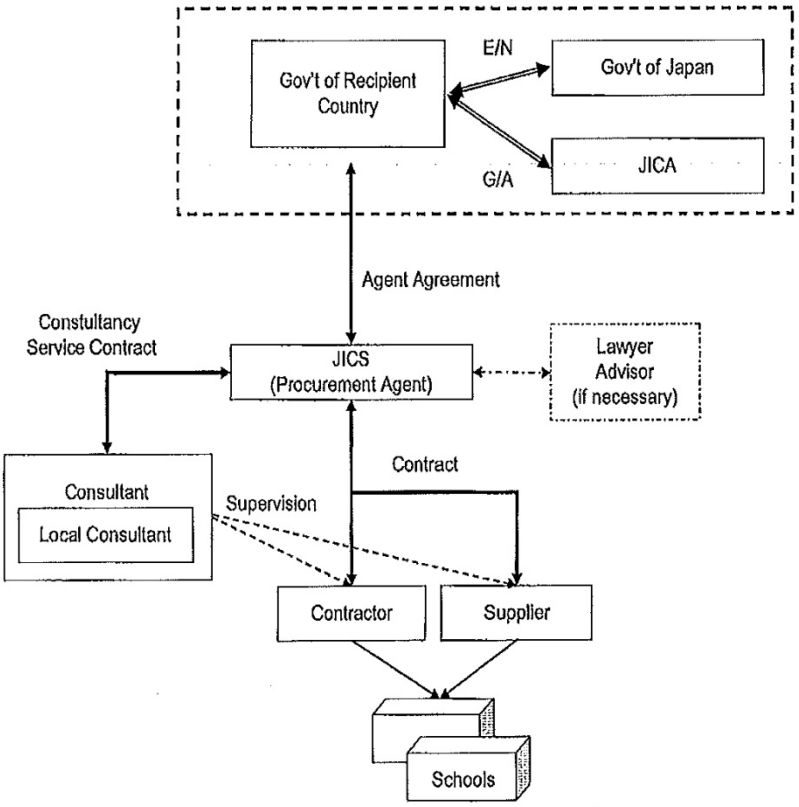
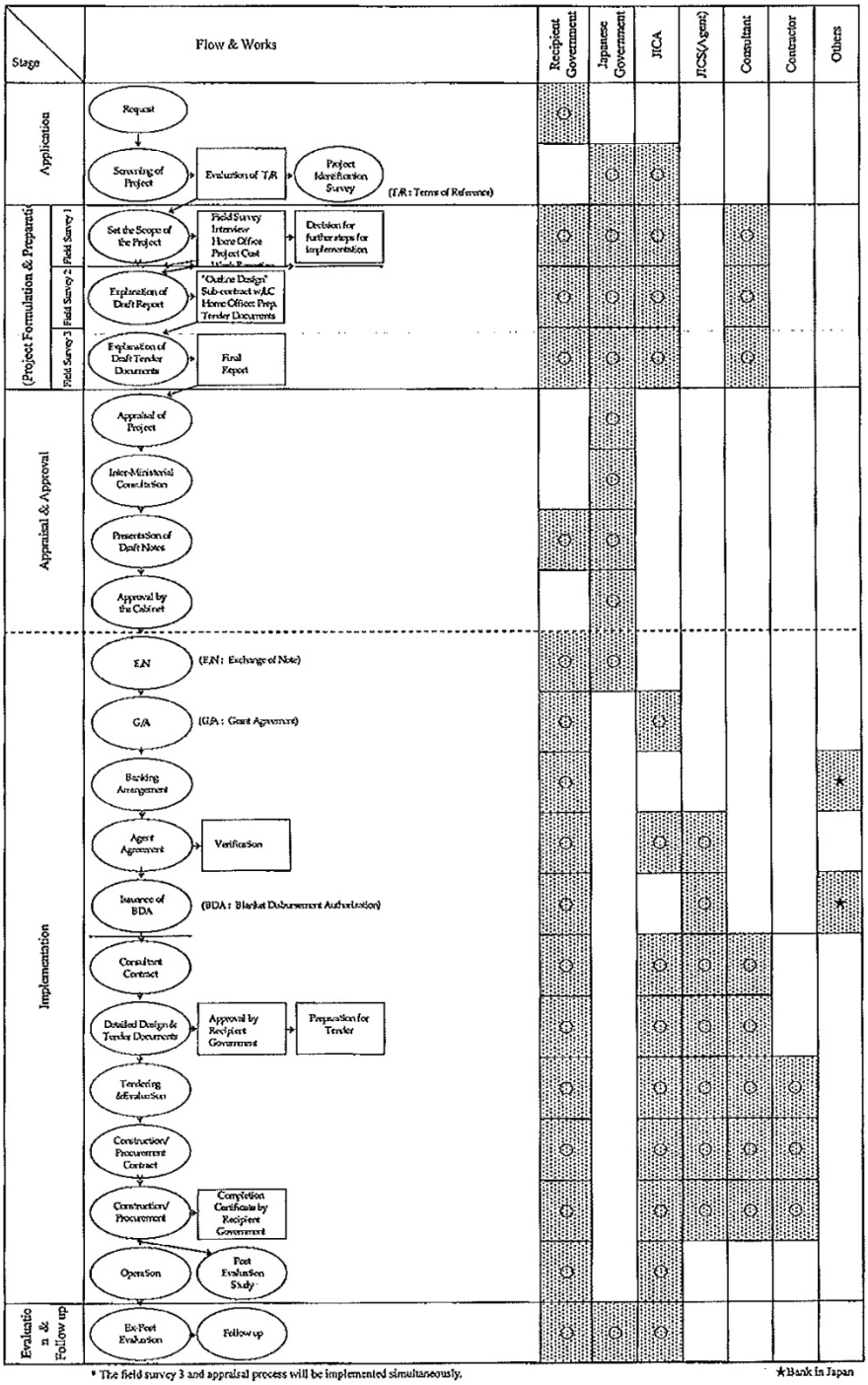
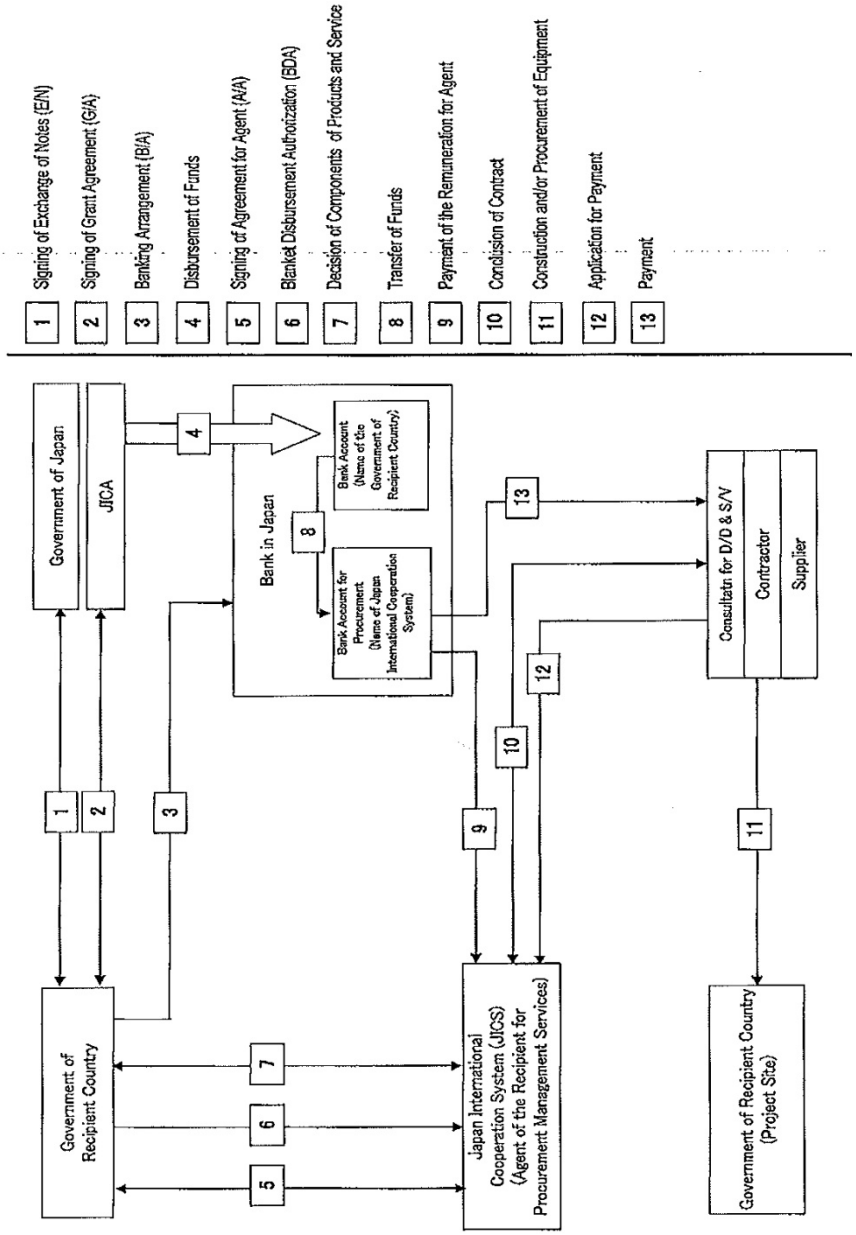
ANNEX 9 Implementation Flow of Japan's Grant Aid for Community Empowerment after E/N and G/A



