

**MALAWI POLYTECHNIC
CIVIL ENGINEERING DEPARTMENT**

**REPORT ON GEOTECHNICAL INVESTIGATIONS ON THE PROJECT
FOR RE-CONSTRUCTION AND EXPANSION
OF SELECTED COMMUNITY DAY SECONDARY SCHOOLS (CDSSs)
PHASE II**

TO: MATSUDA INTERNATIONAL CONSULTANTS

**PREPARED BY: TUTULE MSUKWA, MPhil, BSc Civil Eng,
Reng.**

Geotechnical Engineer

May 2011

INTRODUCTION

1.1 General

Matsuda International Consultant contacted Malawi Polytechnic, Civil Engineering Department to conduct geotechnical investigations and recommend appropriate bearing capacity of structures on various sites in Malawi, namely; Mkwichi CDSS in Lilongwe District, Matenje CDSS in Salima District, Liwaladzi CDSS in Nkhotakota, Mpamba CDSS in Nkhata-Bay and Edingeni, Ezondweni and Zolozolo CDSS in Mzimba district.

Site reconnaissance, insitu testing and soil sampling for all the sites were carried out from 24th March 2011 to 31st March 2011. Laboratory testing proceeded immediately at the Malawi Polytechnic Laboratory in Blantyre.

1.2 Project Description

It is our understanding that the project involves the construction of new standard classroom blocks, laboratory blocks and staff houses in the selected CDSSs. From our knowledge of schools structures in Malawi it is our understanding that the structures to be built will be ground level structures with no storeys and that the structures will be mainly load bearing walls resting on standard mass concrete strip footings.

1.3 Objectives of the Soil Investigation

The purpose of the geotechnical exploration exercise was to:

1. To determine the subsoil conditions under the proposed sites for the construction of tanks.
2. To determine the engineering properties of the subsoil.
3. To comment on the type of foundation to be adopted.
4. To assess the bearing capacity of the soil in line with standard strip footings of width 690mm.

2 Soil Sampling and Testing

In all there were eight sites. In all the sites, trial pits were dug in order to reveal the soil profile, carry out insitu tests and get samples for laboratory testing. Location for trial pits were agreed with Matsuda Consultants. The trial pits were approximately two metres deep. Insitu tests carried out, were Water Penetration test (WPT) and Dynamic Cone Penetration Test (DCP). The soil samples recovered from the trial pits were taken to the Polytechnic laboratory, and examined to confirm the field descriptions. Representative samples were then selected for classification tests (plasticity and grading test) and compaction test. Where possible undisturbed samples for triaxial testing were collected.

2.1 Mkwichi CDSS

Six trial pits for sample collection and testing were dug at and around Mkwichi CDSS. In addition three more pits were dug for Water penetration test. Furthermore 50 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically dark brown firm sandy clays with traces of gravel size materials but nevertheless some pits, pit 4 and 5 showed the presence of a decomposed light grey rock which was difficult to cultivate.

From the triaxial test, the worst case scenario was observed on Pit no. 6 which gave an angle of friction of 11.6 degrees and cohesion intercept of 63kN/m². Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 622kN/m². Applying a Factor of safety of two the safe bearing capacity is 311kN/m².

From the DCP test it was observed that most areas had a Penetration index of more than 20mm/blow (approx CBR of 10). This indicates that basically the surface at Mkwichi CDSS is weak, foundations need to be placed at a depth of more than 1.5m to reach firm ground which has been evidenced by observations and triaxial test results on samples from trial pits. The water penetration results gave an average percolation value of 3.55mm/min which is quite good for soakaways.

2.2 Edingeni CDSS

Six trial pits for sample collection and testing were dug at and around Edingeni CDSS. Water penetration test failed because the pits could not hold water, i.e the permeability was high. 60 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically dark red firm clayey sand soils. Only pit 5 shows a presence of a slightly decomposed rock at 2m depth.

From the triaxial test, the worst case scenario was observed on Pit no. 4 which gave an angle of friction of 10.4 degrees and cohesion intercept of 55kN/m². Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 526kN/m². Applying a Factor of safety of two the safe bearing capacity is 263kN/m².

From the DCP test it was observed that most areas had a Penetration index of more than 20mm/blow (approx CBR of 10). This indicates that basically the surface at Edingeni CDSS is weak, foundations need to be placed at a depth of more than 1.5m to reach firm ground which has been evidenced by observations and triaxial test results from trial pits.

2.3 Ezondweni CDSS

Six trial pits for sample collection and testing were dug at and around Mkwichi CDSS. In addition three more pits were dug for Water penetration test. Furthermore 50 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically dark brown firm clays of high plasticity with traces of sand size.

From the triaxial test, the worst case scenario was observed on Pit no. 5 which gave an angle of friction of 11.3 degrees and cohesion intercept of 54kN/m². Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 540kN/m². Applying a Factor of safety of two the safe bearing capacity is 270kN/m².

From the DCP test it was observed that most areas had a Penetration index of more than 20mm/blow (approx CBR of 10). This indicates that basically the surface at Ezondweni CDSS is weak, foundations need to be placed at a depth of more than 1.5m to reach firm ground which has been evidenced by observations and triaxial test results on samples from trial pits.

The water penetration results gave an average percolation value of 2.25mm/min which is adequate for soakaways.

2.4 Zolozolo CDSS

Six trial pits for sample collection and testing were dug at and around Zolozolo CDSS. Water penetration test failed because the pits could not hold water, i.e. the permeability was high. 50 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically light grey loose sands with occasional silt size particles. The soils were basically non-plastic.

Triaxial test was not carried out because of the nature of the soil. From observation and literature, a safe bearing capacity of 100kN/m^2 can be adopted for 690mm footing. Nevertheless the foundation trench should be treated by putting a well compacted gravel layer of at least 200mm thick before placing the foundation concrete. The gravel layer should be compacted to at least 95%MDD.

2.5 Mpamba CDSS

Six trial pits for sample collection and testing were dug at and around Mpamba CDSS. In addition three more pits were dug for Water penetration test. Furthermore 60 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically reddish loose sandy silt soils. The soils were basically very plastic.

Triaxial test was not carried out because of the nature of the soil. From observation and literature, a safe bearing capacity of 100kN/m^2 can be adopted for 690mm footing. Nevertheless the foundation trench should be treated by putting a well compacted gravel layer of at least 200mm thick before placing the foundation concrete. The gravel layer should be compacted to at least 95%MDD.

The water penetration results gave an average percolation value of 1.23mm/min which is quite low indicating that the soils are of low permeability.

2.6 Liwaladzi CDSS

Six trial pits for sample collection and testing were dug at and around Liwaladzi CDSS. Water Penetration test was not possible because the area was basically water logged. Furthermore 50 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically dark brown firm clays of high plasticity with traces of sand size.

From the triaxial test, the worst case scenario was observed on Pit no. 5 which gave an angle of friction of 9.5 degrees and cohesion intercept of 33kN/m^2 . Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 310kN/m^2 . Applying a Factor of safety of two the safe bearing capacity is 155kN/m^2 .

From the DCP test it was observed that most areas had a Penetration index of more than 20mm/blow (approx CBR of 10). This indicates that basically the surface at Liwaladzi CDSS

is weak , foundations need to be placed at a depth of more than 1.5m to reach firm ground which has been evidenced by observations and triaxial test results on samples from trial pits.

2.7 Matenje CDSS

Six trial pits for sample collection and testing were dug at and around Matenje CDSS. Water Penetration test was carried out on three pits. Furthermore 50 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were basically dark brown firm clays of high plasticity with traces of sand size.

From the triaxial test, the worst case scenario was observed on Pit no. 5 which gave an angle of friction of 14.6 degrees and cohesion intercept of 57kN/m². Using Terzaghis Ultimate bearing capacity equation and assuming a 1m deep foundation and 690mm wide strip footing, the ultimate bearing capacity of the soil is 648kN/m². Applying a Factor of safety of two the safe bearing capacity is 324kN/m².

From the DCP test it was observed that not many areas had a Penetration index of more than 20mm/blow (approx CBR of 10). This indicates that basically the surface at Liwaladzi CDSS is stable for normal strip footing.

The water penetration results gave an average percolation value of 3.8mm/min which is adequate for soakaways.

3 RECOMMENDATIONS

The soil conditions at the proposed CDSS are adequate for Mkwichi CDSS, Edingeni CDSS, Ezondweni CDSS, Liwaladzi CDSS and Matenje CDSS (safe bearing capacity for a strip footing of 690mm greater than 150kN/m²). For Zolozolo CDSS and Mpamba CDSS the foundation trench should be treated by laying at least a 200mm layer of well compacted gravel to 95% MDD.

4 References

1. Soil mechanics by R.F. Graig
2. Elements of Soil mechanics by G.N. Smith

Appendices

1. Site Location
2. Summary report on Geotechnical Investigation
3. Triaxial Test Results
4. DCP Test results

Appendices

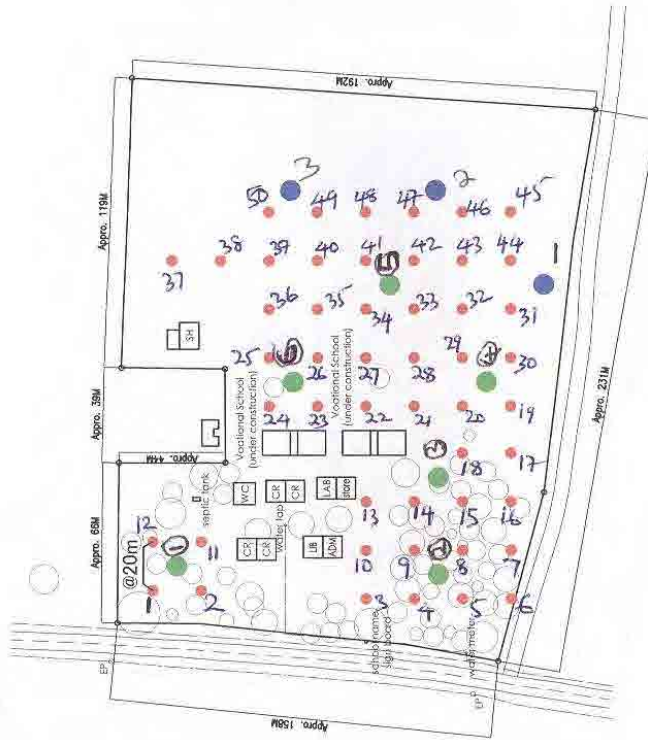
1. Site Location

Appendix 2



Legend (Geotechnical Survey)

- Dynamic Cone Penetrometer Test Points (50 No. @20m)
- Water Penetration Test Points (3 No.)
- Lab. Sample (6 No.)



SCALE 1/2500
Mkwichi CDSS
 Apprx. 3.8ha

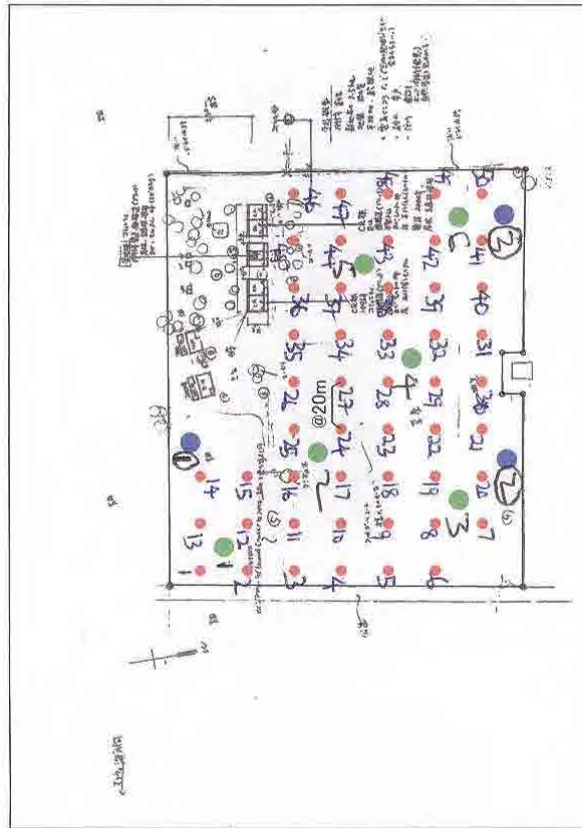
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Handwritten signature



Legend (Geotechnical Survey)

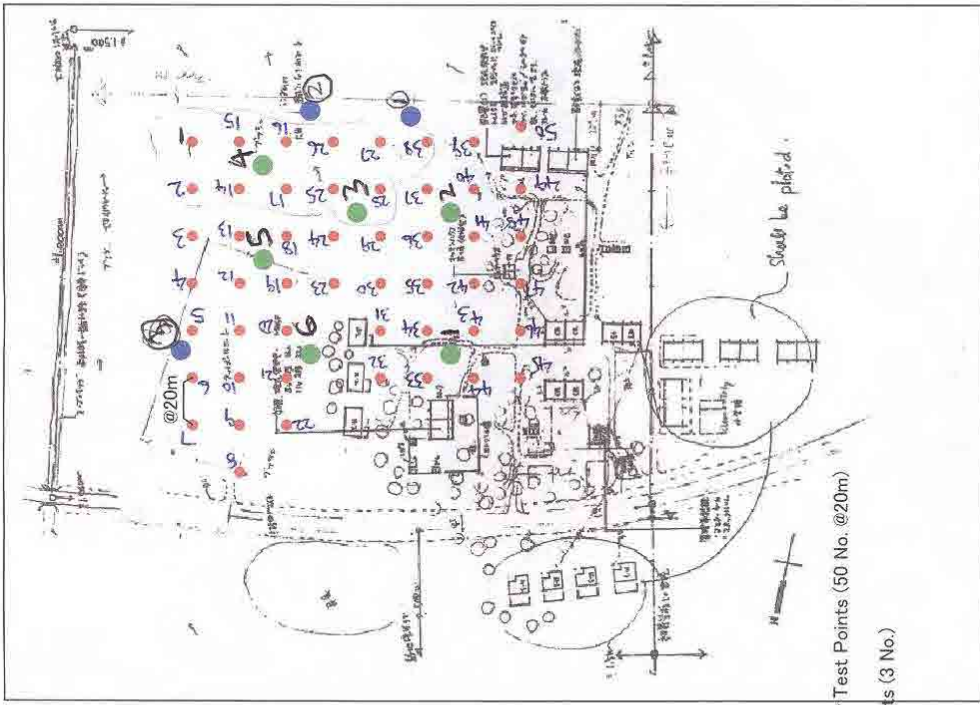
- Dynamic Cone Penetrometer Test Points (50 No. @20m)
- Water Penetration Test Points (3 No.)
- Lab. Sample (6 No.)



SCALE 1/2500
Liwaladzi CDSS
Appro. 3.0ha

21

B. M. M.



Legend (Geotechnical Survey)

- Dynamic Cone Penetrometer Test Points (50 No. @20m)
- Water Penetration Test Points (3 No.)
- Lab. Sample (6 No.)

