ANNEXURE E

ENGINEERING REPORTS AND DESIGNS

Consulting Engineering Geologists, Geotechnical Engineers,
Geotechnicians & Geotechnical Quality Assurance Specialists

GEOSURE (Pty) Ltd

- Geotechnical Engineering Services
- Engineering Geology
- Environmental and Groundwater
- Pile Integrity Testing
- Civil Engineering Laboratory
- Earthworks/Materials Supervision & Control
- Geotechnical Monitoring Systems
- Road Pavement Materials and Design
- Project Management

Report to VNA Consulting on the Results of a Geotechnical Investigation for the Proposed Emoyeni (Emedweleni) River Vehicular Bridge, KwaZulu-Natal

Reference: 344-12.R01

Dated: 29 April 2013

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Report to VNA Consulting on the Results of a Geotechnical Investigation for the Proposed Emoyeni (Emedweleni) River Vehicular Bridge, KwaZulu-Natal

Reference : ***344-12.R01***

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GEOSURE (PTY) LTD
Geotechnical, Environmental & Groundwater Engineering Consultants
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Report to VNA Consulting on the Results of a Geotechnical Investigation for the Proposed Emoyeni (Emedweleni) River Vehicular Bridge, KwaZulu-Natal

Reference: 388-12.R01 **Date: 29 April 2013**

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Report to VNA Consulting on the Results of a Geotechnical Investigation for the Proposed Emoyeni (Emedweleni) River Vehicular Bridge, KwaZulu-Natal

Reference: 388-12.R01 **Date: 29 April 2013**

1. TERMS OF REFERENCE

Geosure (Pty) Ltd was invited by VNA Consulting cc (on behalf of Kwazulu-Natal Department of Transport) to provide a cost estimate to carry out a geotechnical investigation for the proposed Emoyeni (Emedweleni) River Vehicular Bridge, KwaZulu-Natal.

Geosure was subsequently appointed to carry out the work in November 2012.

2. SCOPE OF REPORT

This report sets out the results of a geotechnical investigation carried out for the proposed Emoyeni (Emedweleni) River Vehicular bridge, in the vicinity of Loskop, KwaZulu-Natal.

The subsoil conditions beneath the site are described and comment is made on the general stability of the site. Foundation recommendations, excavatability and rippability and general earthworks for the proposed bridge are provided.

3. INFORMATION SUPPLIED

For the purposes of assisting with this investigation, VNA Consulting provided Geosure with a digital copy of a locality map, showing the position of the proposed bridge structure.

4. SITE DESCRIPTION

The proposed vehicular bridge lies on district road D1238 over the Emedweleni River and is situated at approximate latitude and longitude of 28° 58.581'S and 29° 33.715'E respectively. This is approximately 5km SW of the town of Loskop, Kwazulu-Natal.

There is a temporary bridge that has been constructed at the site to allow for vehicles to cross the stream. The structure consists of shale fill, overlying concrete pipes which allow water to pass through. The diameter of the pipes is considered insufficient resulting in water pooling upstream of the structure. Some seepage was observed near the base of the temporary structure.

The meandering stream traverses undulating terrain. Both banks are relatively steeply sloping down to the river bed level. Shale outcrop is visible in parts of the river bed. Access to the site is from the Lotheni Road onto a series of gravel roads which are utilised by the residents of the area. There are residences in close proximity to the proposed site, particularly on the northern bank.

The general layout of the site is given in Figure 1 at the end of this report. There general locality of the proposed bridge site is shown in Diagram 1 below. A view of the study area is shown in Plate 1 below.