ANNEX 10 Flow Chart of Japan's Grant Aid Procedures for Community Empowerment



ANNEX 11 Flow of Funds for Implementation under the Japan's Grant Aid for Community Empowerment



ANNEX 12 Major Undertaking to be Taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	To secure land		●
2	To clear level and reclaim the site when needed		●
3	To construct gates and fences in and around the site		●
4	To Construct the Parking lot		●
5	To construct roads		
	1) Within the site	●	
	2) Outside the site		●
6	To construct the building	●	
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities		
	1) Electricity		
	a. The distributing line to the site		●
	b. The drop wiring and internal wiring within the site	●	
	c. The main circuit breaker and transformer	●	
	2) Water Supply		
	a. The city water distribution main to the site		●
	b. The supply system within the site (receiving and elevated tanks)	●	
	3) Drainage		
	a. The city drainage main (for storm sewer and others to the site)		●
	b. The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	●	
	4) Gas Supply		
	a. The city gas main to the site		●
	b. The gas supply system within the site	●	
	5) Telephone System		
	a. The telephone trunk line to the main distribution frame/panel (MDF) of the building		●
	b. The MDF and the extension after the frame/panel	●	
	6) Furniture and Equipment		
	a. General furniture		●
	b. Project equipment	●	
8	To bear the commissions to the Japanese bank for banking services based upon B/A		●
9	To ensure prompt customs clearance and to assist internal transportation in the recipient country and to assist internal transportation therein of the products		●
10	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the Components as well as the employment of the Agent be exempted/be borne by its designated authority without using the Grant and its accrued interest.		●
11	To accord Japanese nationals and / or nationals of third countries, including such nationals employed by the Agent, whose services may be required in connection with the supply of the Components such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work (The term "nationals" whenever used in the G/A means Japanese physical persons or Japanese juridical persons controlled by Japanese physical persons in the case of Japanese nationals, and physical or juridical persons of third countries in the case of nationals of third countries.)		●
12	To ensure that the Facilities and the Components be maintained and used properly and effectively for the implementation of the Project		●
13	To bear all the expenses, other than those covered by the Grant and its accrued interest, necessary for the implementation of the Project		●
14	To give due environmental and social consideration in the implementation of the Project		●

(B/A: Banking Arrangement, G/A: Grant Agreement)

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4-2. 概略設計概要説明調査

MINUTES OF DISCUSSIONS
ON
PREPARATORY SURVEY
ON
THE PROJECT FOR CONSTRUCTION OF A TEACHER TRAINING COLLEGE FOR SECONDARY SCHOOL TEACHERS IN LILONGWE
IN
THE REPUBLIC OF MALAWI

From February 2011, Japan International Cooperation Agency (hereinafter referred to as "JICA") had conducted a field survey as a part of the Preparatory Survey on the Project for Construction of a Teacher Training College for Secondary School Teachers in Lilongwe (hereinafter referred to as "the Project") in the Republic of Malawi (hereinafter referred to as "Malawi"). Based on the results of the field survey and subsequent technical examinations conducted in Japan, JICA decided to conduct another field survey as a part of the Preparatory Survey on the Project and send the Survey Team (hereinafter referred to as "the Team"), which is headed by Mr. Toru SHIMODA, Senior Representative, JICA Malawi Office, and is scheduled to stay in the country from December 10, 2012 to December 17, 2012.

