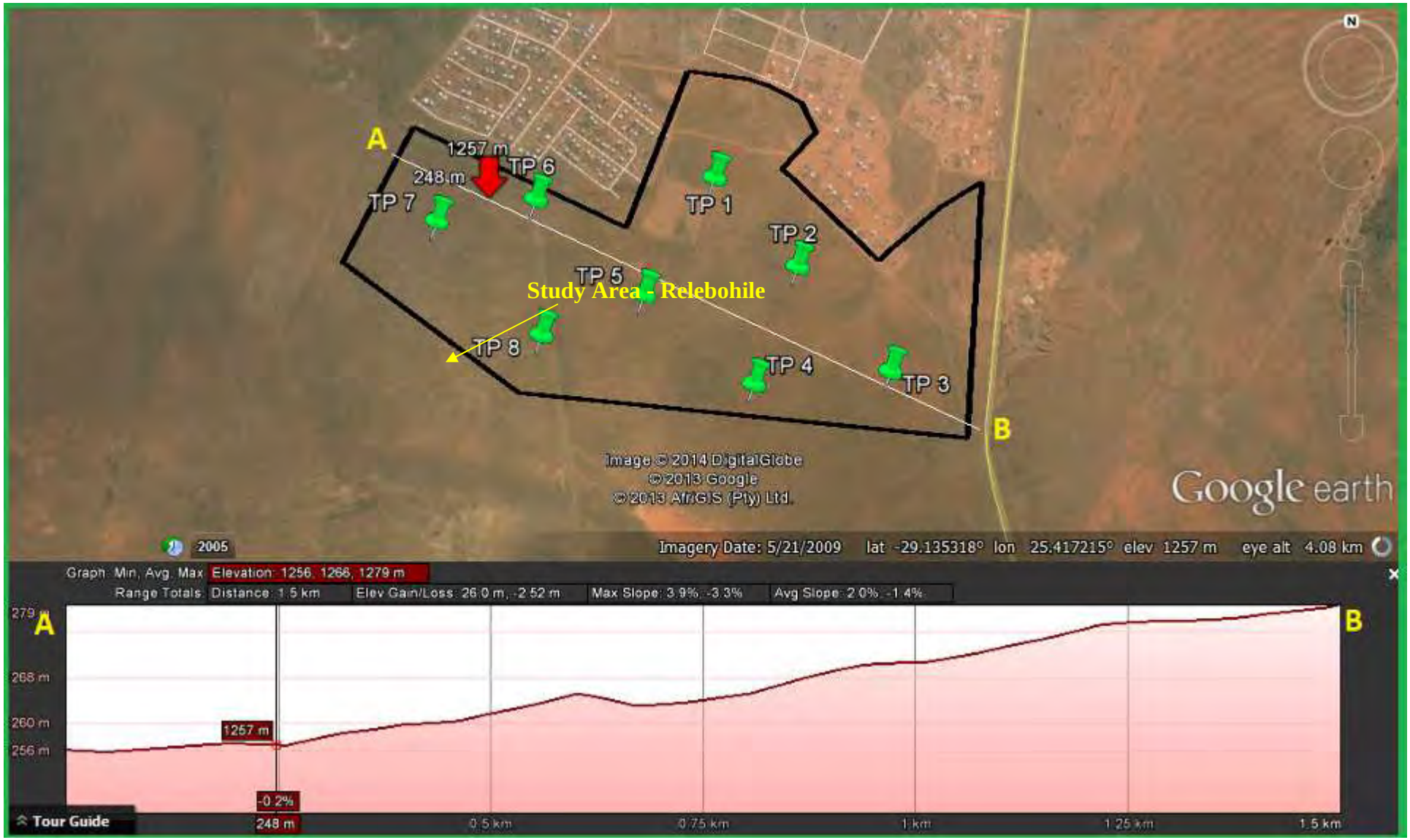


Figure 2: Study Area- Cross-sectional view

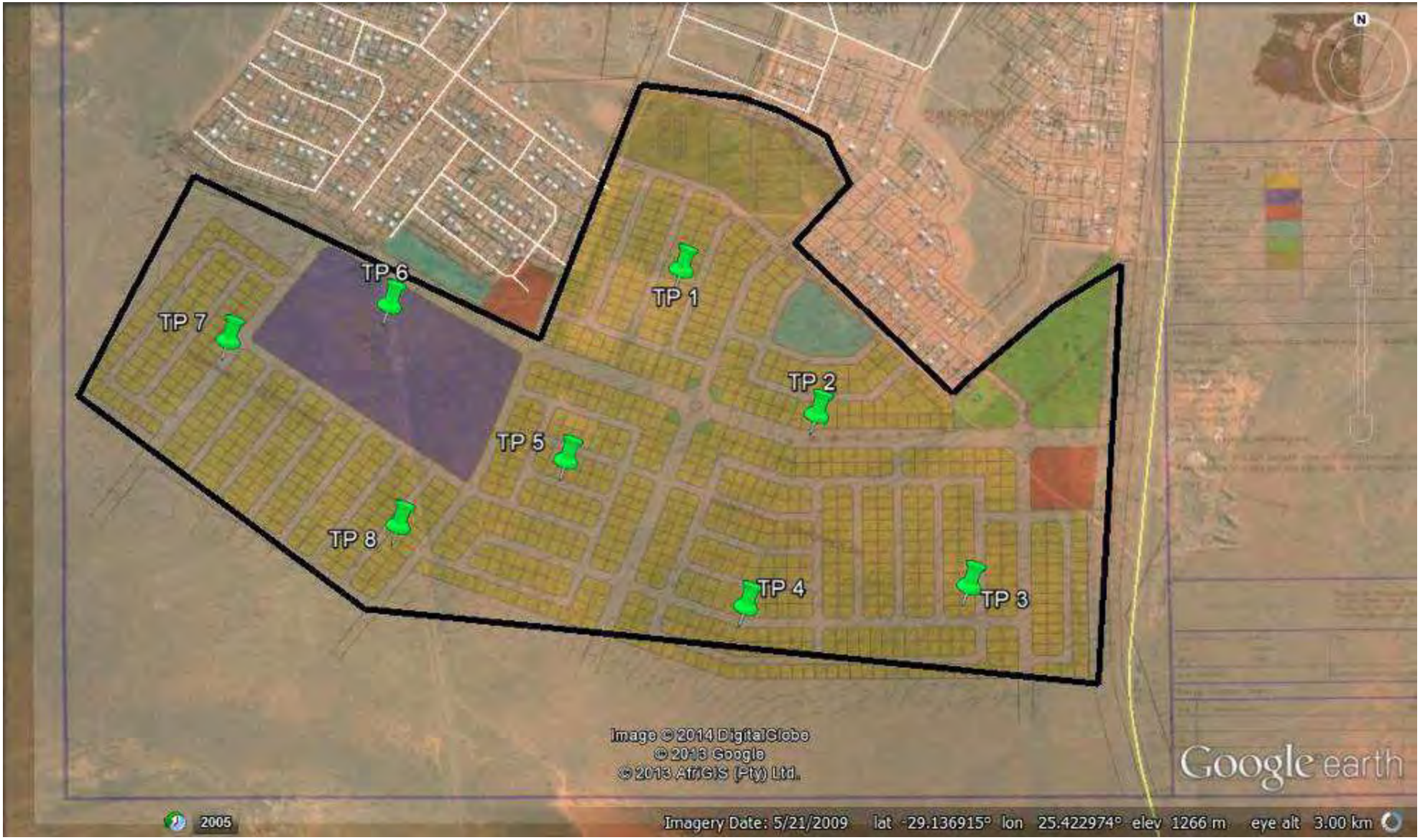


Figure 3: Study Area - Test Pit Locations

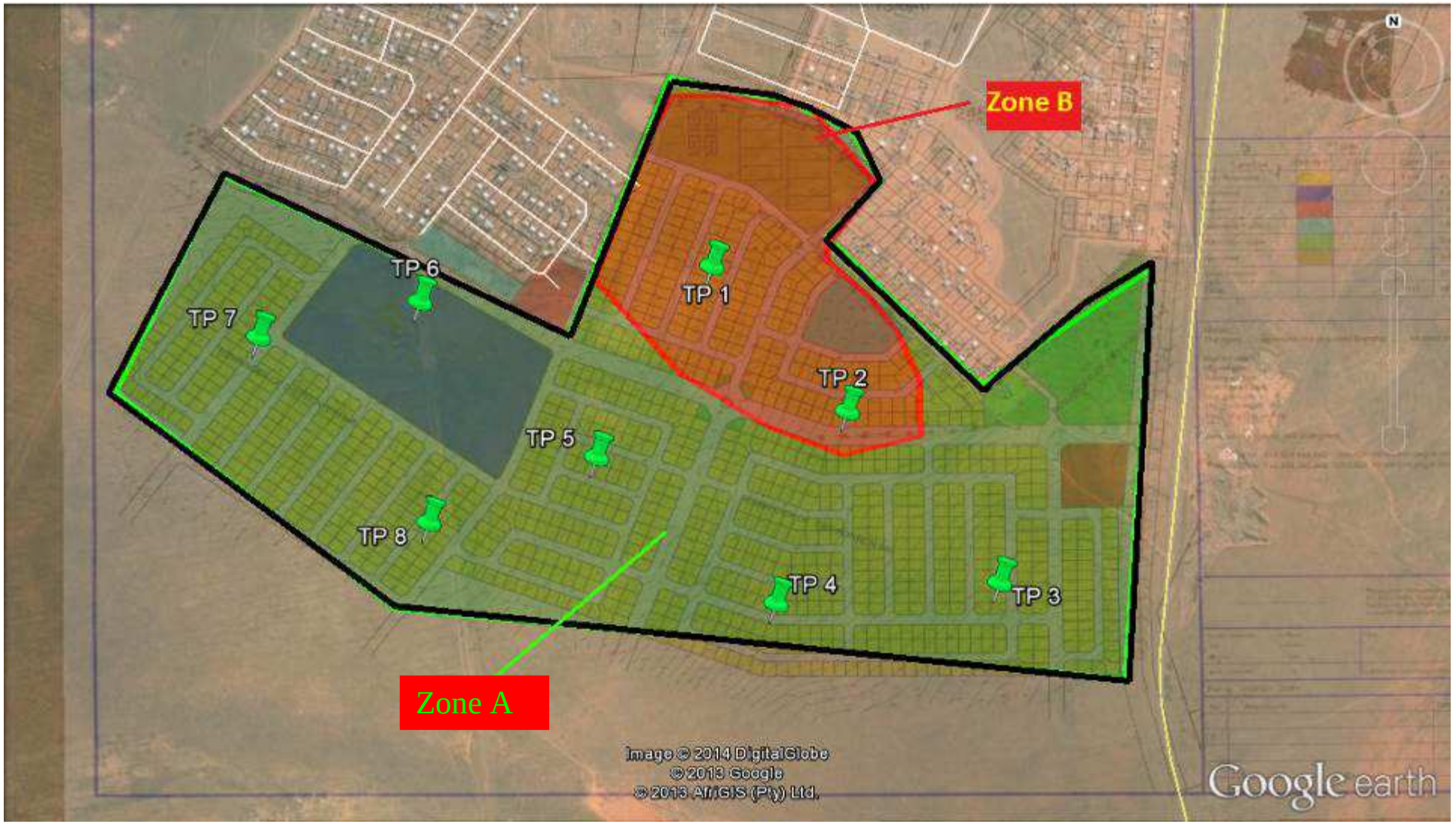
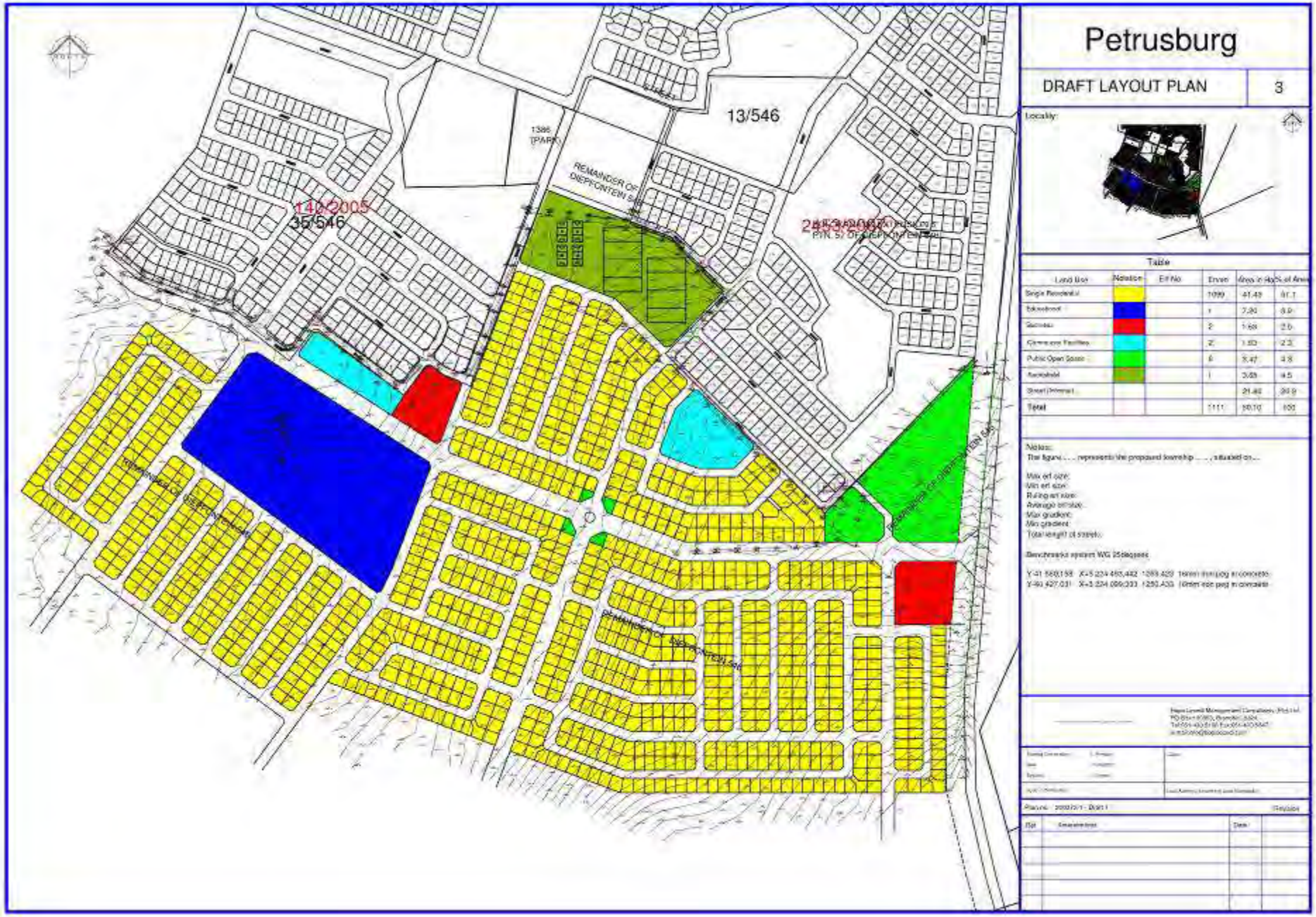


Figure 4: Study Area- Development Potential Zonation


Petrusburg
DRAFT LAYOUT PLAN
3
Locality:
Table
13/546
35/546
REMAINDER OF DIEPFONTEIN 564
Notes:

LETABA LAB PETRUSBURG

GPS CO-ORDINATES

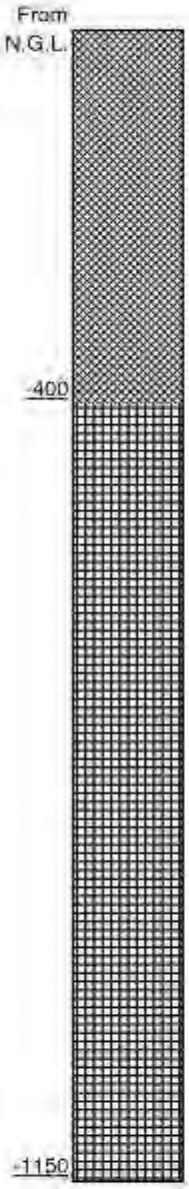
TP:	CO-ORDINATES	DPL No.
PROPOSED CONSTRUCTION AREA COVERED		
TP: 1	S29°8.115' E25°25.348'	DPL No. 1
TP: 2	S29°8.226' E25°25.466'	DPL No. 2
TP: 3	S29°8.356' E25°25.598'	DPL No. 3
TP: 4	S29°8.372' E25°25.404'	DPL No. 4
TP: 5	S29°8.261' E25°25.247'	DPL No. 5
TP: 6	S29°8.142' E25°25.092'	DPL No. 6
TP: 7	S29°8.169' E25°24.950'	DPL No. 7
TP: 8	S29°8.311' E25°25.100'	DPL No. 8

Appendix A

Soil Profiles

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg**

Soil profile for TP No : 1



slightly moist dark Reddish Brown , med dense , silty sand , transported - roots :- Sample No : 1881/1

slightly moist dark grey stained red and black, very dense, sub-angular silty gravel, residual - refusal with TLB :- Sample No : 1881/2

LETABA LAB **Gibb Engineering & Science - Petrusburg**

Test Pit 1

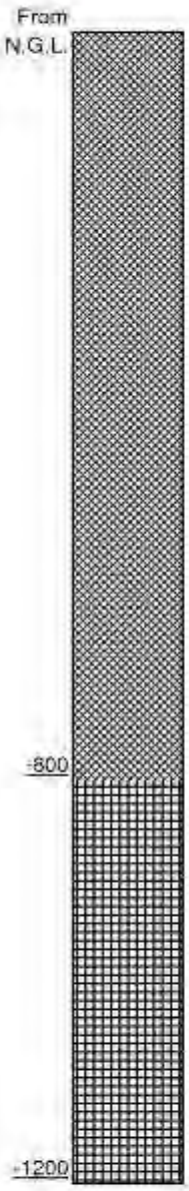
North from TP 1

South from TP 1

Profile - Test Pit 1

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg**

Soil profile for TP No : 2



slightly moist dusky Red , loose , silty sand , transported - roots :- Sample No : 1881/3

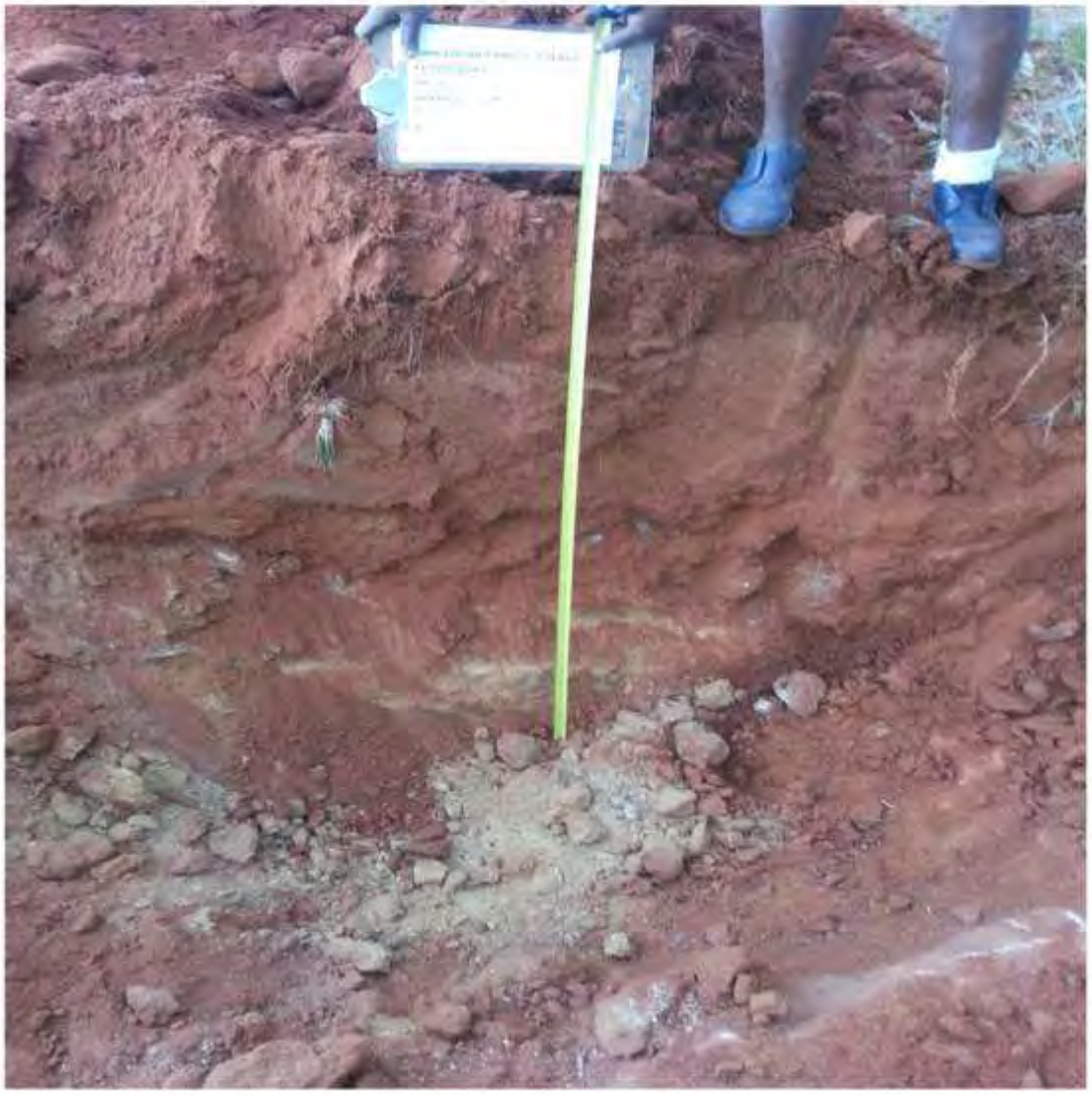
dry light Yellow stained red, very dense, well rounded silty gravel, residual - refusal with TLB :- Sample No : 1881/4