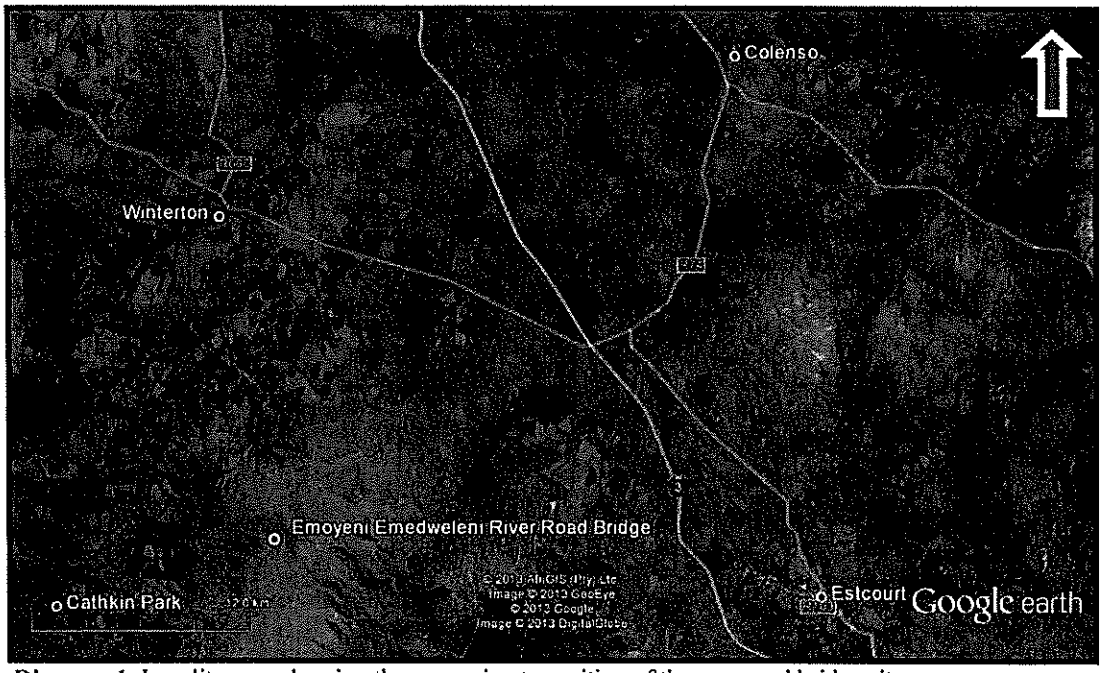


Diagram 1. Locality map showing the approximate position of the proposed bridge site

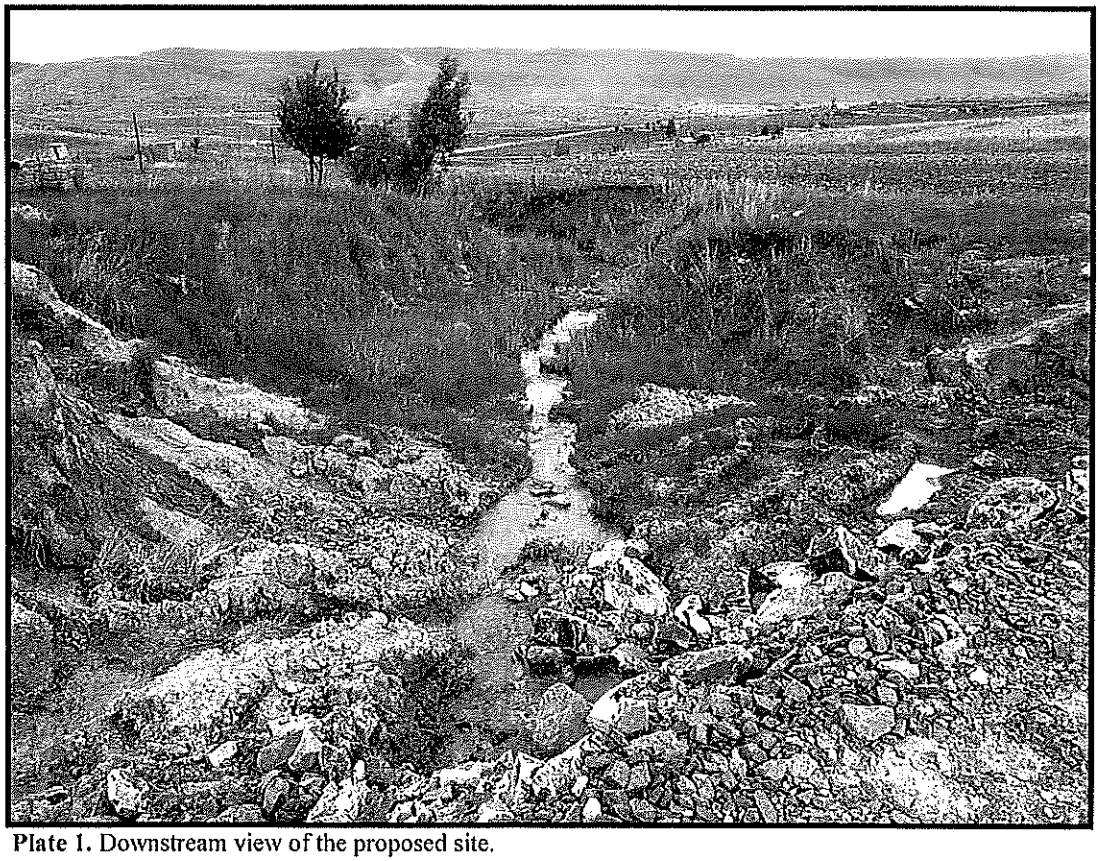


Plate 1. Downstream view of the proposed site.

