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CONTRACT ZNQ 2273/12T : DRILLING INVESTIGATION FOR THE PROPOSED CONSTRUCTION OF A NEW BRIDGE OVER THE NSELENI RIVER IN KWAZULU-NATAL

1. INTRODUCTION

1.1 Appointment

Soilkraft cc was appointed by Mr W Prinsloo on behalf of Enviro Geotech Drilling cc to assist with geotechnical profiling and report compilation on founding conditions for the proposed new bridge crossing the Nseleni River. As part of the investigation a total of eight boreholes were drilled at pre-determined positions of the structure's footprint areas.

The professional team involved with the project includes the following:

- *Consulting Engineer*: Royal Haskoning DHV.
- *Drilling Contractor / Client*: Enviro Geotech Drilling cc.
- *Geotechnical Consultant*: Soilkraft cc.
- *Materials Laboratory*: Geostrada, Pretoria.
- *Rock Laboratory*: Rocklab Rock Mechanics and Excavation Laboratories, Pretoria.

1.2 Investigation Constraints

- *Water Levels*: No piezometers were installed in any of the boreholes.
- *Drill Positions*: All drill positions were identified by the client.

1.3 Terms of Reference

Soil and core descriptions were done according to the provisions of the guidelines as proposed by the Geotechnical Division of SAICE and SAIEG[Reference 8.1]. As the soil moisture content was influenced by the drilling technique (i.e. lubrication), it is not included in the material descriptions unless it could be verified by alternative methods. Rock strength classifications are done according to the proposals as reported by Byrne[Reference 8.2].

2. SITE DESCRIPTION

2.1 Site Location

The proposed new bridge is set to replace the existing steel bridge that currently services this particular location. The bridge is located at the Nseleni River crossing on Road P425. The site is located some 11,3km north east of Empangeni and links the said town to the villages of Lubana and Mabuyeni.

Refer to the attached Figure 1 : Locality Plan.

2.2 Climate

The proposed bridge site is located in an area with an approximate Weinert N-value between 1,2 and 2,0 and a Thornthwaite Moisture Index near zero. Climatically the area may thus be described as sub-humid. This signifies that chemical weathering will dominate over mechanical weathering, resulting in the formation of active clay products – if suitable parent material is available. Minerals such as amphibole, pyroxene and olivine are particularly susceptible to chemical weathering. This, however, does not mean that mechanical weathering will not play a significant role. Mechanical weathering is still very significant in brittle materials such as shale, sandstone, quartzite etc.

2.3 Topography and Vegetation

Mucina and Rutherford[Reference 8.3] describe the site vegetation as the Maputaland Coastal Belt. The belt stretches from the coast inland for up to 35km. In this instance, though, the site investigated is located within the Nseleni River valley, which is very densely vegetated and does not necessarily comply with the listed vegetation given by the editors due to the prevailing micro-climate.

3 METHOD OF INVESTIGATION

3.1 Existing Sources of Information

The following available sources of information were consulted for the compilation of this report:

- 1 : 250 000 scale geological map: 2830 Dundee, published in 1988
- 1 : 50 000 scale Topographical map: 2831DB Empangeni, published in 1985

3.2 Core Drilling

Core drilling was done at eight locations presumably specified by the client. SPT tests were conducted as part of the drilling investigation. The eight locations should represent foot print positions for the proposed new structure. Drilling was done between 3 November and 12 November 2012. Boreholes were logged by a professionally registered engineering geologist at the premises of Royal Haskoning DHV in Pietermaritzburg. The positions of the boreholes are indicated in Table 1 : Borehole Coordinates. The positions of the boreholes are indicated on the attached Figure 2: Site Plan.

Table 1 : Borehole Coordinates

Borehole	X Coordinate	Y (31) Coordinate	Elevation (m)
1	3171499	-92548	30.7
2	3171494	-92543	30.9
3	3171488	-92560	25.4
4	3171482	-92557	23.6
5	3171467	-92582	24.4
6	3171463	-92578	24.3
7	3171454	-92596	30.6
8	3171448	-92590	30.5

The borehole profiles and photographs are included in Addendum A, and the driller’s daily journals are contained in Addendum B.