The Team had a series of discussions with the Malawian officials concerned and conducted the field survey.

In the course of discussions and the field survey, both parties confirmed the main items described on the attached sheets.

Lilongwe, Malawi
December 14, 2012

Dr. Macphail Magwira
Secretary for Education, Science and Technology
Ministry of Education, Science and Technology,
The Republic of Malawi

Mr. Toru SHIMODA
Leader
Preparatory Survey Team
Japan International Cooperation Agency

ATTACHMENT

1. **Contents of the Draft Report**
The Malawian side agreed and accepted in principle the contents of the draft report as explained by the Team.

2. **Components of the Project**
Both sides agreed on the list of components and facilities to be covered by the Project as shown in ANNEX-1. The Malawian side requested expansion of Multi-purpose hall/Kitchen block for additional space of 100 people or more. The Malawian side agreed that the Japanese side would make a final decision on this matter through further study in Japan.

The Malawian side understood there was a possibility to adjust the volume of components as a result of the tenders. In case the volume of components should be reduced, in accordance with the order of priority shown in ANNEX-1. In case fund remaining occurred as a result of the tenders, staff houses will be considered as one of options for an additional component of the Project.

3. **Japan's Grant Aid Scheme and Major Undertakings**
The Malawian side understood the Japan's Grant Aid Scheme, and the Malawian side assured that it shall take necessary measures as indicated in ANNEX-2 of this Minutes of Discussions, which was the same as described in ANNEX-12 of the Minutes of Discussions signed by both parties on February 28, 2011. Particularly, the Malawian side ensured that it would complete to acquire any necessary approvals for construction before starting of construction work and to set up branch pipe from city water main to the site during the construction. The obligations to be covered by the Government of Malawi are described in ANNEX-3.

4. **Final Report of the Preparatory Survey**
JICA will finalize the report in accordance with the result of discussions and forward it to the Government of Malawi soon after the Government of Japan approves the Project officially.

5. **Project Cost Estimation**
The Malawian side understood that the Project cost estimation described in ANNEX-4 was not final at this stage and would be set and approved by the Government of Japan after thorough examinations.

6. **Confidentiality of the Information Related to the Project**
Both sides confirmed that all information related to the Project including design documents of facilities, furniture and equipment shall not be released to any outside parties before concluding all contracts for the Project. Furthermore, both sides agreed that the estimated cost of the Project as described in ANNEX-4 shall never be duplicated or released to any outside parties before concluding all contracts for the Project.

7. **Other Relevant Issues**

7-1. Water Supply
In order to cover shortage of water supply from the boreholes found in this survey, the Malawian side agreed to set up branch pipe from city water main to the site during the construction.
Malawian side requested the additional boreholes due to instability of public water supply.

7-2. Allocation of Necessary Budget and Personnel
The Malawian side assured to allocate necessary budget and personnel for the proper operation and maintenance of the facilities to be covered by the Project. Particularly, Malawian side is to make utmost effort for the opening of TTC-L based on detailed plan, such as schedule of staff employment, selection of students, budgeting, etc. It is also confirmed that the Malawian side will constantly share the preparation progress with JICA.

7-3. Proper Use and Maintenance

Both sides understood that proper use and maintenance of the facilities was indispensable for their long-term use. The Malawian side assured the Team that it would facilitate the proper use and maintenance of the facilities to be covered by the Project with the active involvement of concerned parties.

7-4. Schedule of the Project

The team explained that the implementation schedule of the Project shown in ANNEX 5 was not fixed yet. JICA will inform the Malawian side once the schedule is confirmed.

ANNEX-1 Components and Facilities to be covered by the Project
ANNEX-2 Major Undertakings by Each Government
ANNEX-3 Details of the Obligation of the Government of Malawi
ANNEX-4 Project Cost Estimation
ANNEX-5 Schedule of the Project (TENTATIVE)

A

ANNEX-1 Components and Facilities to be covered by the Project

Component	Building/Description	Priority
Administration Block	Administration building Course management building	A
Library Block	Library, Computer room, Resource center	
Classroom Block	13 Classrooms (40 seats) 2 Lecture halls (80 seats)	
Laboratory Block	Physics and Chemistry laboratory building Biology laboratory building Domestic science building	
Multi-Purpose Hall/Kitchen Block	Multi-Purpose Hall Kitchen Toilet and sick Bay	
Toilet	Toilets for classroom block Toilet for Laboratory block	
Hostel Block	Female Hostel buildings (capacity of 288) Male Hostel buildings (capacity of 312)	
Affiliated Secondary School	Administration building Classroom buildings Laboratory building Toilet buildings	B
Staff Houses	20 staff houses	B
External facilities	Guard house, Gate and Boundary fence, Boreholes and water supply system, Drainage system	A
Furniture	Furniture for the college and hostels	A
	Furniture for the affiliated secondary school	B
Equipment	Laboratory equipment for the college	A
	Laboratory equipment for the affiliated secondary school	B
Computing Equipment	Computers for computer room and resource center	A

Remarks

A: First priority

B: Second priority

Volumes of the components of priority ranking B shall be adjusted within the budget limitation as a result of tenders.