LETABA LAB **Gibb Engineering & Science - Petrusburg**

Test Pit 2

North from TP 2

South from TP 2



Profile - Test Pit 2

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg**

Soil profile for TP No : 3

slightly moist dark Red , loose , rounded silty sand , transported :- roots and Not sampled

slightly moist dark Red , med dense , rounded silty sand , transported :- and Sample No : 1881/5

dry light Olive stainded Grey, very dense , sub-angular silty gravel, residual :- refusal with TLB and Sample No : 1881/6

LETABA LAB Gibb Engineering & Science - Petrusburg

Test Pit 3

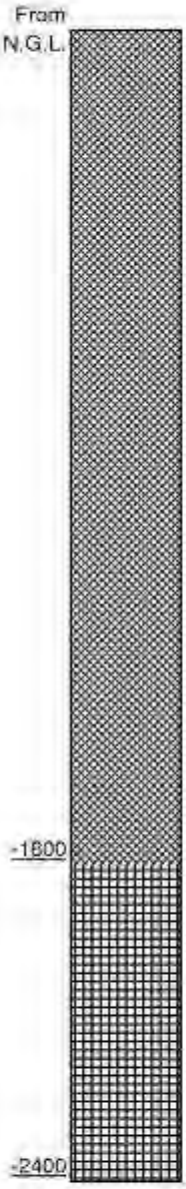
North from TP 3

South from TP 3

Profile - Test Pit 3

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg**

Soil profile for TP No : 4



slighlly moist dusky Red , loose , silty sand , transported - roots :- Sample No : 1881/7

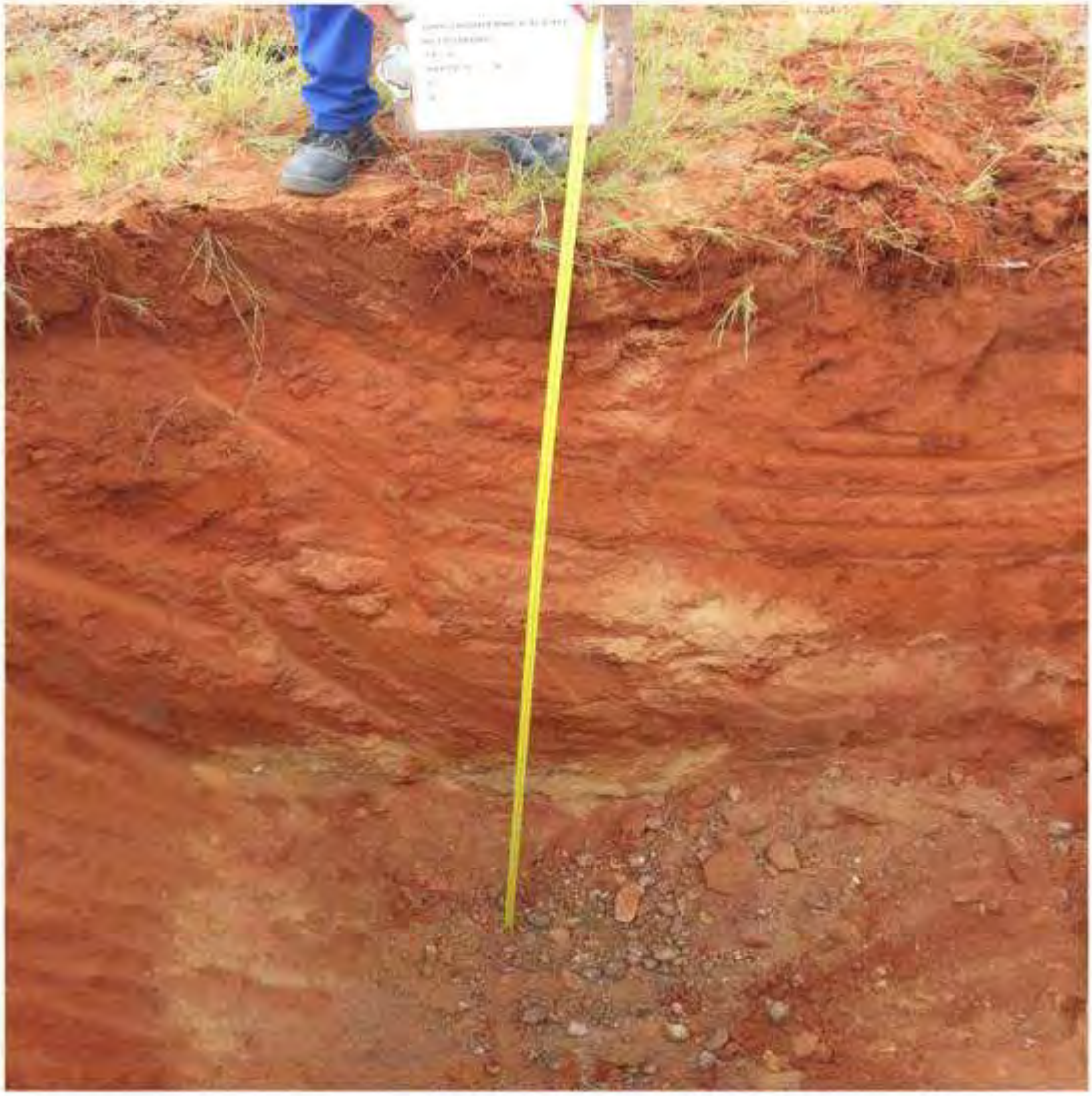
dry light Yellow stained red, very dense, well rounded silty gravel, residual - refusal with TLB :- Sample No : 1881/8

LETABA LAB **Gibb Engineering & Science - Petrusburg**

Test Pit 4

North from TP 4

South from TP 4

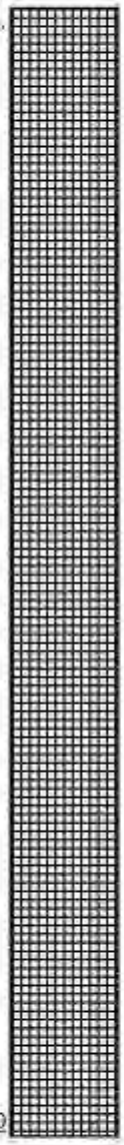


Profile - Test Pit 4

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg**

Soil profile for TP No : 5

From N.G.L.



-2900

slightly moist dark Reddish Orange , med dense , silty sand , residual - Max reach with TLB :- Sample No : 1881/9

LETABA LAB Gibb Engineering & Science - Petrusburg

Test Pit 5

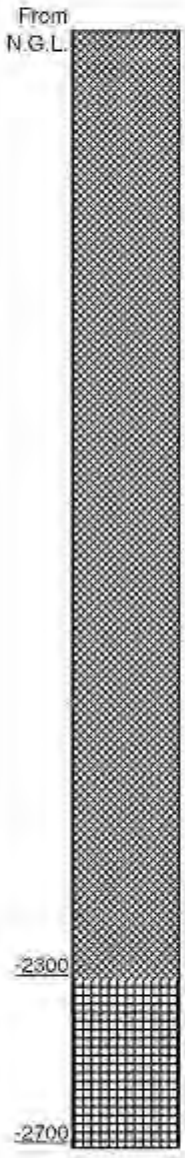
North from TP 5

South from TP 5

Profile - Test Pit 5

LETABA LAB SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg

Soil profile for TP No : 6



slightly moist dusky Red , med dense , silty sand , transported - roots :- Sample No 1881/14

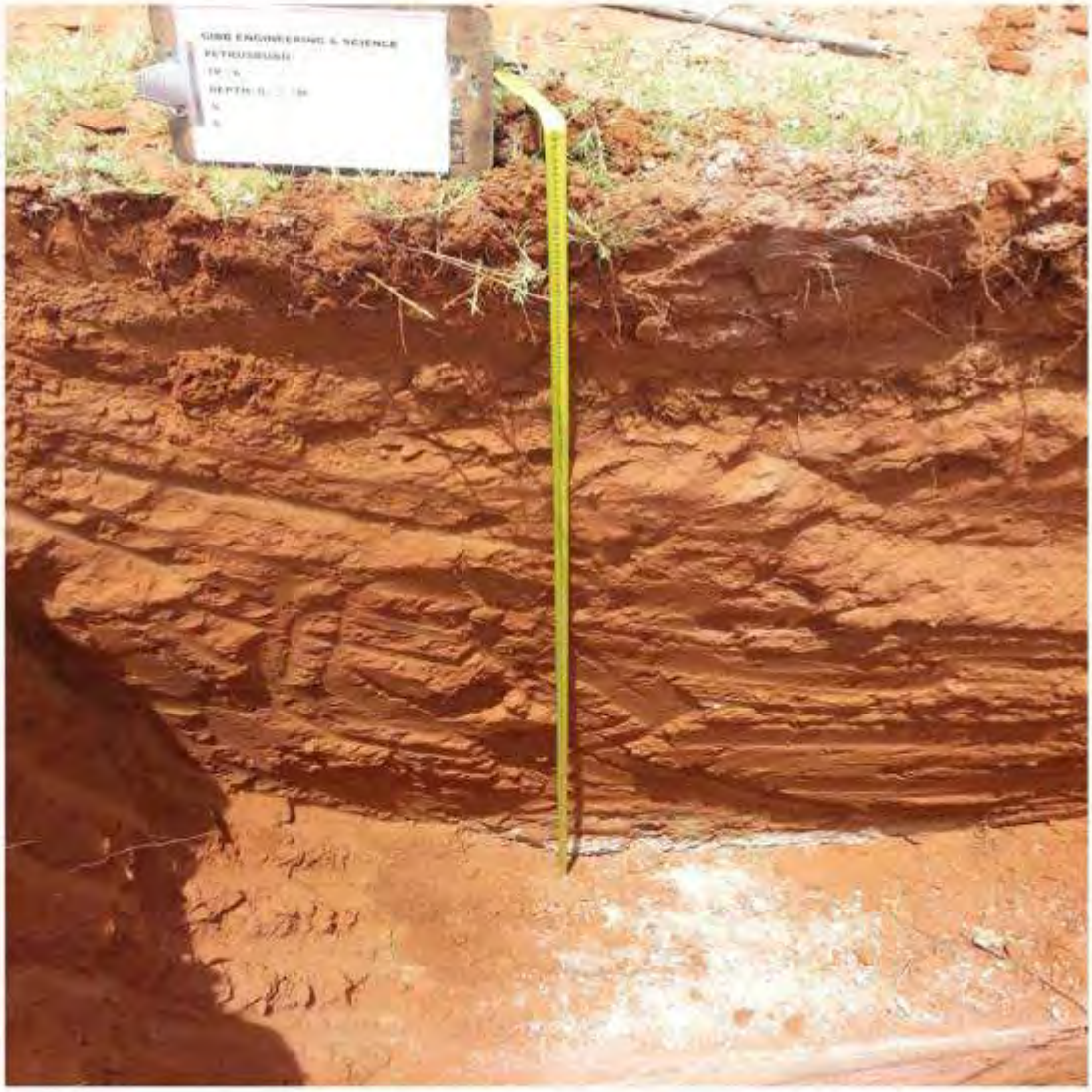
dry white, Orange , very dense, sub-rounded silty gravel, calcrete, residual - refusal with TLB :- Sample No : 1881/15

LETABA LAB Gibb Engineering & Science - Petrusburg

Test Pit 6

North from TP 6

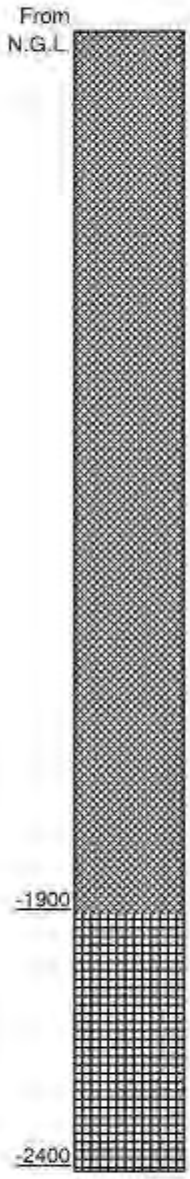
South from TP 6



Profile - Test Pit 6

LETABA LAB SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg

Soil profile for TP No : 7



slightly moist dusky Red , med dense , silty sand , transported - roots :- Sample No : 1881/12

dry White , very dense, silty gravel, calcrete, residual - refusal with TLB :- Sample No : 1881/13

LETABA LAB **Gibb Engineering & Science - Petrusburg**

Test Pit 7

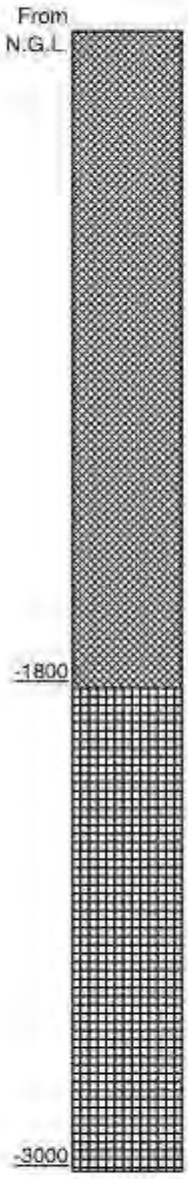
North from TP 7

South from TP 7

Profile - Test Pit 7

LETABA LAB SOIL PROFILES FOR Gibb Engineering & Science - Petrusburg

Soil profile for TP No : 8



slighlly moist dusky Red , med dense , silty sand , transported - roots :- Sample No : 1881/10

dry light Reddish Orange , med dense , silty sand , residual - Max reach with TLB :- Sample No : 1881/11

LETABA LAB Gibb Engineering & Science - Petrusburg

Test Pit 8

North from TP 8

South from TP 8

Profile - Test Pit 8

Appendix B

Lab Results

Bulk Samples

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Cel. No: 084 405 4711
e-mail : jayson@letaba-lab.co.za

GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client : **GIBB ENGINEERING & SCIENCE** | **Doc No:1881/2(i)** | Date Sampled : **29-Jan-14**

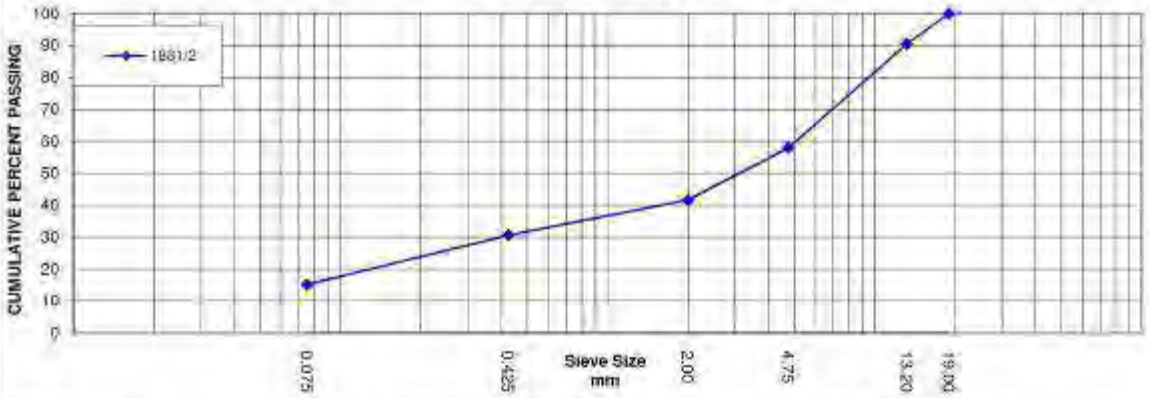
Address: 3 Bermakor park, 52 Reid str, Bloemfontein 9300

Contract : **Petrusburg** | Date Tested : **06-Feb-14**

Description : **TP :1 sampled by lab**

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO - 1998	US. Highway	Group Index
0.4-1.15	1881/2	drk Brown Silty/Clayey sand				100	90	56	42	31	15	2.13	24	5	2.4	sm/sc	G7	A-1-b	0

GRADING ANALYSIS



GENERAL

Effective size (mm)	**<0.075**
Uniformity co-eff.	**5057**
Curvature co-eff.	**31.1**
Oversize Index	**0**
Shrinkage Product	**73**
Grading co-eff.	**33.9**

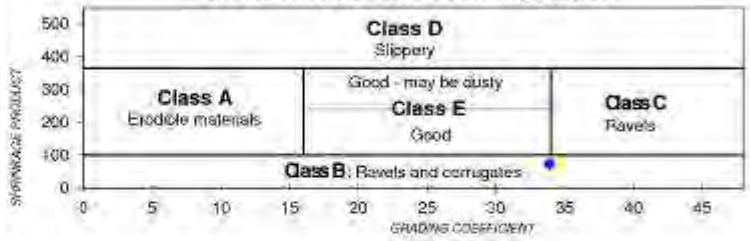
CBR RESULTS (%) :

@ 100% comp.	**36**
@ 98% comp.	**31**
@ 97% comp.	**28**
@ 95% comp.	**23**
@ 93% comp.	**19**
@ 90% comp.	**13**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm)	**11.0%**
Fine Sand (<0.425>0.075mm)	**15.5%**
Material <0.075mm	**15.1%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

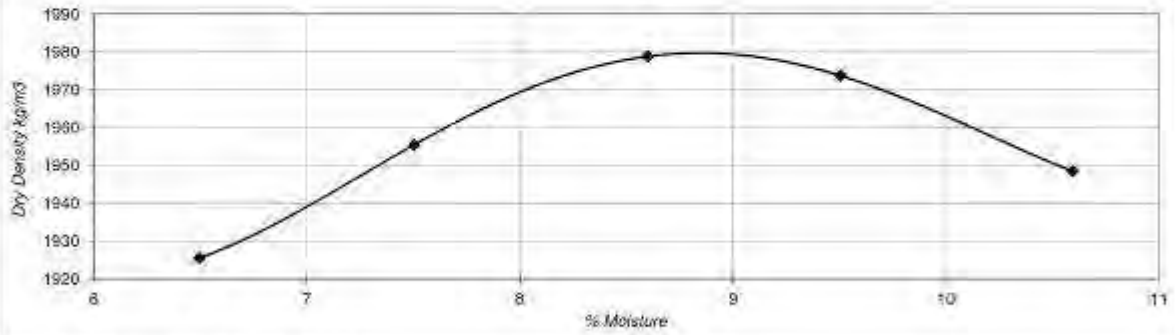
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

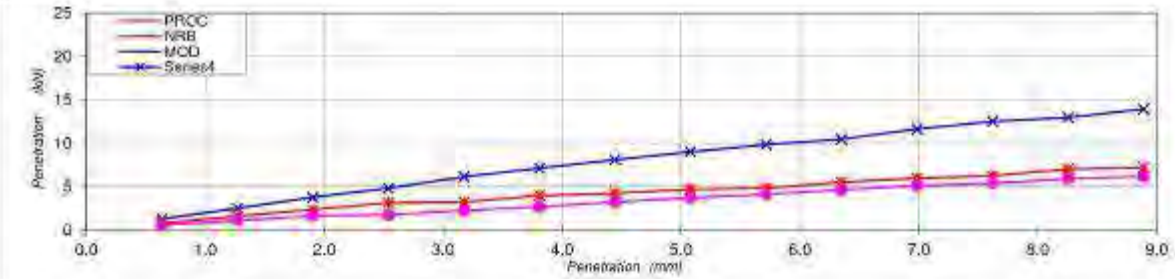
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/2(ii)
Description:	TP ;1 sampled by lab	Sample no:	1881/2

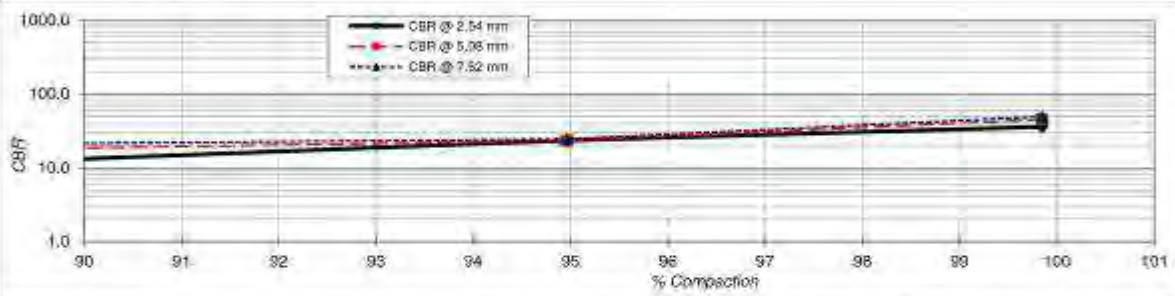
Maximum dry density =	1980	kg/m³
Optimum moisture content =	8.9	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	36	31	28	23	19	13

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1977	1880	1779
Compaction Moisture (%)	8.6	8.5	8.6
Compaction (%)	99.8%	95.0%	89.8%
% Swell	0.54	0.63	0.75

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

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Cel. No: 084 405 4711
e-mail : jayson@letaba-lab.co.za

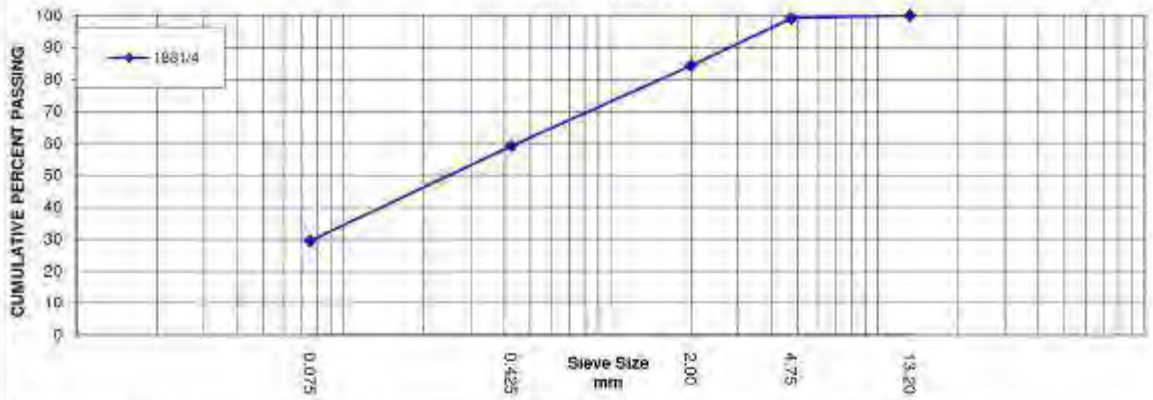
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1881/4(I)**	Date Sampled : **29-Jan-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Petrusburg**		Date Tested : **06-Feb-14**
Description :	**TP :2 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
0.8-1.2	1881/4	drk Yel. Orange Silty/Clayey sand					100	99	84	59	29	1.27	21	5	2.2	sm/sc	G6	A-2-4	0