3.3 Materials Tests

The investigation was further supplemented by limited materials sampling and tests. Representative samples were taken where deemed sensible and the following tests were performed:

- *Foundation Indicator Tests*: Four disturbed samples were taken from the drill core soil materials and delivered to Geostrada for analyses. The foundation indicator testing was done to ascertain the materials' general geotechnical properties including the grading analysis, hydrometer analysis (0,002mm minimum size) and Atterberg Limits (and associated parameters).
- *Unconfined Compressive Strength (UCS)*: For this project a total of five UCS samples were extracted from drill core and submitted to Rocklab for analyses. The results of UCS testing are used as an important input to the calculation of rock strength parameters.

The results of the materials testing are contained in Addendum C to this report while the test results are summarised in Table 2.

4 DISCUSSION

4.1 Groundwater

4.1.1 Regional Groundwater Conditions

Vegter[Reference 8.4] indicates the probability of drilling successfully for water in the area to be between 40% and 60% and should water be encountered, the probability is between 10% and 20% that the yield of such a borehole will exceed 2l/s. Groundwater in the area generally occurs in mafic or basic lavas and tends to occur between depths of ten and twenty metres when not affected by water courses. In this instance, though, the prevailing Nseleni River is likely to affect groundwater properties.

4.1.2 Site Groundwater Conditions

Groundwater conditions on the site are likely to differ from the regional groundwater scenario, due to the fact that the river forms a temporary base level and accumulates surface water runoff. The prevailing groundwater level will therefore be affected by the river level itself. Seeing as no piezometers were installed, little comment can be made regarding the prevailing water levels.

Water rest levels were recorded at the end of drilling shifts. The water levels measured after drilling each of the boreholes is summarised in Table 3. It must be emphasised, though, that these water levels should not be considered representative of the prevailing groundwater levels. It is anticipated that the water levels recorded here reflect the level at which drill water remained. It is unlikely that sufficient time passed between the completion of drilling and water measurements to allow equilibration of the prevailing water levels.

Table 3 : Water Rest Levels

Borehole	Water Level Depth from Surface (m)	Water Level Elevation (m above mean sea level)
1	9.3	21.4
2	5.2	25.7
3	3.0	22.4
4	2.6	21.0
5	5.0	19.4
6	5.0	19.3
7	12.0	18.6
8	11.0	19.5

4.2 Regional Geology

According to the regional geological map the site investigated is located on the Letaba Formation of the Lebombo Group. The Lebombo Group, in turn, forms part of the Karoo Supergroup. Regional information indicates that the Letaba Formation consists of basaltic bedrock. A fault zone striking north east to south west is present to the east of the study area.

The borehole core confirmed the presence of basaltic bedrock; however it was clear that magma segregation occurred in the basalt. The bedrock frequently had dark green colour, followed by red brown colour. Hydrothermal veins, phenocrysts and amygdales were also common. All things considered, it is deduced that the basalt either segregated, or more likely, intruded in multiple phases.

The regional geology is indicated on the attached Figure 3 : Regional Geology.

4.3 Site Specific Discussion

Site conditions at the bridge site are depicted in Photo Plate 1. The photographs were provided by Mr Bernardt Burger of Enviro Geotechnical Drilling cc.

4.3.1 Access to the Site

The proposed new alignment of the bridge can be accessed via the existing road reserves adjacent to the existing steel bridge. Access was severely impeded by dense vegetation and undergrowth, which necessitated extensive clearing, particularly to allow movement of equipment. As illustrated in the photo plate, the prevailing gradient also necessitated that a working platform be dug into the flanks of the river valley. Overall then, conditions of difficult to very difficult access applies to this site.

4.3.2 Site Environment

The base of the river valley which hosts the Nseleni River is situated at an altitude just below 21m above mean sea level, according to the land surveyor's site drawing. As already mentioned, the entire valley is characterised by dense vegetation, with the perennial river at its base. The vegetation in the valley vegetation does not necessarily comply with that of the surrounding region, as the river valley has its own micro-climate. The site can be summarised as follows:

- *Gradient:* The river valley was characterised by a slightly steeper valley wall on the south western side than on the north eastern side. Consulting the surveyor's drawing the two banks were eleven metres high. While the south western bank had an average gradient between 33,1% and 40,56%, the north eastern bank's average gradient was calculated as 32,6%.
- *Available Services*: The presence and extent of services in the vicinity is not known to the author; however any services that are present are likely located parallel to the existing bridge and located within one metre from the boundary of the road reserve.
- *Drainage*: Drainage takes place by means of surface sheet wash and potentially gully wash, depending on the intensity of precipitation. The steep valley sidewalls mean that turbulent flow may be induced in surface runoff. Surface runoff drains directly into the Nseleni River.
- *Vehicular Access*: Vehicular access to the site is not possible at present until substantial clearing has been done to remove dense vegetation. Even after vegetation has been removed, it is likely that the site will only be accessible to track-mounted vehicles due to the steep gradient. Earthworks will be required to allow easier vehicular site access.