SCALE 1/2500

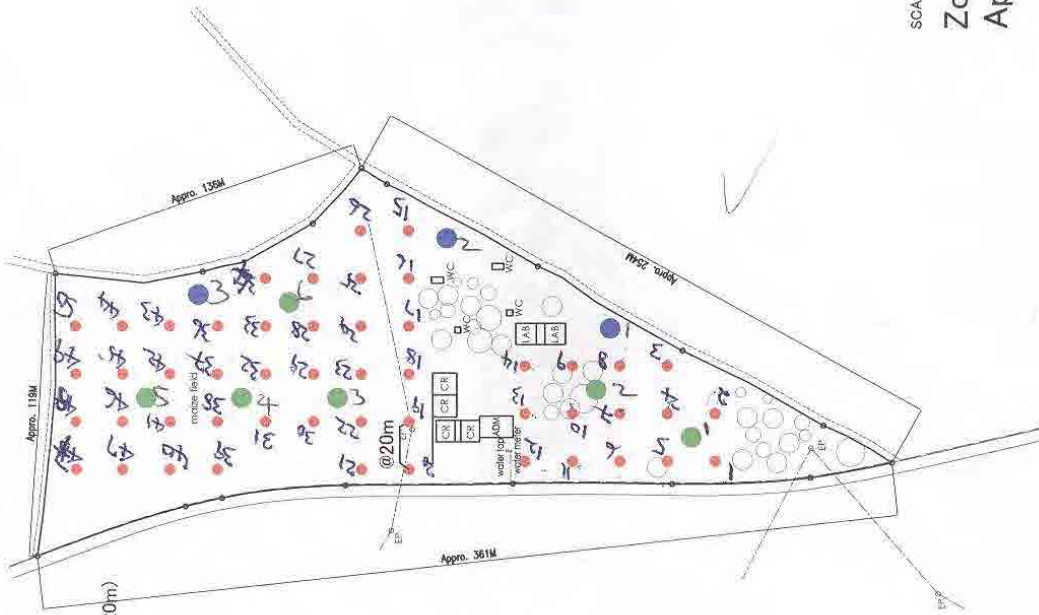
Matenje CDSS
Appro. 4.0ha

Handwritten mark resembling a stylized 'S' or '5'.

Handwritten signature or initials.



Legend
 --- Water Supply
 --- Electric Supply



Legend (Geotechnical Survey)

- Dynamic Cone Penetrometer Test Points (50 No. @20m)
- Water Penetration Test Points (3 No.)
- Lab. Sample (6 No.)

SCALE 1/2500
 Zolozolo CDSS
 Appra. 2.9ha

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Appendices

2. Summary report on Geotechnical Investigation



UNIVERSITY OF MALAWI

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SUMMARY REPORT ON GEOTECHNICAL INVESTIGATIONS

| SITE | SOIL TYPE | PENETRATION RATE OF WATER (mm/min) | DCP PENETRATION INDEX | APPROXIMATE COMPARATIVE CBR | DEGREE OF COMPACTION | COMMENTS & RECOMMENDATIONS |
|----------------|--|---|-----------------------|-----------------------------|--|--|
| MKWICHI CDSS | Dark brown firm sandy clay with traces of gravel size material | 3.55 (good for soakaways) | >20 mm/blow | 10 | SOFT Weak surface | Foundations need to be placed at a depth of more than 1.5m to reach firm ground. |
| EDINGENI CDSS | Dark red firm clayey sandy soil | High Permeability (pit not hold water) | >20 mm/blow | 10 | VERY SOFT | Foundation trench to be treated by putting a well compacted to at least 95% MDD gravel layer of at least 200mm thick before placing the foundation concrete. |
| EZONDWENI CDSS | Dark brown firm clay of high plasticity with traces of sand | 2.25 (good for soakaways) | >20 mm/blow | 10 | SOFT | Foundations need to be placed at a depth of more than 1.5m to reach firm ground. |
| ZOLOZOLO CDSS | Light grey loose sand with silt size particles of non-plastic | High Permeability (pit not hold water) | >20 mm/blow | 10 | VERY SOFT | Foundation trench to be treated by putting a well compacted to at least 95% MDD gravel layer of at least 200mm thick before placing the foundation concrete. |
| MPAMBA CDSS | Reddish loose sandy silt soil with high plastic | 1.23 (Low Permeability) | >20 mm/blow | 10 | SOFT | Foundations need to be placed at a depth of more than 1.5m to reach firm ground. |
| LIWALADZI CDSS | Dark brown firm clay of high PI | Waterlogged (test not possible) | >20 mm/blow | 10 | FIRM Weak surface | Foundations need to be placed at a depth of more than 1.5m to reach firm ground. |
| MATENJE CDSS | Dark brown firm clay of high PI | 3.8 (good for soakaways) | <20 mm/blow | 10 | FIRM Basically stable surface for normal Strip Footing. | Can ably accommodate normal foundation loads from buildings & >20mm/blow points to be recompacted to improve bearing capacity or be avoided. |

D.B.KASIMPHA

Appendices

3. Triaxial Test Results

UNIVERSITY OF MALAWI – THE POLYTECHNIC
DEPARTMENT OF CIVIL ENGINEERING

DATE : 03rd May,2011

SUMMARY OF RESULTS FOR SOIL INVESTIGATIONS – MATSUDA INTERNATIONAL CONSULTANTS

| SITE | PIT NO | GRADING | ATTERBERG LIMITS | | | TRIAIAL TEST | |
|---------------------------|--------|---------|------------------|---------------|------------------|--------------------------|-----------------------|
| | | | LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX | COHENSION INTERCEPT (C') | ANGLE OF SHEARING (Ø) |
| MKWICHI (LILONGWE) | 1 | DONE | NP | NP | NP | Decomposed Rock | |
| | 2 | DONE | 41.7 | 21.7 | 20.0 | 69 kN/m ² | 11.3° |
| | 3 | DONE | NP | NP | NP | Decomposed Rock | |
| | 4 | DONE | NP | NP | NP | Decomposed Rock | |
| | 5 | DONE | 46.0 | 27.7 | 18.3 | 67 kN/m ² | 10.2° |
| | 6 | DONE | 47.0 | 25.3 | 21.7 | 63 kN/m ² | 11.6° |
| EDINGENI (MZIMBA) | 1 | DONE | 32.3 | 13.9 | 18.4 | 80 kN/m ² | 8.3° |
| | 2 | DONE | 28.5 | 16.2 | 12.3 | 85 kN/m ² | 8.8° |
| | 3 | DONE | 31.8 | 13.3 | 18.5 | 55 kN/m ² | 10.4° |
| | 4 | DONE | 36.3 | 19.4 | 17.0 | 63 kN/m ² | 10.2° |
| | 5 | DONE | NP | NP | NP | Slightly Decomposed Rock | |
| | 6 | DONE | 37.5 | 19.8 | 17.7 | 60 kN/m ² | 11.3° |
| EZONDWENI (MZIMBA) | 1 | DONE | 30.2 | 17.8 | 12.4 | 125 kN/m ² | 7.5° |
| | 2 | DONE | 31.0 | 15.9 | 15.1 | 69 kN/m ² | 8.7° |
| | 3 | DONE | 30.5 | 19.1 | 11.4 | 115 kN/m ² | 9.0° |
| | 4 | DONE | 29.8 | 17.7 | 12.1 | 129 kN/m ² | 7.3° |
| | 5 | DONE | 34.5 | 15.3 | 19.2 | 54 kN/m ² | 11.3° |
| | 6 | DONE | 35.0 | 20.0 | 15.0 | 66 kN/m ² | 8.5° |
| ZOLOZOLO (MZUZU) | 1 | DONE | NP | NP | NP | Sandy Soil | |
| | 2 | DONE | NP | NP | NP | Sandy Soil | |
| | 3 | DONE | NP | NP | NP | Sandy Soil | |
| | 4 | DONE | NP | NP | NP | Sandy Soil | |
| | 5 | DONE | NP | NP | NP | Sandy Soil | |
| | 6 | DONE | NP | NP | NP | Sandy Soil | |
| MPAMBA (NKHATABAY) | 1 | DONE | 49.0 | 25.7 | 23.3 | Loose Soft Material | |
| | 2 | DONE | 38.9 | 22.1 | 16.8 | Loose Soft Material | |
| | 3 | DONE | 40.1 | 24.1 | 16.0 | Loose Soft Material | |
| | 4 | DONE | 40.3 | 21.6 | 18.7 | Loose Soft Material | |
| | 5 | DONE | 47.5 | 27.2 | 20.3 | Loose Soft Material | |
| | 6 | DONE | 46.9 | 21.1 | 25.8 | Loose Soft Material | |
| LIWALADZI (NKHOTAKOTA) | 1 | DONE | NP | NP | NP | Slightly Decomposed Rock | |
| | 2 | DONE | 38.2 | 20.6 | 17.6 | 38 kN/m ² | 4.6° |
| | 3 | DONE | 38.0 | 17.0 | 21.0 | 35 kN/m ² | 7.8° |
| | 4 | DONE | 35.0 | 18.7 | 16.3 | 42 kN/m ² | 5.5° |
| | 5 | DONE | 38.3 | 17.6 | 20.7 | 33 kN/m ² | 9.5° |

| | | | | | | | |
|---------------------|---|------|------|------|------|-----------------------|-------|
| | 6 | DONE | 34.3 | 18.3 | 16.0 | 44 kN/m ² | 5.9° |
| | | | | | | | |
| MATENJE (SALIMA) | 1 | DONE | 35.0 | 12.4 | 22.6 | 74 kN/m ² | 22.8° |
| | 2 | DONE | 33.8 | 13.5 | 20.3 | 79 kN/m ² | 21.8° |
| | 3 | DONE | 46.3 | 28.3 | 18.0 | 103 kN/m ² | 18.5° |
| | 4 | DONE | 45.7 | 24.8 | 20.9 | 112 kN/m ² | 18.6° |
| | 5 | DONE | 45.0 | 22.9 | 22.1 | 57 kN/m ² | 14.6° |
| | 6 | DONE | 45.4 | 18.2 | 27.2 | 89 kN/m ² | 13.8° |
| | | | | | | | |

COMPILED BY : Ishmael Ng'oma

CHECKED BY : D.B.Kasimpha

Appendices

4. DCP Test results



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DCP TEST RESULTS FOR MKWICHI CDSS IN LILONGWE

| POINT | TOTAL NO OF BLOWS | PENETRATION (mm) | DCP NUMBER (mm/blow) | IN SITU CBR |
|-------|-------------------|------------------|----------------------|-------------|
| 1 | 180 | 2000 | 11 | 20 |
| 2 | 100 | 2000 | 20 | 9 |
| 3 | 180 | 2000 | 11 | 20 |
| 4 | 70 | 2000 | 29 | 6 |
| 5 | 60 | 2000 | 33 | 5 |
| 6 | 220 | 2000 | 9 | 25 |
| 7 | 180 | 2000 | 11 | 20 |
| 8 | 28 | 2000 | 71 | 2 |
| 9 | 200 | 2000 | 10 | 22 |
| 10 | 50 | 2000 | 40 | 4 |
| 11 | 100 | 2000 | 20 | 9 |
| 12 | 44 | 2000 | 45 | 4 |
| 13 | 48 | 2000 | 42 | 4 |
| 14 | 60 | 2000 | 33 | 5 |
| 15 | 49 | 2000 | 41 | 4 |
| 16 | 60 | 2000 | 33 | 5 |
| 17 | 140 | 2000 | 14 | 15 |
| 18 | 180 | 2000 | 11 | 20 |
| 19 | 100 | 2000 | 20 | 9 |
| 20 | 185 | 2000 | 11 | 20 |
| 21 | 70 | 2000 | 29 | 6 |
| 22 | 160 | 2000 | 13 | 16 |
| 23 | 86 | 2000 | 23 | 8 |
| 24 | 50 | 2000 | 40 | 4 |
| 25 | 100 | 2000 | 20 | 9 |
| 26 | 210 | 2000 | 10 | 22 |
| 27 | 200 | 2000 | 10 | 22 |
| 28 | 30 | 2000 | 67 | 2 |

| | | | | |
|----|-----|------|----|----|
| 29 | 36 | 2000 | 56 | 2 |
| 30 | 40 | 2000 | 50 | 3 |
| 31 | 60 | 2000 | 33 | 5 |
| 32 | 60 | 2000 | 33 | 5 |
| 33 | 200 | 2000 | 10 | 22 |
| 34 | 75 | 2000 | 27 | 6 |
| 35 | 180 | 2000 | 11 | 20 |
| 36 | 70 | 2000 | 29 | 6 |
| 37 | 37 | 2000 | 54 | 2 |
| 38 | 35 | 2000 | 57 | 2 |
| 39 | 45 | 2000 | 44 | 3 |
| 40 | 65 | 2000 | 31 | 5 |
| 41 | 50 | 2000 | 40 | 4 |
| 42 | 100 | 2000 | 20 | 9 |
| 43 | 38 | 2000 | 53 | 3 |
| 44 | 40 | 2000 | 50 | 3 |
| 45 | 100 | 2000 | 20 | 9 |
| 46 | 115 | 2000 | 17 | 12 |
| 47 | 105 | 2000 | 19 | 10 |
| 48 | 65 | 2000 | 31 | 5 |
| 49 | 104 | 2000 | 19 | 10 |
| 50 | 100 | 2000 | 20 | 9 |

LEGEND:

*DCP NUMBER (mm/blow) : Is found by dividing total penetration (2000mm) by total number of blows.

* BLOW(S) : Counting the freely falling force applied to the DCP to attain penetration.

* IN SITU CBR : Comparative values with the DCP NUMBER found on the chart provided by the suppliers of the DCP machine.

Hoping this is in order.

Thanks for doing good business with us.

Yours truly,

D.B.Kasimpha
For Civil Engineering Laboratory



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DCP TEST RESULTS FOR EZONDWENI CDSS IN MZIMBA

| POINT | TOTAL NO OF BLOWS | PENETRATION (mm) | DCP NUMBER (mm/blow) | IN SITU CBR |
|--------------|--------------------------|-------------------------|-----------------------------|--------------------|
| 1 | 36 | 2000 | 56 | 2 |
| 2 | 37 | 2000 | 54 | 2 |
| 3 | 40 | 2000 | 50 | 3 |
| 4 | 37 | 2000 | 54 | 2 |
| 5 | 58 | 2000 | 34 | 5 |
| 6 | 63 | 2000 | 32 | 5 |
| 7 | 66 | 2000 | 30 | 6 |
| 8 | 69 | 2000 | 29 | 6 |
| 9 | 60 | 2000 | 33 | 5 |
| 10 | 55 | 2000 | 36 | 4 |
| 11 | 46 | 2000 | 43 | 4 |
| 12 | 49 | 2000 | 41 | 4 |
| 13 | 40 | 2000 | 50 | 3 |
| 14 | 38 | 2000 | 53 | 3 |
| 15 | 51 | 2000 | 39 | 4 |
| 16 | 49 | 2000 | 41 | 4 |
| 17 | 59 | 2000 | 34 | 5 |
| 18 | 63 | 2000 | 32 | 5 |
| 19 | 65 | 2000 | 31 | 5 |
| 20 | 63 | 2000 | 32 | 5 |
| 21 | 60 | 2000 | 33 | 5 |
| 22 | 61 | 2000 | 33 | 5 |
| 23 | 65 | 2000 | 31 | 5 |
| 24 | 60 | 2000 | 33 | 5 |
| 25 | 53 | 2000 | 38 | 4 |
| 26 | 52 | 2000 | 38 | 4 |
| 27 | 63 | 2000 | 32 | 5 |

| | | | | |
|----|----|------|----|---|
| 28 | 60 | 2000 | 33 | 5 |
| 29 | 60 | 2000 | 31 | 5 |
| 30 | 66 | 2000 | 30 | 6 |
| 31 | 63 | 2000 | 32 | 5 |
| 32 | 67 | 2000 | 30 | 6 |
| 33 | 60 | 2000 | 33 | 5 |
| 34 | 54 | 2000 | 37 | 4 |
| 35 | 52 | 2000 | 38 | 4 |
| 36 | 50 | 2000 | 40 | 4 |
| 37 | 56 | 2000 | 36 | 4 |
| 38 | 53 | 2000 | 38 | 4 |
| 39 | 51 | 2000 | 39 | 4 |
| 40 | 56 | 2000 | 36 | 4 |
| 41 | 54 | 2000 | 37 | 4 |
| 42 | 53 | 2000 | 38 | 4 |
| 43 | 52 | 2000 | 38 | 4 |
| 44 | 56 | 2000 | 36 | 4 |
| 45 | 50 | 2000 | 40 | 4 |
| 46 | 59 | 2000 | 41 | 4 |
| 47 | 51 | 2000 | 39 | 4 |
| 48 | 48 | 2000 | 42 | 4 |
| 49 | 51 | 2000 | 39 | 4 |
| 50 | 52 | 2000 | 38 | 4 |

LEGEND:

*DCP NUMBER (mm/blow) : Is found by dividing total penetration (2000mm) by total number of blows.