5. FIELDWORK

The fieldwork for the investigation was carried out on 11 December 2012 and 23 January 2013 and comprised the following:

- Inspection Pits
- Dynamic Cone Penetrometer Tests

5.1 Inspection Pits

Four (4No.) inspection pits, designated IP1 through IP4, were excavated with a Tractor-Loader-Backhoe (TLB) at the approximate positions given in Figure 1. Access to site with a tracked excavator was not possible due to lack of plant being available in the area, and difficult access to the site. The test pitting was carried out at the along the proposed bridge alignment. The inspection pits were profiled using the South African Geoterminology Guidelines (2002)[1]. Copies of the detailed profiles are given in Appendix A. Diagram 2 below displays a summary of the geological profiles logged during the investigation.

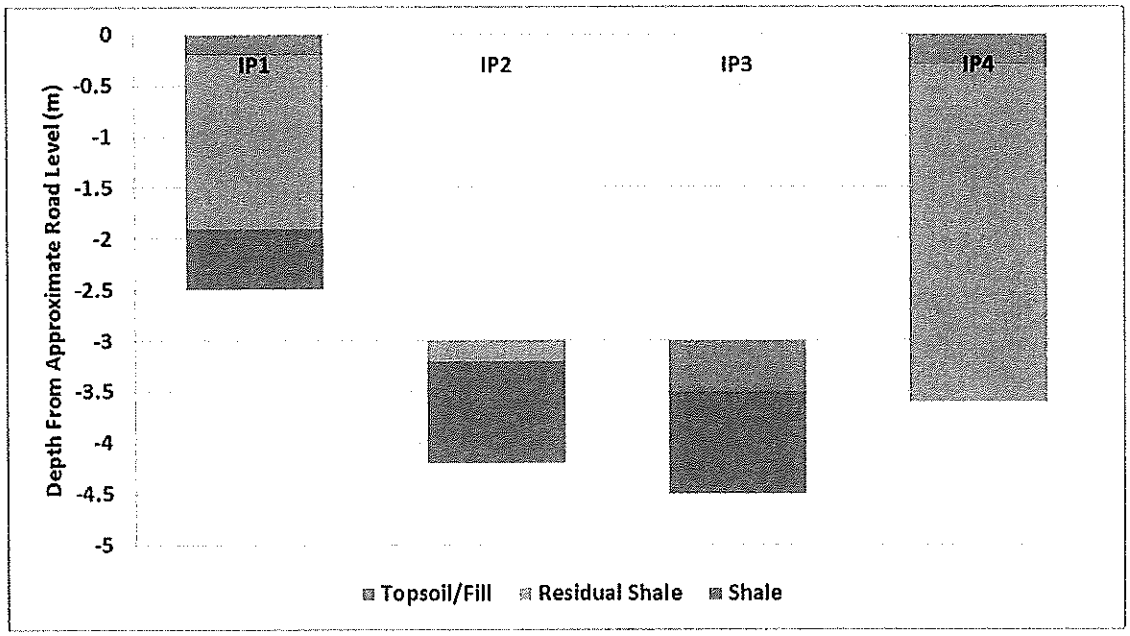


Diagram 2. Graphical representation of soil profiles referenced to approximate existing road level.

6. GEOLOGY AND SUBSOILS

The site is generally underlain by silty sandy topsoil, overlying residual shale, which grades into very soft to soft, highly fractured shale bedrock of the Beaufort Group, of the Karoo Supergroup.

[1] Geoterminology Workshop (2002) – Guidelines for Soil and Rock Logging – SAIEG – AEG – SAICE (Geotechnical Division) pp 47.

In general, the following geological units can be recognised across the site:

Unit 1 – Dry to slightly moist, dark grey, firm, intact, silty sandy CLAY with occasional shale and sandstone clasts as well as plant roots - Topsoil.