4.3.3 Existing Structure

The superstructure of the existing bridge consists of steel trusses. The design of the substructure is not known.

4.3.4 Site Geology

As mentioned in Section 4.2, the site is located on the Letaba Formation of the Lebombo Group (Karoo Supergroup). The basaltic bedrock was verified at depth; however an array of properties were identified in the bedrock. Most notably, extensive hydrothermal veins occurred in the bedrock, which suggests that some tectonic activity or hydrothermal activity must have taken place in the region. It is considered that the hydrothermal features may be attributed to or associated with the nearby fault.

The segregation observed in some of the boreholes likely occurred when the lava was expelled from the mantle. In borehole seven a small (i.e. 100mm diameter) xenolith was also noted in the basalt. The magma segregation was best observed as variations in colour. Two distinctive colours were noted (i.e. green grey and brown red). The nature of the bedrock and its implications will be discussed in more detail in a later section of this report.

Cross sections of the valley are depicted in Figure 4 and Figure 5. The cross-sections were compiled using borehole logs and the data was extrapolated; hence the models are for illustrative purposes only. The models suggest that the bulk of the soil profile consists of alluvium with pockets of colluvium. The bulk of the colluvial materials appear to have been weathered away or removed by surface water washing into the river. The residual basalt is erratically distributed and the presence thereof would most likely have been determined by the groundwater movement in recent geological times. The same applies to the basaltic bedrock which had been weathered to various degrees. It is clear from the models, though, that competent bedrock prevails at the base of the valley below the river water level (assumed to be 21m above mean sea level).

4.3.5 Soil Profiles

The soil profile encountered in the boreholes on site can be simplified as follows:

- *Alluvium 1*: Alluvial soils are contained as extensive horizons in the soil profile encountered in the boreholes. In general the upper intervals of the alluvium was found to be organic-rich and had dark grey brown colour. Underneath the organic-rich interval the alluvium generally comprised grey brown silty sand. Test results revealed that one sample was moderately expansive, while the remaining three samples were not expansive. Active clay contents ranged from 5% to 18%. The expansive sample had a plasticity index of 14% while all other sample had a non-plastic nature. Grading moduli were between 0,47 and 1,27 while PRA classifications of A-2-6 and A-6 were awarded. Clearly the thickness of the alluvial materials is strongly affected by the shape of the river valley.
- *Alluvium 2*: A second horizon of alluvial material was identified and discerned here from the first as it was significantly different. Whereas the first alluvial material largely consisted of soil, the second consisted of sub-rounded gravel and cobbles of mixed origins. The horizon did not occur uniformly and was present in some boreholes, limited in other and completely absent in other boreholes still. No samples were extracted due to the coarse nature of the horizon.
- *Residual Basalt*: Residual basalt was encountered in boreholes two, three and four. In borehole two the material consisted of pale grey clayey silt, but in the remaining boreholes the residual material comprised of gravel and cobbles of basalt in a clayey silty matrix, which graded into weathered bedrock. The material was not sampled.

4.3.6 Excavation Potential

In terms of the provisions of SANS 1200D, the materials on site can be regarded as follows:

- *Colluvium:* Colluvial soils are expected to be easily excavatible by mechanical means. Hand excavation is likely to be less suitable due to the inclusion of gravel in the soil.