* BLOW(S) : Counting the freely falling force applied to the DCP to attain penetration.

* IN SITU CBR : Comparative values with the DCP NUMBER found on the chart provided by the suppliers of the DCP machine.

Hoping this is in order.

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For Civil Engineering Laboratory



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DCP TEST RESULTS FOR MATENJE CDSS IN SALIMA

| POINT | TOTAL NO OF BLOWS | PENETRATION (mm) | DCP NUMBER (mm/blow) | IN SITU CBR |
|-------|-------------------|------------------|----------------------|-------------|
| 1 | 160 | 2000 | 13 | 16 |
| 2 | 158 | 2000 | 13 | 16 |
| 3 | 155 | 2000 | 13 | 16 |
| 4 | 120 | 2000 | 17 | 12 |
| 5 | 82 | 2000 | 24 | 7 |
| 6 | 73 | 2000 | 27 | 6 |
| 7 | 75 | 2000 | 27 | 6 |
| 8 | 82 | 2000 | 24 | 7 |
| 9 | 77 | 2000 | 26 | 7 |
| 10 | 79 | 2000 | 25 | 7 |
| 11 | 76 | 2000 | 26 | 7 |
| 12 | 101 | 2000 | 20 | 9 |
| 13 | 129 | 2000 | 16 | 13 |
| 14 | 160 | 2000 | 13 | 16 |
| 15 | 162 | 2000 | 12 | 18 |
| 16 | 175 | 2000 | 11 | 20 |
| 17 | 168 | 2000 | 12 | 18 |
| 18 | 140 | 2000 | 14 | 15 |
| 19 | 115 | 2000 | 17 | 12 |
| 20 | 86 | 2000 | 23 | 8 |
| 21 | 81 | 2000 | 25 | 7 |
| 22 | 80 | 2000 | 25 | 7 |
| 23 | 112 | 2000 | 18 | 11 |
| 24 | 135 | 2000 | 15 | 14 |
| 25 | 146 | 2000 | 14 | 15 |
| 26 | 174 | 2000 | 11 | 20 |
| 27 | 102 | 2000 | 20 | 9 |
| 28 | 110 | 2000 | 18 | 11 |

| | | | | |
|----|-----|------|----|----|
| 29 | 115 | 2000 | 17 | 12 |
| 30 | 113 | 2000 | 18 | 11 |
| 31 | 89 | 2000 | 22 | 8 |
| 32 | 82 | 2000 | 24 | 7 |
| 33 | 84 | 2000 | 24 | 7 |
| 34 | 80 | 2000 | 25 | 7 |
| 35 | 100 | 2000 | 20 | 9 |
| 36 | 120 | 2000 | 17 | 12 |
| 37 | 125 | 2000 | 16 | 13 |
| 38 | 111 | 2000 | 18 | 11 |
| 39 | 86 | 2000 | 23 | 8 |
| 40 | 100 | 2000 | 20 | 9 |
| 41 | 102 | 2000 | 20 | 9 |
| 42 | 88 | 2000 | 22 | 8 |
| 43 | 75 | 2000 | 27 | 6 |
| 44 | 55 | 2000 | 36 | 4 |
| 45 | 58 | 2000 | 34 | 5 |
| 46 | 51 | 2000 | 39 | 4 |
| 47 | 89 | 2000 | 22 | 8 |
| 48 | 95 | 2000 | 21 | 9 |
| 49 | 97 | 2000 | 21 | 9 |
| 50 | 87 | 2000 | 23 | 8 |

LEGEND:

*DCP NUMBER (mm/blow) : Is found by dividing total penetration (2000mm) by total number of blows.

* BLOW(S) : Counting the freely falling force applied to the DCP to attain penetration.

* IN SITU CBR : Comparative values with the DCP NUMBER found on the chart provided by the suppliers of the DCP machine.

Hoping this is in order.

Thanks for doing good business with us.

Yours truly,

D.B.Kasimpha
For Civil Engineering Laboratory



UNIVERSITY OF MALAWI

PRINCIPAL
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Our Ref.:

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Date: **07th July, 2011**

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ATT: Matsuda Consultants International

DCP TEST RESULTS FOR ZOLOZOLO CDSS IN MZUZU

| POINT | TOTAL NO OF BLOWS | PENETRATION (mm) | DCP NUMBER (mm/blow) | IN SITU CBR |
|-------|-------------------|------------------|----------------------|-------------|
| 1 | 37 | 2000 | 57 | 3 |
| 2 | 41 | 2000 | 49 | 3 |
| 3 | 39 | 2000 | 51 | 3 |
| 4 | 33 | 2000 | 61 | 2 |
| 5 | 45 | 2000 | 44 | 4 |
| 6 | 33 | 2000 | 61 | 2 |
| 7 | 29 | 2000 | 69 | 2 |
| 8 | 36 | 2000 | 56 | 3 |
| 9 | 37 | 2000 | 54 | 3 |
| 10 | 45 | 2000 | 44 | 4 |
| 11 | 38 | 2000 | 53 | 3 |
| 12 | 43 | 2000 | 47 | 3 |
| 13 | 39 | 2000 | 51 | 3 |
| 14 | 40 | 2000 | 50 | 3 |
| 15 | 46 | 2000 | 43 | 4 |
| 16 | 66 | 2000 | 30 | 6 |
| 17 | 69 | 2000 | 29 | 6 |
| 18 | 70 | 2000 | 29 | 6 |
| 19 | 65 | 2000 | 31 | 6 |
| 20 | 71 | 2000 | 28 | 6 |
| 21 | 73 | 2000 | 27 | 6 |
| 22 | 69 | 2000 | 29 | 6 |
| 23 | 73 | 2000 | 27 | 6 |
| 24 | 71 | 2000 | 28 | 6 |
| 25 | 72 | 2000 | 28 | 6 |
| 26 | 55 | 2000 | 36 | 4 |
| 27 | 59 | 2000 | 34 | 5 |
| 28 | 70 | 2000 | 29 | 6 |

| | | | | |
|----|----|------|----|---|
| 29 | 71 | 2000 | 28 | 6 |
| 30 | 68 | 2000 | 29 | 6 |
| 31 | 68 | 2000 | 29 | 6 |
| 32 | 70 | 2000 | 29 | 6 |
| 33 | 65 | 2000 | 31 | 6 |
| 34 | 64 | 2000 | 31 | 6 |
| 35 | 67 | 2000 | 30 | 6 |
| 36 | 65 | 2000 | 31 | 6 |
| 37 | 66 | 2000 | 30 | 6 |
| 38 | 73 | 2000 | 27 | 6 |
| 39 | 64 | 2000 | 31 | 6 |
| 40 | 66 | 2000 | 30 | 6 |
| 41 | 64 | 2000 | 31 | 6 |
| 42 | 65 | 2000 | 31 | 6 |
| 43 | 76 | 2000 | 26 | 7 |
| 44 | 74 | 2000 | 27 | 6 |
| 45 | 67 | 2000 | 30 | 6 |
| 46 | 71 | 2000 | 28 | 6 |
| 47 | 66 | 2000 | 30 | 6 |
| 48 | 69 | 2000 | 29 | 6 |
| 49 | 66 | 2000 | 30 | 6 |
| 50 | 59 | 2000 | 34 | 5 |

LEGEND:

*DCP NUMBER (mm/blow) : Is found by dividing total penetration (2000mm) by total number of blows.

* BLOW(S) : Counting the freely falling force applied to the DCP to attain penetration.

* IN SITU CBR : Comparative values with the DCP NUMBER found on the chart provided by the suppliers of the DCP machine.

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For Civil Engineering Laboratory



UNIVERSITY OF MALAWI

PRINCIPAL
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Our Ref.:

Your Ref:

Date: **07th July, 2011**

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ATT: Matsuda Consultants International

DCP TEST RESULTS FOR MPAMBA CDSS IN NKHATABAY

| POINT | TOTAL NO OF BLOWS | PENETRATION (mm) | DCP NUMBER (mm/blow) | IN SITU CBR |
|-------|-------------------|------------------|----------------------|-------------|
| 1 | 29 | 2000 | 69 | 2 |
| 2 | 35 | 2000 | 57 | 3 |
| 3 | 30 | 2000 | 67 | 2 |
| 4 | 30 | 2000 | 67 | 2 |
| 5 | 25 | 2000 | 80 | 1 |
| 6 | 28 | 2000 | 71 | 2 |
| 7 | 29 | 2000 | 69 | 2 |
| 8 | 31 | 2000 | 65 | 2 |
| 9 | 30 | 2000 | 67 | 2 |
| 10 | 26 | 2000 | 77 | 2 |
| 11 | 26 | 2000 | 77 | 2 |
| 12 | 29 | 2000 | 69 | 2 |
| 13 | 31 | 2000 | 65 | 2 |
| 14 | 55 | 2000 | 36 | 4 |
| 15 | 33 | 2000 | 61 | 2 |
| 16 | 38 | 2000 | 53 | 3 |
| 17 | 23 | 2000 | 87 | 1 |
| 18 | 27 | 2000 | 74 | 2 |
| 19 | 34 | 2000 | 59 | 3 |
| 20 | 32 | 2000 | 63 | 2 |
| 21 | 33 | 2000 | 61 | 2 |
| 22 | 36 | 2000 | 56 | 3 |
| 23 | 28 | 2000 | 71 | 2 |
| 24 | 28 | 2000 | 71 | 2 |
| 25 | 29 | 2000 | 69 | 2 |
| 26 | 37 | 2000 | 54 | 3 |
| 27 | 31 | 2000 | 65 | 2 |
| 28 | 25 | 2000 | 80 | 1 |

| | | | | |
|----|----|------|----|---|
| 29 | 24 | 2000 | 83 | 1 |
| 30 | 26 | 2000 | 77 | 2 |
| 31 | 35 | 2000 | 57 | 3 |
| 32 | 37 | 2000 | 54 | 3 |
| 33 | 35 | 2000 | 57 | 3 |
| 34 | 40 | 2000 | 50 | 3 |
| 35 | 36 | 2000 | 56 | 3 |
| 36 | 36 | 2000 | 56 | 3 |
| 37 | 27 | 2000 | 74 | 2 |
| 38 | 29 | 2000 | 69 | 2 |
| 39 | 32 | 2000 | 63 | 2 |
| 40 | 31 | 2000 | 65 | 2 |
| 41 | 32 | 2000 | 63 | 2 |
| 42 | 24 | 2000 | 83 | 1 |
| 43 | 37 | 2000 | 54 | 3 |
| 44 | 33 | 2000 | 61 | 2 |
| 45 | 32 | 2000 | 63 | 2 |
| 46 | 33 | 2000 | 61 | 2 |
| 47 | 30 | 2000 | 67 | 2 |
| 48 | 34 | 2000 | 59 | 3 |
| 49 | 32 | 2000 | 63 | 2 |
| 50 | 27 | 2000 | 74 | 2 |
| 51 | 30 | 2000 | 67 | 2 |
| 52 | 26 | 2000 | 77 | 2 |
| 53 | 27 | 2000 | 74 | 2 |
| 54 | 28 | 2000 | 71 | 2 |
| 55 | 24 | 2000 | 83 | 1 |
| 56 | 28 | 2000 | 71 | 2 |
| 57 | 31 | 2000 | 65 | 2 |
| 58 | 33 | 2000 | 61 | 2 |
| 59 | 35 | 2000 | 57 | 3 |
| 60 | 37 | 2000 | 54 | 3 |

LEGEND:

*DCP NUMBER (mm/blow) : Is found by dividing total penetration (2000mm) by total number of blows.

* BLOW(S) : Counting the freely falling force applied to the DCP to attain penetration.

* IN SITU CBR : Comparative values with the DCP NUMBER found on the chart provided by the suppliers of the DCP machine.

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E-Mail: principal@poly.ac.mw

ATT: Matsuda Consultants International

DCP TEST RESULTS FOR EZONDWENI CDSS IN MZIMBA

| POINT | TOTAL NO OF BLOWS | PENETRATION (mm) | DCP NUMBER (mm/blow) | IN SITU CBR |
|--------------|--------------------------|-------------------------|-----------------------------|--------------------|
| 1 | 152 | 2000 | 13 | 16 |
| 2 | 149 | 2000 | 13 | 16 |
| 3 | 166 | 2000 | 13 | 16 |
| 4 | 90 | 2000 | 22 | 8 |
| 5 | 95 | 2000 | 21 | 9 |
| 6 | 97 | 2000 | 21 | 9 |
| 7 | 158 | 2000 | 13 | 16 |
| 8 | 151 | 2000 | 13 | 16 |
| 9 | 155 | 2000 | 13 | 16 |
| 10 | 153 | 2000 | 13 | 16 |
| 11 | 159 | 2000 | 13 | 16 |
| 12 | 160 | 2000 | 13 | 16 |
| 13 | 101 | 2000 | 20 | 9 |
| 14 | 100 | 2000 | 20 | 9 |
| 15 | 95 | 2000 | 21 | 9 |
| 16 | 87 | 2000 | 23 | 8 |
| 17 | 68 | 2000 | 29 | 6 |
| 18 | 57 | 2000 | 35 | 5 |
| 19 | 120 | 2000 | 17 | 12 |
| 20 | 119 | 2000 | 17 | 12 |
| 21 | 89 | 2000 | 22 | 8 |
| 22 | 90 | 2000 | 22 | 8 |
| 23 | 93 | 2000 | 22 | 8 |
| 24 | 98 | 2000 | 20 | 9 |
| 25 | 86 | 2000 | 23 | 8 |
| 26 | 56 | 2000 | 35 | 5 |
| 27 | 67 | 2000 | 32 | 5 |
| 28 | 70 | 2000 | 29 | 6 |

| | | | | |
|----|-----|------|----|----|
| 29 | 73 | 2000 | 27 | 6 |
| 30 | 81 | 2000 | 25 | 7 |
| 31 | 86 | 2000 | 23 | 8 |
| 32 | 140 | 2000 | 14 | 15 |
| 33 | 152 | 2000 | 13 | 16 |
| 34 | 135 | 2000 | 15 | 14 |
| 35 | 140 | 2000 | 14 | 15 |
| 36 | 159 | 2000 | 13 | 16 |
| 37 | 146 | 2000 | 14 | 15 |
| 38 | 141 | 2000 | 14 | 15 |
| 39 | 85 | 2000 | 23 | 8 |
| 40 | 67 | 2000 | 30 | 6 |
| 41 | 53 | 2000 | 38 | 4 |
| 42 | 60 | 2000 | 33 | 5 |
| 43 | 90 | 2000 | 22 | 8 |
| 44 | 66 | 2000 | 30 | 6 |
| 45 | 69 | 2000 | 29 | 6 |
| 46 | 57 | 2000 | 35 | 5 |
| 47 | 67 | 2000 | 30 | 6 |
| 48 | 76 | 2000 | 26 | 7 |
| 49 | 80 | 2000 | 25 | 7 |
| 50 | 86 | 2000 | 23 | 8 |

LEGEND:

*DCP NUMBER (mm/blow) : Is found by dividing total penetration (2000mm) by total number of blows.