ANNEX-2 Major Undertakings by Each Government

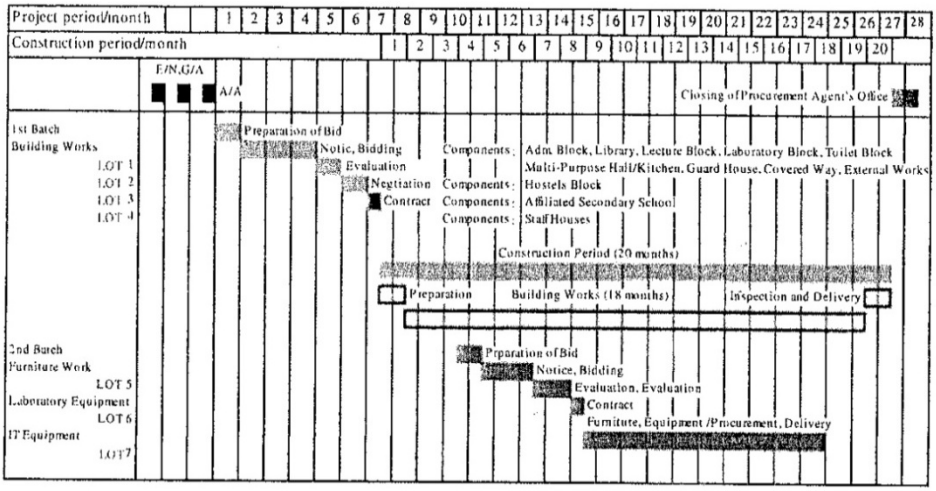
Relevant works	To be covered by Grant Aid	To be covered by Recipient Side
1. To secure land		•
2. To clear level and reclaim the site when needed		•
3. To construct gates and fences in and around the site	•	
4. To construct the parking lot		•
5. To construct roads		
1) Within the site	•	
2) Outside the site		•
6. To construct the building	•	
7. To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities	•	
1) Electricity		
a. The distributing line to the site		•
b. The drop wiring and internal wiring within the site	•	
c. The main circuit breaker and transformer	•	
2) Water supply		
a. The city water distribution main to the site		•
b. The supply system within the site (receiving and elevated tanks)	•	
3) Drainage		
a. The city drainage main (for storm sewer and others to the site)		•
b. The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	•	
4) Gas supply		
a. The city gas main to the site		•
b. The gas supply system within the site	•	
5) Telephone system		
a. The telephone trunk line to the main distribution frame/panel (MDF) of the building		•
b. The MDF and the extension after the frame/panel	•	
6) Furniture and Equipment		
a. General furniture		•
b. Project equipment	•	
8. To bear the commissions to the Japanese bank for banking services based on B/A		•
9. To ensure prompt customs clearance and to assist internal transportation in the recipient country and to assist internal transportation therein of the products		•
10. To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the Components as well as the employment of the Agent be exempted/be borne by its designated authority without using the Grant and its accrued interest.		•
11. To accord Japanese nationals and/or nationals of third countries, including such nationals employed by the Agent, whose services may be required in connection with the supply of the Components such facilities may be necessary for their entry into the recipient country and stay therein for the performance of their work (The term "nationals" wherever used in the G/A means Japanese physical persons or Japanese juridical persons controlled by Japanese physical persons in the case of Japanese nationals, and physical or juridical persons of third countries in the case of nationals of third countries.)		•
12. To ensure that the Facilities and the Components be maintained and used properly and effectively for the implementation of the Project		•
13. To bear all the expenses, other than those covered by the Grant and its accrued interest, necessary for the implementation of the Project		•
14. To give due environmental and social consideration in the implementation of the Project		•

(B/A: Banking Arrangement, G/A: Grant Arrangement)

ANNEX-3 Details of the Obligation of the Government of Malawi

Necessary works		Requirement
Proceeding for environmental affairs related to EIA	○	To be completed prior to Bidding
Extension of Power line	○	To be extended during construction period
Setting up branch pipe from city water main to the site	○	To be set up during construction period

ANNEX-5 Schedule of the Project (TENTATIVE)



E/A: Exchange of Notes
G/A: Grant Agreement
A/A: Agent Agreement

5. 入手資料リスト

	資料名	発行年	種類	発行/著作者
1	2010-2011 Financial Statement Budget Document No.3	2010	書籍	Ministry of Finance, Government of Malawi
2	Draft Estimates of Expenditure on Recurrent and Capital Budget for the Financial Year 2010/2011 Vol.2 Budget Document No.4	2010	コピー	Ministry of Finance, Government of Malawi
3	Approved Estimates of Expenditure on Recurrent and Capital Budget for the Financial Year 2009/10 Vol.3 Budget Document No.5	2009	コピー	Ministry of Finance, Government of Malawi
4	Approved Estimates of Expenditure on Recurrent and Capital Budget for the Financial Year 2008/09 Vol.VII Budget Document No.4	2009	コピー	Ministry of Finance, Government of Malawi
5	Approved Estimates of Expenditure on Recurrent and Capital Budget for the Financial Year 2007/08 Vol.VIII Budget Document No.4	2008	コピー	Ministry of Finance, Government of Malawi
6	Guidelines for Environmental Impact Assessment	1997.12	書籍	Ministry of Forestry, Fisheries and Environmental Affairs Environment Affairs Department
7	CONSTRUCTION OF PHALOMBE TEACHER TRAINING COLLEGE BIDDING DOCUMENT 1 OF 4	2011	コピー	Ministry of Education Science and Technology
8	Senior Secondary School Teaching Syllabus (Biology)	2001.2	コピー	Ministry of Education, Science and Technology
9	Junior Secondary School Teaching Syllabus (Biology)	1998.12	コピー	Ministry of Education, Science and Technology
10	Senior Secondary School Teaching Syllabus (Physical Science Form 3 - 4)	2001.1	コピー	Ministry of Education, Science and Technology
11	Junior Secondary School Teaching Syllabus (Physical Science)	1998.12	コピー	Ministry of Education, Sports and Culture
12	Physics Lab. Manual (Year-1_3), Diploma of Education, Department of Physical Science	2004. 4	コピー	Domasi College of Education Malawi World University Service of Canada
13	Biology Lab. Manual (Year-1_3), Diploma of Education, Department of Physical Science	2005. 1	コピー	Domasi College of Education Malawi
14	Chemistry Lab. Manual (Year-1_3), Diploma of Education, Department of Physical Science	2005. 1	コピー	Domasi College of Education Malawi Japan International Cooperation Agency
15	University of Malawi Chancellor College Organization Structure	2010	コピー	University of Malawi Chancellor College