- *Alluvium 1*: The alluvial soil is expected to be machine excavatible. Hand excavation was proven in the upper organic-rich part of the profile; however hand excavation to depth is unlikely to be viable.
- *Alluvium 2*: The inclusion of cobbles and boulders in this horizon is likely to impede excavation. As a result, it is anticipated that an excavator may be required to efficiently excavate through the horizon.
- *Residual Basalt*: As with the lower alluvial horizon, the residual basalt contain cobbles and boulders which would be best handled with the aid of an excavator. It is likely that the residual materials will also offer significant resistance to excavation seeing as it grades into bedrock. The use of pneumatic equipment may therefore be necessary.
- *Weathered Basalt*: In most instances the upper part of the basalt bedrock was found to be moderately or highly weathered. While these materials may be excavatible to a limited extent with the aid of an excavator, it is likely that pneumatic equipment and/or splitting may be required.
- *Slightly Weathered Basalt*: The competent bedrock at depth is riddled with hydrothermal veins and other structural features; nevertheless blasting or splitting will likely be required to remove the bedrock material.
- *Water Levels*: Conditions of wet excavation can be expected due to water ingress from the valley sidewalls. Such conditions are likely to be exacerbated near the base of the valley.
- *Sidewall Stability*: The steep valley flanks is likely to subject to instability, particularly when excess moisture is present. It must also be considered that any excavations made into the flanks of the valley will disturb the stability equilibrium of the slope and may induce adverse or unstable conditions in the slope.

4.3.7 Scouring of Foundation Supports

The properties of the materials in the soil profiles at the Nseleni Bridge were reviewed in the context of the United States Bureau of Reclamation (dated 1974). The document considers a material's erosion resistance as a function of its Unified classification. The alluvial soils tested from the Nseleni River site were awarded Unified classifications of CL or SC. According to the said guidelines, the SC materials are moderately susceptible to erosion, while the CL materials are highly erodible. With this in mind, the soil materials in the riverbed are likely to be subject to erosion and scouring by water movement and must be anticipated. Foundations located on these materials may thus be subject to scour.

5 FOUNDING CONDITIONS

5.1 Material Description

To follow is a description of the material intercepted in the boreholes. The vertical distribution of the materials are summarised in Table 4. The table indicates the lower levels of each of the materials discussed.

5.1.1 Colluvium

Surface horizons of colluvium were encountered in boreholes one, four and six. The horizon was described either as dark brown silty sand or dark brown clayey sand. The horizon included gravel of mixed origins and in some cases (i.e. borehole four) had a short transition to residual dolerite. No samples were taken of this material. Due to its location in the soil profile the colluvium is not even considered as a horizon suitable to host bridge foundations.

TABLE 4 : STRATIGRAPHIC SUMMARY

Horizon	Base Level (metres above mean sea level)							
	BH1	**BH2**	**BH3**	**BH4**	**BH5**	**BH6**	**BH7**	**BH8**
Surface Elevation	30,7	30,9	25,4	23,6	24,4	24,3	30,6	30,5
Colluvium	29,2			22,1		22,4		
Alluvium	25,5	27,8	20,6		19,3	18,8	20,5	19,6
Residual Basalt		26,3	19,3	21,0			20,3	
Highly Weathered Basalt	21,0	20,2				18,3		
Slightly Weathered Basalt	16,2	15,7	14,1	15,2	13,5	12,3	14,3	14,5

5.1.2 Alluvium

Considering the properties of the alluvial soils as well as the surface topography, founding on the alluvial horizons is not recommended. Based on the results of the SPT testing the alluvium is usually of loose to medium dense consistency only. The bearing capacity associated with such conditions is usually less than 150kPa and therefore not suitable to at best marginally suitable for founding bridge structures. The alluvial beds are located above the normal level of the river. Considering the side slopes of the river canal, foundations placed within the alluvium may be subject to shear failure, particularly in case of flooding when the soils become saturated and are subjected to flood force. Founding in the alluvium is thus not regarded as a viable option.

5.1.3 Residual Basalt

The residual basalt was distributed erratically across the borehole profiles. This, in addition to its composition, means that it is unlikely to be an effective founding horizon.

5.1.4 Highly Weathered Basalt

It is anticipated that the highly weathered basalt bedrock holds some potential for construction provided a method such as spread footings can be used to distribute the founding loads effectively. This will require that the foundation stresses do not exceed 300kPa. However, the highly weathered basalt was encountered in boreholes one and two only at a depth exceeding 4500mm. Founding by spread footings at this depth is a difficult exercise and it borders on conditions where piling can be used successfully. For this reason the highly weathered basalt is discounted on the basis that the working environment will be extremely challenging.

5.1.5 Slightly Weathered Basalt

Considering all the variables in the study site, it was deduced that the slightly weathered, more competent, basalt bedrock presents the most suitable alternative for founding. The bedrock had to be assessed to obtain an indication of the expected strength and founding potential.