GRADING ANALYSIS



GENERAL

Effective size (mm) :	**<0.075**
Uniformity co-eff. :	**447**
Curvature co-eff. :	**13.4**
Oversize Index :	**0**
Shrinkage Product :	**130**
Grading co-eff. :	**15.6**

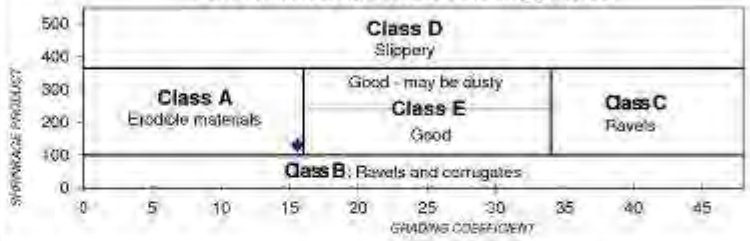
CBR RESULTS (%) :

@ 100% comp. :	**50**
@ 98% comp. :	**40**
@ 97% comp. :	**35**
@ 95% comp. :	**28**
@ 93% comp. :	**22**
@ 90% comp. :	**16**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**25.1%**
Fine Sand (<0.425>0.075mm) :	**29.7%**
Material <0.075mm :	**29.5%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

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Technical signatory (Name) : **Jayson Wingrove** *Signature:*

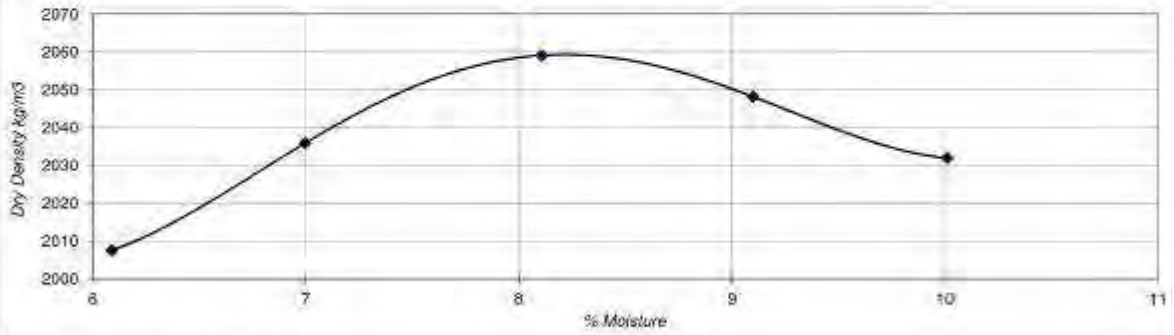
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

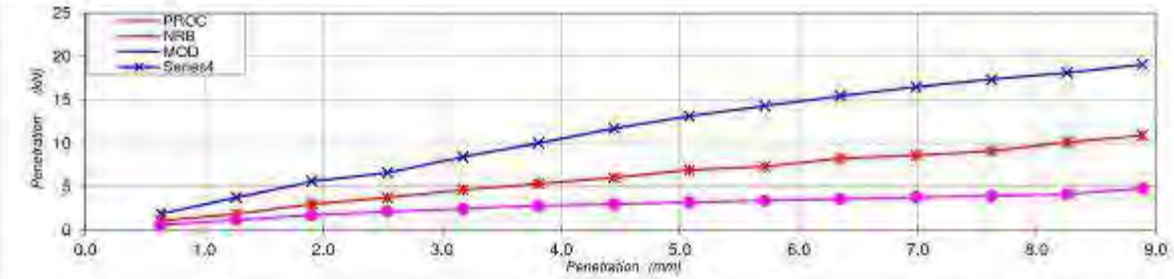
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/4(ii)
Description:	TP :2 sampled by lab	Sample no:	1881/4

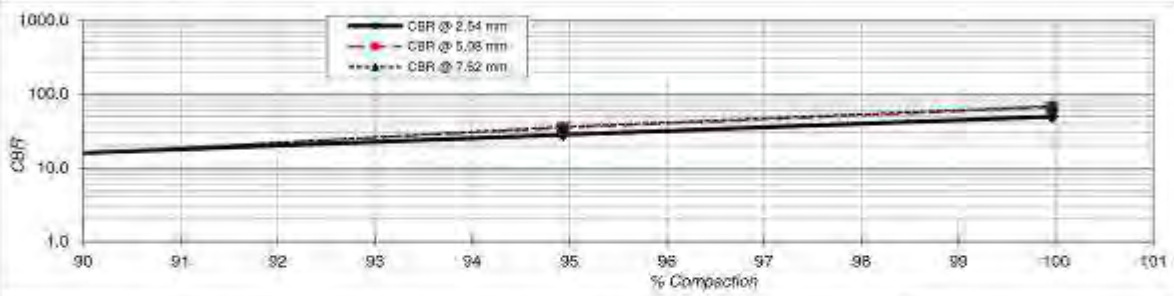
Maximum dry density =	2060	kg/m³
Optimum moisture content =	8.3	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	50	40	35	28	22	16

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	2059	1956	1853
Compaction Moisture (%)	8.1	8.0	8.1
Compaction (%)	100.0%	94.9%	89.9%
% Swell	0.55	0.63	0.71

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

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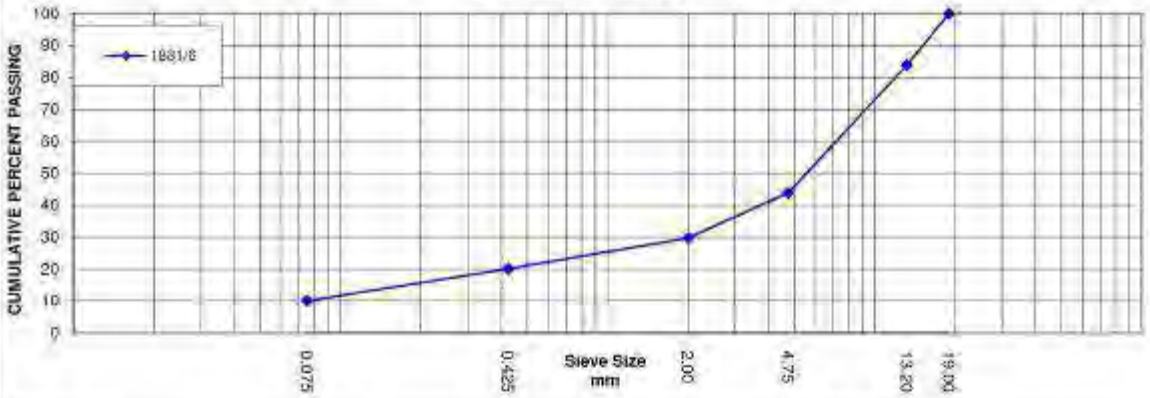
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1881/6(I)**	Date Sampled : **29-Jan-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Petrusburg**		Date Tested : **06-Feb-14**
Description :	**TP :3 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
1.2-1.8	1881/6	drk Brown Poorly graded silty/clayey gravel				100	84	44	30	20	10	2.40	23	4	1.9	GP/GM/GC	G8	A-1-a	0

GRADING ANALYSIS



GENERAL

Effective size (mm) :	**<0.075**
Uniformity co-eff. :	**7171**
Curvature co-eff. :	**575.4**
Oversize Index :	**0**
Shrinkage Product :	**38**
Grading co-eff. :	**30.8**

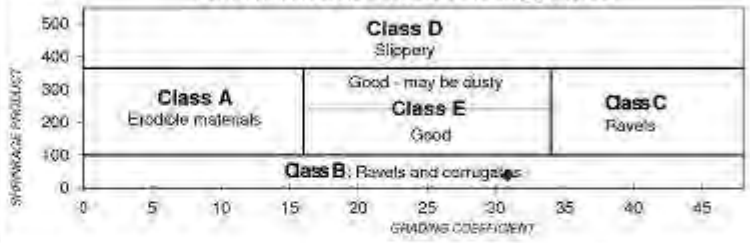
CBR RESULTS (%) :

@ 100% comp. :	**34**
@ 98% comp. :	**27**
@ 97% comp. :	**24**
@ 95% comp. :	**19**
@ 93% comp. :	**14**
@ 90% comp. :	**9**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**9.7%**
Fine Sand (<0.425>0.075mm) :	**10.0%**
Material <0.075mm :	**10.0%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

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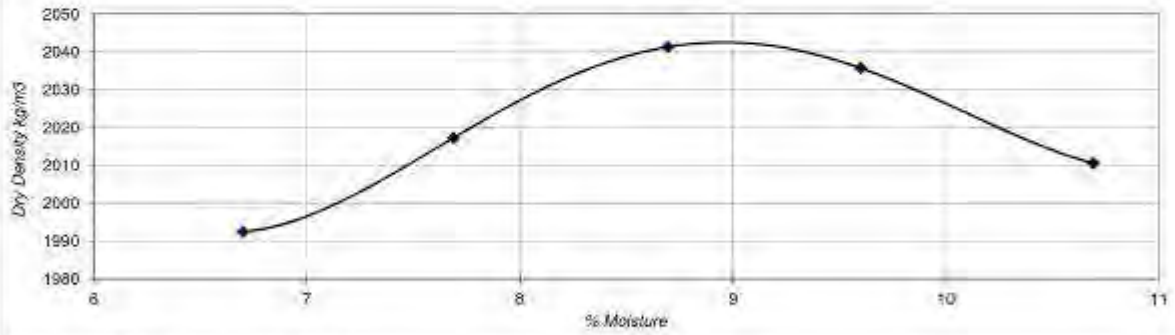
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

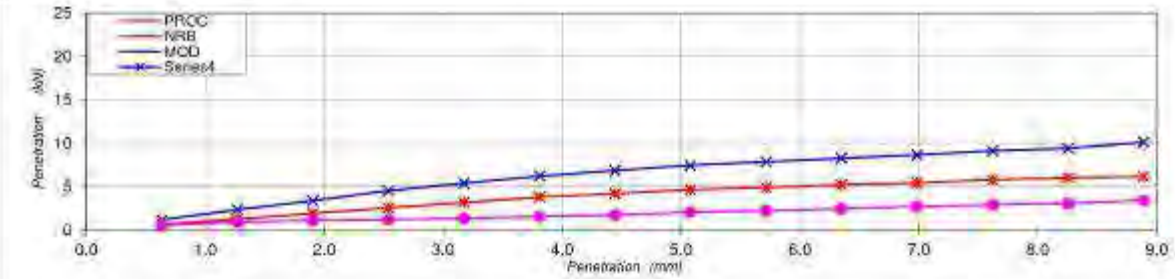
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/6(ii)
Description:	TP :3 sampled by lab	Sample no:	1881/6

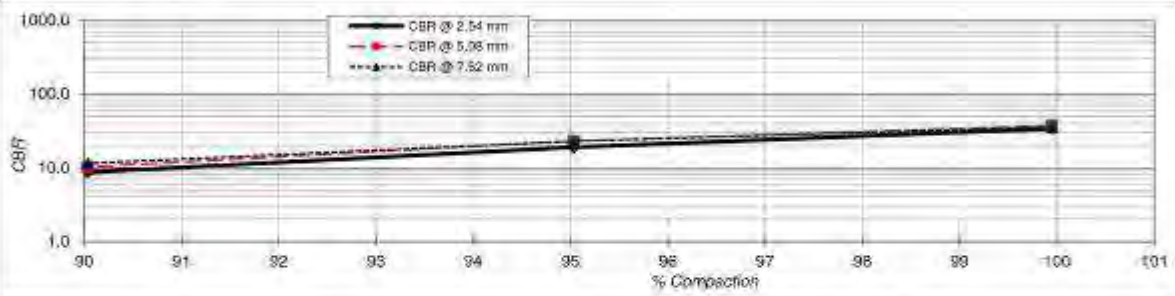
Maximum dry density =	2043	kg/m³
Optimum moisture content =	9.0	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	34	27	24	19	14	9

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	2041	1941	1839
Compaction Moisture (%)	8.7	8.6	8.7
Compaction (%)	99.9%	95.0%	90.0%
% Swell	0.49	0.59	0.70

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GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client : **GIBB ENGINEERING & SCIENCE** | **Doc No:1881/7(I)** | Date Sampled : **29-Jan-14**

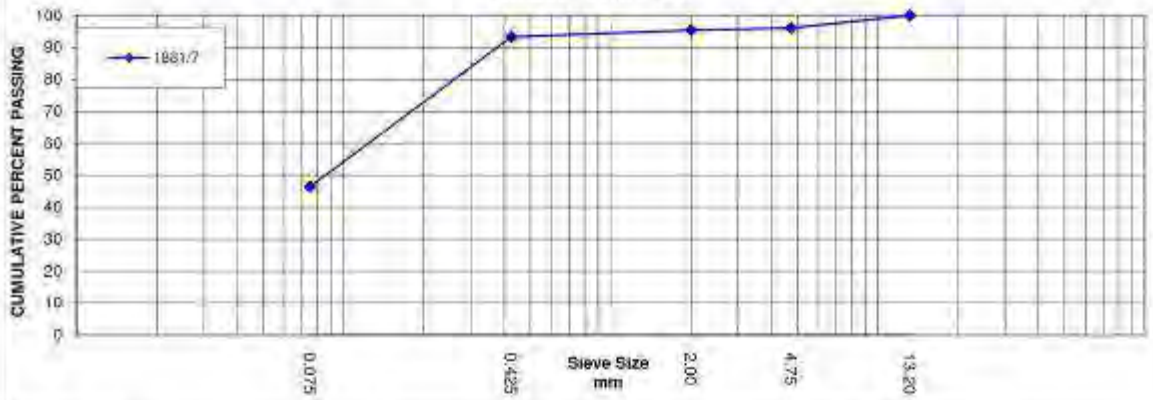
Address: 3 Bermakor park, 52 Reid str, Bloemfontein 9300

Contract : **Petrusburg** | Date Tested : **06-Feb-14**

Description : **TP :4 sampled by lab**

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
0-1.8	1881/7	drk Brown Silty/Clayey sand					100	96	95	93	46	0.65	27	5	2.3	sm/sc	>G9	A-4	2

GRADING ANALYSIS



GENERAL

Effective size (mm)	**<0.075**
Uniformity co-eff.	**124**
Curvature co-eff.	**0.8**
Oversize Index	**0**
Shrinkage Product	**215**
Grading co-eff.	**4.4**

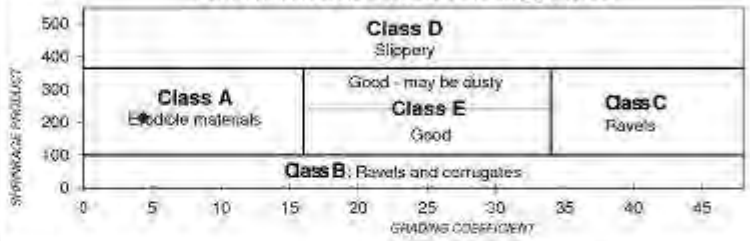
CBR RESULTS (%) :

@ 100% comp.	**57**
@ 98% comp.	**51**
@ 97% comp.	**48**
@ 95% comp.	**43**
@ 93% comp.	**40**
@ 90% comp.	**36**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm)	**2.2%**
Fine Sand (<0.425>0.075mm)	**46.8%**
Material <0.075mm	**46.5%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

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Technical signatory (Name) : **Jayson Wingrove** *Signature:*

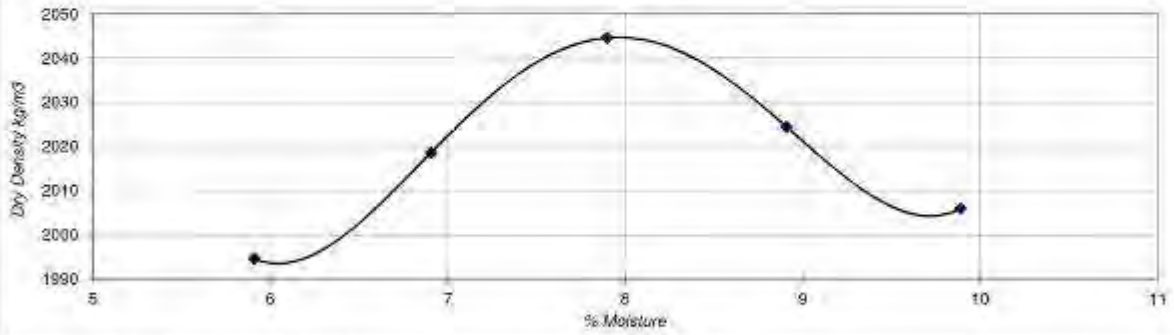
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

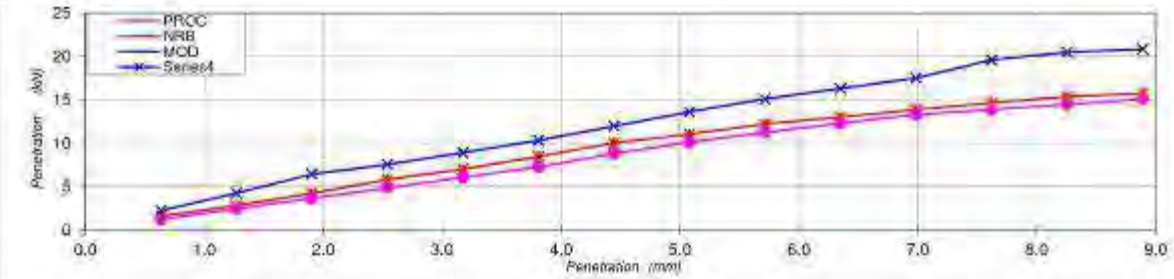
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/7(ii)
Description:	TP :4 sampled by lab	Sample no:	1881/7

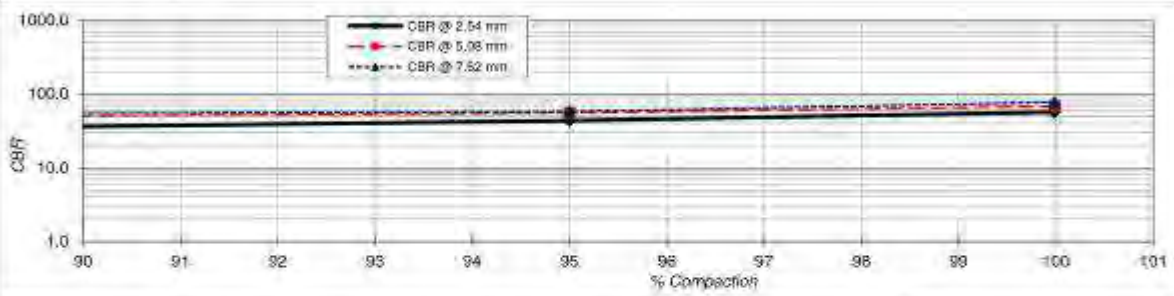
Maximum dry density =	2045	kg/m³
Optimum moisture content =	8.0	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	57	51	48	43	40	36

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	2044	1943	1840
Compaction Moisture (%)	7.9	7.9	7.9
Compaction (%)	100.0%	95.0%	90.0%
% Swell	0.71	0.87	1.02

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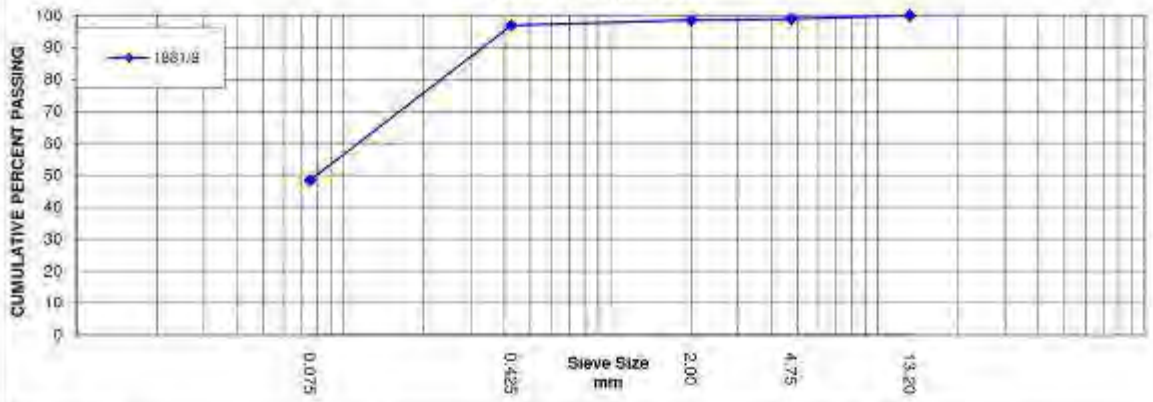
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1881/9(I)**	Date Sampled : **29-Jan-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Petrusburg**		Date Tested : **06-Feb-14**
Description :	**TP :5 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
0-2.9	1881/9	drk Red. Orange Silty/Clayey sand					100	99	99	97	46	0.56	23	5	2.6	sm/sc	>G9	A-4	3

GRADING ANALYSIS



GENERAL

Effective size (mm) :	**<0.075**
Uniformity co-eff. :	**113**
Curvature co-eff. :	**0.9**
Oversize Index :	**0**
Shrinkage Product :	**252**
Grading co-eff. :	**1.4**

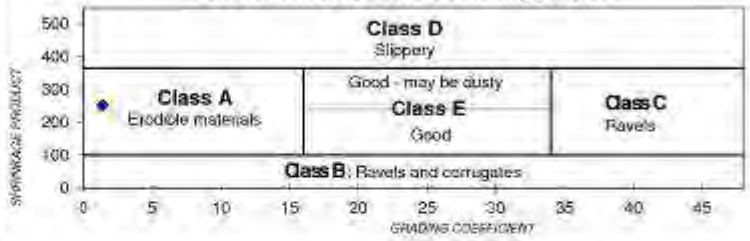
CBR RESULTS (%) :