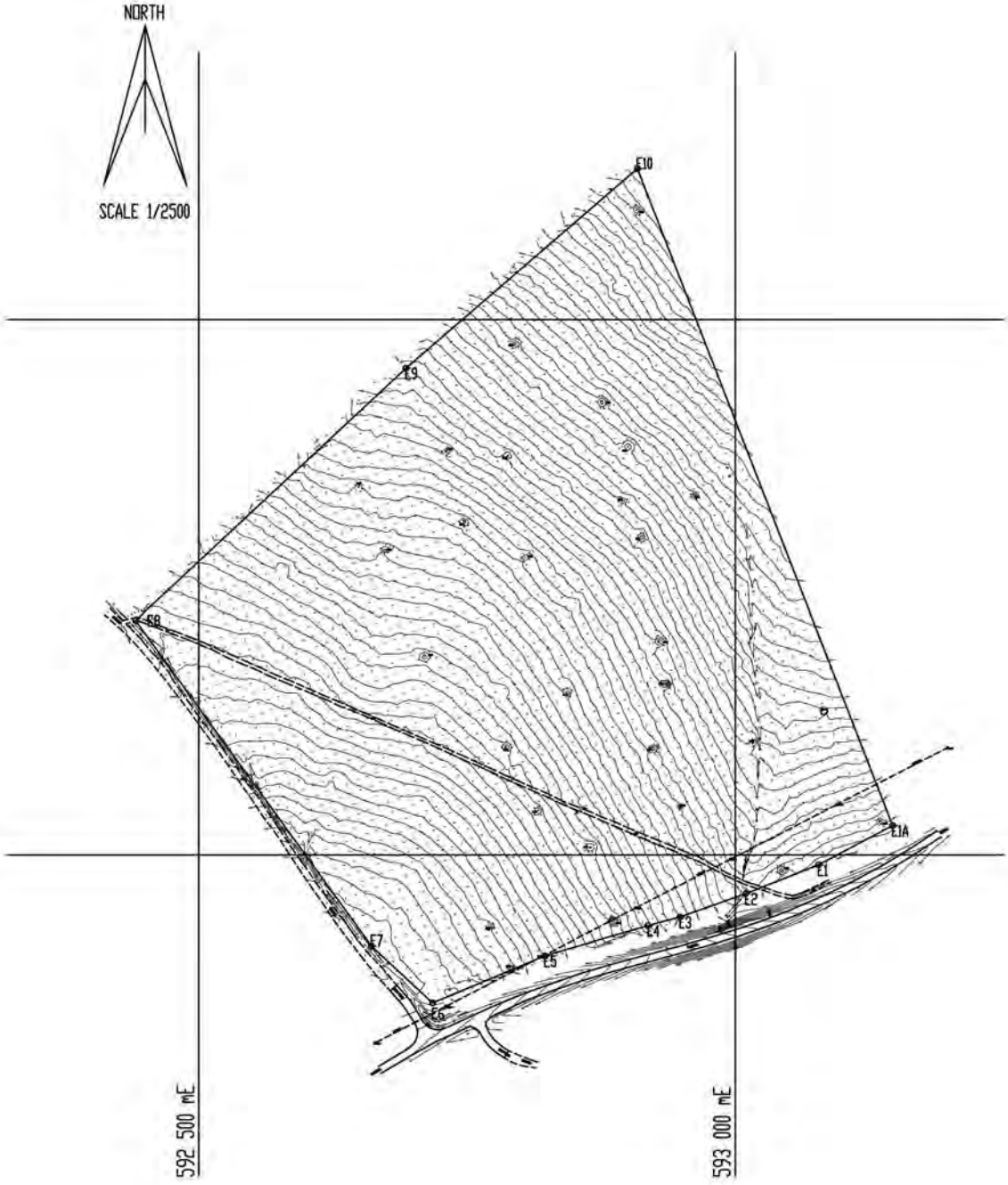
6. その他の資料・情報

6-1 敷地測量図

6-2 地質調査結果（抜粋）

6-3 井戸試掘調査結果

6-1 敷地測量図


NORTH
SCALE 1/2500
E10
E9
E8
E7
E6
E5
E4
E3
E2
E1
E1A
592 500 mE
593 000 mE

MALAWI POLYTECHNIC
CIVIL ENGINEERING DEPARTMENT

REPORT ON GEOTECHNICAL INVESTIGATIONS ON THE PROJECT FOR CONSTRUCTION OF A TEACHER TRAINING COLLEGE FOR SECONDARY SCHOOL TEACHERS IN LILONGWE

TO: MATSUDA INTERNATIONAL CONSULTANTS

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

May 2011

INTRODUCTION

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; Nalikule Forests in Lilongwe 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.

Project Description

It is our understanding that the project involves the construction of a full Teachers Training college at Nalikule forests in Lilongwe. 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.

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.

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.

Nalikule Forests

Eighteen trial pits for sample collection and testing evenly distributed were dug on Nalikule Forests. In addition six more pits were dug for Water penetration test. Furthermore 161 points were selected for DCP testing.

Observations on trial pits at 2m depth and classification tests indicated that the soils were alternating between light red lateritic firm sandy clays to decomposed light grey rock dominated by gravelly sand.

From the triaxial test, the worst case scenario was observed on Pit no. 17 which gave an angle of friction of 6 degrees and cohesion intercept of 45kN/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 307kN/m^2. Applying a Factor of safety of two the safe bearing capacity is 154kN/m^2

From the DCP test it was observed that very few areas had a Penetration Index (PI) of more than 20mm/blow (approx CBR of 10). This indicates that averagely Nalikule forest has a quite strong and stable ground condition which can ably accommodate normal foundation loads from buildings. In areas where the PI is greater than 20mm/blow, the areas can be recompacted to improve their bearing capacity or otherwise they can be avoided.

The water penetration results gave an average percolation value of 0.8mm/min.

RECOMMENDATIONS

The soil conditions at the proposed CDSS are adequate for Nalikule Forest (safe bearing capacity for a strip footing of 690mm greater than 150kN/m^2)..