Unit 2 – Wet, yellow brown, stained black, loose to very loose, gravel to cobble sized angular shale fragments - Fill.

Unit 3 – Slightly moist to moist, dark orange brown speckled yellow brown and dark grey brown, firm to stiff, intact, gravelly silty CLAY to sandy silty CLAY with abundant shale fragments. – Residual Shale.

Unit 4 – Yellowish brown stained dark grey to black, highly weathered, highly fractured, foliated, very soft rock to soft rock - SHALE.

An indication of the typical subsoil geology encountered across the site given in Plate 2 and Plate 3 below. Plate 4 and Plate 5 below show the shale bedrock outcropping in the river bed downstream of the proposed bridge site.

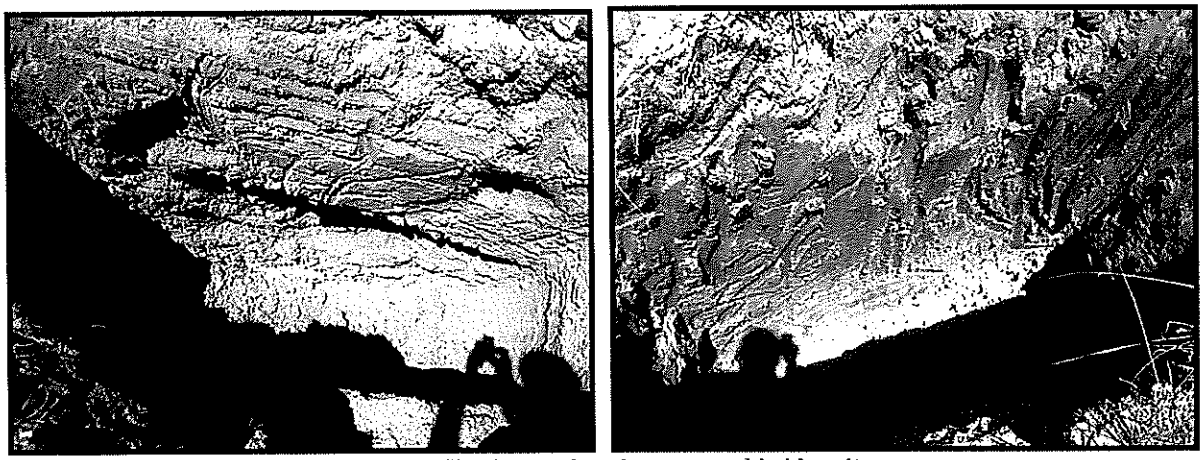


Plate 2 and Plate 3. The general soil profile observed at the proposed bridge site.

7. GROUNDWATER OCCURRENCE

Ground water occurrence was noted in inspection pits IP 2 and IP 3 at depths of 0.50m and 0.80m respectively. Flow rate was strong due to the proximity of the inspection pits to the stream. It is recommended that allowance be made for dewatering during construction of foundations.

8. DISCUSSION

8.1 Proposed Bridge Structure

At the time of reporting no details were available with regards to the type of design proposed, as well as foundation loads for the bridge structure.

8.2 General Stability of the Site

Based on the results of the fieldwork undertaken during this investigation, it is considered that this site is generally stable and suitable for development, provided that the recommendations given in this report are adhered to.

8.3 Excavatability and Rippability Assessment

Generally the transported and residual sandy/gravelly clays will be easily excavated using conventional light earthmoving equipment and will classify as SOFT excavation in terms of SANS 1200DA. While boulders were not observed during the investigation, an allowance should be made for BOULDER EXCAVATION CLASS A should boulder beds be encountered during excavation. INTERMEDIATE to HARD excavation is anticipated in the underlying weathered bedrock.

Consideration should be given to using the following percentages for classification of excavations:

Soft Excavation	15%
Intermediate Excavation	50%
Boulder Excavation	5%
Hard Excavation	30%

The type of excavation plant and nature of the underlying bedrock will determine actual excavatability depths.

8.4 General Earthworks

All earthworks should be carried out in a manner to promote stable development of the site. It is recommended that earthworks be carried out along the guidelines given in SANS 1200 (current version).

All vegetation should be removed from the areas over which fills are to be built. Where natural ground slopes are steeper than $1_{(vertical)}:6_{(horizontal)}$ (6 degrees), the fill must be benched into the slope. Benches should be minimum 0.5m deep and 2.0m wide. A minimum of three benches per fill is recommended.