@ 100% comp. :	**46**
@ 98% comp. :	**42**
@ 97% comp. :	**41**
@ 95% comp. :	**38**
@ 93% comp. :	**33**
@ 90% comp. :	**27**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**1.7%**
Fine Sand (<0.425>0.075mm) :	**48.5%**
Material <0.075mm :	**48.5%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

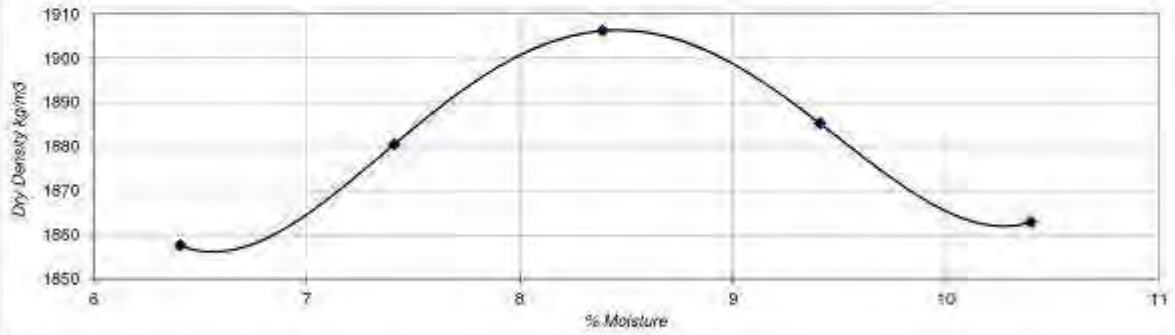
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

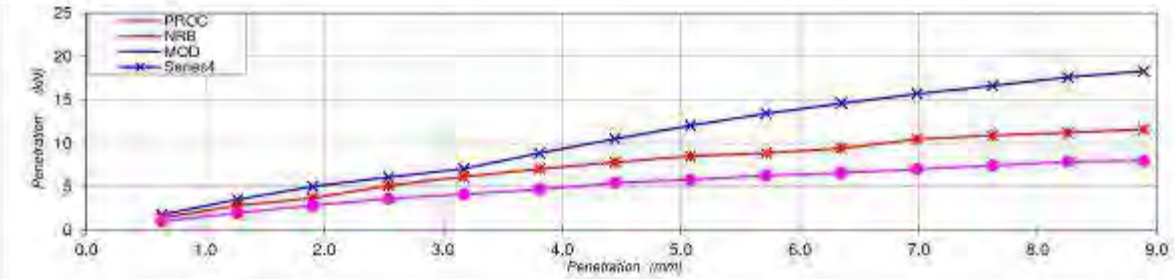
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/9(ii)
Description:	TP :5 sampled by lab	Sample no:	1881/9

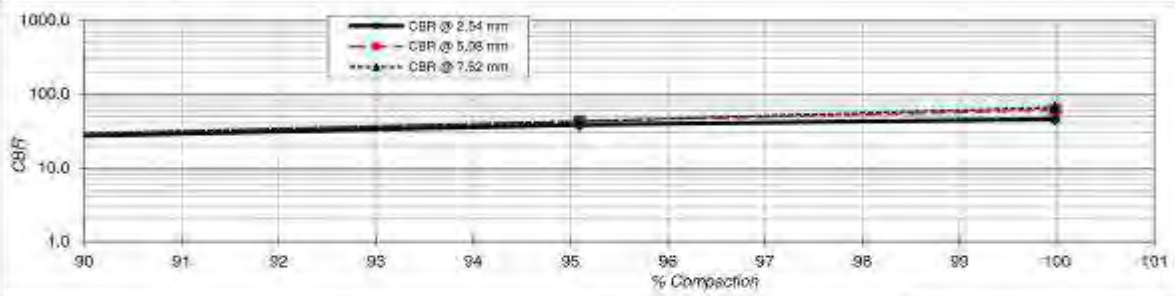
Maximum dry density =	1906	kg/m³
Optimum moisture content =	8.5	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	46	42	41	38	33	27

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1906	1813	1715
Compaction Moisture (%)	8.4	8.4	8.4
Compaction (%)	100.0%	95.1%	90.0%
% Swell	0.60	0.71	0.87

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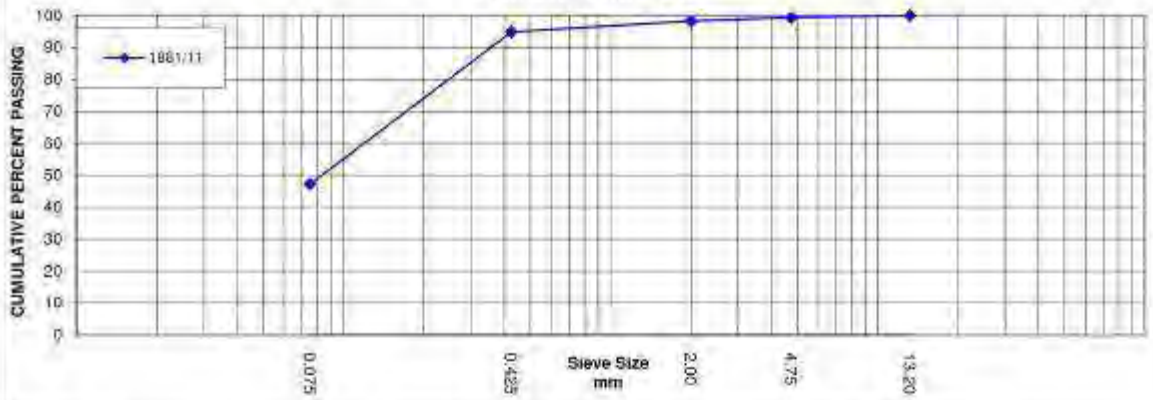
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1881/11(**	Date Sampled : **29-Jan-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Petrusburg**		Date Tested : **06-Feb-14**
Description :	**TP :8 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
1.8-3.0	1881/11	drk Yel. Orange Silty/Clayey sand					100	99	98	95	47	0.60	25	4	2.1	sm/sc	>G9	A-4	2

GRADING ANALYSIS



GENERAL

Effective size (mm) :	**<0.075**
Uniformity co-eff. :	**119**
Curvature co-eff. :	**0.8**
Oversize Index :	**0**
Shrinkage Product :	**199**
Grading co-eff. :	**1.7**

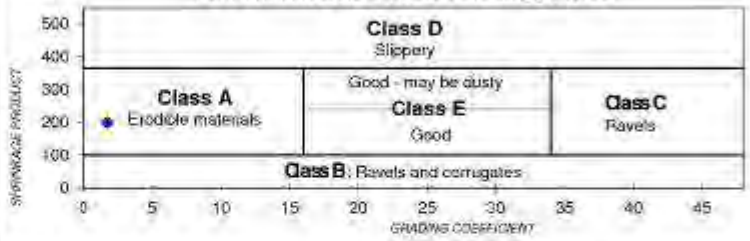
CBR RESULTS (%) :

@ 100% comp. :	**51**
@ 98% comp. :	**46**
@ 97% comp. :	**44**
@ 95% comp. :	**39**
@ 93% comp. :	**35**
@ 90% comp. :	**30**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**3.4%**
Fine Sand (<0.425>0.075mm) :	**47.6%**
Material <0.075mm :	**47.3%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

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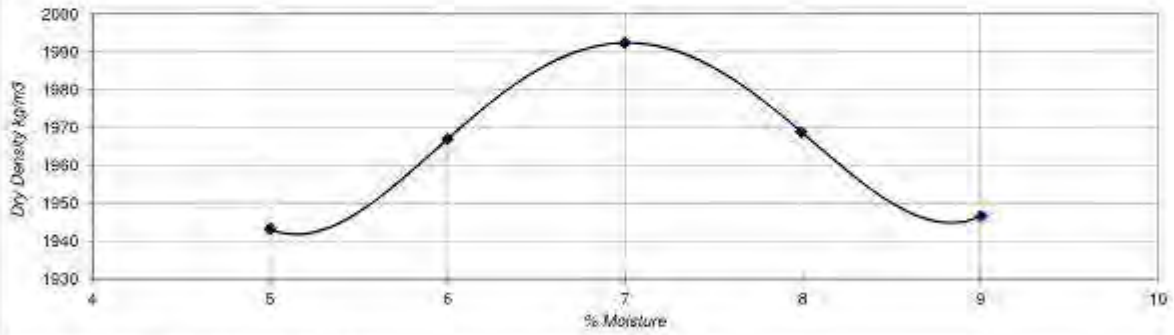
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

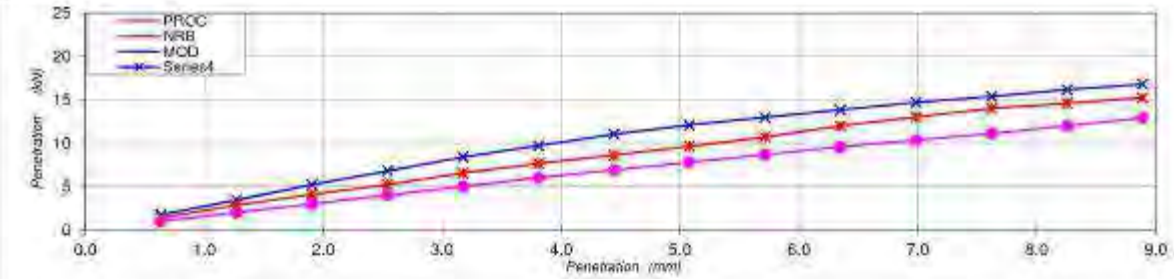
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/11(ii)
Description:	TP ;8 sampled by lab	Sample no:	1881/11

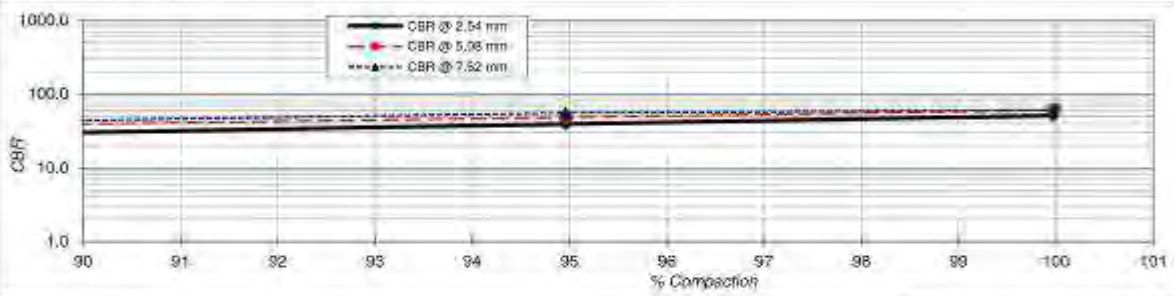
Maximum dry density =	1993	kg/m³
Optimum moisture content =	7.0	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	51	46	44	39	35	30

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1993	1893	1793
Compaction Moisture (%)	7.0	7.0	7.0
Compaction (%)	100.0%	95.0%	90.0%
% Swell	0.54	0.66	0.79

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

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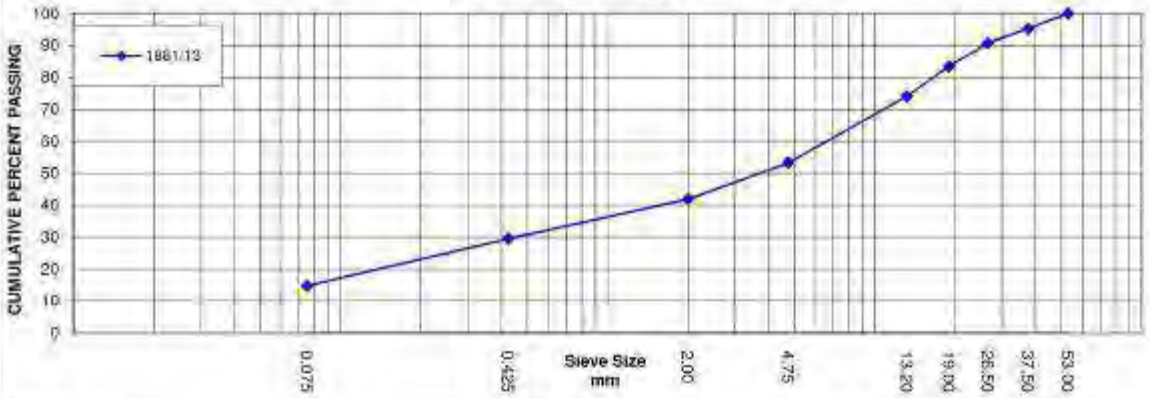
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1881/13(**	Date Sampled : **29-Jan-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Petrusburg**		Date Tested : **06-Feb-14**
Description :	**TP :7 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
1.9-2.4	1881/13	ll Brown Silty/Clayey sand	100	95	91	83	74	53	42	29	15	2.14	23	4	1.9	sm/sc	G5	A-1-a	0

GRADING ANALYSIS



GENERAL

Effective size (mm) :	**<0.075**
Uniformity co-eff. :	**6618**
Curvature co-eff. :	**31.0**
Oversize Index :	**5**
Shrinkage Product :	**56**
Grading co-eff. :	**26.0**

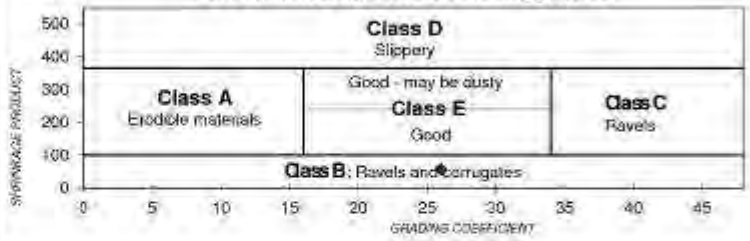
CBR RESULTS (%) :

@ 100% comp. :	**68**
@ 98% comp. :	**61**
@ 97% comp. :	**58**
@ 95% comp. :	**52**
@ 93% comp. :	**50**
@ 90% comp. :	**46**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**12.4%**
Fine Sand (<0.425>0.075mm) :	**14.7%**
Material <0.075mm :	**14.7%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

Please note that this is a calcretic material and was classified as such

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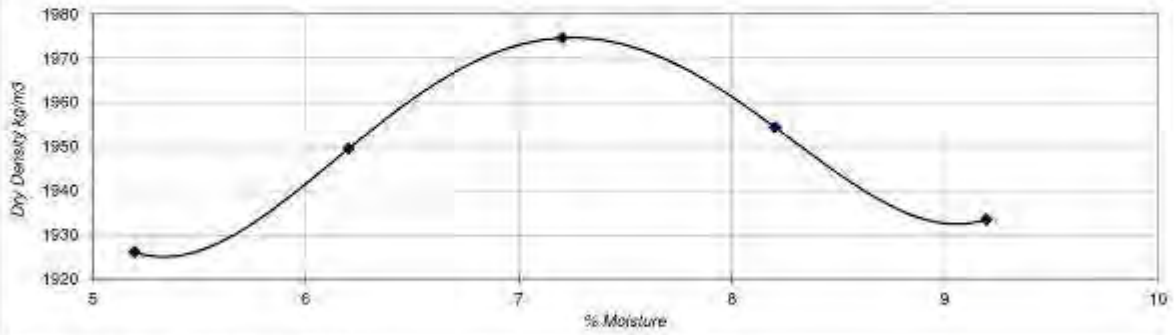
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

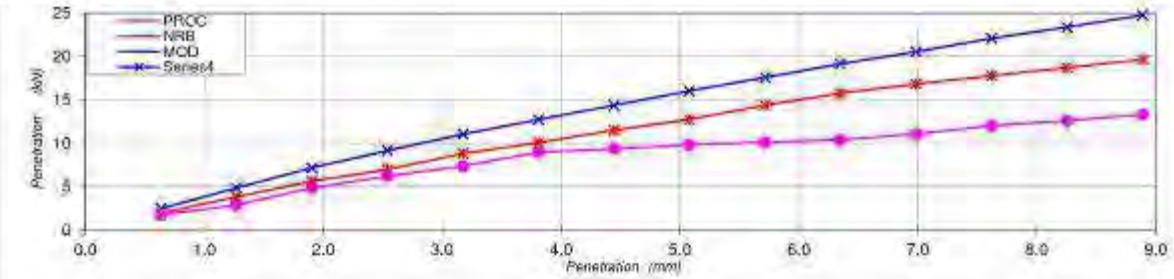
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/13(ii)
Description:	TP :7 sampled by lab	Sample no:	1881/13

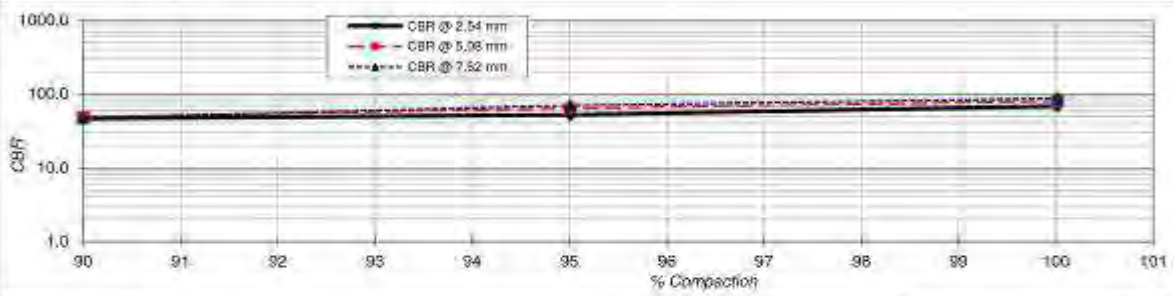
Maximum dry density =	1975	kg/m³
Optimum moisture content =	7.3	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	68	61	58	52	50	46

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1975	1876	1777
Compaction Moisture (%)	7.2	7.2	7.2
Compaction (%)	100.0%	95.0%	90.0%
% Swell	0.39	0.55	0.71

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

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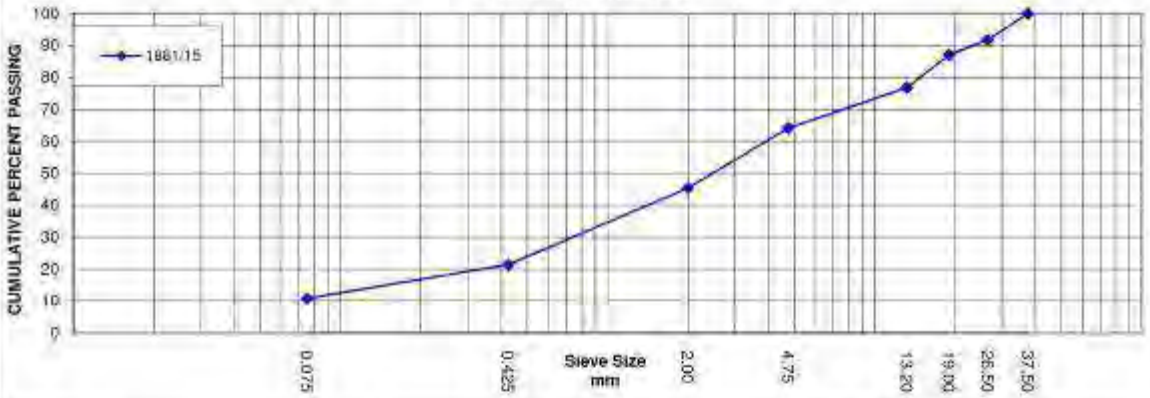
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1(1986)
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1881/15(**	Date Sampled : **29-Jan-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Petrusburg**		Date Tested : **06-Feb-14**
Description :	**TP :6 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO - 1998	US. Highway	Group Index
2.3-2.7	1881/15	ll Red. Orange Poorly graded silty/clayey sand		100	92	87	77	64	45	21	11	2.22	23	4	2.1	sp/sm/sc	G9	A-1-a	0

GRADING ANALYSIS



GENERAL

Effective size (mm) :	**<0.075**
Uniformity co-eff. :	**3923**
Curvature co-eff. :	**140.1**
Oversize Index :	**0**
Shrinkage Product :	**45**
Grading co-eff. :	**29.7**

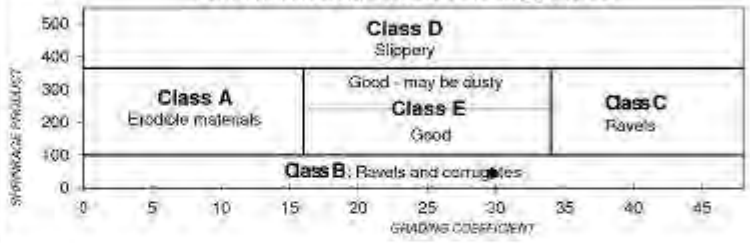
CBR RESULTS (%) :

@ 100% comp. :	**21**
@ 98% comp. :	**16**
@ 97% comp. :	**14**
@ 95% comp. :	**10**
@ 93% comp. :	**9**
@ 90% comp. :	**6**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**24.0%**
Fine Sand (<0.425>0.075mm) :	**10.6%**
Material <0.075mm :	**10.8%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

Please note that this is a calcretic material and was classified as such

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

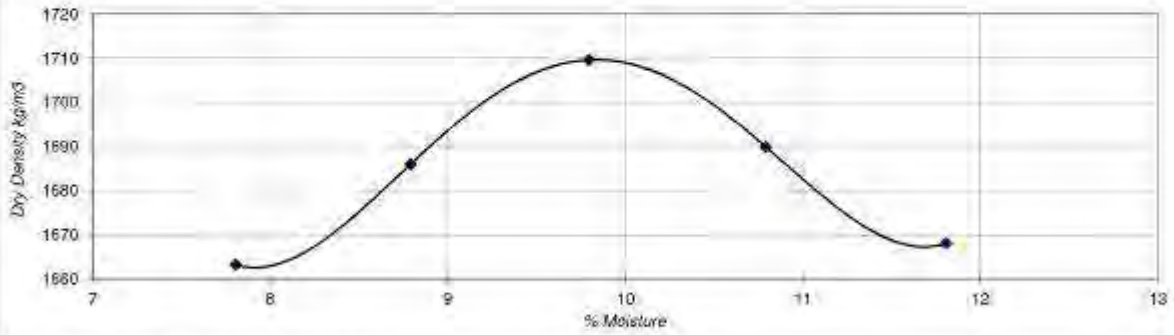
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