References

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

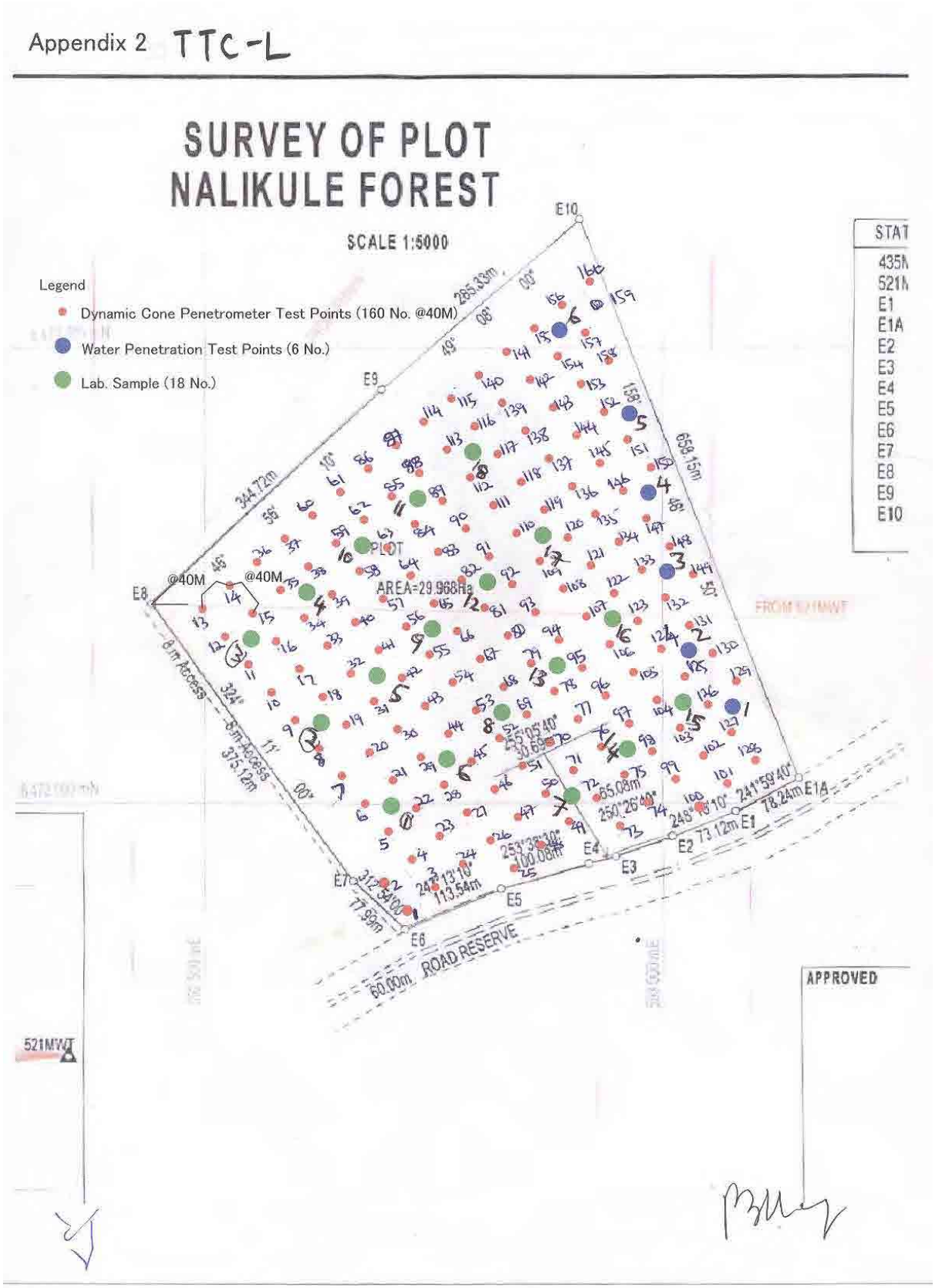
Appendices

1. Site Location
2. Summary Report on Geotechnical Investigations
3. Triaxial Test Results
4. DCP Test results

Appendices

1. Site Location
2. Summary Report on Geotechnical Investigations
3. Triaxial Test Results
4. DCP Test results

1. Site Location



2. Summary Report on Geotechnical Investigations

UNIVERSITY OF MALAWI

PRINCIPAL
Grant Kululanga, PhD. Eng., MSc. Eng., BSc. Eng., MASCE

Please address all correspondence to the Principal
The Malawi Polytechnic
Private Bag 303
Chichiri
Blantyre 3
MALAWI
Tel: (265) 01 870 411
Fax: (265) 01 870 578
E-Mail: principal@poly.ac.mw

Our Ref.:

Your Ref:

Date: **15th June, 2011**

ATT: Matsuda International Consultants

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
NALIKULE FOREST	Light red lateritic firm sandy clay to decomposed light grey rock & gravelly sand	0.8 (Low Permeability)	<20 mm/blow	10	STIFF Strong and stable ground	Can ably accommodate normal foundation loads from buildings & >20mm/blow points to be recompacted to improve bearing capacity or be avoided.

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			TRIAXIAL TEST	
			LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	COHENSION INTERCEPT (C')	ANGLE OF SHEARING (Ø)
NALIKULE FOREST (LILONGWE)	1	DONE	38.0	24.0	**14.0**	70 kN/m^2	26.6°
	2	DONE	48.0	21.0	**27.0**	57 kN/m^2	18.3°
	3	DONE	NP	NP	**NP**	Decomposed Rock	
	4	DONE	NP	NP	**NP**	Decomposed Rock	
	5	DONE	NP	NP	**NP**	Decomposed Rock	
	6	DONE	39.0	23.8	**15.2**	58 kN/m^2	10.2°
	7	DONE	NP	NP	**NP**	Decomposed Rock	
	8	DONE	NP	NP	**NP**	Decomposed Rock	
	9	DONE	NP	NP	**NP**	Decomposed Rock	
	10	DONE	36.8	20.8	**16.0**	66 kN/m^2	21.8°
	11	DONE	25.8	12.8	**13.0**	73 kN/m^2	20.3°
	12	DONE	NP	NP	**NP**	Decomposed Rock	
	13	DONE	NP	NP	**NP**	Decomposed Rock	
	14	DONE	NP	NP	**NP**	Decomposed Rock	
	15	DONE	40.9	19.9	**21.0**	55 kN/m^2	14.6°
	16	DONE	NP	NP	**NP**	Decomposed Rock	
	17	DONE	43.3	20.3	**23.0**	45 kN/m^2	5.7°
	18	DONE	32.0	16.8	**15.2**	70 kN/m^2	6.0°