Placement of fill layers should be undertaken in layers not exceeding 200mm thick when placed loose and compacted using suitable compaction plant to achieve 93% Modified AASHTO maximum dry density at ±2% optimum moisture content. Boulders larger than $^2/_3$ of the layer thickness must not be included in the fill material. A carefully engineered fill embankment should not settle more than 0.5% of its height due to self weight.

Density control of placed fill material should be undertaken at regular intervals during fill construction.

Cut and fill embankments should generally not exceed $1_{(vertical)}:2_{(horizontal)}$ and will need to be protected from undercutting scour during times of high river flows or heavy rainfall.

8.5 Foundation Recommendations

All foundation loads will need to be transferred to competent weathered bedrock. Due to the shallow depth to bedrock, the following foundation types can be considered:

- Spread Footings; or
- Caissons.

This is provided that measures are put in place for dewatering and stabilisation of potential collapsing excavation sidewalls at each footing.

The approximate depths of competent weathered bedrock identified in the inspection pits are given below in Table 1.

Table 2: Summary of approximate depth to bedrock below EGL

IP No.	Approximate depth (m) of bedrock below EGL
IP1	1.9
IP2	0.2
IP3	0.5
IP4	No bedrock encountered but anticipate bedrock to occur within 5m from existing ground surface.

Consideration could be given to using a combination of both spread footings and caissons. Due to the shallow depths to bedrock, less than 1.0m in certain instances, it is considered that piled foundations will not be a practical or cost effective solution.

Consideration should also be given to creation of a low dam or coffer dam around the foundation construction, so that the site can be de-watered or the water level controlled and construction can proceed largely in the dry.

Shale bedrock is highly susceptible to weathering, and will begin to break down soon after exposure to water and air. It is therefore imperative that the spread footings are constructed immediately after excavation down to foundation level.

8.5.1. Spread Footings

Due to the shallow depth to bedrock, it will be possible to employ conventional spread footings which have been taken into the competent weathered bedrock (at least soft to medium hard rock) and anchored by dowelling at least 2.0m into the rock beneath the footing. The final depth of dowelling will need to be determined by the structural/civil engineer depending on the results of a flood hydraulic analysis and anticipated debris loads of the river.

Care must be taken to remove loose slabs of rock from the excavation to ensure foundations are laid onto competent bedrock.

A maximum allowable bearing pressure of 300kN/m^2 is considered applicable. Settlement of such footings should be negligible (<5mm) provided the concrete is cast directly onto clean competent bedrock.

It is recommended that all foundation excavations be inspected and approved by Geosure (Pty) Ltd prior to blinding and casting concrete.

8.5.2. Caissons

Caissons may be considered as an alternative to the spread footings and may be more practical to use where the depth to bedrock is significant. The caissons must be taken into competent weathered bedrock of at least medium hard rock strength, where a maximum allowable bearing pressure of 300kN/m^2 is considered applicable, and anchored by dowelling at least 2.0m into the rock.

Use of caissons could avoid the need for lateral support, but it is considered that dewatering will be necessary.

It is recommended that all foundation excavations be inspected and approved by Geosure (Pty) Ltd prior to blinding and casting concrete.

9. CONCLUSION

This report details the results of a geotechnical investigation for the proposed new vehicular bridge located at Emoyeni Emedweleni, in the vicinity of Loskop, KwaZulu-Natal.

The site is generally underlain by a combination of transported sandy gravelly clay, gravelly sandy clay residual material and very soft to soft rock shale of the Beaufort Group, of the Karoo Supergroup.

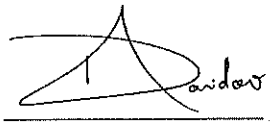
The competent shale bedrock provides a suitable founding medium. A combination of caisson and spread footing type foundations are proposed, founded onto competent shale bedrock. A maximum allowable bearing pressure for the shale bedrock of 300kN/m^2 is considered applicable. The final foundation design needs to be undertaken by a competent structural engineer.

It should be noted that no shale bedrock was observed at position IP4. It is however anticipated that bedrock will be encountered within 5m from existing groundlevel. In the unlikely event that bedrock not be encountered within these depths, piling may need be required in the vicinity of this position.