* BLOW(S) : Counting the freely falling force applied to the DCP to attain penetration.

* IN SITU CBR : Comparative values with the DCP NUMBER found on the chart provided by the suppliers of the DCP machine.

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D.B.Kasimpha
For Civil Engineering Laboratory

6-3 Borehole Investigation Reports (Abstract)

1. Matenge CDSS

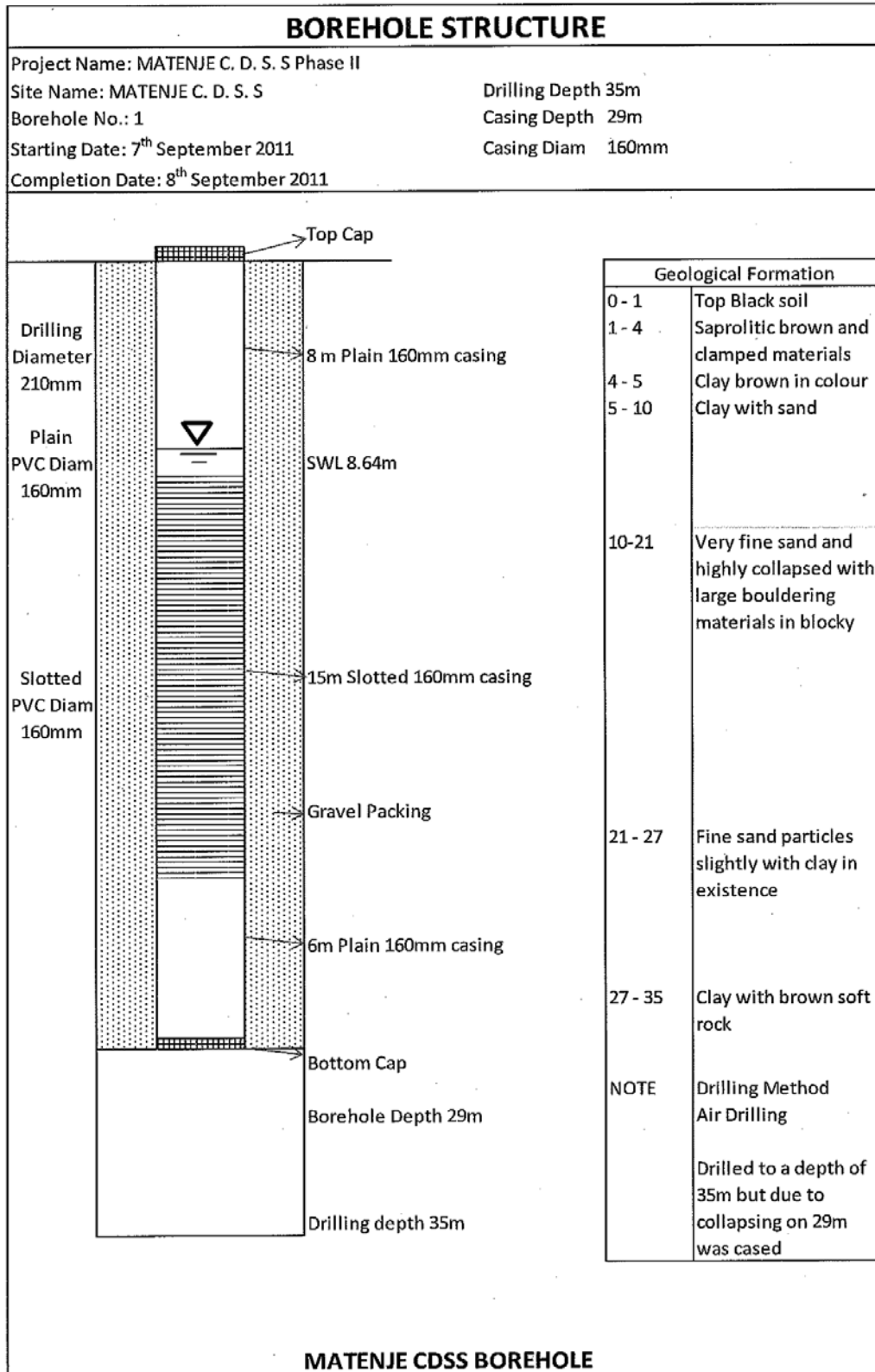
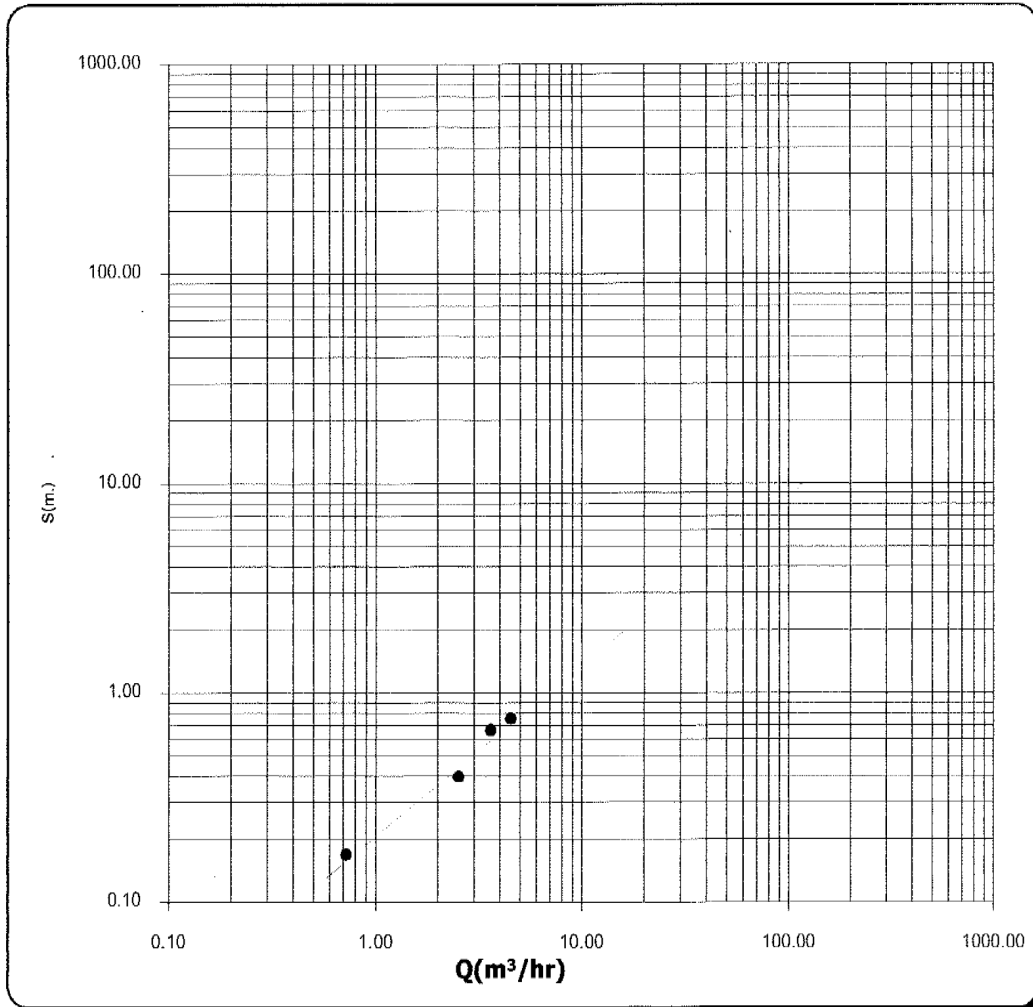


Figure-1 Matenge CDSS Borehole Structure

STEP DRAWDOWN TEST

| | | | |
|--------------|---------------|--------------------|----------|
| PROJECT NAME | CDSS Phase II | | |
| BOREHOLE No. | Matenje No.1 | STATIC WATER LEVEL | 8.64 m. |
| SITE | Matenge CDSS | DATE | 10/09/11 |

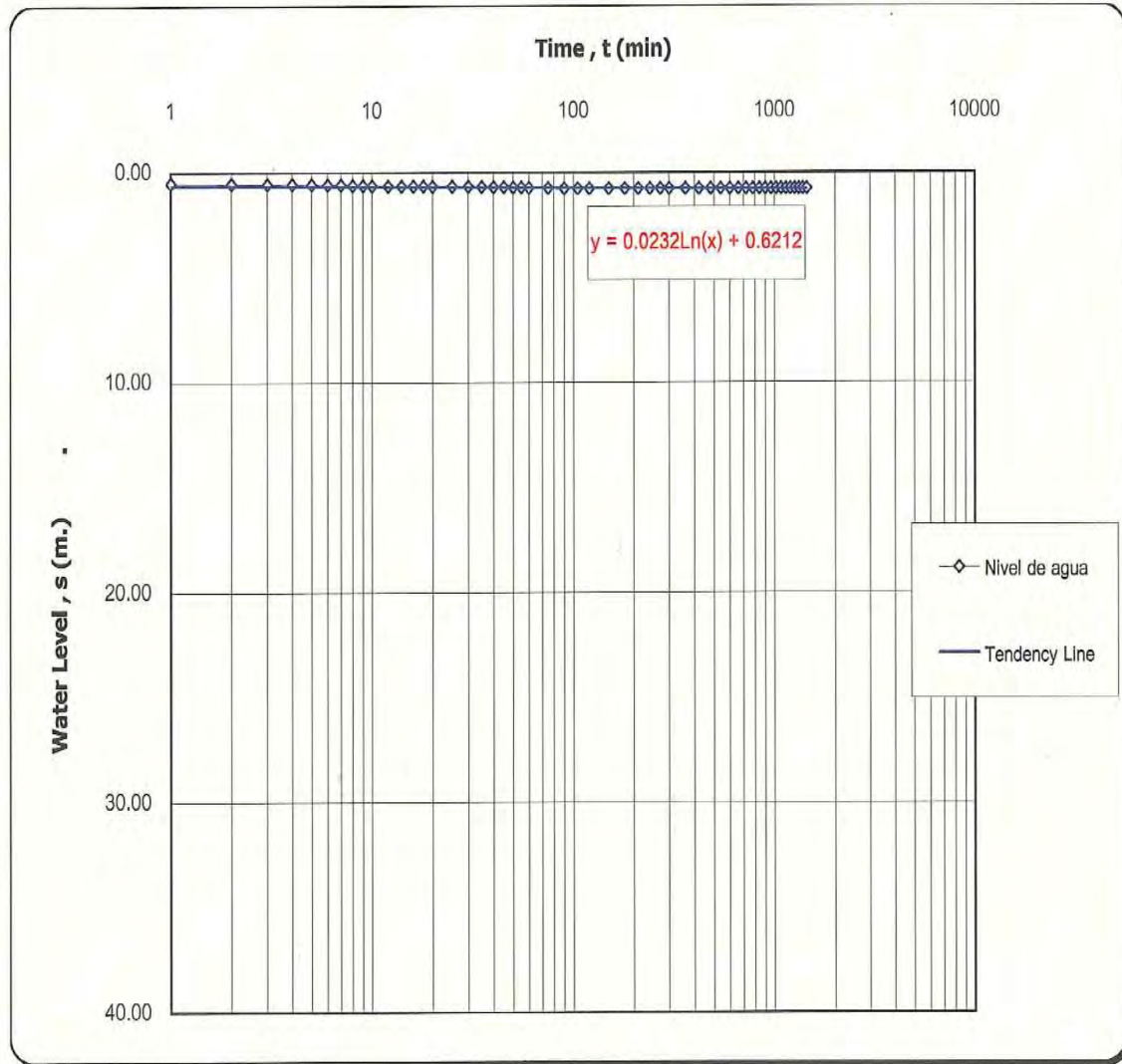


| STEP | DISCHARGE Q (m³/hr.) | DYNAMIC LEVEL N.D. (m.) | DRAWDOWN S (m.) | SPECIFIC CAPACITY Q/S (m³/hr/m.) |
|-------------|-------------------------|----------------------------|--------------------|-------------------------------------|
| FIRST(1st) | 0.72 | 8.81 | 0.17 | 4.2353 |
| SECOND(2nd) | 2.52 | 9.04 | 0.40 | 6.3000 |
| THIRD(3rd) | 3.60 | 9.31 | 0.67 | 5.3731 |
| FORTH(4th) | 4.50 | 9.40 | 0.76 | 5.9211 |
| FIFTH(5th) | | | | |

Figure-2 Matenje CDSS(No.1) Step Drawdown Test

CONSTANT DISCHARGE TEST

| | | | |
|--------------|---------------------------|--------------------|----------|
| PROJECT NAME | Malawi CDSS & TTC Phase 2 | | |
| BOREHOLE No. | Matenje No.1 | STATIC WATER LEVEL | 8.64 m. |
| SITE | Matenje CDSS | DATE | 12/09/11 |