4. DCP Test results

UNIVERSITY OF MALAWI

PRINCIPAL

Grant Kululanga, PhD. Eng., MSc. Eng., BSc. Eng., MASCE

Please address all correspondence to the Principal

The Malawi Polytechnic
Private Bag 303
Chichiri
Blantyre 3
MALAWI

Tel: (265) 01 870 411

Fax: (265) 01 870 578

E-Mail: principal@poly.ac.mw

Our Ref.:

Your Ref:

Date: **07th July, 2011**

ATT: Matsuda Consultants International

DCP TEST RESULTS FOR NALIKULE FOREST IN LILONGWE

POINT	TOTAL NO OF BLOWS	PENETRATION (mm)	DCP NUMBER (mm/blow)	IN SITU CBR
1	106	2000	19	10
2	104	2000	19	10
3	94	2000	21	9
4	96	2000	21	9
5	110	2000	18	11
6	89	2000	22	8
7	78	2000	26	7
8	84	2000	24	7
9	96	2000	21	9
10	84	2000	24	7
11	77	2000	26	7
12	82	2000	24	7
13	110	2000	18	11
14	230	2000	9	25
15	220	2000	9	25
16	225	2000	9	25
17	180	2000	11	20
18	184	2000	11	20
19	200	2000	10	22
20	235	2000	9	25
21	335	2000	6	45
22	330	2000	6	45
23	280	2000	7	35
24	295	2000	7	35
25	300	2000	7	35
26	300	2000	7	35
27	335	2000	6	45

28	315	2000	6	45
29	300	2000	7	35
30	315	2000	6	45
31	115	2000	17	12
32	120	2000	17	12
33	130	2000	15	14
34	130	2000	15	14
35	130	2000	15	14
36	120	2000	17	12
37	125	2000	16	13
38	130	2000	15	14
39	145	2000	14	15
40	150	2000	13	16
41	180	2000	11	20
42	235	2000	9	25
43	230	2000	9	25
44	230	2000	9	25
45	235	2000	9	25
46	280	2000	7	35
47	300	2000	7	35
48	335	2000	6	45
49	320	2000	6	45
50	330	2000	6	45
51	250	2000	8	30
52	155	2000	13	16
53	160	2000	13	16
54	145	2000	14	15
55	160	2000	13	16
56	127	2000	16	13
57	135	2000	15	14
58	140	2000	14	15
59	165	2000	12	18
60	170	2000	12	18
61	150	1000	7	35
62	120	1000	8	30
63	215	1000	5	55
64	230	1000	4	75
65	220	1000	5	55
66	155	1000	7	35
67	125	1000	8	30
68	175	1000	6	45
69	180	1000	6	45
70	200	1000	5	55
71	255	1000	4	75
72	190	1000	5	55
73	190	1000	5	55
74	255	1000	4	75
75	195	1000	5	55
76	185	1000	5	55
77	185	1000	5	55
78	195	1000	5	55
79	175	1000	6	45
80	165	1000	6	45
81	155	1000	7	35
82	200	1000	5	55
83	225	1000	4	75
84	220	1000	5	55

85	225	1000	4	75
86	180	1000	6	45
87	190	1000	5	55
88	205	1000	5	55
89	210	1000	5	55
90	160	1000	6	45
91	160	1000	6	45
92	195	1000	5	55
93	200	1000	5	55
94	235	1000	4	75
95	200	1000	5	55
96	185	1000	5	55
97	205	1000	5	55
98	180	1000	6	45
99	165	1000	6	45
100	230	1000	4	75
101	230	1000	4	75
102	232	1000	4	75
103	166	1000	6	45
104	180	1000	6	45
105	198	1000	5	55
106	208	1000	5	55
107	210	1000	5	55
108	185	1000	5	55
109	165	1000	6	45
110	200	1000	5	55
111	210	1000	5	55
112	205	1000	5	55
113	210	1000	5	55
114	215	1000	5	55
115	225	1000	4	75
116	235	1000	4	75
117	190	1000	5	55
118	190	1000	5	55
119	200	1000	5	55
120	205	1000	5	55
121	175	1000	6	45
122	235	1000	4	75
123	230	1000	4	75
124	235	1000	4	75
125	230	1000	4	75
126	240	1000	4	75
127	235	1000	4	75
128	185	1000	6	45
129	190	1000	5	55
130	185	1000	6	45
131	165	1000	6	45
132	155	2000	13	16
133	120	2000	17	12
134	155	2000	13	16
135	145	2000	14	15
136	145	2000	14	15
137	150	2000	13	16
138	165	2000	12	18
139	170	2000	12	18
140	165	2000	12	18
141	165	2000	12	18

142	155	2000	13	16
143	175	2000	11	20
144	180	2000	11	20
145	165	2000	12	18
146	165	2000	12	18
147	167	2000	12	18
148	155	2000	13	16
149	150	2000	13	16
150	180	2000	11	20
151	155	2000	13	16
152	180	2000	11	20
153	190	2000	11	20
154	200	2000	10	22
155	235	2000	9	25
156	230	2000	9	25
157	245	2000	8	30
158	250	2000	8	30
159	155	2000	13	16
160	165	2000	12	18

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

6-3 井戸試掘調査結果

1. 井戸試掘調査結果

1-1. 調査の目的と方法

リロングェ中等教員養成校建設計画(以下 TTCL)において、対象 TTCL Nalikure サイトの給水施設建設に必要な地下水水源の確認を目的として試掘調査を実施した。試掘調査に当たっては、マラウイ共和国(以下、「マ」国)の現地の井戸掘削業者を選定し再委託により実施した。水質評価は「マ」国　農業・灌漑・水資源省の水質分析室により飲料水水質評価を行った。