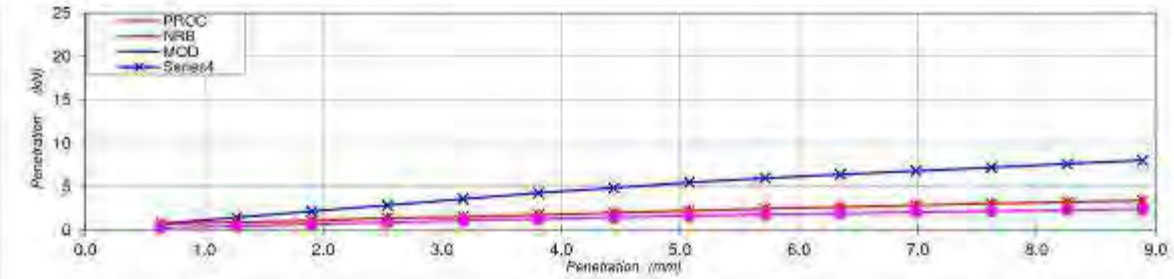
TMH 1:1986 Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	06-Feb-14
Contract :	Petrusburg	Doc no:	1881/15(ii)
Description:	TP ;6 sampled by lab	Sample no:	1881/15

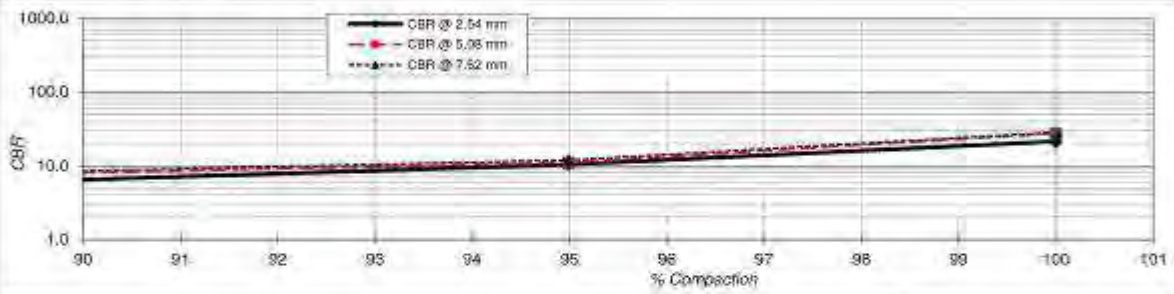
Maximum dry density =	1710	kg/m³
Optimum moisture content =	9.9	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	21	16	14	10	9	6

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1709	1624	1538
Compaction Moisture (%)	9.8	9.8	9.8
Compaction (%)	100.0%	95.0%	90.0%
% Swell	0.47	0.63	0.87

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

Appendix B

Lab Results

Disturbed Samples

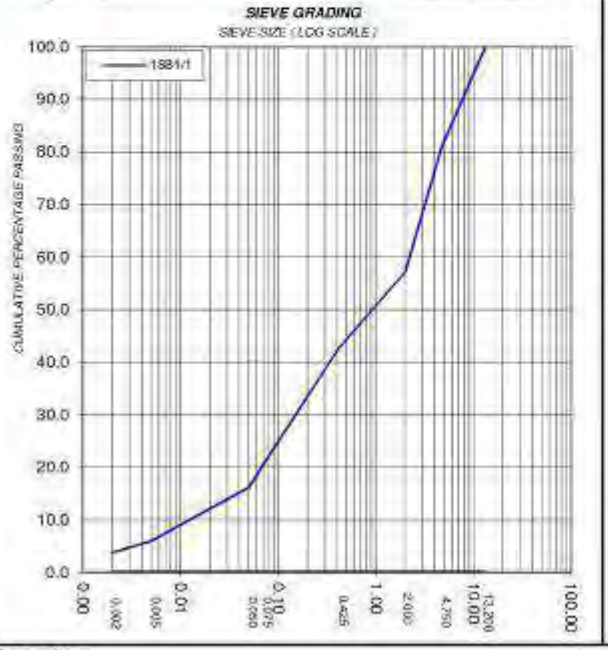
LETABA LAB

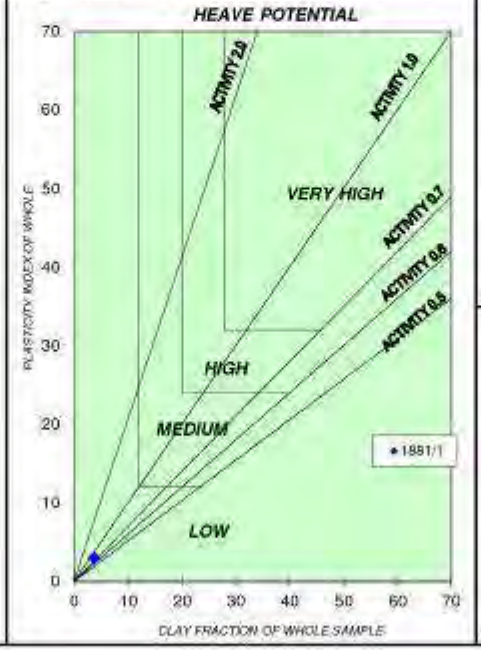
GRAVEL, SOIL AND SAND ANALYSIS

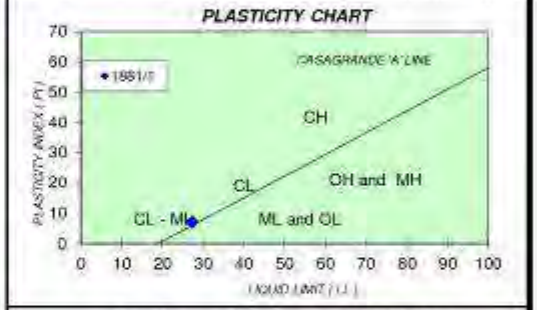
Contract : **Petrusburg** | Client : **GIBB ENINEERING & SCIENCE** | Date : **31-Jan-14**

Description : **TP 1 from 0-0.4 m below NGL** | Job No : **1881**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	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	TRH 14	US Highway	Group Index
0-0,4	1881/1	dirk Reddish Brown Silty Clayey sand					100	81	57	43	21	16,2	6,0	3,7	25,1	46,6	17,9	10,4	0,012	179,2	0,6	1,79	27	7	3,2	sm/sc	-	A-2-4	0







Remarks:

pH : -

Electrical Conductivity : -

JOB 1881-1 TP1_F-IND_0-0.4

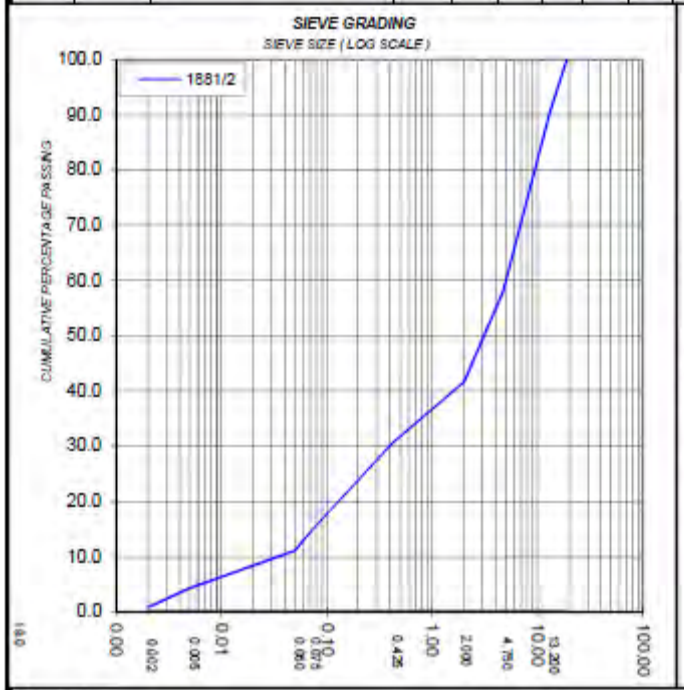
LETABA LAB

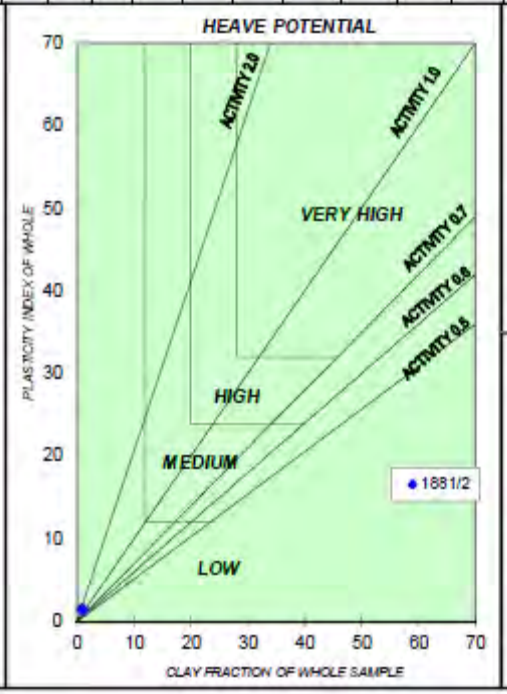
GRAVEL, SOIL AND SAND ANALYSIS

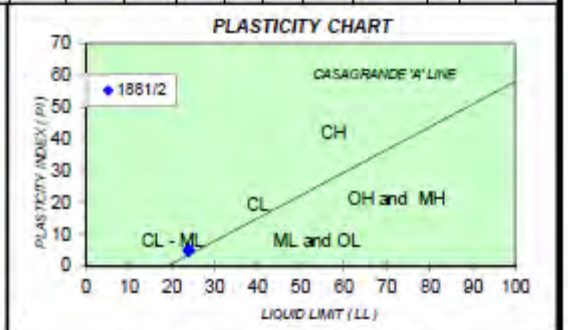
Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14

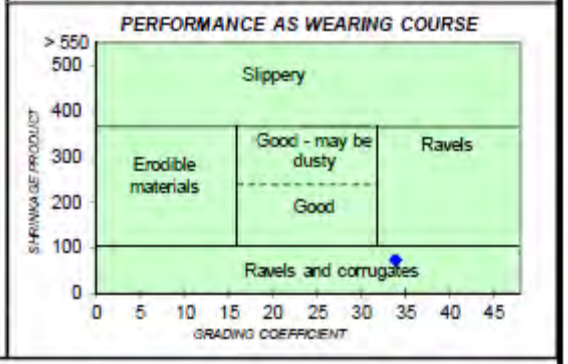
Description : TP 1 from 0.4-1.150 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	US Highway	Group Index
0.4-1.150	1881/2	drk Grey Silty/Clayey sand				##	90	58	42	31	15	11.1	4.3	0.9	26.4	47.0	16.3	10.3	0.035	145.3	0.9	2.13	24	5	2.4	sm/sc	-	A-1-b	0









Remarks:

pH : 6.5

Electrical Conductivity : 385 µS

JOB 1881-2 TP1_FIND_0.4-1.15

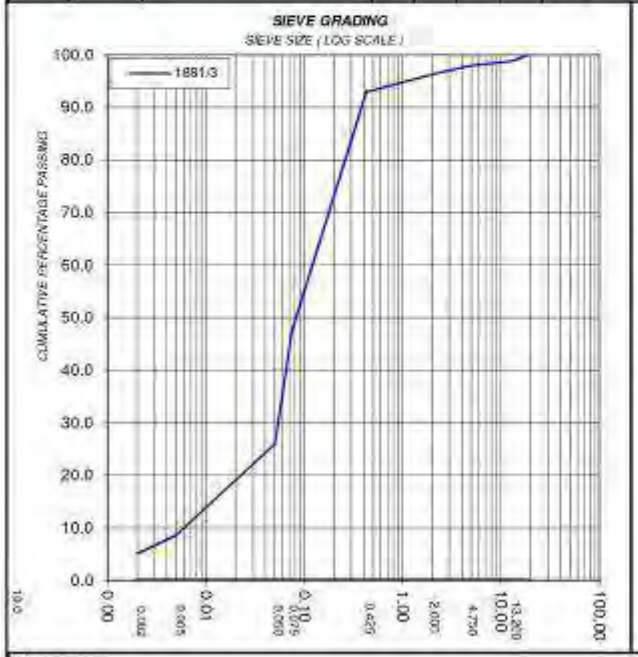
LETABA LAB

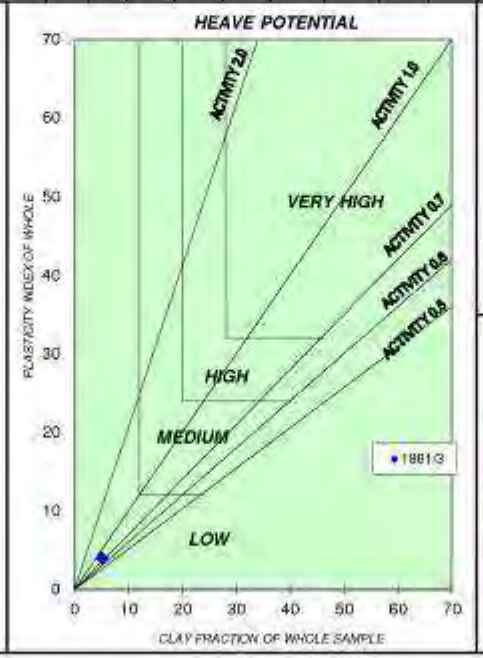
GRAVEL, SOIL AND SAND ANALYSIS

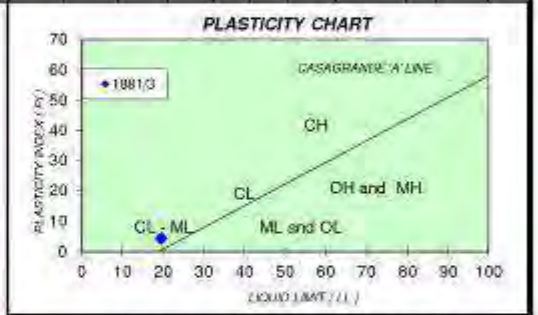
Contract : **Petrusburg** | Client : **GIBB ENINEERING & SCIENCE** | Date : **31-Jan-14**

Description : **TP 2 from 0-0.8 m below NGL** | Job No : **1881**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	US Highway	Group Index
0-0.8	1881/3	drk Red Silty/Clayey sand				100	99	98	96	93	48	25.9	8.6	5.1	3.5	69.5	18.0	9.0	0.006	20.2	4.0	0.63	20	4	2.1	sm/sc	-	A-4	3







Remarks:

pH : -

Electrical Conductivity : -

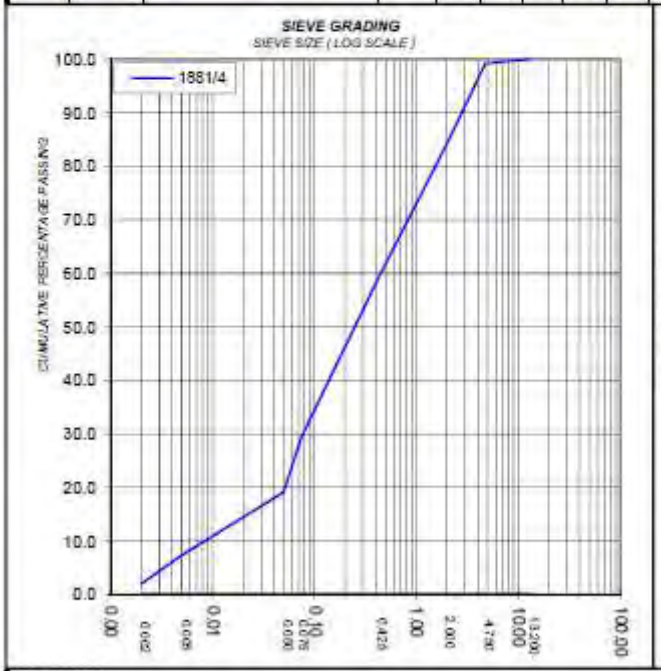
JOB 1881-3 TP2_F-IND_0-0.8

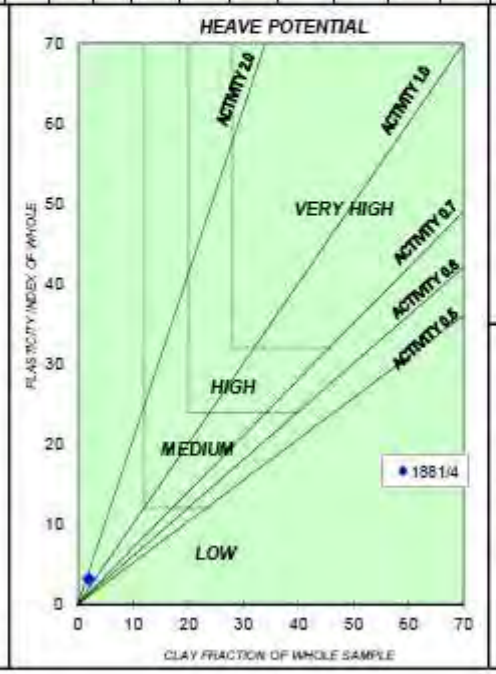
LETABA LAB

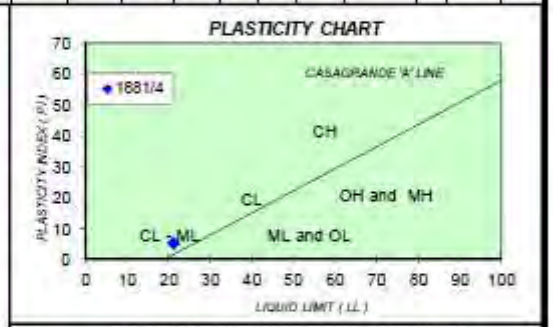
GRAVEL, SOIL AND SAND ANALYSIS

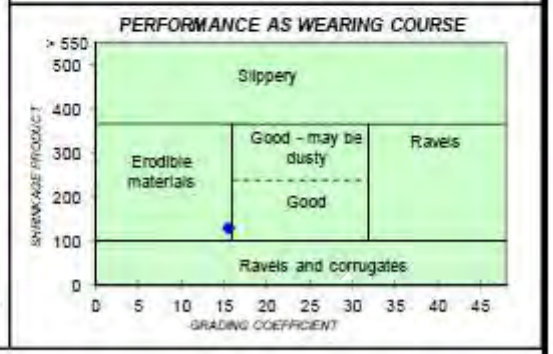
Contract :	Petrusburg	Client : GIBB ENINEERING & SCIENCE	Date : 31-Jan-14
Description :	TP 2 from 0.8-1.2 m below NGL		Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			63,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	U.S.Highway	Group Index
0.8-1.2	1881/4	drk Yellow Silty/Clayey sand					100	99	84	59	29	19.2	7.4	2.0	29.8	47.5	14.0	8.7	0.008	53.5	1.6	1.27	21	5	2.2	sm/sc	-	A-2-4	0









Remarks:

pH : 6.93

Electrical Conductivity : 222 µS

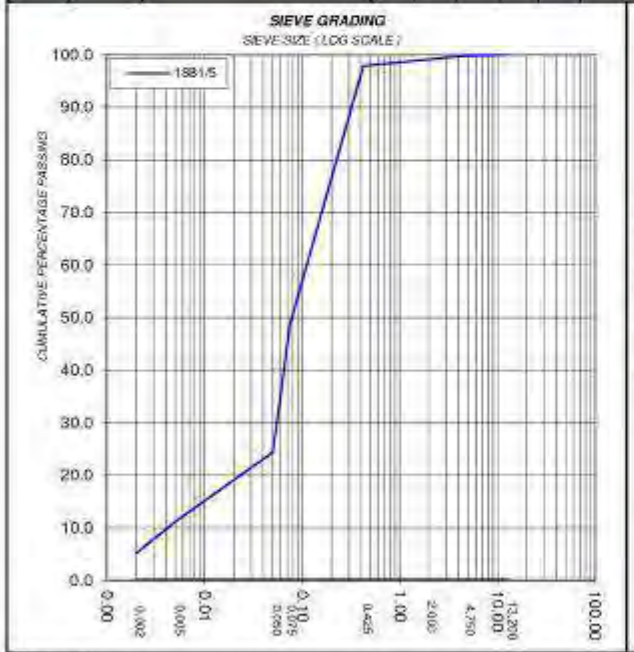
LETABA LAB

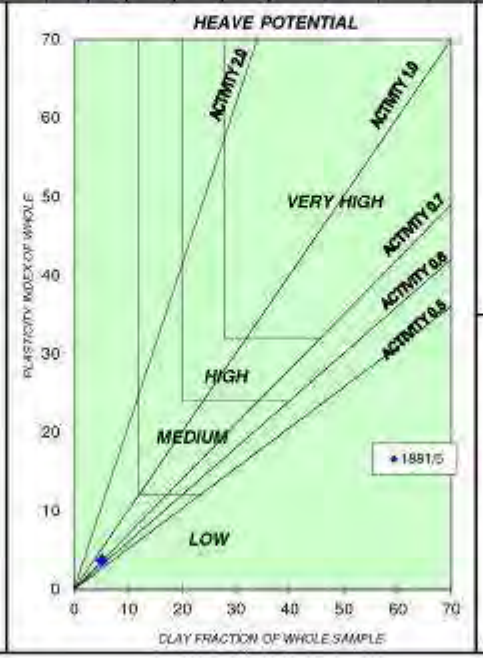
GRAVEL, SOIL AND SAND ANALYSIS

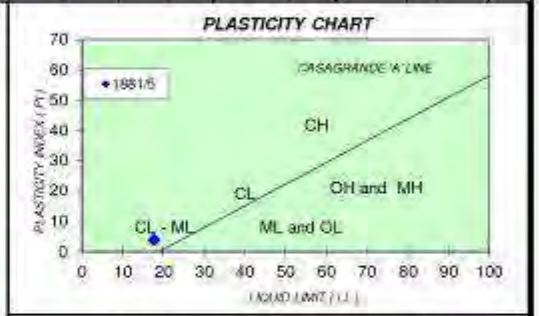
Contract : **Petrusburg** | Client : **GIBB ENINEERING & SCIENCE** | Date : **31-Jan-14**