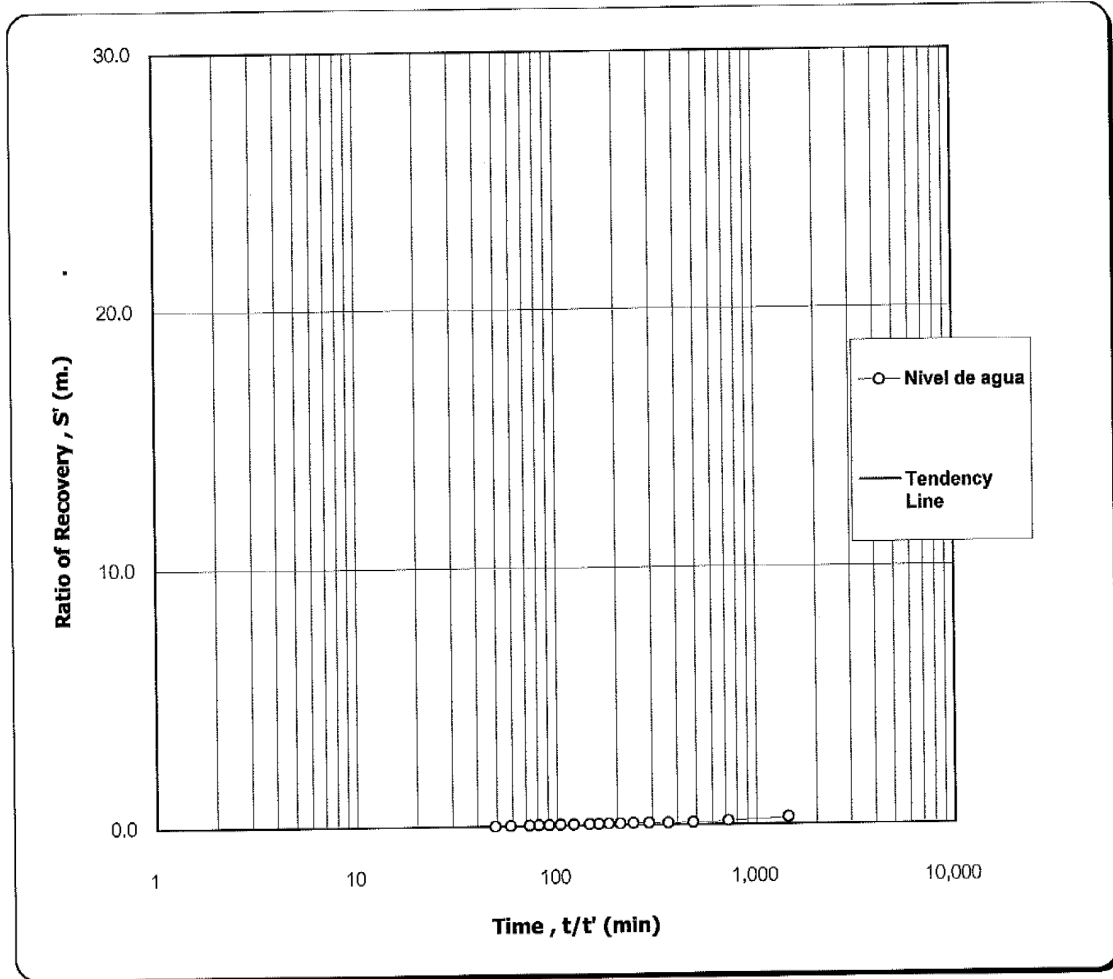


| DESCRIPTION | |
|--|---------------------------|
| Discharge, Q (m ³ /hr.) | 4.50 m ³ /hr. |
| water Level ,ΔS (m.) | 0.77 m. |
| Transmissivity , T (m ² /hr.) | |
| $T = (2.30 Q) / (4\pi\Delta S)$ | 1.070 m ² /hr. |
| Screen Length , b (m.) | 15.00 m. |
| Hydraulic Gradient , K (m./hr.) | |
| $K = T/b$ | 7.131E-02 m./hr. |

Figure-3 Matenje CDSS(No.1) Constant Discharge Test

WATER LEVEL RECOVERY TEST

| | | | |
|--------------|---------------------------|--------------------|----------|
| PROYECT NAME | Malawi CDSS & TTC Phase 2 | | |
| BOREHOLE No. | Matenje No.1 | STATIC WATER LEVEL | 8.64 m. |
| SITE | Matenje CDSS | DATE | 13/09/11 |



| DESCRIPTION | |
|---|--------------------------|
| Discharge, Q (m ³ /hr.) | 4.50 m ³ /hr. |
| Water Level, ΔS (m.) | 0.77 m. |
| Transmissivity, T (m ² /hr.) | 1.07 m ² /hr. |
| $T = (2.30 Q)/(4\pi\Delta S)$ | |
| Screen Length, b (m.) | 15.00 m. |
| Hydraulic Gradient, K (m./hr.) | 7.131E-02 m./hr. |
| $K = T/b$ | |

Figure-4 Matenje CDSS(No.1) Water Level Recovery Test

Table-1 Matenje CDSS(No.1)Water Quality Test

FORM No. WQPC 12/1



MINISTRY OF AGRICULTURE, IRRIGATION & WATER DEVELOPMENT

WATER QUALITY TEST RESULTS

| | | |
|--|---|--|
| LAB No. | 680 | |
| DATE SAMPLED | 11/09/2011 | |
| WATER RESOURCE UNIT | | |
| MAP SHEET/GRID REF. | | |
| SOURCE TYPE/LOCATION | MATENJE COMMUNITY DAY SECONDARY SCHOOL BOREHOLE, T/A KHOMBEDZA SALIMA | MALAWI STANDARDS FOR BOREHOLE WATER (MS733:2005) |
| pH Value | 7.20 | 6.0-9.5 |
| CONDUCTIVITY ($\mu\text{s}/\text{cm}$ at 25 °C) | 1, 170 | 3, 500 |
| TOTAL DISSOLVED SOLIDS, mg/l | 608 | 2, 000 |
| CARBONATE (as CO_3^{2-}), mg/l | 48 | - |
| BICARBONATE (as HCO_3^{2-}), mg/l | 366 | - |
| CHLORIDE (as Cl ⁻), mg/l | 40.2 | 750 |
| SULPHATE (as SO_4^{2-}), mg/l | 92.1 | 800 |
| NITRATE (as NO_3^-), mg/l | 0.470 | 45 |
| FLUORIDE (as F ⁻), mg/l | 0.59 | 6.0 |
| SODIUM (as Na ⁺), mg/l | 57 | 500 |
| POTASSIUM (as K ⁺), mg/l | 11.5 | - |
| CALCIUM (as Ca ⁺⁺), mg/l | 112 | 250 |
| MAGNESIUM (as Mg ⁺⁺), mg/l | 29.2 | 200 |
| IRON (Fe ⁺⁺), mg/l | <0.001 | 3.0 |
| TOTAL HARDNESS (as CaCO ₃), mg/l | 399 | 800 |
| TOTAL ALKALINITY (as CaCO ₃), mg/l | 380 | - |
| SILICA (as SiO ₂) mg/l | 37 | - |
| TURBIDITY, NTU | 12 | 25 |
| SUSPENDED SOLIDS, mg/l | 8 | - |
| faecal coliform, Count/100ml | 110 | 50 |

ANALYSIS CARRIED OUT BY CENTRAL WATER LABORATORY

Table-2 Matenje CDSS(No.1)Water Quality Test (2nd)

Table 1: Bacteriological Test Results of water samples from boreholes at Matenje and Luwaladzi Community Day Secondary Schools in Salima and Nkhotakota Districts, respectively

| No. | Sample source/location | Bacteria Type enumerated, counts/100 ml | |
|-----|---|---|--------------------------|
| | | Faecal coliform (FC) | Faecal streptococci (FS) |
| 1 | Matenje Community Day Secondary School (CDSS), Salima | 0 | 0 |
| 2 | Luwaladzi Community Day Secondary School (CDSS), Nkhotakota | 0 | 0 |

| | |
|---|--|
|  |  |
| <p>1. Matenje CDSS Drilling Rig at Drilling Site (Matenje No.1)</p> | <p>2. Matenje CDSS Drilled Geological Samples each 1m (Matenje No.1)</p> |
|  |  |
| <p>3. Matenje Town near Matanje CDSS (September 2011)</p> | <p>4. Matenje CDSS Test Drilling No.1</p> |
|  |  |
| <p>5. Matenje CDSS (Matenje No.1 drilled 30m & under Development)</p> | <p>6. Matenje CDSS (Matenje No.1 Pumping Test)</p> |

Figure-5 Matenje CDSS(No.1) Photo(2011. Sep)

2. Liwaladzi CDSS

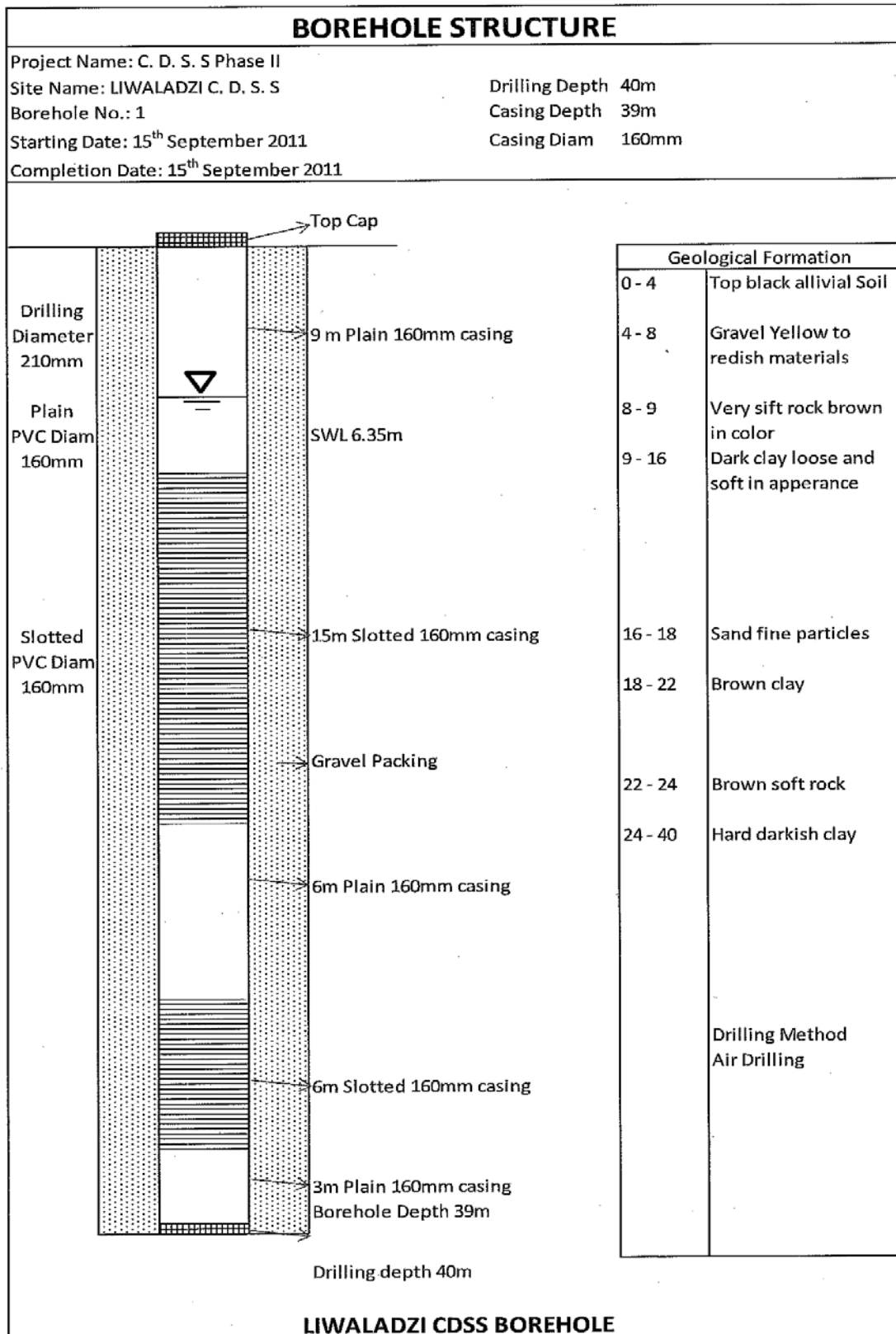
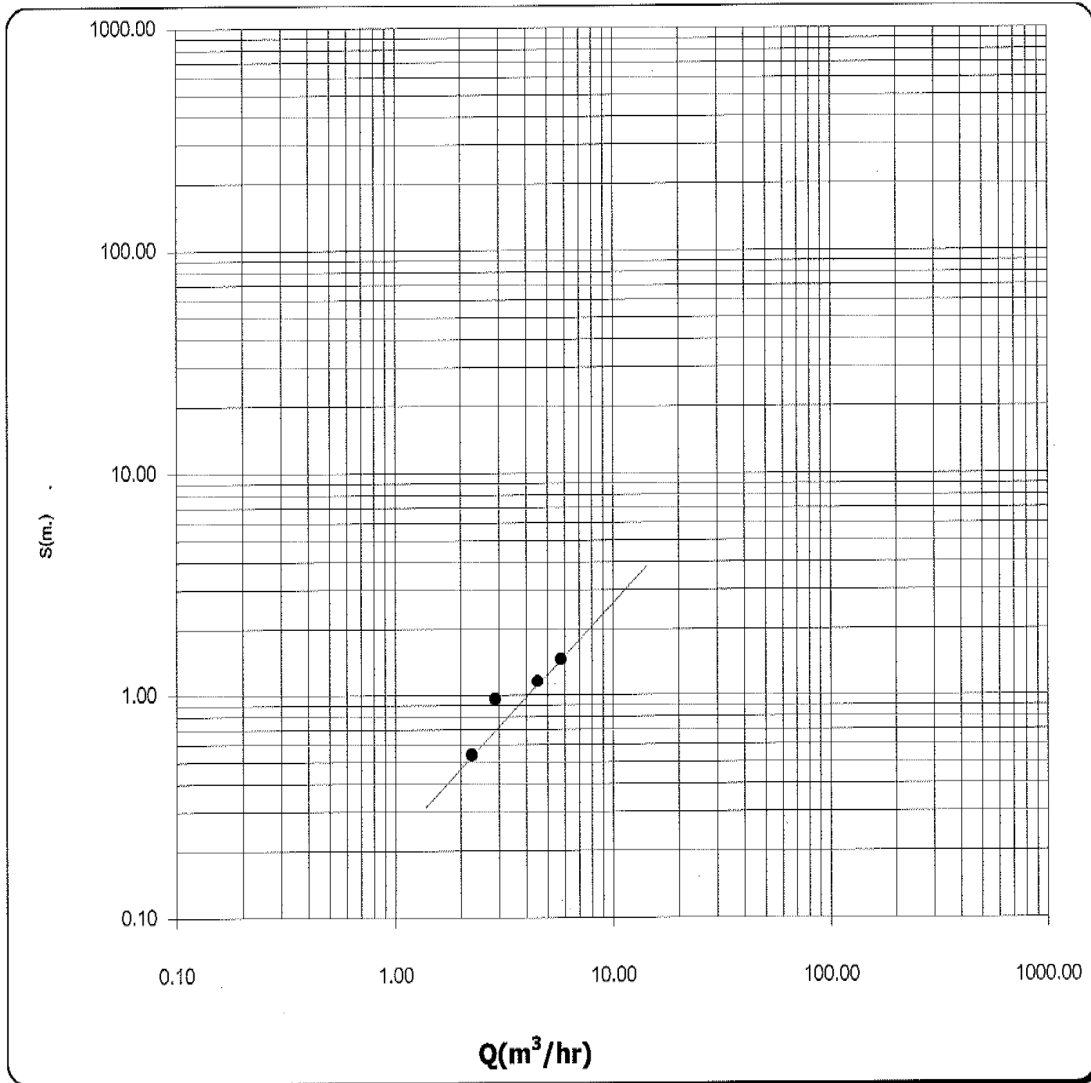


Figure-6 Liwaladzi CDSS (No.1) Borehole Structure

STEP DRAWDOWN TEST

| | | | |
|--------------|----------------------|--------------------|----------|
| PROJECT NAME | Malawi CDSS Phase II | | |
| BOREHOLE No. | Liwaladzi No.1 | STATIC WATER LEVEL | 6.35 m. |
| SITE | Liwaladzi CDSS | DATE | 16/09/11 |