The ground conditions given in this report refer specifically to the field tests carried out on site. It is therefore, quite possible that conditions at variance with those given in this report can be encountered elsewhere on site during construction. It is therefore important that Geosure (Pty) Ltd be appointed to carry out a strict quality assurance program during construction. Any change from the anticipated ground conditions could then be taken into account to avoid unnecessary expense.

29 April 2013

Author – L Dalton ***Date***



29 April 2013

Reviewed By – D Naidoo Pr. Sci. Nat. ***Date***

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APPENDIX A

INSPECTION PITS AND EXISTING EXPOSURE PROFILES

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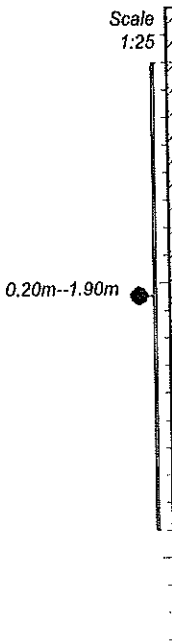
Department of Transport
Emoyen Emedweleni River Vehicle Bridge

HOLE No: IP1
Sheet 1 of 1

JOB NUMBER: 344-12



0.00 Dry to slightly moist, dark grey, firm, intact, silty sandy CLAY with shale and sandstone cobbles and boulders. Topsoil.

0.20 Slightly moist to moist, dark orange brown speckled yellow brown and dark grey brown, firm to stiff, intact, gravelly silty CLAY to sandy silty CLAY with abundant shale fragments. Residual Shale.

1.90 Yellowish brown stained red / grey and brown / purple, completely to highly weathered, very thinly laminated, highly fractured, very soft, fissile rock. SHALE.

2.30

NOTES

1) No ground water seepage observed.

2) Sample taken at:
S1 0,20m--1,90m (Ind)

3) Refusal depth on rock at 2,30m.

CONTRACTOR :
MACHINE : By Hand
DRILLED BY :
PROFILED BY : P. Naidoo

TYPE SET BY : P. Ramsuraj
SETUP FILE : NEW.SET

INCLINATION :
DIAM :
DATE : 23 January 2013
DATE : 23 January 2013

DATE : 30/04/13 08:39
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION :
X-COORD : 28 58'34.57"S
Y-COORD : 29 33'43.00"E

HOLE No: IP1

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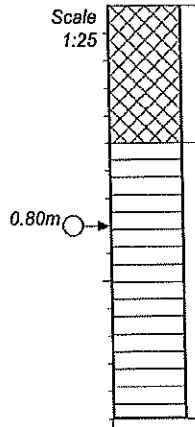
Department of Transport
Emoyen Emedweleni River Vehicle Bridge

HOLE No: IP3
Sheet 1 of 1

JOB NUMBER: 344-12

Scale 1:25



0.00 Wet, yellow brown stained black, loose to very loose, gravel to cobble sized angular shale fragments. FILL.

0.50 Yellow brown stained black, highly weathered, highly fractured, foliated, very soft rock. SHALE.

1.50

NOTES

1) Ground water seepage observed from 0.80m.

2) Pit located in centre of stream bed.

3) Refusal depth on shale bedrock at 1,50m.

CONTRACTOR :
MACHINE : By Hand
DRILLED BY :
PROFILED BY : P. Naidoo

TYPE SET BY : P. Ramsuraj
SETUP FILE : NEW.SET

INCLINATION :
DIAM :
DATE : 23 January 2013
DATE : 23 January 2013

DATE : 30/04/13 08:39
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION :
X-COORD : 28 58'34.86"S
Y-COORD : 29 33'42.93"E

HOLE No: IP3

APPENDIX B

CBR DYNAMIC CONE PENETROMETER (LIGHT) TESTS

GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

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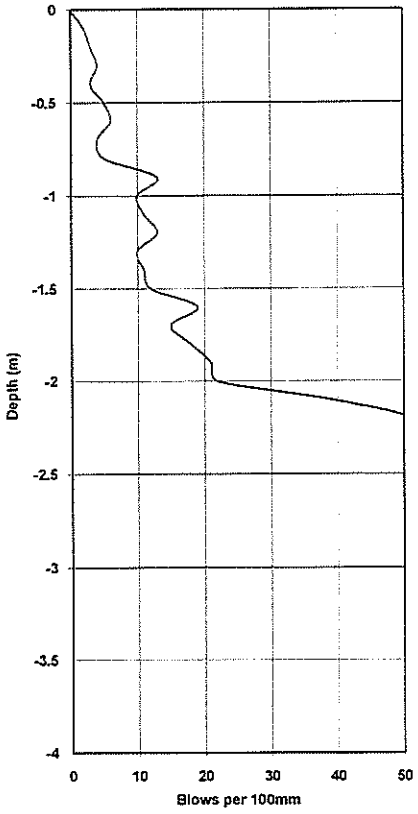
Client: Department of Transport
Project: Emoyeni Emedweleni River Vehicle Bridge
Section:

Ref.No. 344-12
Date: 23-01-2013
Operator: P. Naidoo

CBR Penetrometer Probe ---------- Test No. DC 1

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth metres	Blows per 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	2	Loose	<30 deg	3
0.2	3	Loose	<30 deg	5
0.3	4	Med.Dense	30 deg	7
0.4	3	Loose	<30 deg	5
0.5	5	Med.Dense	32 deg	8
0.6	6	Med.Dense	33 deg	10
0.7	4	Med.Dense	30 deg	7
0.8	5	Med.Dense	32 deg	8
0.9	13	Dense	37 deg	23
1	10	Med.Dense	36 deg	17
1.1	11	Dense	36 deg	19
1.2	13	Dense	37 deg	23
1.3	10	Med.Dense	36 deg	17
1.4	11	Dense	36 deg	19
1.5	12	Dense	36 deg	21
1.6	19	Dense	37 deg	35
1.7	15	Dense	37 deg	27
1.8	18	Dense	37 deg	33
1.9	21	Dense	38 deg	40
2	22	Dense	38 deg	42
2.1	39	Very Dense	>38 deg	>55
	Refusal			



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Client: Department of Transport
Project: Emoyeni Emedweleni River Vehicle Bridge
Section:

Ref.No. 344-12
Date: 23-01-2013
Operator: P. Naidoo

CBR Penetrometer Probe ---------- Test No. DC 2

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth metres	Blows per 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	2	Loose	<30 deg	3
0.2	4	Med.Dense	30 deg	7
0.3	3	Loose	<30 deg	5
0.4	5	Med.Dense	32 deg	8
0.5	7	Med.Dense	34 deg	12
0.6	8	Med.Dense	35 deg	14
0.7	11	Dense	36 deg	19
0.8	9	Med.Dense	35 deg	15
0.9	13	Dense	37 deg	23
1	12	Dense	36 deg	21
1.1	14	Dense	37 deg	25
1.2	15	Dense	37 deg	27
1.3	19	Dense	37 deg	35
1.4	18	Dense	37 deg	33
1.5	21	Dense	38 deg	40
1.6	22	Dense	38 deg	42
1.7	20	Dense	38 deg	37
1.8	19	Dense	37 deg	35
1.9	18	Dense	37 deg	33
2	23	Dense	38 deg	44
2.1	20	Dense	38 deg	37
2.2	17	Dense	37 deg	31
2.3	13	Dense	37 deg	23
2.4	18	Dense	37 deg	33
2.5	23	Dense	38 deg	44
2.6	19	Dense	37 deg	35
2.7	27	Very Dense	>38 deg	54
2.8	39	Very Dense	>38 deg	>55
	Refusal			