Description : **TP 3 from 0-1.2 m below NGL** | Job No : **1881**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	US Highway	Group Index
0-1,2	1881/5	dk Red Silty/Clayey sand					100	100	99	98	49	24,4	11,1	5,2	1,3	74,2	13,4	11,2	0,004	26,4	6,4	0,54	18	4	1,6	sm/sc	-	A-4	3







Remarks:

pH : -

Electrical Conductivity : -

JOB 1881-5 TP3_F-IND_0-1.2

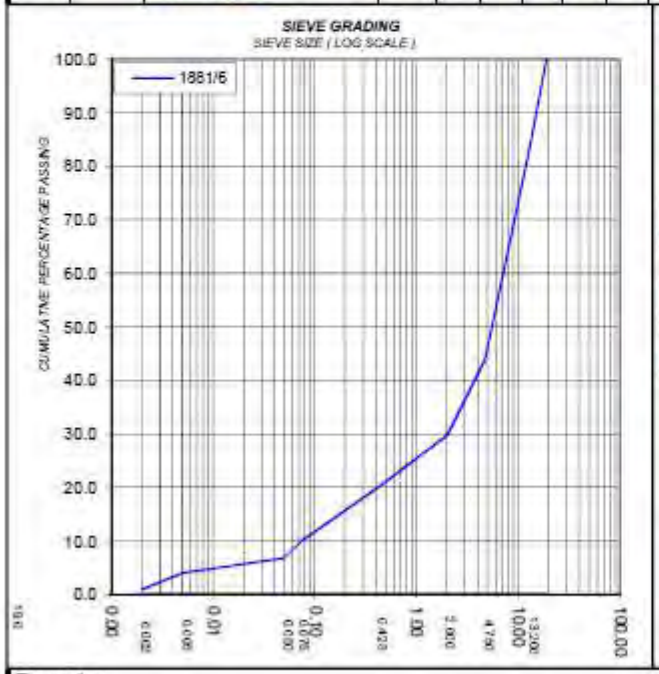
LETABA LAB

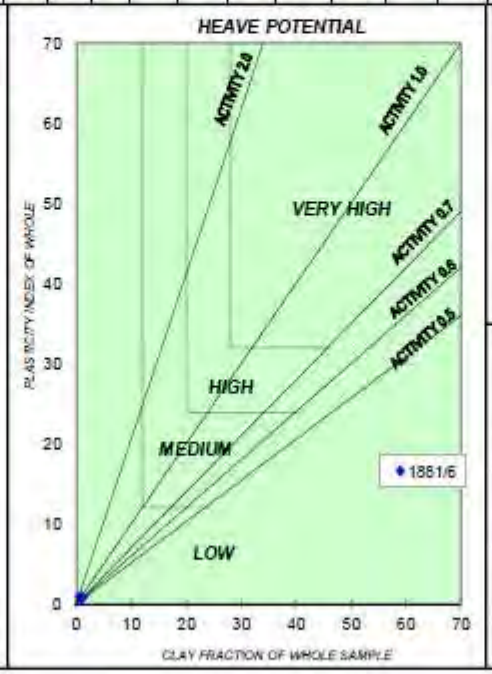
GRAVEL, SOIL AND SAND ANALYSIS

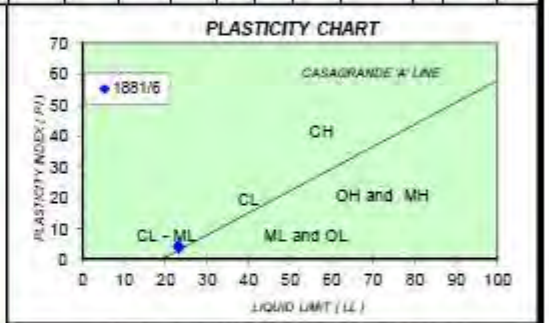
Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14

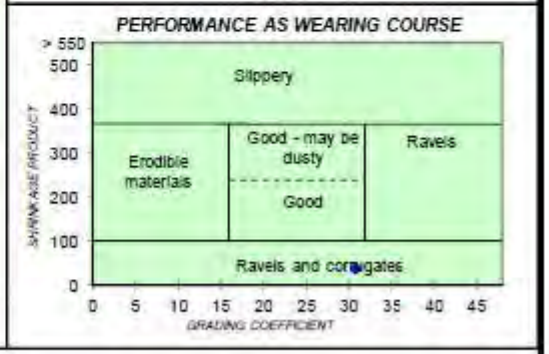
Description : TP 3 from 1.2-1.9 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm	0,006 mm	0,002 mm	Coarse - sand <2,0 >0,425mm	Fine - sand <0,425 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	U.S.Highway	Group Index
1.2-1.9	1881/6	lt Grey Poorly graded silty/clayey gravel				##	84	44	30	20	10	6.8	4.0	0.9	32.5	44.5	9.4	13.5	0.075	96.0	7.7	2.40	23	4	1.9	GP/GM/GC	-	A-1-a	0









Remarks:

pH : 7.22

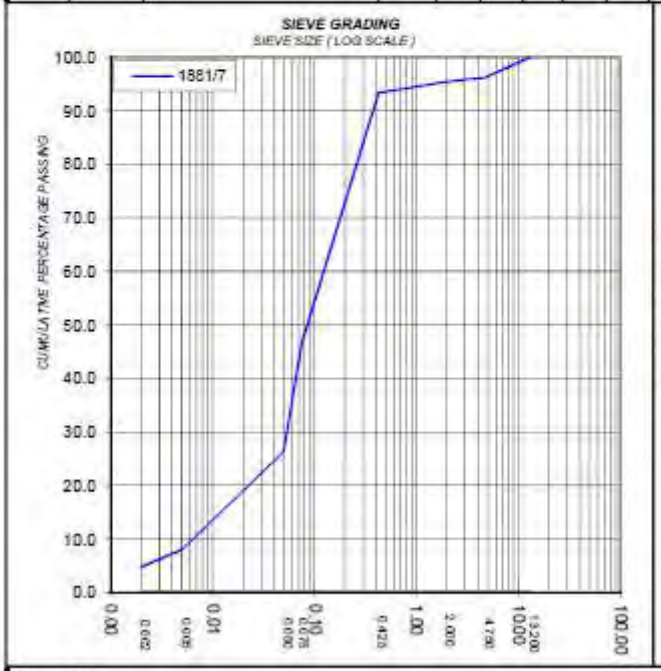
Electrical Conductivity : 261 µS

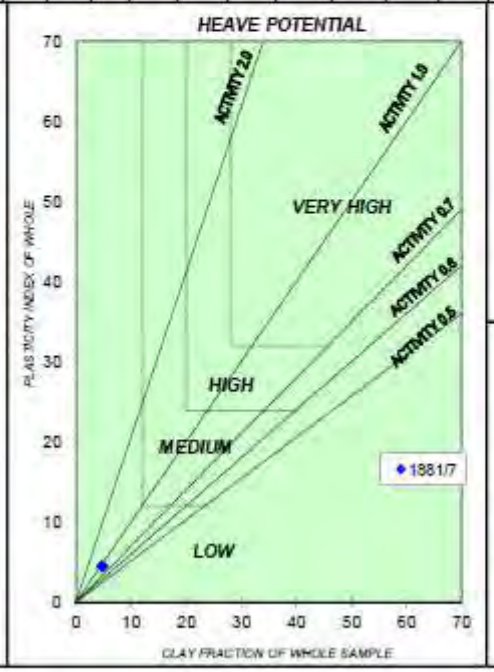
LETABA LAB

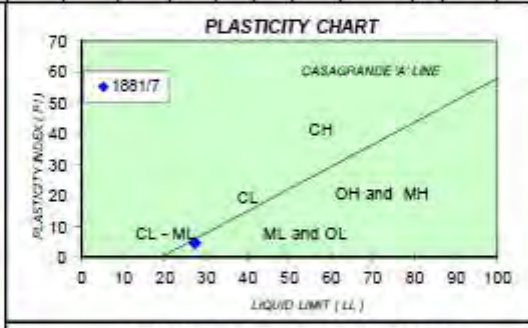
GRAVEL, SOIL AND SAND ANALYSIS

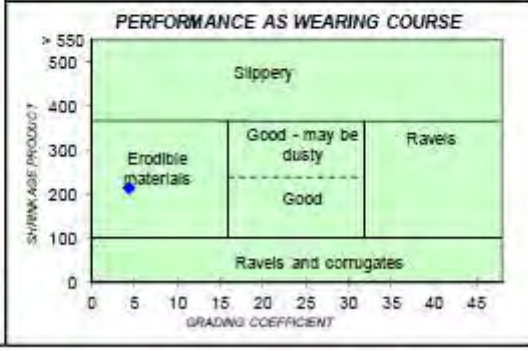
Contract :	Petrusburg	Client : GIBB ENINEERING & SCIENCE	Date : 31-Jan-14
Description :	TP 4 from 0-1.8 m below NGL		Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	US Highway	Group Index
0-1.8	1881/7	drk Red Silty/Clayey sand					100	96	95	93	46	26.3	8.1	4.8	2.3	70.2	19.0	8.5	0.005	19.4	3.7	0.65	27	5	2.3	sm/sc	-	A-4	2









Remarks:

pH : 7.21

Electrical Conductivity : 99 µS

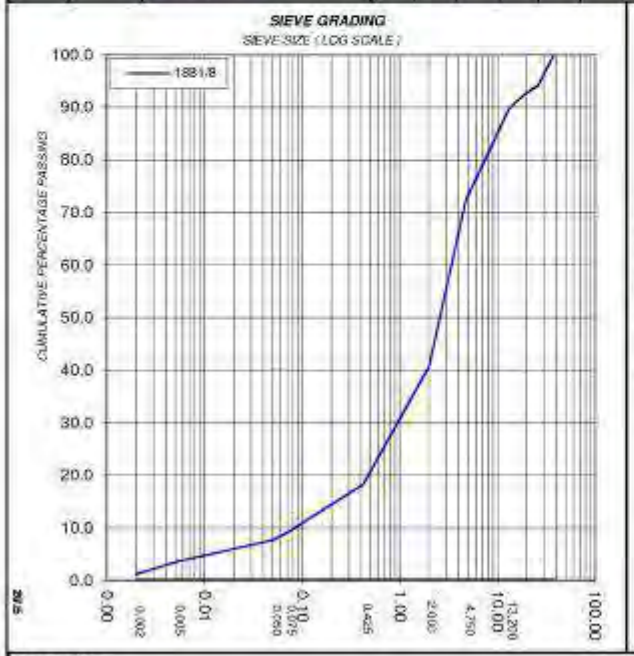
LETABA LAB

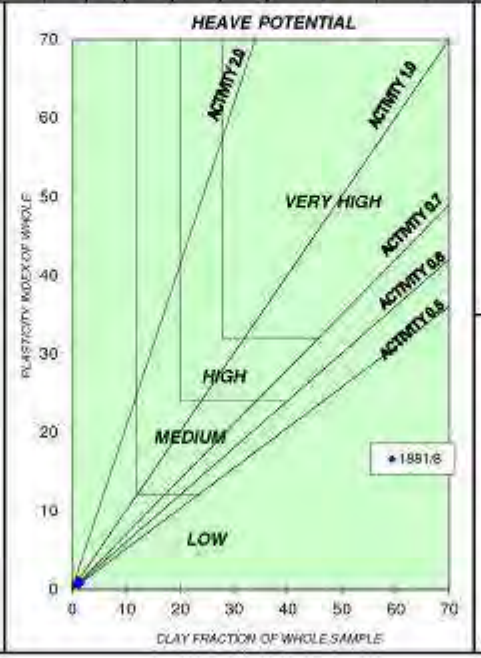
GRAVEL, SOIL AND SAND ANALYSIS

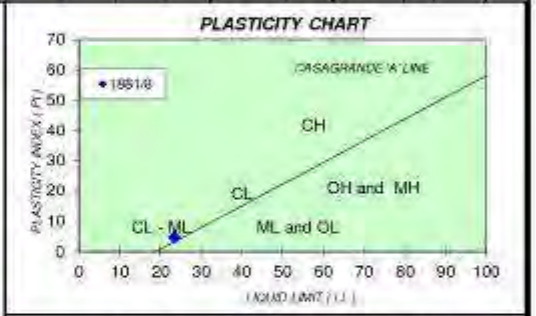
Contract : **Petrusburg** | Client : **GIBB ENINEERING & SCIENCE** | Date : **31-Jan-14**

Description : **TP 4 from 1.8-2.4 m below NGL** | Job No : **1881**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing												Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	US Highway	Group Index
1,8-2,4	1881/8	dirk Yellow Well graded silty/clayey sand		100	94	92	90	72	41	18	9	7,6	3,5	1,2	55,1	26,2	10,2	8,5	0,085	40,1	3,2	2,32	24	5	2,3	sw/sm/sc	-	A-1-a	0







Remarks:

pH : -

Electrical Conductivity : -

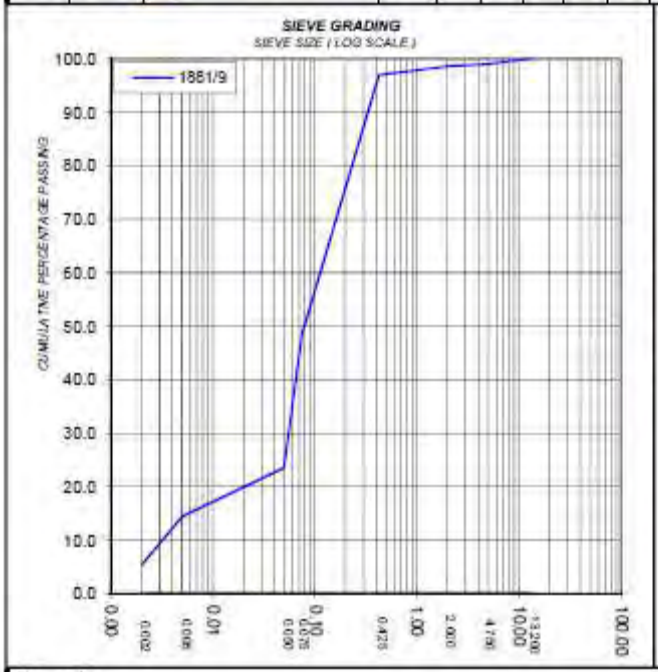
JOB 1881-8 TP4_F-IND_1.8-2.4

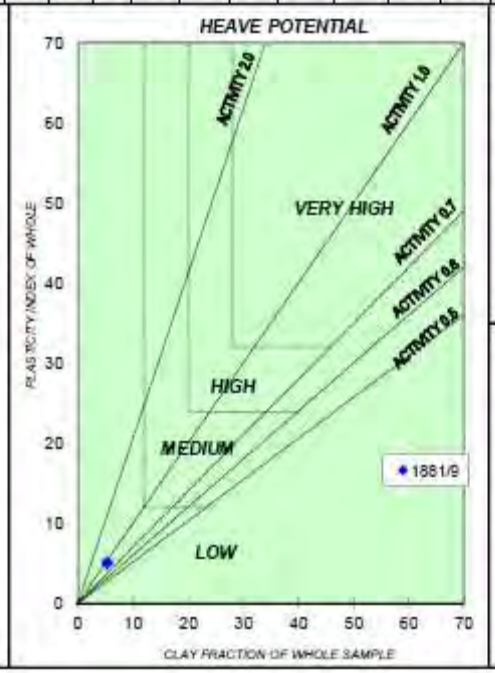
LETABA LAB

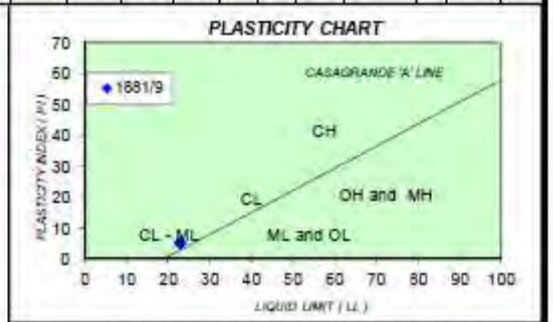
GRAVEL, SOIL AND SAND ANALYSIS

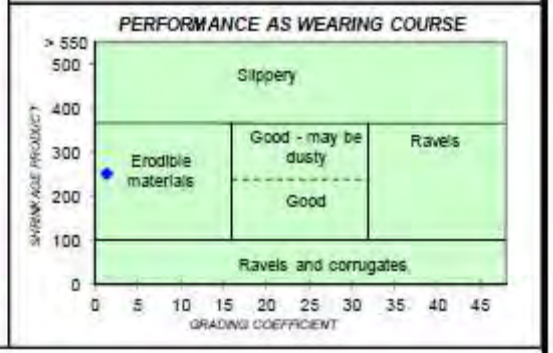
Contract :	Petrusburg	Client : GIBB ENINEERING & SCIENCE	Date : 31-Jan-14
Description :	TP 5 from 0-2.9 m below NGL		Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	USHighway	Group Index
0-2.9	1881/9	drk Red. Orange Silty/Clayey sand					100	99	99	97	48	23.5	14.4	5.4	1.7	74.5	9.2	14.6	0.003	35.4	8.5	0.56	23	5	2.6	sm/sc	-	A-4	3









Remarks:

pH : 7.31

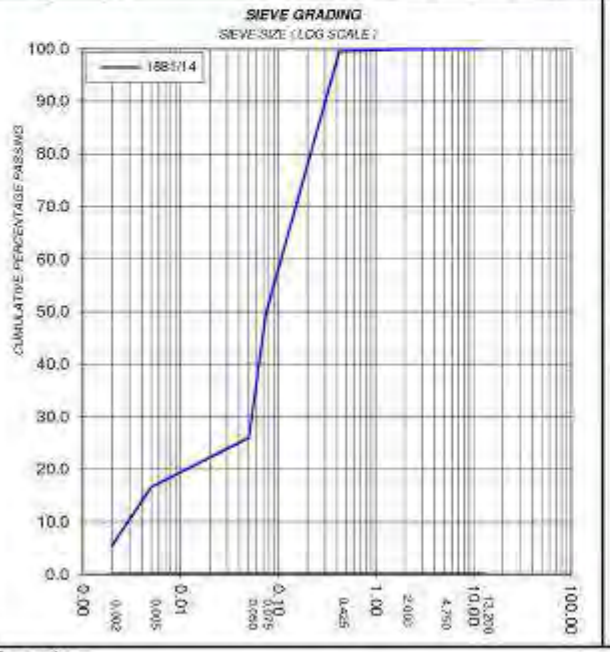
Electrical Conductivity : 137 µS

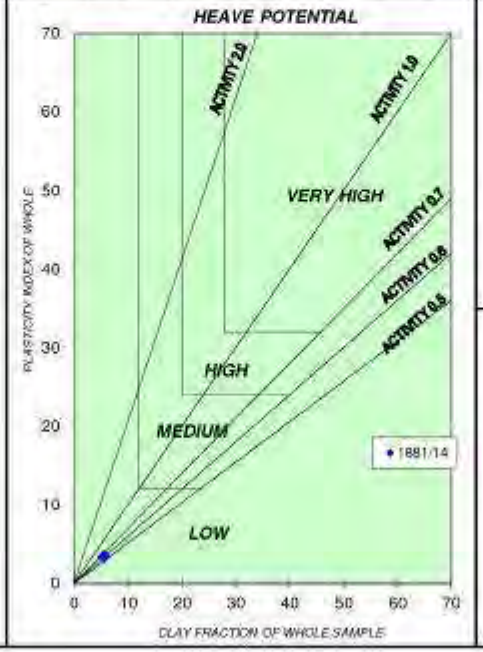
LETABA LAB

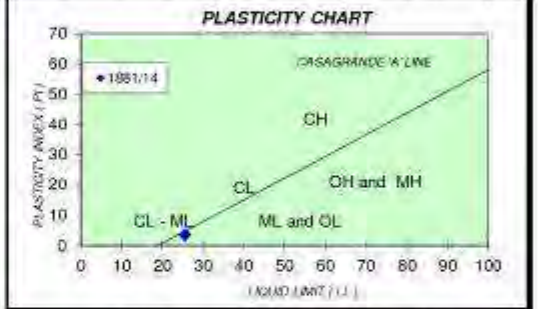
GRAVEL, SOIL AND SAND ANALYSIS

Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14
Description : TP 6 from 0-2.3 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	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	TRH 14	US Highway	Group Index
(+0.3	1881/14	dark Red Inorganic silt					100	100	100	99	50	26,1	16.6	5,6	0.4	73.5	9.5	16.6	0.003	37.1	9.2	0.51	26	3	1.8	ML	-	A-4	3







Remarks:

pH : -
Electrical Conductivity : -

JOB 1881-14 TP6_F-IND_0-2.3

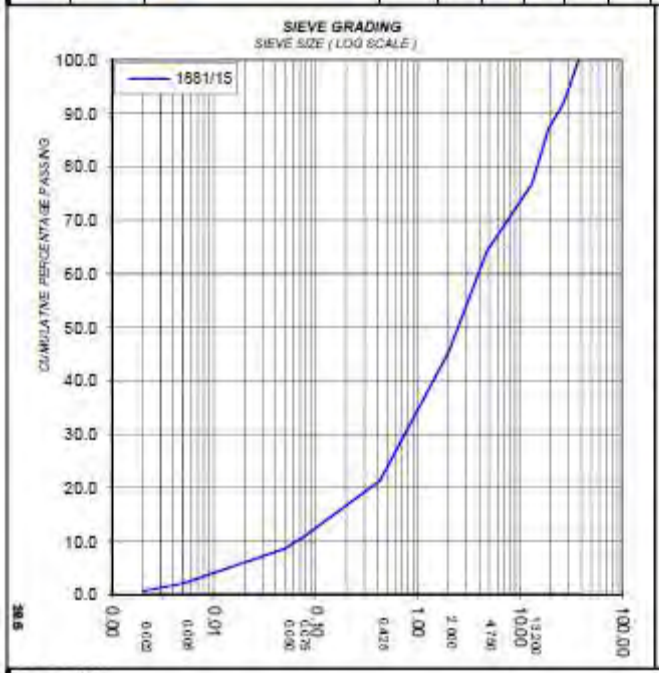
LETABA LAB

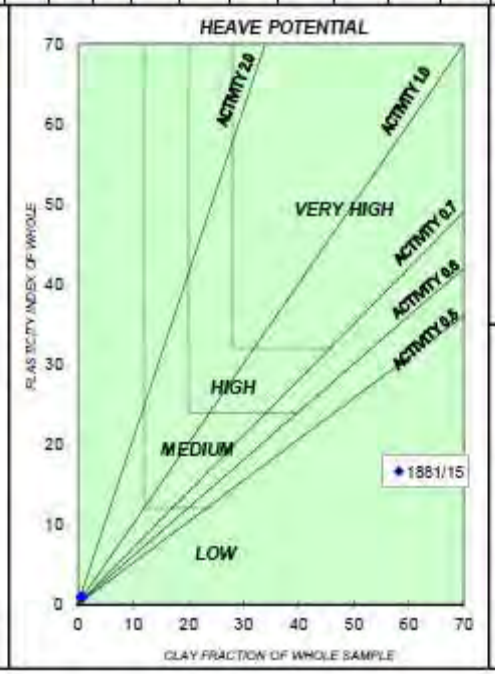
GRAVEL, SOIL AND SAND ANALYSIS

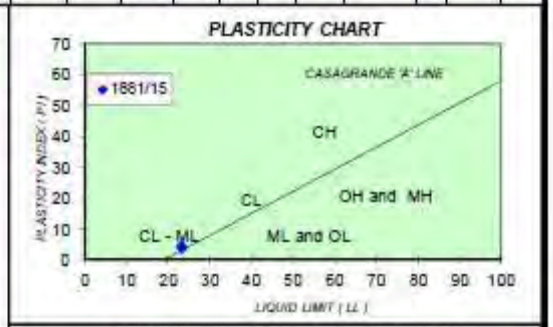
Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14