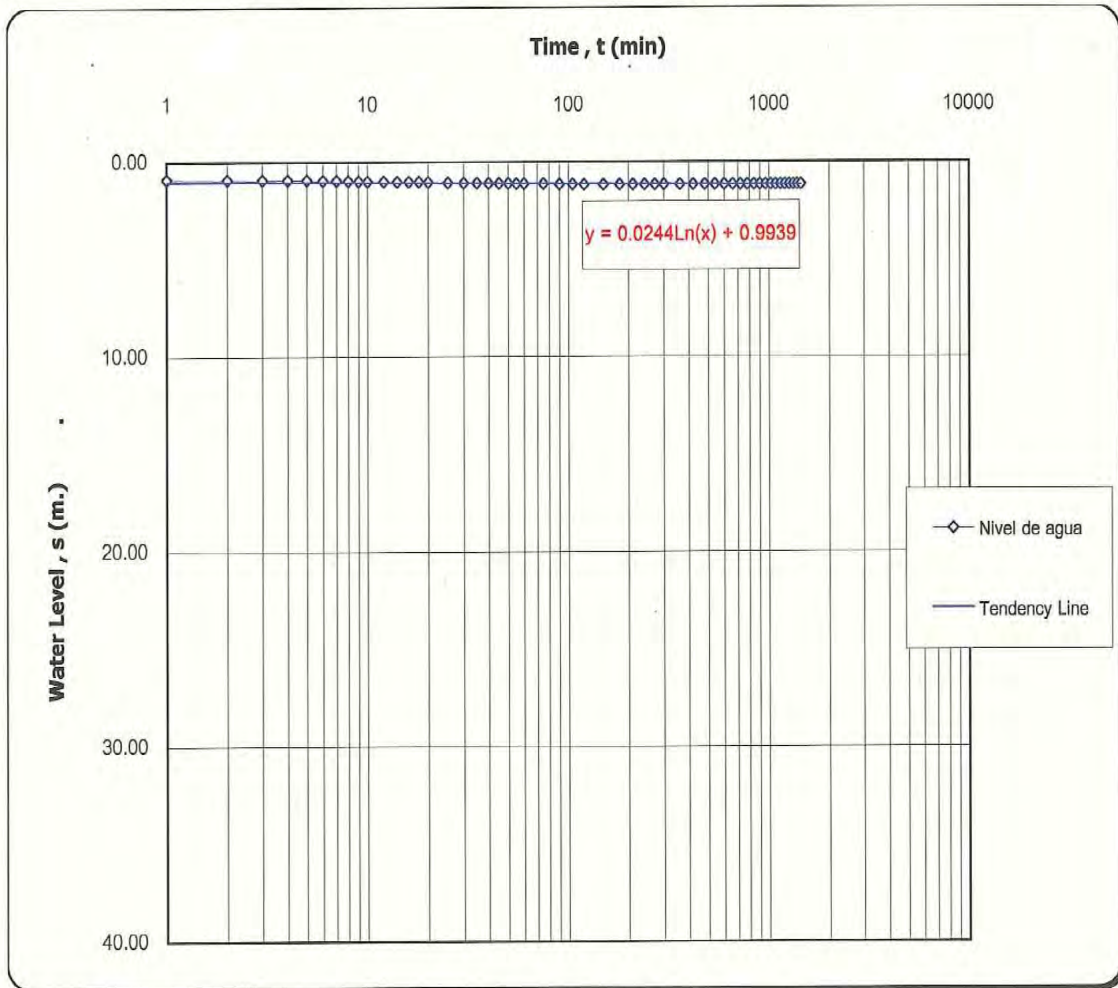


| STEP | DISCHARGE Q (m³/hr.) | DYNAMIC LEVEL N.D. (m.) | DRAWDOWN S (m.) | SPECIFIC CAPACITY Q/S (m³/hr/m.) |
|-------------|-------------------------|----------------------------|--------------------|-------------------------------------|
| FIRST(1st) | 2.25 | 6.89 | 0.54 | 4.1667 |
| SECOND(2nd) | 2.88 | 7.31 | 0.96 | 3.0000 |
| THIRD(3rd) | 4.50 | 7.51 | 1.16 | 3.8793 |
| FORTH(4th) | 5.76 | 7.82 | 1.47 | 3.9184 |
| FIFTH(5th) | | | | |

Figure-7 Liwaladzi CDSS (No.1) Step Drawdown Test

CONSTANT DISCHARGE TEST

| | | | |
|--------------|----------------------|--------------------|----------|
| PROYECT NAME | Malawi CDSS Phase II | | |
| BOREHOLE No. | Liwaladzi No.1 | STATIC WATER LEVEL | 6.35 m. |
| SITE | Liwaladzi CDSS | DATE | 17/09/11 |

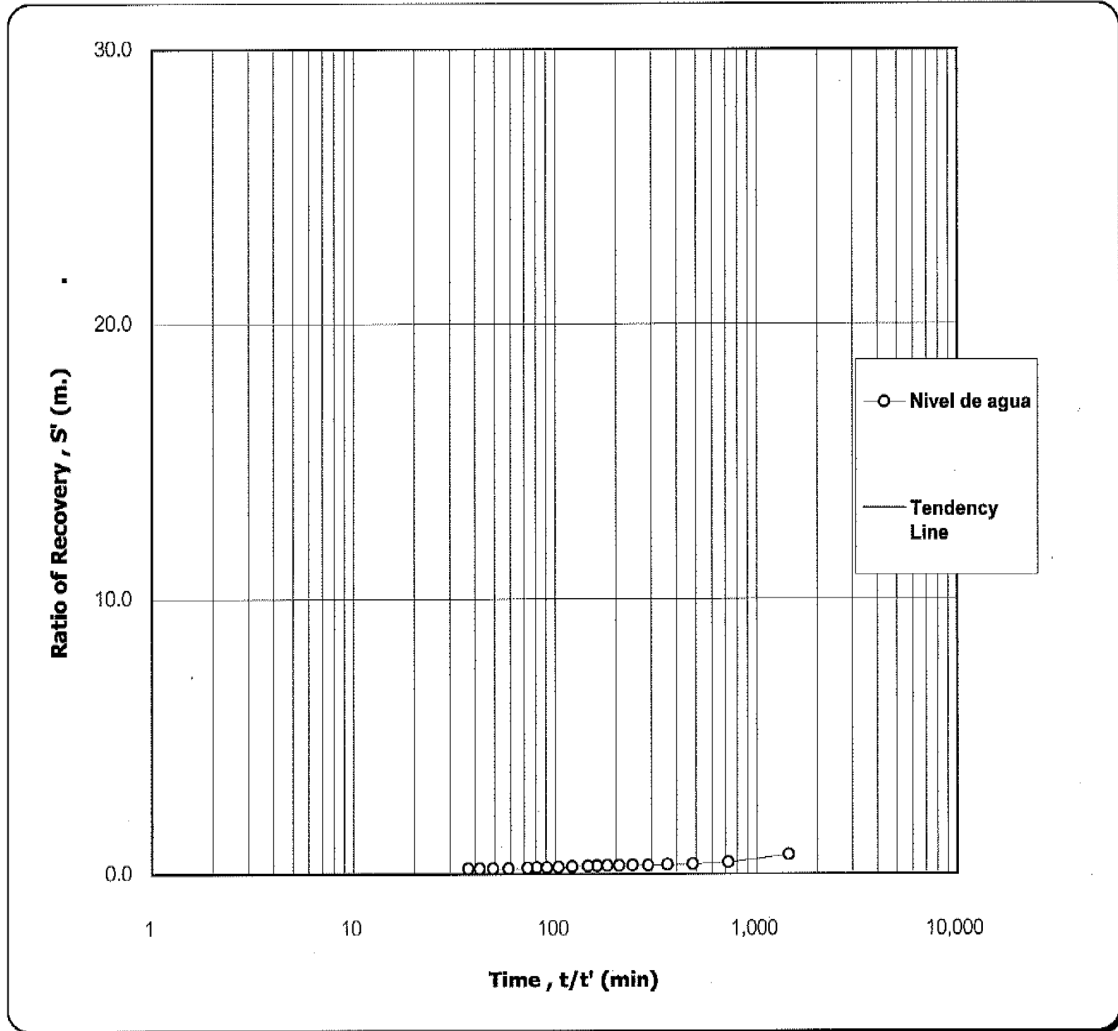


| DESCRIPTION | |
|--|---------------------------|
| Discharge, Q (m ³ /hr.) | 4.50 m ³ /hr. |
| water Level ,ΔS (m.) | 1.17 m. |
| Transmissivity , T (m ² /hr.) | |
| $T = (2.30 Q) / (4\pi\Delta S)$ | 0.704 m ² /hr. |
| Screen Length , b (m.) | 21.00 m. |
| Hydraulic Gradient , K (m./hr.) | |
| $K = T/b$ | 3.352E-02 m./hr. |

Figure-8 Liwaladzi CDSS (No.1) Constant Discharge Test

WATER LEVEL RECOVERY TEST

| | | | |
|--------------|----------------------|--------------------|----------|
| PROYECT NAME | Malawi CDSS Phase II | | |
| BOREHOLE No. | Liwaladzi No.1 | STATIC WATER LEVEL | 6.35 m. |
| SITE | Liwaladzi CDSS | DATE | 18/09/11 |





| DESCRIPTION | |
|---|--------------------------|
| Discharge, Q (m ³ /hr.) | 4.50 m ³ /hr. |
| Water Level, ΔS (m.) | 1.15 m. |
| Transmissivity, T (m ² /hr.) | 0.72 m ² /hr. |
| $T = (2.30 Q) / (4\pi \Delta S)$ | 0.72 m ² /hr. |
| Screen Length, b (m.) | 21.00 m. |
| Hydraulic Gradient, K (m./hr.) | 3.411E-02 m./hr. |
| $K = T/b$ | 3.411E-02 m./hr. |

Figure-9 Liwaladzi CDSS (No.1) Water Level Recovery Test

Table-3 Liwaladzi CDSS (No.1) Water Quality Test

FORM No. WQPC 12/1

MINISTRY OF AGRICULTURE, IRRIGATION & WATER DEVELOPMENT

WATER QUALITY TEST RESULTS

| | | |
|--|--|--|
| LAB No. | 680 | |
| DATE SAMPLED | 17/09/2011 | |
| WATER RESOURCE UNIT | | |
| MAP SHEET/GRID REF. | | |
| SOURCE TYPE/LOCATION | LUWALAZI COMMUNITY DAY SECONDARY SCHOOL BOREHOLE, T/A KANYENDA NKHOTAKOTA DISTRICT | MALAWI STANDARDS FOR BOREHOLE WATER (MS733:2005) |
| pH Value | 6.11 | 6.0-9.5 |
| CONDUCTIVITY ($\mu\text{s}/\text{cm}$ at 25 °C) | 112 | 3, 500 |
| TOTAL DISSOLVED SOLIDS, mg/l | 86 | 2, 000 |
| CARBONATE (as CO_3^{2-}), mg/l | 0.00 | - |
| BICARBONATE (as HCO_3^{2-}), mg/l | 42 | - |
| CHLORIDE (as Cl^-), mg/l | 8.7 | 750 |
| SULPHATE (as SO_4^{2-}), mg/l | 6.0 | 800 |
| NITRATE (as NO_3^-), mg/l | 0.026 | 45 |
| FLUORIDE (as F^-), mg/l | 0.37 | 6.0 |
| SODIUM (as Na^+), mg/l | 7.0 | 500 |
| POTASSIUM (as K^+), mg/l | 2.0 | - |
| CALCIUM (as Ca^{++}), mg/l | 8.0 | 250 |
| MAGNESIUM (as Mg^{++}), mg/l | 4.0 | 200 |
| IRON (Fe^{++}), mg/l | 0.01 | 3.0 |
| TOTAL HARDNESS (as CaCO_3), mg/l | 36 | 800 |
| TOTAL ALKALINITY (as CaCO_3), mg/l | 34 | - |
| SILICA (as SiO_2), mg/l | 41 | - |
| TURBIDITY, NTU | 2.0 | 25 |
| SUSPENDED SOLIDS, mg/l | <0.10 | - |
| Faecal coliform, Count/100ml | 40 | 50 |

ANALYSIS CARRIED OUT BY CENTRAL WATER LABORATORY

Table-4 Liwaladzi CDSS (No.1) Water Quality Test(2nd)

Table 1: Bacteriological Test Results of water samples from boreholes at Matenje and Luwaladzi Community Day Secondary Schools in Salima and Nkhotakota Districts, respectively

| No. | Sample source/location | Bacteria Type enumerated, counts/100 ml | |
|-----|---|---|--------------------------|
| | | Faecal coliform (FC) | Faecal streptococci (FS) |
| 1 | Matenje Community Day Secondary School (CDSS), Salima | 0 | 0 |
| 2 | Luwaladzi Community Day Secondary School (CDSS), Nkhotakota | 0 | 0 |







| | |
|--|---|
|  |  |
| <p>1. Liwaladzi CDSS Drilling Point (Matenje No.1 together with Head Teacher)</p> | <p>2. Liwaladzi CDSS Drilled by Mud Surculation Method (Lilawadzi No.1)</p> |
|  |  |
| <p>3. Liwaladzi No.1 installed Screen & Casing (September 2011)</p> | <p>4. Liwaladzi No.1 Pumping Test (September 2011)</p> |
|  |  |
| <p>5. Liwaladzi CDSS , Liwaladzi No.1 (Village Family taking Water from Pumping Test)</p> | <p>6. Liwaladzi CDSS, Liwaladzi No.1 (Water Quality Sampling from Lilongwe Laboratory, Ministry of Agriculture, Irrigation and Water Development)</p> |