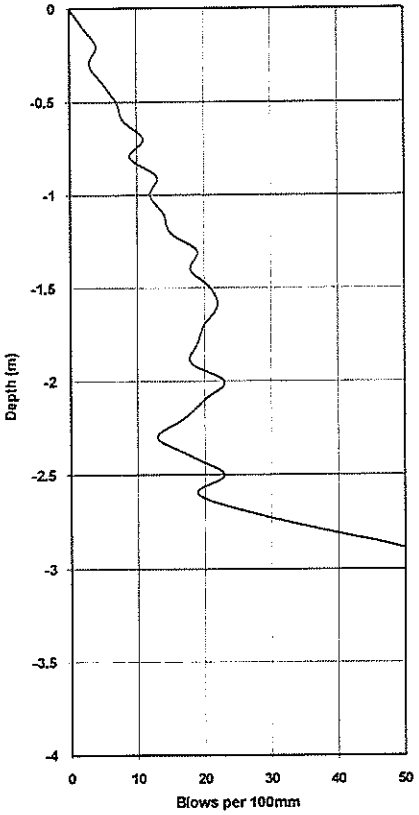
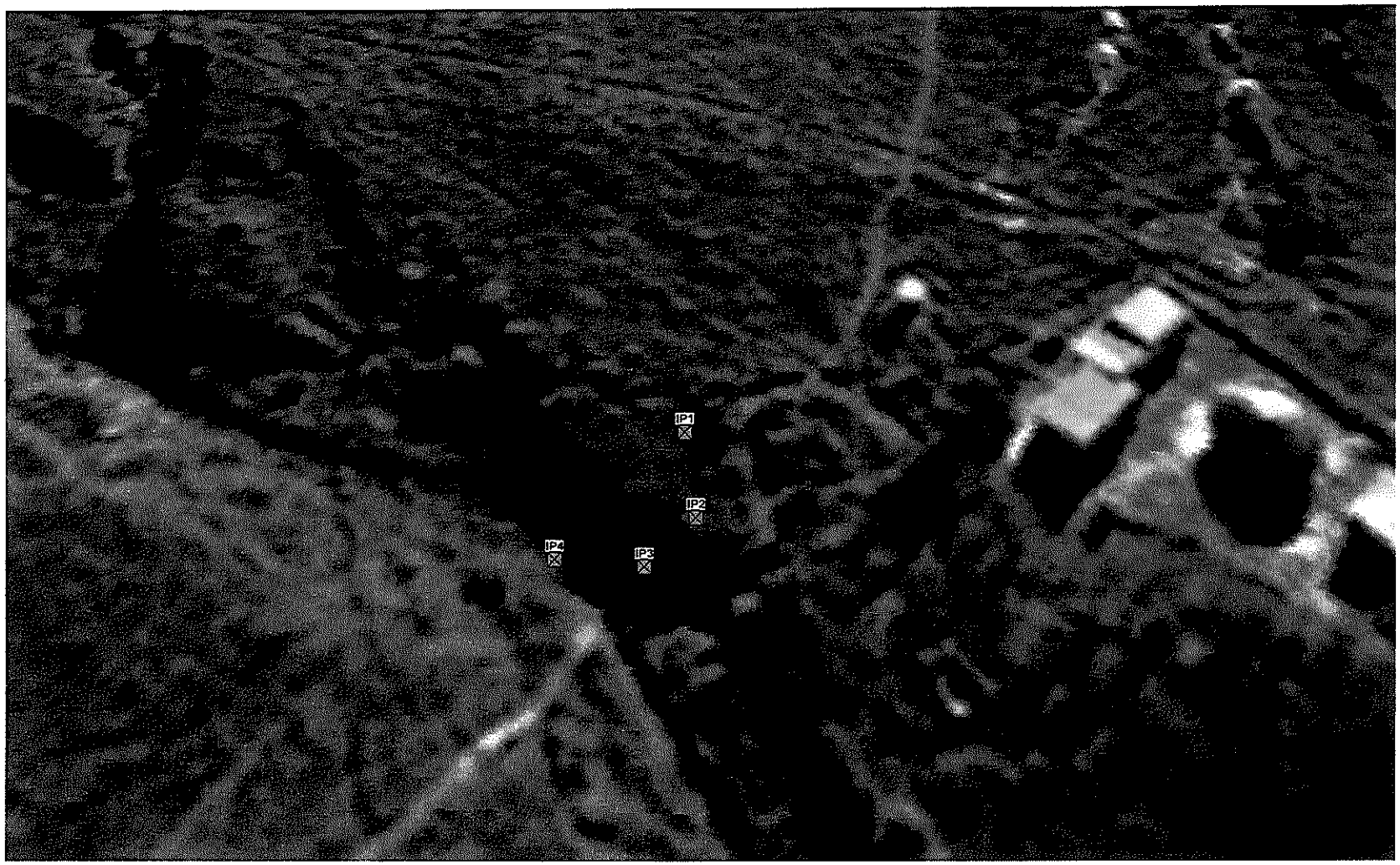


FIGURE 1

SITE PLAN



KEY:

IP1 ☒ Approximate position of Inspection Pit.

Site Plan showing approximate position of :

(i) Inspection Pits.

Scale 1:250

Department of Transport
Emoyeni Emedweleni River Vehicle Bridge

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DATE 08-04-2012
DRAWN V. Gounden
CHECK L. Dalton
REFERENCE No. 344-12

Figure 1