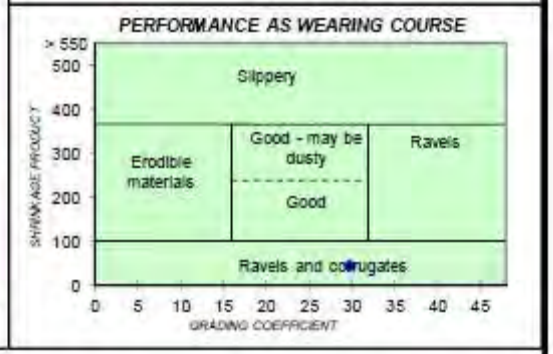
Description : TP 6 from 2.3-2.7 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	USHighway	Group Index
2.3-2.7	1881/15	White Well graded silty/clayey sand		100	92	87	77	64	45	21	11	8.6	2.2	0.7	52.9	28.1	14.2	4.7	0.065	60.5	2.2	2.22	23	4	2.1	sw/sm/sc	-	A-1-a	0









Remarks:

pH : 7.91

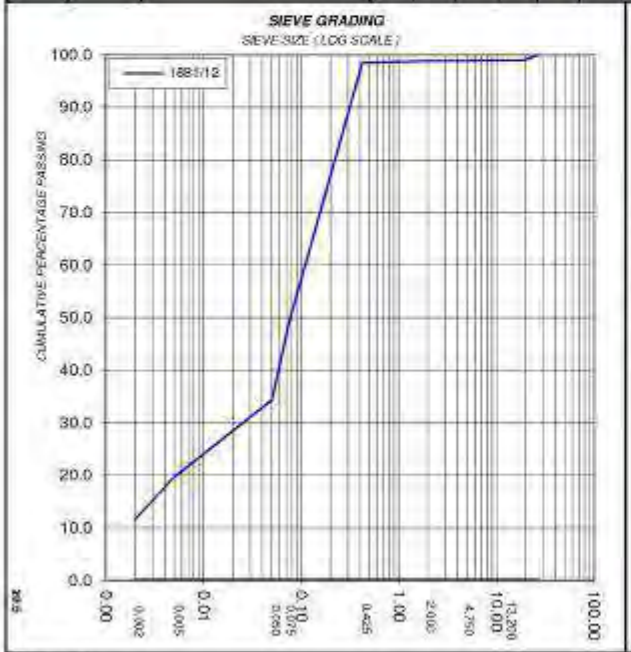
Electrical Conductivity : 302 µS

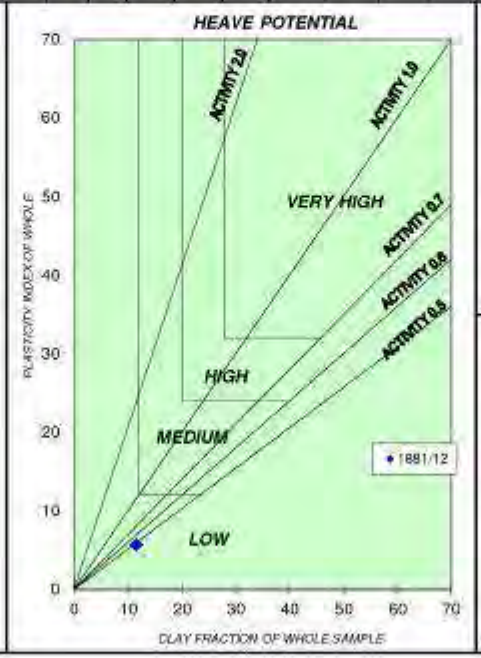
LETABA LAB

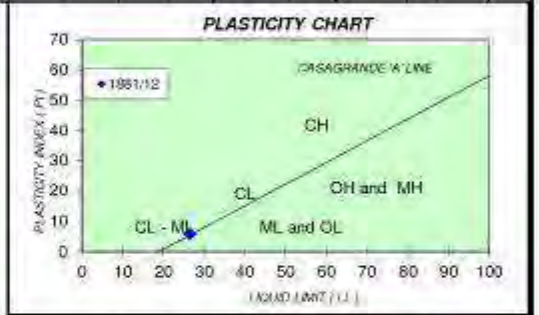
GRAVEL, SOIL AND SAND ANALYSIS

Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14
Description : TP 7 from 0-1.9 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	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	TRH 14	US Highway	Group Index
0-1.9	1881/12	drk Red Silty/Clayey sand			100	99	99	99	99	99	49	34.3	19.6	11.6	0.3	64.9	14.9	19.9	<0.002	110.1	58	0.54	26	6	2.9	sm/sc	-	A-4	3







Remarks:

pH : -
Electrical Conductivity : -

JOB 1881-12 TP7_F-IND_0-1.9

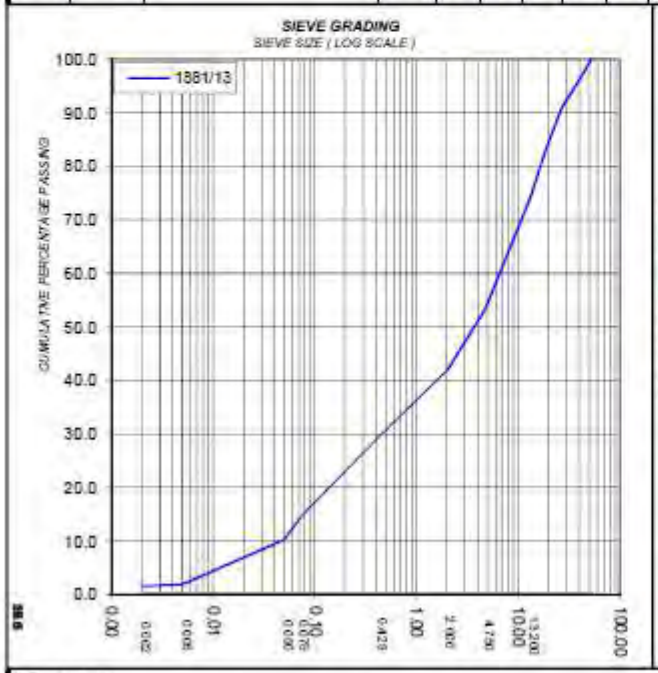
LETABA LAB

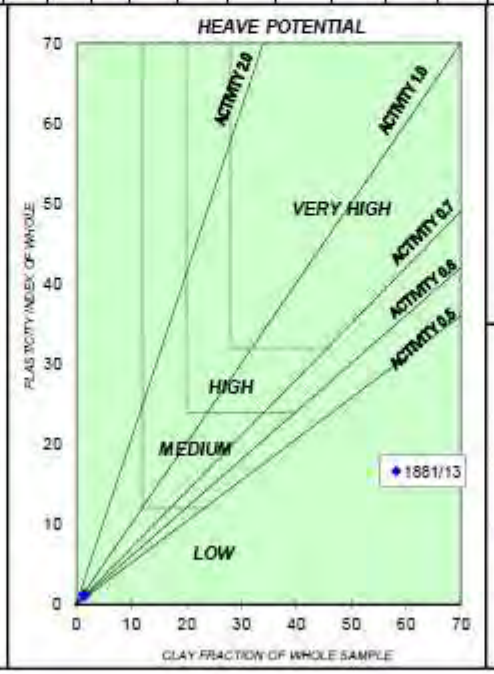
GRAVEL, SOIL AND SAND ANALYSIS

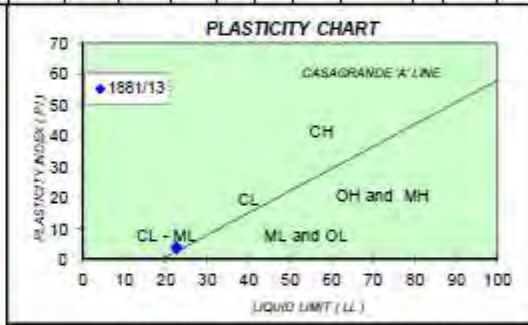
Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14

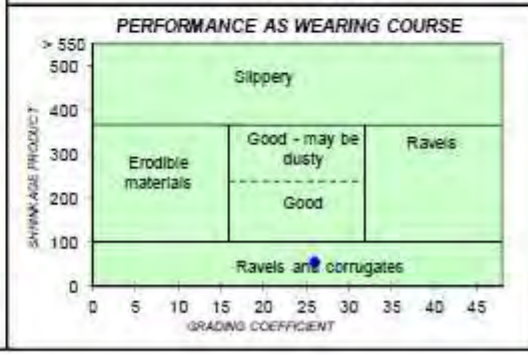
Description : TP 7 from 1.9-2.4 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm	0,006 mm	0,002 mm	Coarse - sand <2,0 >0,425mm	Fine - sand <0,425 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	US Highway	Group Index
1,9-2,4	1881/13	White Silty/Clayey sand	100	95	91	83	74	53	42	29	15	10,3	1,9	1,5	29,6	45,9	19,9	4,6	0,047	142,1	0,7	2,14	23	4	1,9	sm/sc	-	A-1-a	0









Remarks:

pH : 8.19

Electrical Conductivity : 205 µS

LETABA LAB

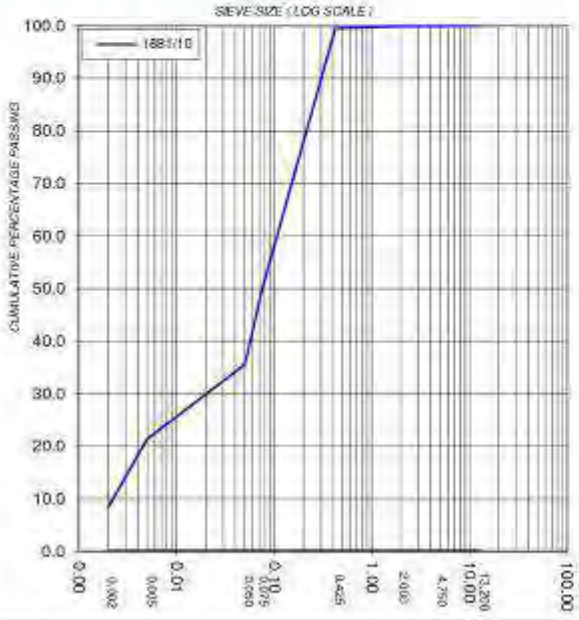
GRAVEL, SOIL AND SAND ANALYSIS

Contract : **Petrusburg** | Client : **GIBB ENINEERING & SCIENCE** | Date : **31-Jan-14**

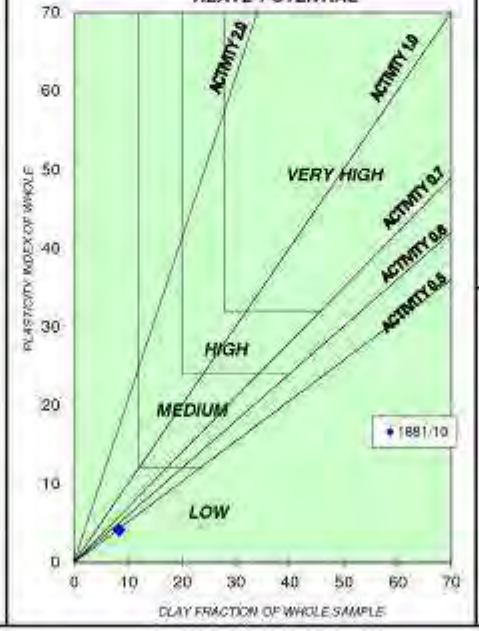
Description : **TP 8 from 0-1.8 m below NGL** | Job No : **1881**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	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	TRH 14	US Highway	Group Index
0-1.8	1881/10	dk Red Inorganic clay					100	100	100	100	50	35.6	21.3	8.4	0.3	64.1	14.2	21.4	0.002	47.8	1.7	0.51	23	4	2.2	CL	-	A-4	3

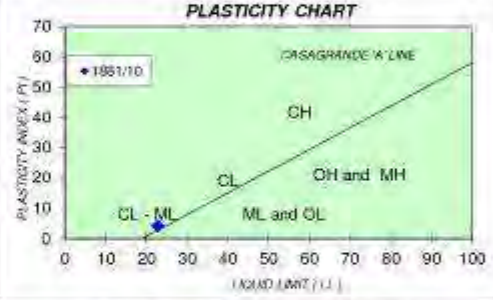
SIEVE GRADING



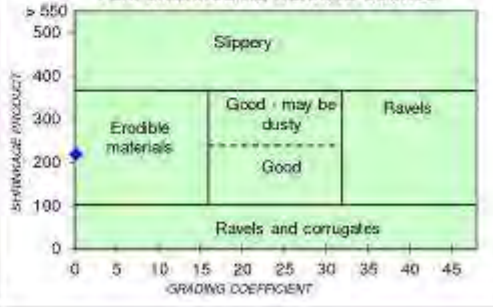
HEAVE POTENTIAL



PLASTICITY CHART



PERFORMANCE AS WEARING COURSE



Remarks:

pH : -

Electrical Conductivity : -

JOB 1881-10 TP8_F-IND_0-0.4

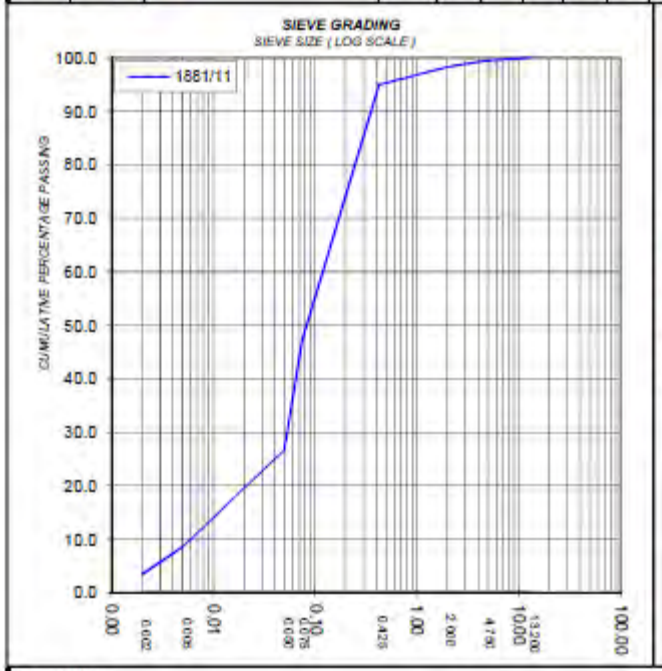
LETABA LAB

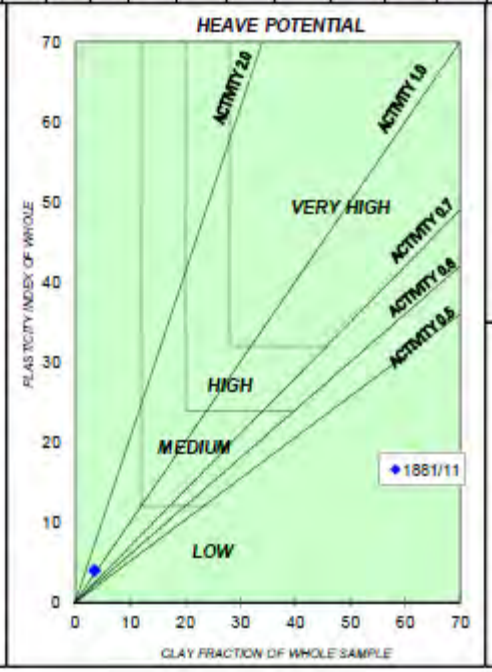
GRAVEL, SOIL AND SAND ANALYSIS

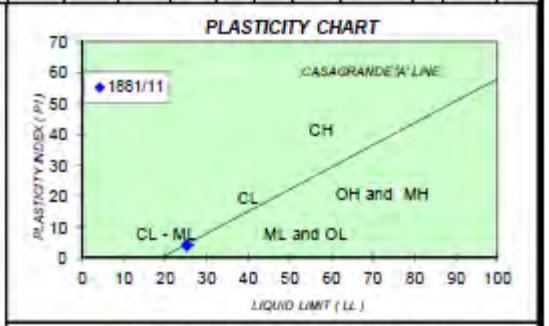
Contract : Petrusburg | Client : GIBB ENINEERING & SCIENCE | Date : 31-Jan-14

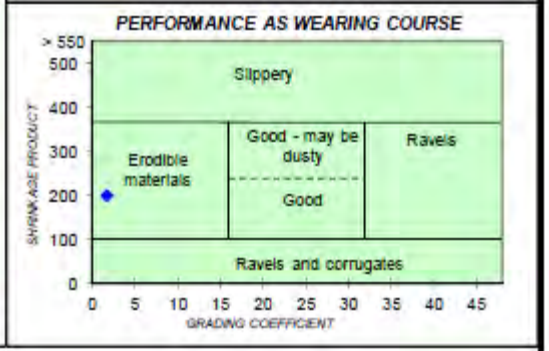
Description : TP 8 from 1.8-3.0 m below NGL | Job No : 1881

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing											Soil Mortar Analysis % of mat. <2,00 mm				Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits			Classifications			
			53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 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 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm					Liquid Limit	Plasticity Index	Linear Shrinkage	Unified Soil	TRH 14	U.S.Highway	Group Index
1.8-3.0	1881/11	lt Red. Orange Silty/Clayey sand					100	99	98	95	47	26.7	8.6	3.5	3.4	69.4	18.3	8.8	0.006	20.1	4.0	0.60	25	4	2.1	sm/sc	-	A-4	2









Remarks:

pH : 7.8

Electrical Conductivity : 147 µS

LETABA LAB Pty) Ltd Reg 95/01251/07

CIVIL ENGINEERING MATERIALS LABORATORY

• P.O. Box 22874, Exton Road, 9301 • Tel. No: 051 433 4057 • Fax. No: 051 433 4236 • adminlab@letabalab.co.za

SAMPLE DATA					SUMMARY OF TEST RESULTS																						
					SIEVE ANALYSIS % PASSING											ATTERBURG CONSTANTS			GM	MODIFIED AASHTO		CBR		CBR (ITS /UCS)*			STABILIZED WITH
km DISTANCE	Test Position	DEPTH	SAMPLE NO	DESCRIPTION	63.0	53.0	37.5	26.5	19.0	13.2	4.75	2.0	0.425	0.075					OMC	MDD	COMP MOIST	SWELL	95%	98%	90%	IN SITU MOISTURE %
	TP1	0-0.6	1881/1	dirk reddish Brown silty/clayey sand						100	81	57	43	23	27	7	3.2	1.79								
	TP1	0.6-1.15	1881/2	dirk Brown silty/clayey sand	G7				100	90	58	42	31	15	24	5	2.4	2.13	8.9	1980	8.6	0.54	23	19	13	
	TP2	0-0.8	1881/3	dirk Red silty/clayey sand					100	99	98	96	93	48	20	4	2.1	0.63								
	TP2	0.8-1.2	1881/4	dirk yel. Orange silty/clayey sand	G6					100	99	84	59	29	21	5	2.2	1.27	8.4	2062	8.1	0.55	28	23	16	
	TP3	0-1.2	1881/5	dirk Red silty/clayey sand						100	100	99	98	49	18	4	1.6	0.56								
	TP3	1.2-1.9	1881/6	dirk Brown Poorly graded silty/clayey gravel	G8				100	84	64	30	20	10	23	4	1.9	2.4	9	2043	8.7	0.49	19	14	9	
	TP4	0-1.8	1881/7	dirk Brown silty/clayey sand	>G9					100	96	95	93	46	27	5	2.3	0.65	8	2045	7.9	0.71	43	40	36	
	TP4	1.8-2.4	1881/8	dirk Yellow well graded silty/clayey sand				100	94	92	90	72	41	18	9	24	5	2.3	2.32								
	TP5	0-2.9	1881/9	dirk Red orange silty/clayey sand	>G9						100	99	99	97	48	25	5	2.6	0.56	8.5	1906	8.4	0.6	38	33	27	
	TP6	0-2.3	1881/14	dirk Red organic silt							100	100	100	99	50	26	3	1.8	0.51								
	TP6	2.3-2.7	1881/15	lt Red. Orange Poorly graded silty/clayey sand	G9			100	92	87	77	64	45	21	11	23	4	2.1	2.22	9.9	1710	9.8	0.47	10	9	6	
	TP7	0-1.9	1881/12	dirk Red silty/clayey sand					100	99	99	99	99	49	26	6	2.9	0.56								
	TP7	1.9-2.4	1881/13	lt Brown silty/clayey sand	G5		100	95	91	83	74	53	42	29	15	25	4	1.9	2.14	7.3	1875	7.2	0.39	52	50	46	
	TP8	0-1.8	1881/10	Dirk Red inorganic clay						100	100	100	100	50	23	4	2.2	0.51								
	TP8	1.8-3.0	1881/11	dirk yel. Orange silty/clayey sand	>G9					100	99	98	95	47	25	4	2.1	0.6	7	1998	7	0.54	39	35	30	

* Average value in kPa, obtained at MOD AASHTO compaction and OMC are shown against the amount of stabilising agents.