Figure-10 Liwaladzi CDSS (No.1) Photo

3. Ezondweni CDSS

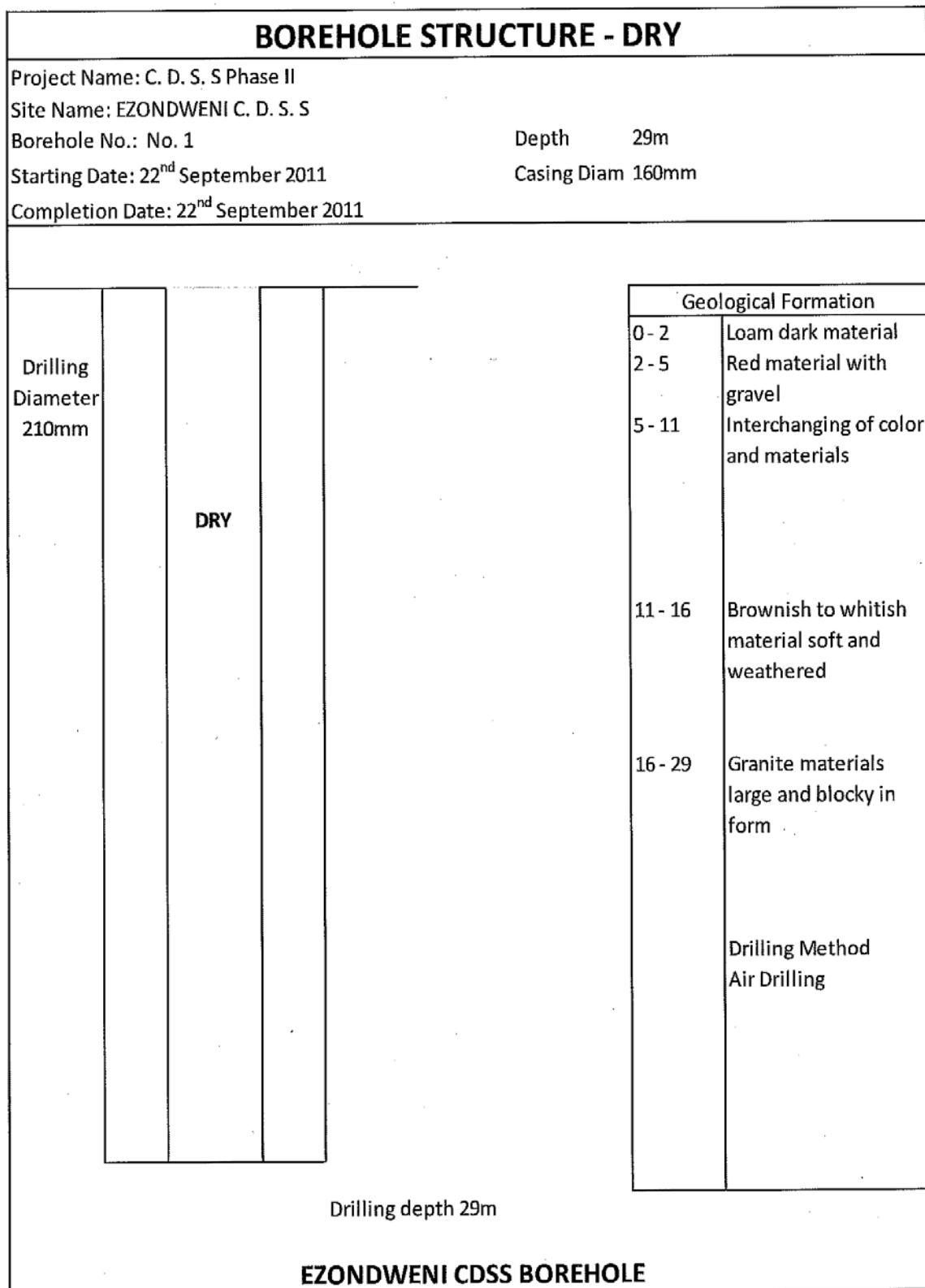


Figure-11 Ezondweni CDSS (No.1) Borehole Structure

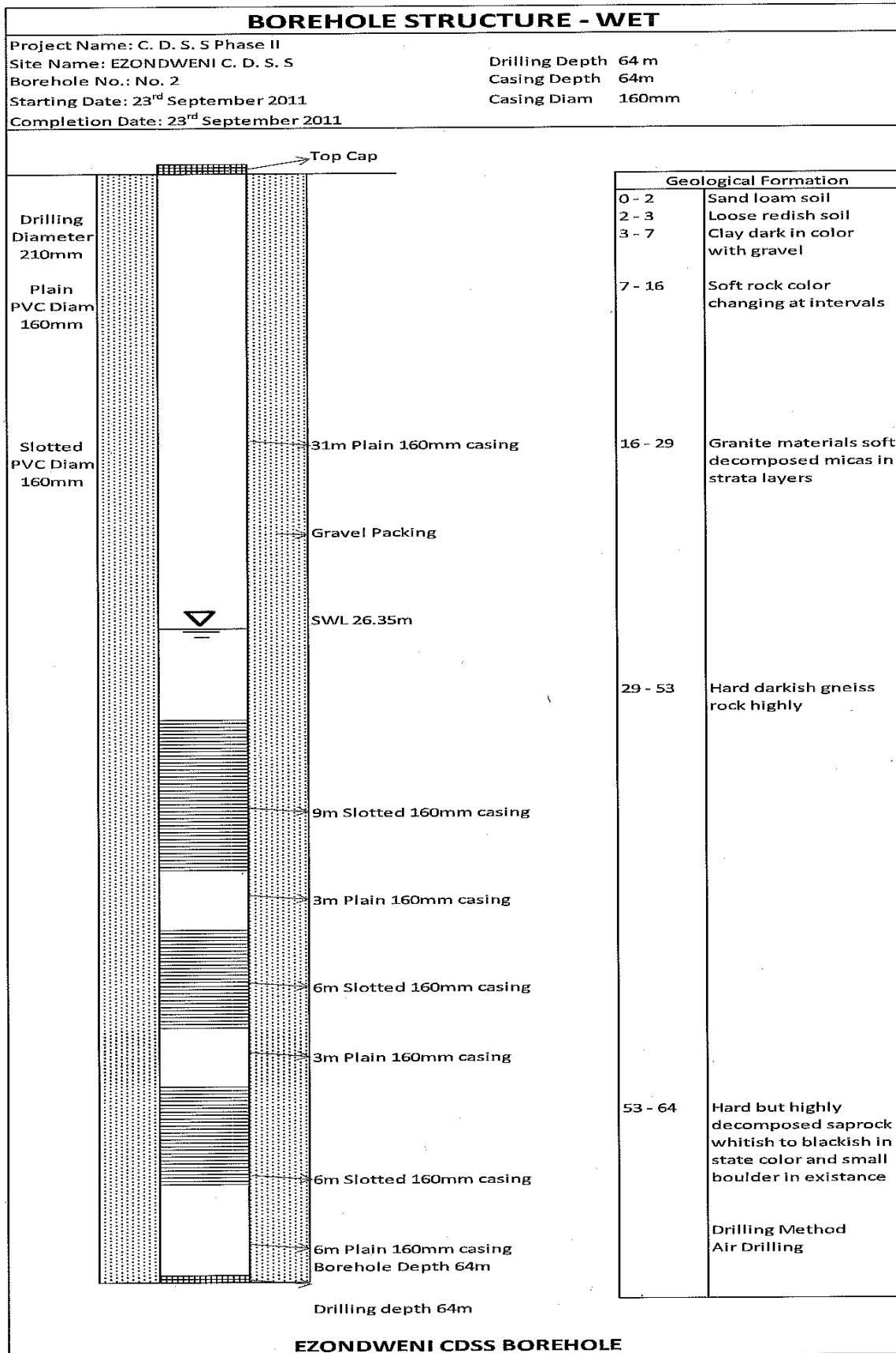
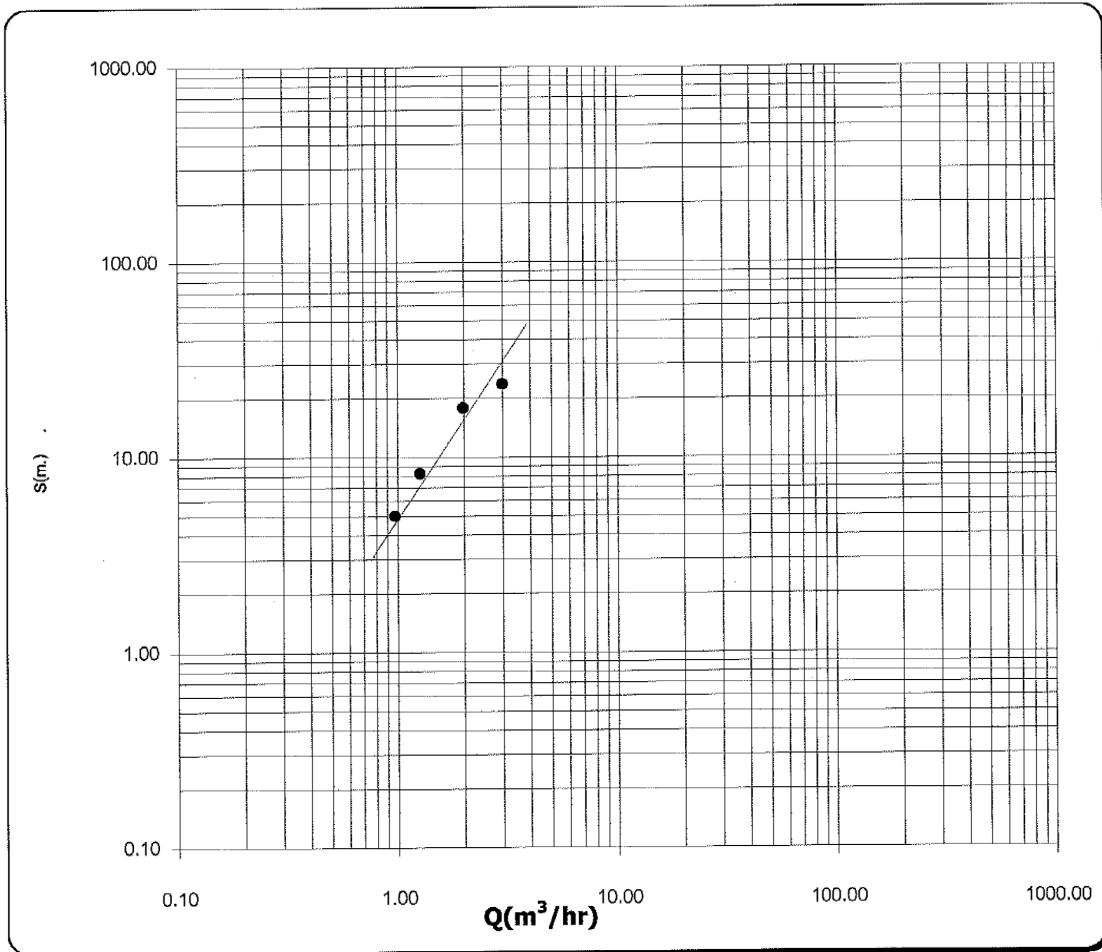


Figure-12 Ezondweni CDSS (No.2) Borehole Structure

STEP DRAWDOWN TEST

| | | | |
|--------------|---------------------------|--------------------|----------|
| PROYECT NAME | Malawi CDSS & TTC Phase 2 | | |
| BOREHOLE No. | Ezondweni No.2 | STATIC WATER LEVEL | 26.35 m. |
| SITE | Ezondweni CDSS | DATE | 24/09/11 |

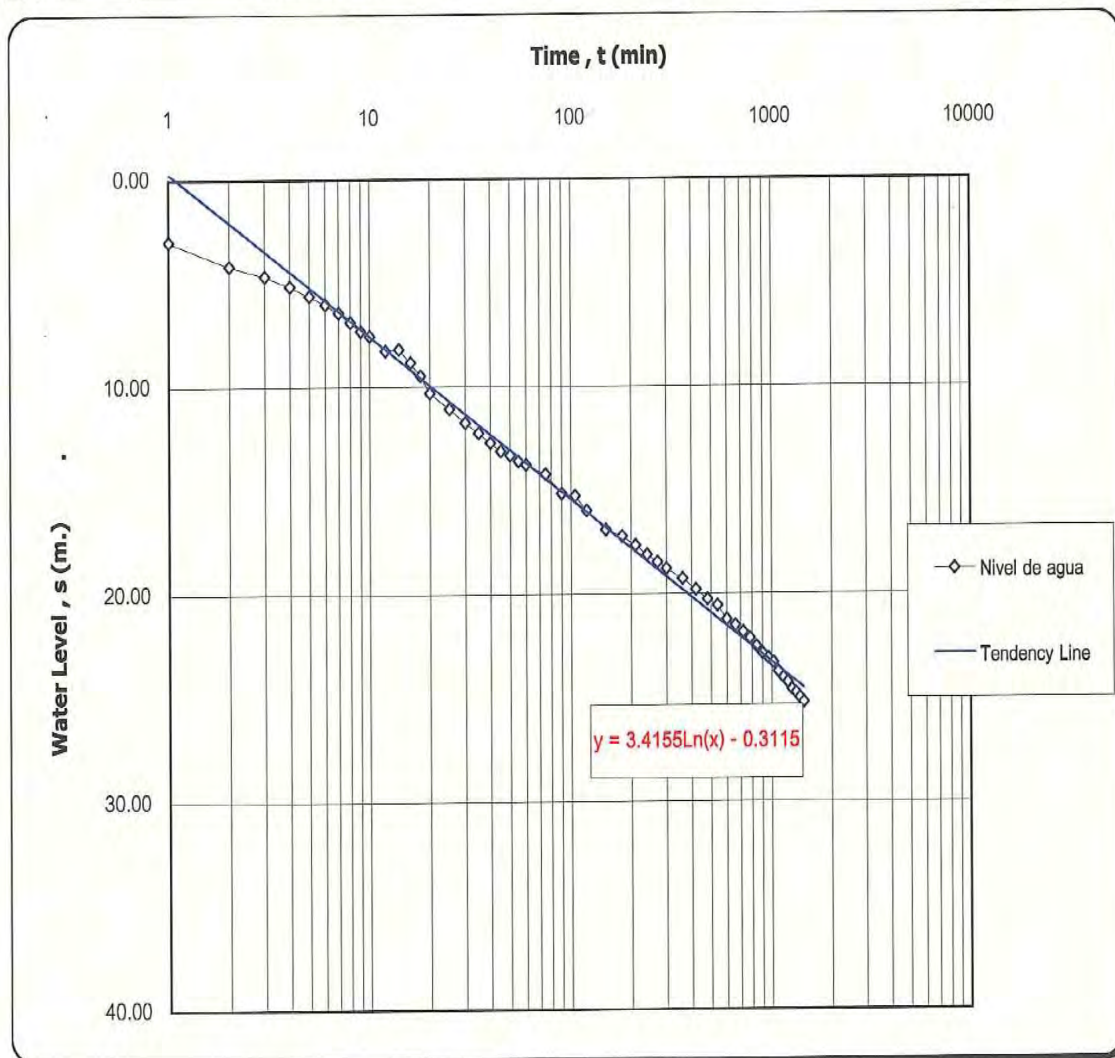


| STEP | DISCHARGE Q (m³/hr.) | DYNAMIC LEVEL N.D. (m.) | DRAWDOWN S (m.) | SPECIFIC CAPACITY Q/S (m³/hr/m.) |
|-------------|-------------------------|----------------------------|--------------------|-------------------------------------|
| FIRST(1st) | 0.97 | 31.37 | 5.02 | 0.1936 |
| SECOND(2nd) | 1.26 | 34.60 | 8.25 | 0.1527 |
| THIRD(3rd) | 1.98 | 44.22 | 17.87 | 0.1108 |
| FORTH(4th) | 2.99 | 50.08 | 23.73 | 0.1259 |
| | | | | |

Figure-13 Ezondweni CDSS (No.2) Step Drawdown Test

CONSTANT DISCHARGE TEST

| | | | |
|--------------|---------------------------|--------------------|----------|
| PROJECT NAME | Malawi CDSS & TTC Phase 2 | | |
| BOREHOLE No. | Ezondweni No.2 | STATIC WATER LEVEL | 26.35 m. |
| SITE | Ezondweni CDSS | DATE | 26/09/11 |