Five UCS tests were performed on basalt core samples extracted from the drill core. Clearly the sampling was biased towards rock core which is intact and of sufficient length to allow UCS tests. As such, care must be taken not to over-estimate the rock mass's capabilities and cognisance must be taken of the state of the bedrock (i.e. extensive hydrothermal veins etc.). The UCS test results revealed that the basalt core samples had uni-axial compressive strengths between 32,6MPa and 64,0MPa, indicating that the material is considered hard rock.

From the boreholes the following can be concluded:

- *State of Bedrock:* The general state of bedrock showed inconsistent variation, particularly as far as jointing or fracturing is concerned. The effect is compounded by the abundance of hydrothermal veins which detracts from the overall rock strength. This is illustrated by the mode of failure of sample UCS-03. The mode of failure in this hydrothermal-rich core was recorded as complete failure along multiple discontinuities. Despite the degree of weathering and discontinuities the material still achieved good failure strengths.
- *Rock Quality Designation:* The state of bedrock is clearly depicted by the RQD and fracture frequencies recorded. The minim RQD of 27,9% was recorded for the basalt bedrock under consideration here, while a maximum RQD of 100% was recorded. Fracture frequencies for this material were markedly better than that of overlying, weathered basalt bedrock. The recorded fracture frequencies ranged from two to fifteen fractures per metre; however in general values were below nine.
- *Condition of Discontinuities:* For the most part joints were rough, clean and closed, though exceptions were noted. In some instances joints were open, undulating and contained dark green silty sand filling. It must be noted here that hydrothermal veins frequently broke open when the

core was retrieved from the boreholes. As such, the veins are considered weak planes that may for practical purposes also be considered as discontinuities, though they do have significant shear strength.

The results of the data processing in RocLab© as per Hoek[Reference 8.5] indicate that the fractures (and probably hydrothermal veins) affect the overall rock strength significantly. The lowest tested rock strength (i.e. 32,6MPa) was considered in analyses. The results of the software calculations are summarised in Table 5.

TABLE 5 : HOEK-BROWN ROCK MASS PARAMETERS

Parameter	Value
Tensile Strength	0,044 MPa
UCS	2,622 MPa
Bearing Capacity	9,802 MPa
Young's Modulus	4899,37 MPa

5.2 Rock Mass Classification

As an aid to the Hoek-Brown calculations, the rock mass classification proposed by Bieniawksi[Reference 8.6] is considered. Bieniawksi proposed a parametric classification of rock quality for founding and tunnelling purposes based on the various rock characteristics. His method assigned a weighted value to each rock mass characteristic, eventually providing a single figure as Rock Mass Classification.

The classification summary is given in Table 6. The classification derived by the author considers an array of rock properties to provide a general depiction of the rock quality and is descriptive of the slightly weathered basalt bedrock only

TABLE 6 : BIENIAWSKI ROCK MASS CLASSIFICATION

Item	Parameter	Class
1	**Rock Quality (RQD)**	12
2	**Weathering**	7
3	**Intact Rock Strength**	1
4	**Spacing of Joints**	10
5	**Separation of Joints**	5
6	**Continuity of Joints**	3
7	**Groundwater***	5
8	**Strike and Dip Orientation**	10
Total		**53**
Rock Class		**Fair rock**

* Assuming moderate water ingress

6 CONCLUSIONS

Based on the above discussion, the following conclusions can be made:

- *Site Access*: Difficult to very difficult site access must be anticipated. The site is very densely vegetated and is characterised by a steep gradient. Vehicular movement on site is not possible at present. The site therefore will require extensive preparation for establishing a construction unit for purposes of building the proposed bridge.
- *Geology*: The bridge site is situated on basaltic bedrock associated with the Letaba Formation of the Lebombo Group, Karoo Supergroup. The lithology was verified by bedrock. The bedrock also shows magma segregation, amygdales, extensive hydrothermal veins and very rare xenolith inclusions.
- *Soil Profile*: The soil profiles encountered in boreholes comprised alluvial materials overlaying residual basalt and/or basaltic bedrock. The alluvium could be divided into an upper, sandy horizon and basal, coarse (i.e. gravel and cobbles) horizon. Residual basalt occurred erratically in the profile.
- *Groundwater*: Groundwater is expected to be present and may occur as ingress water from the valley sidewalls. Founding conditions are likely to be below groundwater level.
- *Conditions of Excavation*: The majority of soil materials would be best or most viably excavated with the aid of an excavator. Slope stability issues are expected to dictate soil (and other) excavation. Bedrock materials will require the use of pneumatic tools, splitting and/or blasting.
- *Scour*: Alluvial soil materials in the profile are expected to be moderately to highly susceptible to scouring and water erosion.
- *Founding Conditions*: Of all the materials encountered in the borehole profiles the slightly weathered basalt bedrock located at the base of boreholes is deemed the best option for founding. Other horizons were discounted from contention for quality or safety reasons.