CS:Course Sand, FS:Fine Sand, LL: Liquid Limit, PI:Plasticity Index, LS:Linear Shrinkage, GM:Grading Modulus,
OMC:Optimum Moisture Content, MDD:Maximum Dry Density, CBR:California Bearing Ratio, UCS:Unconfined Compressive Strength,
ITS:Indirect Tensile Strength, N/C:No Classification, N/S:No Sample

Client : Gibb Engineering & Science JOB : 1881 Project : Petrusburg

Appendix C

DPL Results

LETABA LAB CC
CIVIL ENGINEERING MATERIALS LABORATORY

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Cel. No: 084 405 4711
e-mail : jayson@letabalab.co.za

Client: Gibb Engineering & Science
Contact: Petrusburg
Description: DPL done from existing ground level

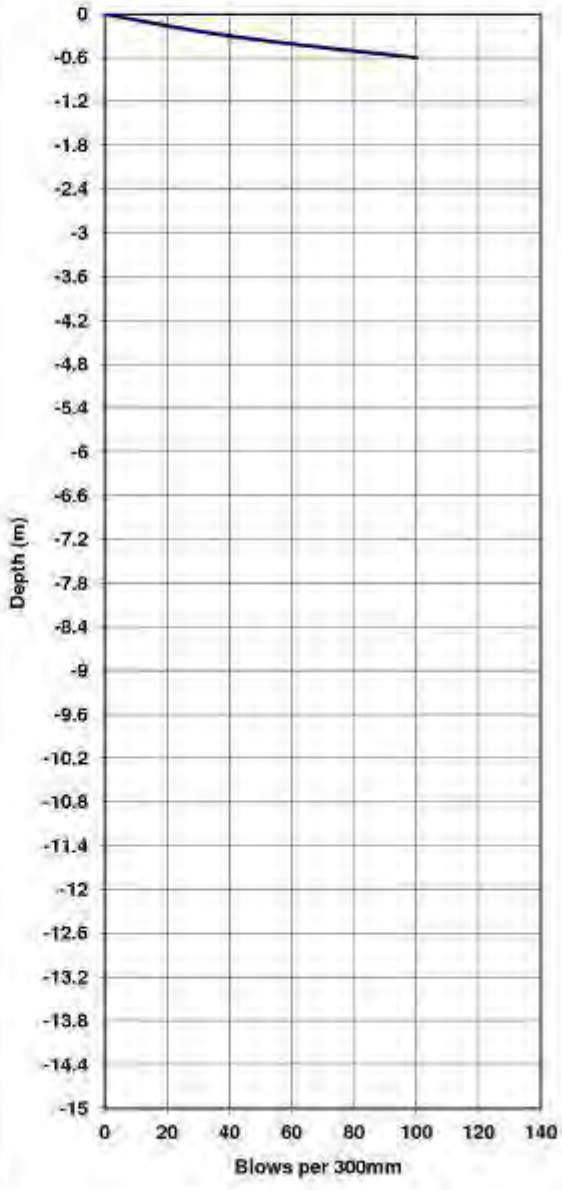
Job.No. 1881
Date: 30-Jan-2014
Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 1 at TP 1***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	40	Med.Dense	36 deg
0.6	100	Very Dense	>38 deg
	END		



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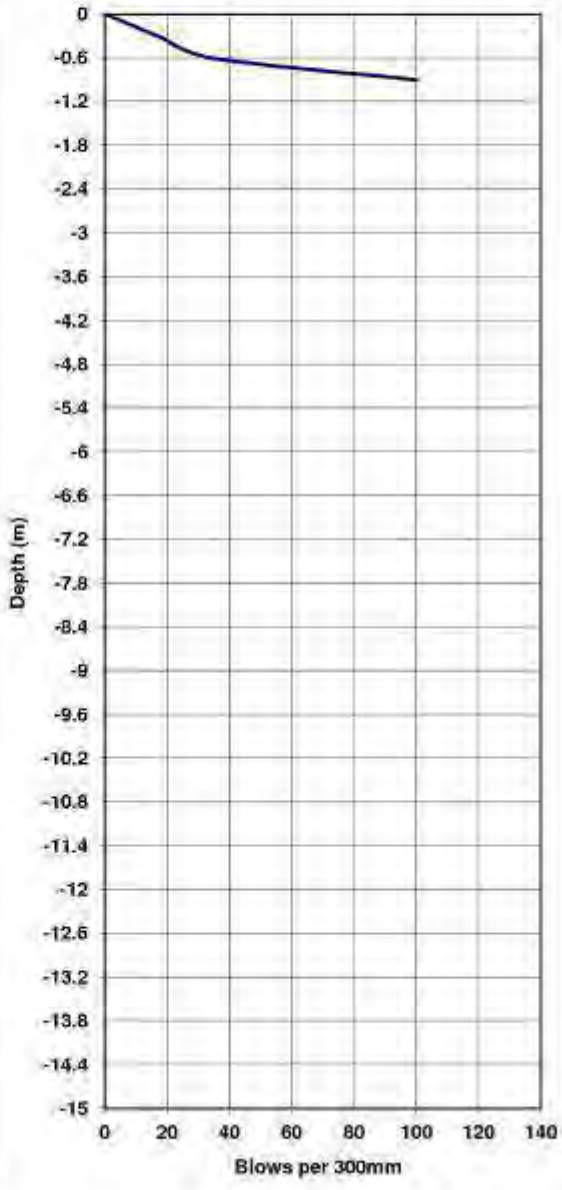
Client: **Gibb Engineering & Science** Job.No. 1881
Contact: **Petrusburg** Date: 30-Jan-2014
Description: **DPL done from existing ground level** Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 2 at TP 2***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	17	Med.Dense	31 deg
0.6	34	Med.Dense	33 deg
0.9	100	Very Dense	>38 deg
	END		



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e-mail : jayson@letabalab.co.za

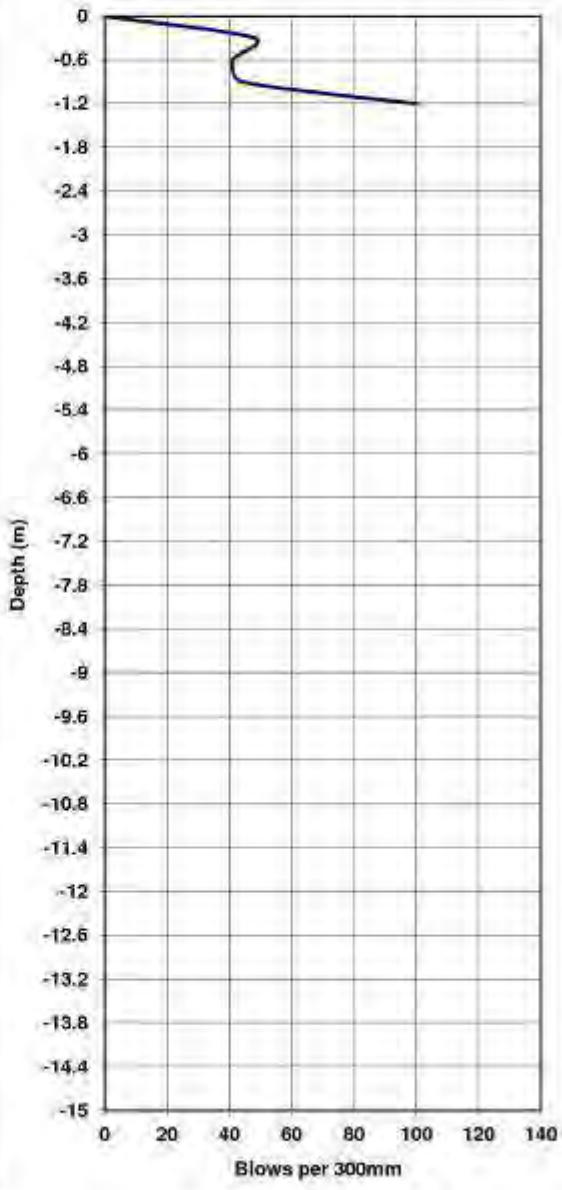
Client: **Gibb Engineering & Science** Job.No. 1881
Contact: **Petrusburg** Date: 30-Jan-2014
Description: **DPL done from existing ground level** Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 3 at TP 3***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	48	Dense	36 deg
0.6	41	Dense	36 deg
0.9	44	Dense	36 deg
1.2	100	Very Dense	>38 deg
	END		



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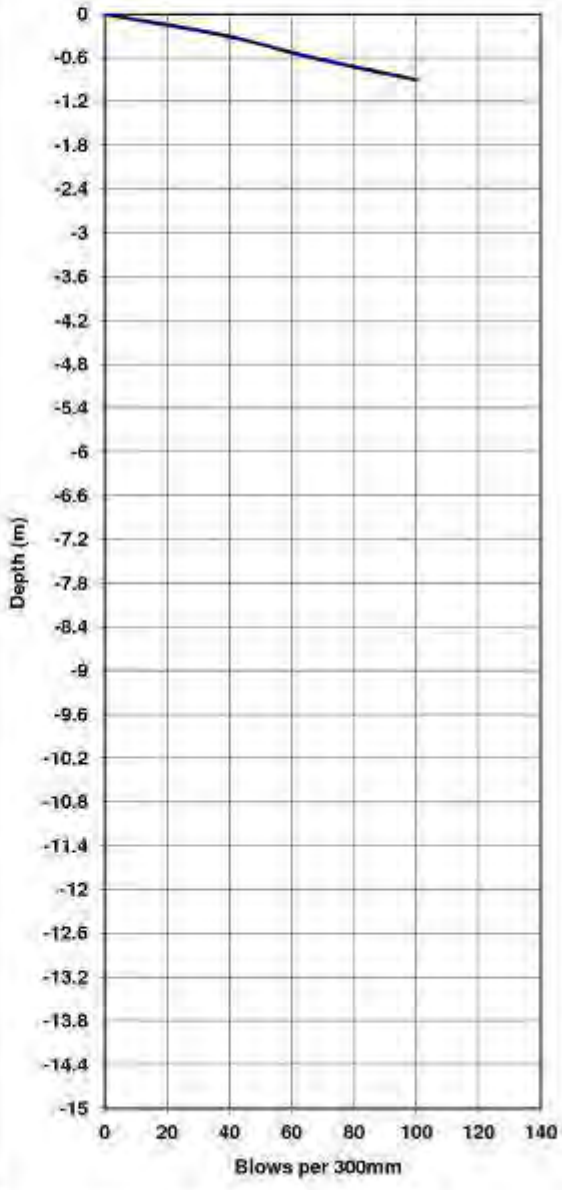
Client: **Gibb Engineering & Science** Job.No. 1881
Contact: **Petrusburg** Date: 30-Jan-2014
Description: **DPL done from existing ground level** Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 4 at TP 4***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	35	Med.Dense	36 deg
0.6	67	Dense	37 deg
0.9	100	Very Dense	>38 deg
	END		



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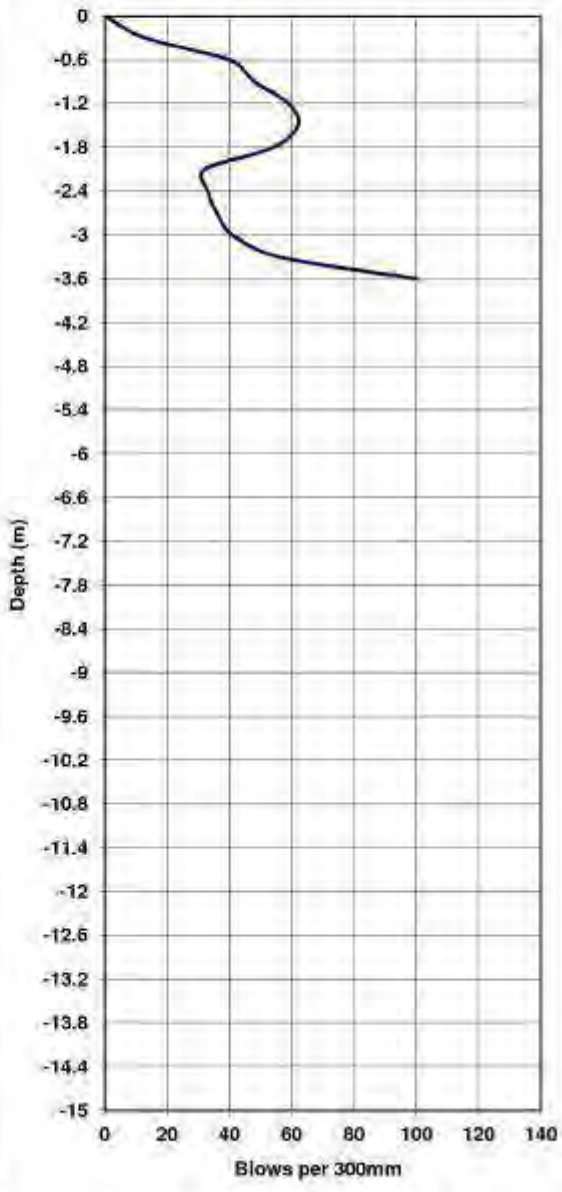
Client: **Gibb Engineering & Science** Job.No. 1881
Contact: **Petrusburg** Date: 30-Jan-2014
Description: **DPL done from existing ground level** Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 5 at TP 5***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	13	Loose	<30 deg
0.6	40	Med.Dense	36 deg
0.9	46	Dense	36 deg
1.2	59	Dense	37 deg
1.5	62	Dense	37 deg
1.8	54	Dense	37 deg
2.1	32	Med.Dense	35 deg
2.4	33	Med.Dense	35 deg
2.7	36	Med.Dense	35 deg
3	41	Dense	36 deg
3.3	56	Dense	37 deg
3.6	100	Very Dense	>38 deg
	END		



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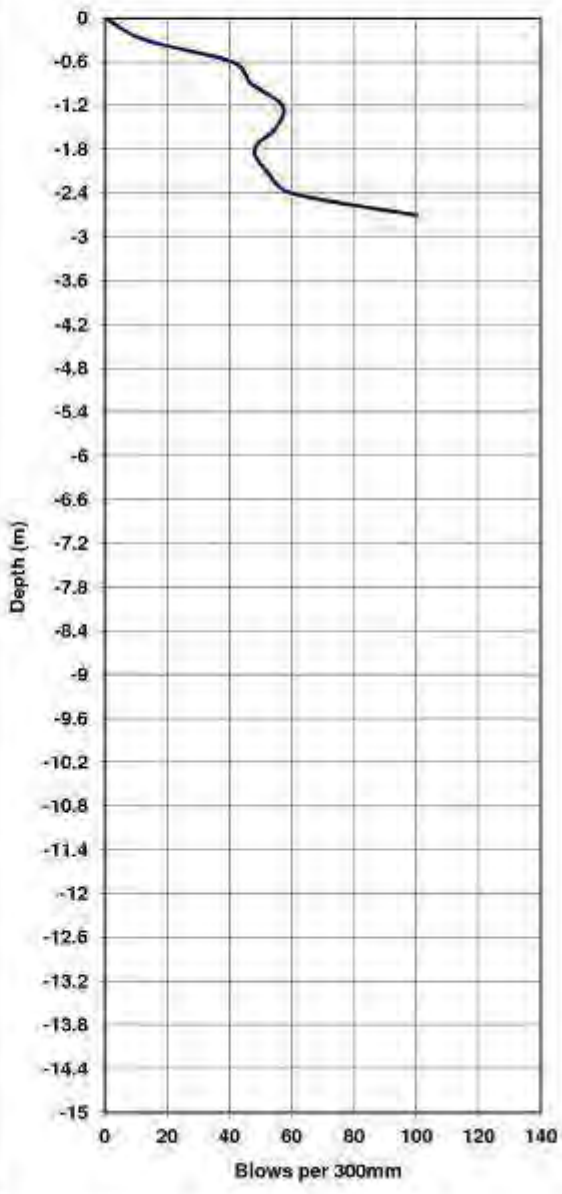
Client: **Gibb Engineering & Science** Job.No. 1881
Contact: **Petrusburg** Date: 30-Jan-2014
Description: **DPL done from existing ground level** Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 6 at TP 6***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	13	Loose	<30 deg
0.6	41	Dense	36 deg
0.9	47	Dense	36 deg
1.2	57	Dense	37 deg
1.5	55	Dense	37 deg
1.8	46	Dense	36 deg
2.1	52	Dense	37 deg
2.4	60	Dense	37 deg
2.7	100	Very Dense	>38 deg
	END		



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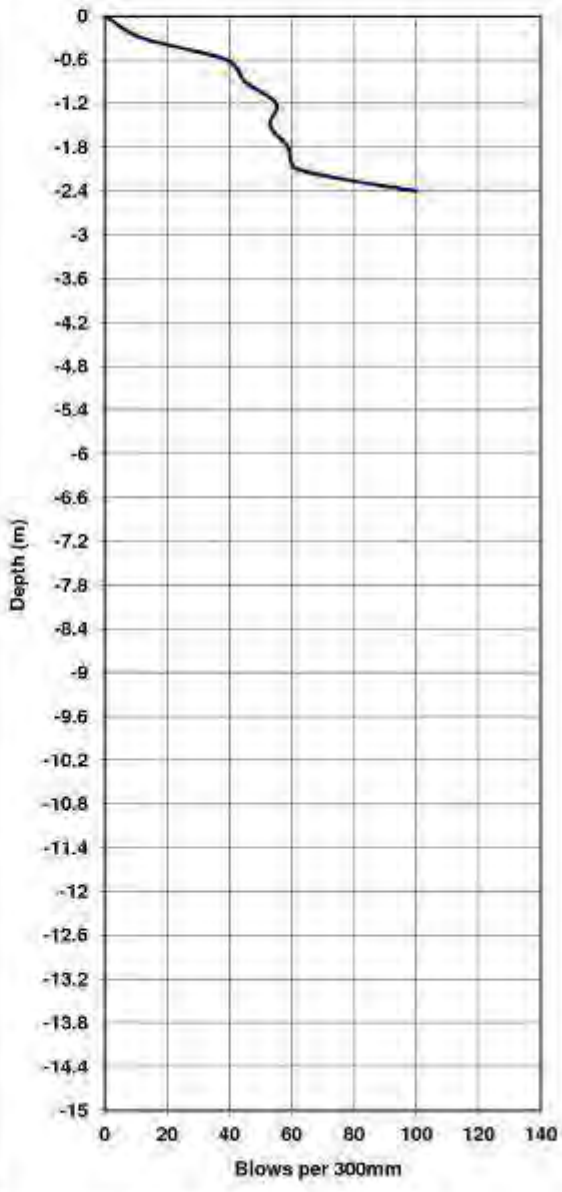
Client:	Gibb Engineering & Science	Job.No.	1881
Contact:	Petrusburg	Date:	30-Jan-2014
Description:	DPL done from existing ground level	Operator:	Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 7 at TP 7***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	12	Loose	<30 deg
0.6	39	Med.Dense	36 deg
0.9	45	Dense	36 deg
1.2	55	Dense	37 deg
1.5	58	Dense	37 deg
1.8	59	Dense	37 deg
2.1	62	Dense	37 deg
2.4	100	Very Dense	>38 deg
	END		



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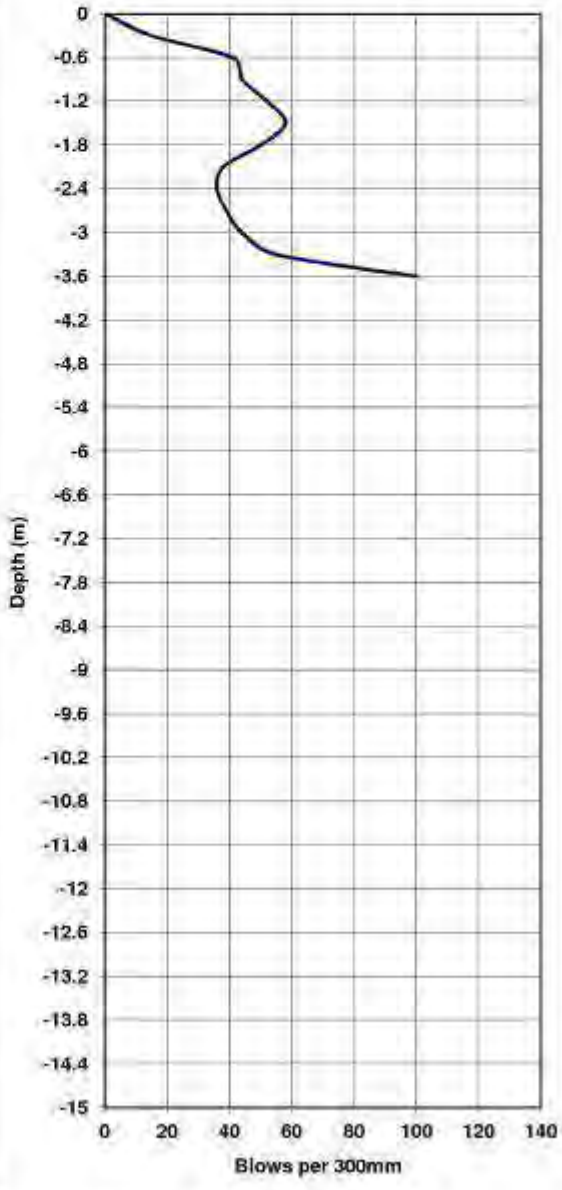
Client: **Gibb Engineering & Science** Job.No. 1881
Contact: **Petrusburg** Date: 30-Jan-2014
Description: **DPL done from existing ground level** Operator: Letaba Lab

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 8 at TP 8***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	15	Loose	<30 deg
0.6	41	Dense	36 deg
0.9	44	Dense	36 deg
1.2	52	Dense	37 deg
1.5	58	Dense	37 deg
1.8	60	Dense	38 deg
2.1	38	Med.Dense	36 deg
2.4	36	Med.Dense	35 deg
2.7	39	Med.Dense	36 deg
3	44	Dense	36 deg
3.3	55	Dense	37 deg
3.6	100	Very Dense	>38 deg
	END		



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