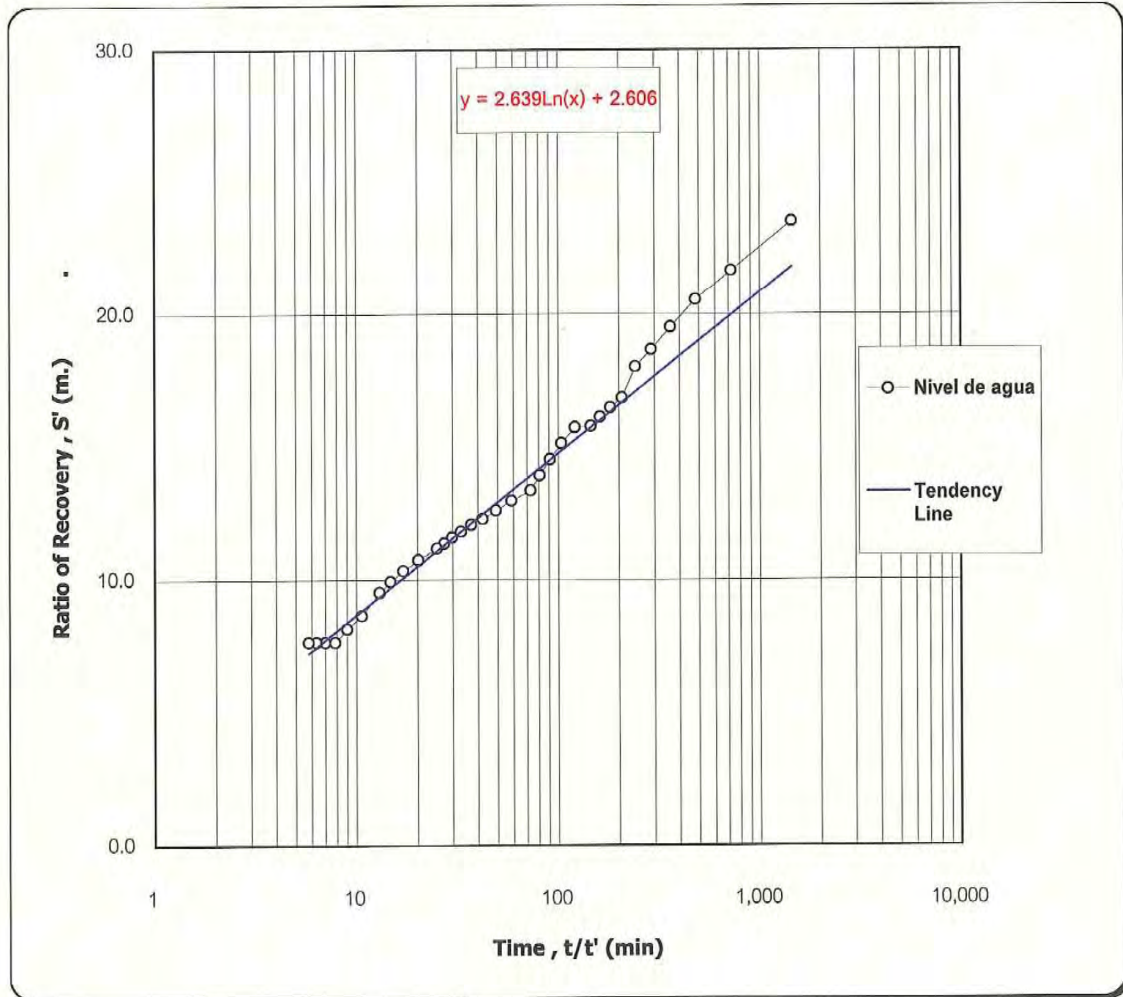


| DESCRIPTION | |
|--|---------------------------|
| Discharge, Q (m ³ /hr.) | 2.16 m ³ /hr. |
| water Level ,ΔS (m.) | 25.23 m. |
| Transmissivity , T (m ² /hr.) | |
| $T = (2.30 Q)/(4\pi\Delta S)$ | 0.016 m ² /hr. |
| Screen Length , b (m.) | 21.00 m. |
| Hydraulic Gradient , K (m./hr.) | |
| $K = T/b$ | 7.462E-04 m./hr. |

Figure-14 Ezondweni CDSS (No.2) Constant Discharge Test

WATER LEVEL RECOVERY TEST

| | | | |
|--------------|---------------------------|--------------------|----------|
| PROYECT NAME | Malawi CDSS & TTC Phase 2 | | |
| BOREHOLE No. | Ezondweni No.2 | STATIC WATER LEVEL | 26.35 m. |
| SITE | Ezondweni CDSS | DATE | 27/09/11 |



| DESCRIPTION | |
|---|--------------------------|
| Discharge, Q (m ³ /hr.) | 2.16 m ³ /hr. |
| Water Level, ΔS (m.) | 25.23 m. |
| Transmissivity, T (m ² /hr.) | |
| $T = (2.30 Q) / (4\pi\Delta S)$ | 0.02 m ² /hr. |
| Screen Length, b (m.) | 21.00 m. |
| Hydraulic Gradient, K (m./hr.) | |
| $K = T/b$ | 7.462E-04 m./hr. |

Figure-15 Ezondweni CDSS (No.2) Water Level Recovery Test

Table-5 Ezondweni CDSS (No.2) Water Quality Test

FORM No. WQPC 12/1



MINISTRY OF AGRICULTURE, IRRIGATION & WATER DEVELOPMENT

WATER QUALITY TEST RESULTS



| | | |
|--|---|--|
| LAB No. | 704 | |
| DATE SAMPLED | 29/09/2011 | |
| WATER RESOURCE UNIT | | |
| MAP SHEET/GRID REF. | | |
| SOURCE TYPE/LOCATION | IZONDWENI COMMUNITY DAY SECONDARY SCHOOL (CDSS) BOREHOLE T/A MTWALO MZIMBA DISTRICT | MALAWI STANDARDS FOR BOREHOLE WATER (MS733:2005) |
| pH Value | 6.30 | 6.0-9.5 |
| CONDUCTIVITY ($\mu\text{s}/\text{cm}$ at 25 °C) | 279 | 3, 500 |
| TOTAL DISSOLVED SOLIDS, mg/l | 180 | 2, 000 |
| CARBONATE (as CO_3^{2-}), mg/l | 0.00 | - |
| BICARBONATE (as HCO_3^{2-}), mg/l | 118 | - |
| CHLORIDE (as Cl^-), mg/l | 20.0 | 750 |
| SULPHATE (as SO_4^{2-}), mg/l | 6.70 | 800 |
| NITRATE (as NO_3^-), mg/l | 0.219 | 45 |
| FLUORIDE (as F^-), mg/l | <0.01 | 6.0 |
| SODIUM (as Na^+), mg/l | 16.0 | 500 |
| POTASSIUM (as K^+), mg/l | 2.4 | - |
| CALCIUM (as Ca^{++}), mg/l | 25.0 | 250 |
| MAGNESIUM (as Mg^{++}), mg/l | 9.0 | 200 |
| IRON (Fe^{++}), mg/l | <0.001 | 3.0 |
| TOTAL HARDNESS (as CaCO_3), mg/l | 99 | 800 |
| TOTAL ALKALINITY (as CaCO_3), mg/l | 97 | - |
| SILICA (as SiO_2), mg/l | 43 | - |
| TURBIDITY, NTU | 1.0 | 25 |
| SUSPENDED SOLIDS, mg/l | 0.9 | - |
| Faecal coliform, Count/100ml | 340 | Zero |

ANALYSIS CARRIED OUT BY CENTRAL WATER LABORATORY

Table-6 Ezondweni CDSS (No.2) Water Quality Test(2nd)

Table 1: Bacteriological Test Results of a water sample from borehole at the proposed site for Izondweni Community Day Secondary School in Mzimba

| No. | Sample source/location | Bacteria Type enumerated, counts/100 ml | |
|-----|---|---|--------------------------|
| | | Faecal coliform (FC) | Faecal streptococci (FS) |
| 1 | Proposed Site for Izondweni Community Day Secondary School (CDSS), Mzimba | 410 | 0 |

Table-7 Ezondweni CDSS (No.2) Water Quality Test(3rd)

Table 1: Bacteriological Test Results of a water sample from a Borehole at Izondweni Community Day Secondary School in Mzimba District

| No. | Sample source/location | Bacteria Type enumerated, counts/100ml | |
|-----|---|--|---------------------|
| | | Faecal coliform | Faecal streptococci |
| 1 | Izondweni Community Day Secondary School (CDSS), Mzimba | 0 | 0 |







| | |
|--|---|
|  |  |
| <p>1. Ezondweni CDSS Test Drilling (Ezondweni No.1 Unsuccessful Dryhole)</p> | <p>2. Ezondweni CDSS Drilled Ezondweni No.2 (Groundwater hit at 36m in depth)</p> |
|  |  |
| <p>3. Ezondweni No.2 Down The Hammer (DTH) Drilling Method (Success No.2, September 2011)</p> | <p>4. Ezondweni No.2 Pumping Test (Village Family taking Water from Pumping Test)</p> |
|  |  |
| <p>5. Ezondweni CDSS , Ezondweni No.2 Water Quality Sampling from Mzuzu Laboratory, Ministry of Agriculture, Irrigation & Water Development)</p> | <p>6. Ezondweni No.2 Water Guard for New Borehole and Closed (September 2011)</p> |

Figure-16 Ezondweni CDSS (No.1&No.2) Photo(2011. Sep)

4. Mpamba CDSS

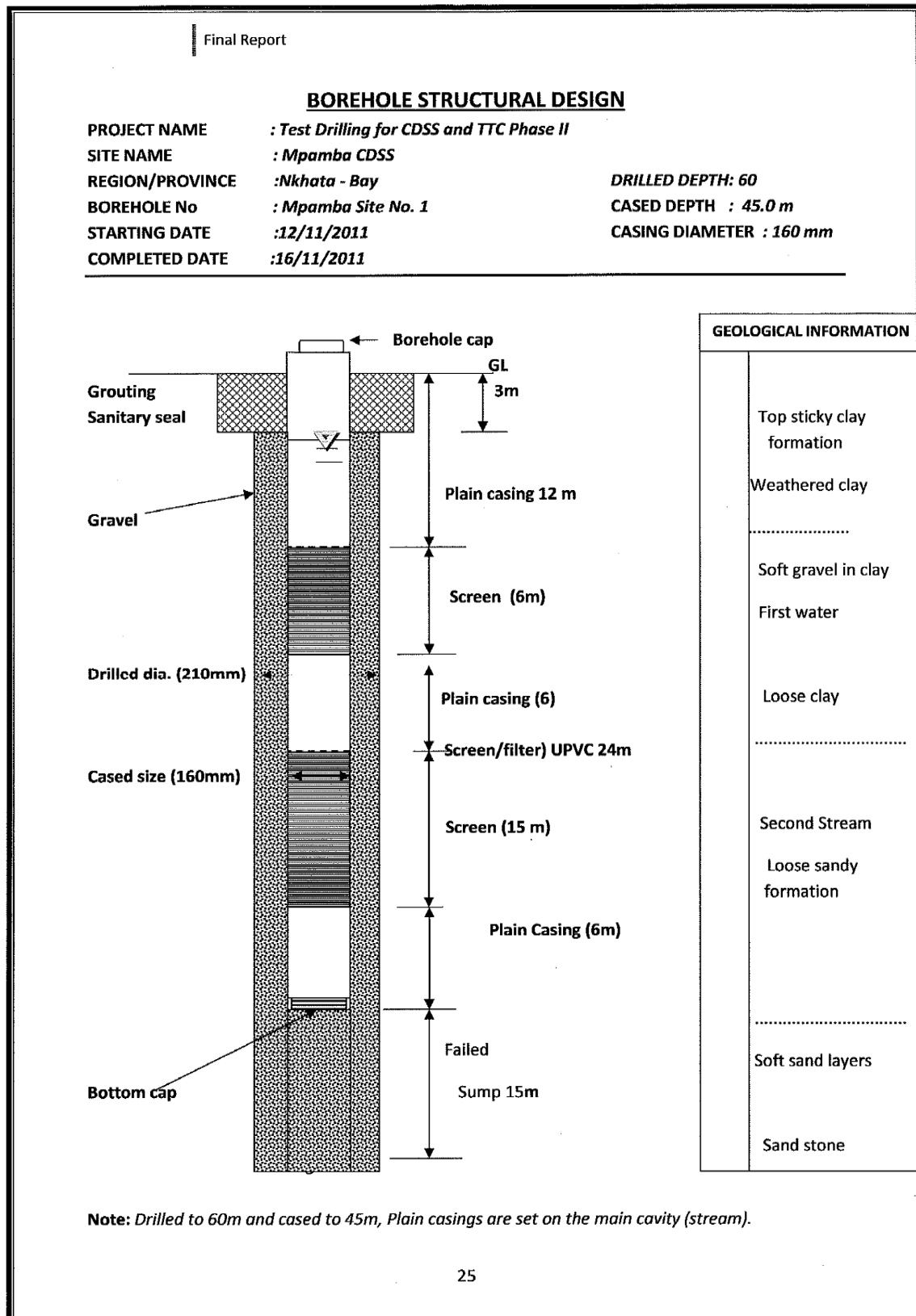


Figure-17 Mpamba CDSS (No.1) Borehole Structure

Table-8 Mpamba CDSS (No.1) Water Quality Test

Final Report

FORM No. WQPC 12/1



MINISTRY OF AGRICULTURE, IRRIGATION & WATER DEVELOPMENT

WATER QUALITY TEST RESULTS

| | | |
|--|--|---|
| LAB No. | 885 | |
| DATE SAMPLED | 28/11/2011 | |
| WATER RESOURCE UNIT | | |
| MAP SHEET/GRID REF. | | |
| SOURCE IDENTITY/LOCATION | MPAMBA COMMUNITY DAY SECONDARY SCHOOL BH No.... T/A TIMBILI, NKHATABAY DISTRICT | MALAWI DRINKING WATER STANDARDS FOR BOREHOLE WATER (MS733:2005) |
| pH Value | 5.60 | 6.0-9.5 |
| CONDUCTIVITY ($\mu\text{S}/\text{cm}$ at 25°C) | 40 | 3, 500 |
| TOTAL DISSOLVED SOLIDS, mg/l | 26 | 2, 000 |
| CARBONATE (as CO_3^{2-}), mg/l | 0.00 | - |
| BICARBONATE (as HCO_3^{2-}), mg/l | 10 | - |
| CHLORIDE (as Cl^-), mg/l | 6.0 | 750 |
| SULPHATE (as SO_4^{2-}), mg/l | 0.90 | 800 |
| NITRATE (as NO_3^-), mg/l | 0.017 | 100 |
| FLUORIDE (as F), mg/l | 0.21 | 3.0 |
| SODIUM (as Na^+), mg/l | 3.8 | 500 |
| POTASSIUM (as K^+), mg/l | 1.2 | - |
| CALCIUM (as Ca^{++}), mg/l | 2.0 | 250 |
| MAGNESIUM (as Mg^{++}), mg/l | 1.0 | 200 |
| IRON (Fe^{++}), mg/l | 0.21 | 3.0 |
| TOTAL HARDNESS (as CaCO_3), mg/l | 9.5 | 800 |
| TOTAL ALKALINITY (as CaCO_3), mg/l | 9.0 | - |
| SILICA (as SiO_2), mg/l | 9.0 | - |
| TURBIDITY, NTU | 0.80 | 25 |
| SUSPENDED SOLIDS, mg/l | <0.10 | 25 |
| <i>Faecal coliform</i> (FC), Count ml/100 ml | 480 | 50 |
| <i>Faecal streptococci</i> (FS), Count/100 ml | 0 | 0 |



Figure-18 Mpamba CDSS (No.1) Photo (2011. Nov)