7 RECOMMENDATIONS

The methods of founding below are provided in good faith. It is proposed that the conditions be discussed with an experienced contractor and his advice also obtained. It is further recommended that alluvial materials not be considered for founding, due to its susceptibility to scouring.

7.1 Proposed Method of Founding

7.1.1 Piling

Considering all parameters and aspects that affect the proposed site, it appears as if piling is the optimum solution for founding except at the position of borehole four. Considering the variable composition and quality of the overburden, it is proposed that the use of rotapiles be considered. Allowing for the anticipated presence of water, it is expected that casing may be required. The piles shall also be designed as end-bearing units which transfer their load directly to competent basaltic bedrock. End-bearing piles may be installed at levels as indicated below in Table 7 : Stratigraphic and Founding Summary. Foundation induced stresses shall not exceed the calculated safe bearing capacity of 9,80MPa.

TABLE 7 : STRATIGRAPHIC AND FOUNDING SUMMARY

Horizon	Base Level (metres above mean sea level)							
	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8
Surface Elevation	30,7	30,9	25,4	23,6	24,4	24,3	30,6	30,5
Colluvium	29,2			22,1		22,4		
Alluvium	25,5	27,8	20,6		19,3	18,8	20,5	19,6
Residual Basalt		26,3	19,3	21,0			20,3	
Highly Weathered Basalt	21,0	20,2				18,3		
Slightly Weathered Basalt	16,2	15,7	14,1	15,2	13,5	12,3	14,3	14,5
Proposed Level of Founding*	20,6	19,9	19,0	21,0	19,0	17,9	20,1	19,0
Founding Method	End-bearing piles socketed into bedrock			Spread footing	End-bearing piles socketed into bedrock			

* Excluding socketing depth

7.1.2 Spread Footings

In the position of borehole four the structure can be founded by means of spread footings. The basalt shall be excavated to the indicated level and a blinding layer of mass concrete cast to ensure a stable platform for placing the foundation. The anticipated safe bearing capacity shall not be exceeded.

7.2 Alternative Designs

Alternative designs to the proposals as per Section 7.1 are not considered as viable for the given conditions. However, the use of augered piles may be considered. Should this method be used, care must be taken when penetrating the alluvial gravels and cobbles, as well as the highly weathered soft rock lava. Casing may be required in these conditions. Rock chisels will be necessary to excavate a socket.

7.3 Pile Integrity Tests

If the piles are cased during construction, pile integrity testing may not be an issue. However, should casing not be used, collapse of the strata may influence the quality of the piles, especially the sections penetrating the gravel beds. It is therefore recommended that piles located in the positions of boreholes three, six and eight be considered for nuclear testing, should any doubt arise regarding the integrity of the piles.

8 SOURCES OF REFERENCE

8.1 SAIEG-AEG-SAICE : *Guidelines for Soil and Rock Logging* – Proceedings of the 1990 Geoterminology Workshop.

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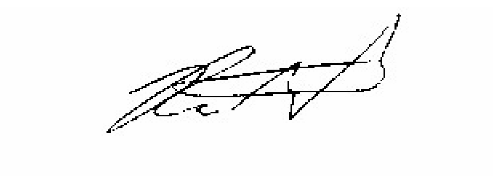
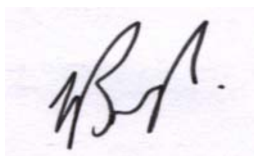
8.3 Mucina L et al : *The Vegetation of South Africa, Lesotho and Swaziland*, page 335, published in 2006 by SANBI.

8.4 Vegter JR : *An Explanation of a Set of National Groundwater Maps*, published in 1995 by the Water Research Commission.

8.5 Hoek E et al : *Hoek-Brown Failure Criterion* – 2002 edition.

8.6 Bieniawski ZT : *Engineering Classification of Jointed Rock Masses*, published in the civil engineer in South Africa, Volume 15, Number 12, December 1973.





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For Soilkraft cc