1-2. 調査期間

試掘調査期間は、中等学校建設計画（CDSS フェーズ 2）の 4 サイトを含め、2011 年 9 月初旬より 10 月下旬までの 2 ヶ月間を予定した。TTCL サイトの試掘調査は 10 月初旬より約 1 ヶ月間で完了したが、CDSS サイトに対する調査は全国的な車両燃料の枯渇問題が発生したことにより大幅な調査工程の遅延を余儀なくされた。

1-3. 調査結果要約

(1)　調査対象 TTCL サイトの水量と水質の評価

試掘調査結果は、下表 - 1 に要約した。水量的には、①TTC No.1 は空井戸、②TTC No.2 は少量の水、③TTC No.3 及び④TTC No.4 井戸では一定の水量が得られ、水源として利用可能であることを確認したが、計画水需要 75m3/日に対して必要量の全てを確保することは困難である。試掘調査結果を水理地質的に評価し、水需要を得るために必要な技術的提案を行う。水質評価については、揚水試験の終了時に、「マ」国　農業・灌漑、水資源省の水質分析室担当官が現場で水質サンプルを採取して、「マ」国の飲料水水質基準及び WHO 飲料水質ガイドラインに沿って飲料水水質評価を行った。地下水水質については、試掘井戸 3 井ともに飲料水として最適な水質であることが確認された。

対象 TTCL サイトの試掘地点は、図-1 に示す通り、緯度経度を GPS により計測し、Google Earth 地図上に概略位置をプロットした。

表-1　　TTCL の試掘調査結果

試掘対象サイト	試掘井	試掘地点		井戸深度 (掘削深度)	水量・ 水質評価
		緯度(南緯)	経度(東経)		
1.TTCL　Nalikure	TTC No.1	13° 49′ 17.5″ S	33° 51′ 38.6″ E	－　(53m)	×
	TTC No.2	13° 49′ 10.2″ S	33° 51′ 38.3″ E	54m　(54m)	△
	TTC No.3	13° 49′ 7.0″ S	33° 51′ 37.3″ E	61m　(61m)	◎
	TTC No.4	13° 49′ 00.7″ S	33° 51′ 38.3″ E	70m　(70m)	○

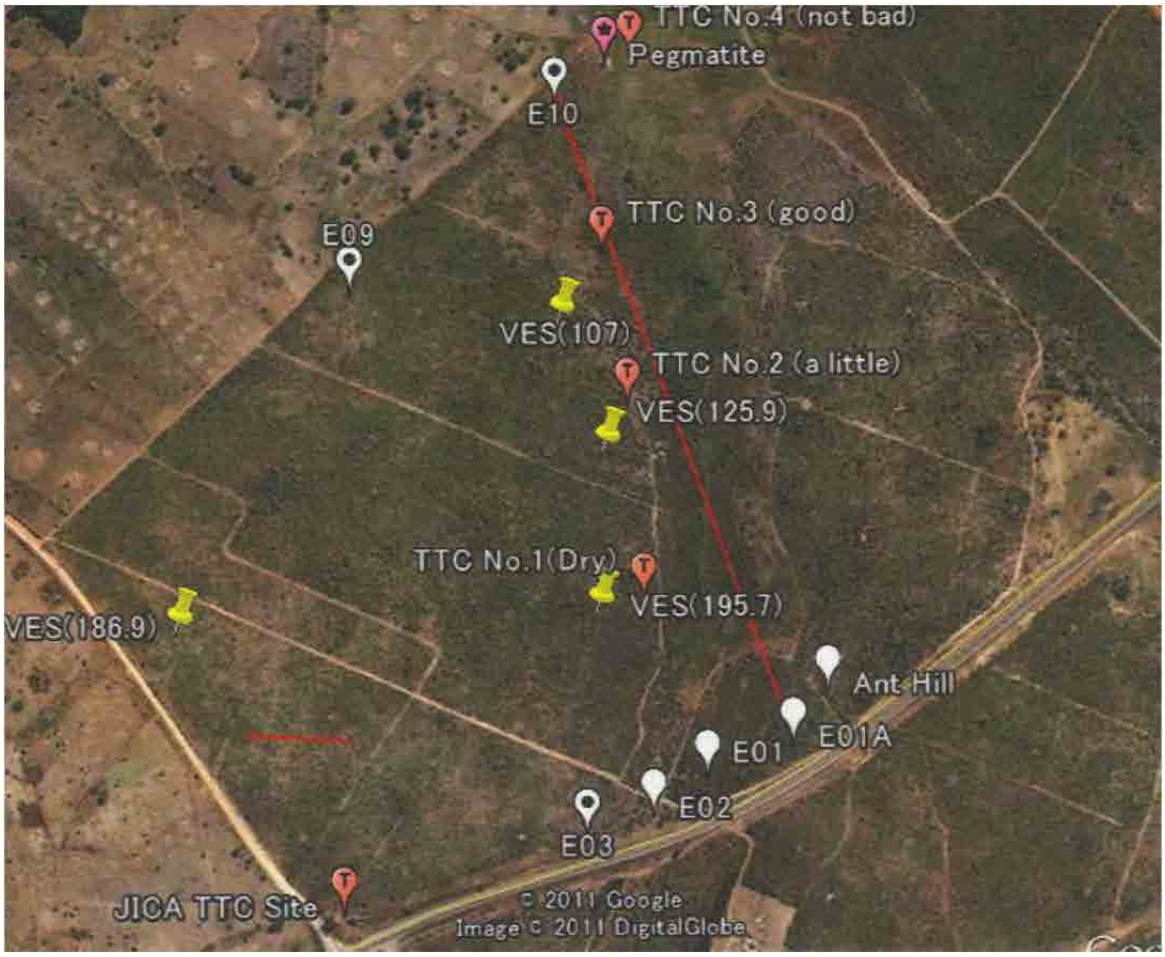


図-1　TTCL (Nalikure)　試掘調査位置図

凡例：　1)　赤の丸印 TTC No.1～No. 4 が試掘井戸位置

2)　黄色 VES(4 地点)は、電気探査(垂直探査地点)

3)　白色の丸(E01A～E10)は、TTC の敷地の境界を示す基点

4)　図中下部の赤線は、図の縮尺 100m 長を示す。

5)　画像データは、Google Earth に井戸位置を GPS 測定によりプロットした。

(2)　調査対象井戸仕様

試掘調査は、下表‐2 に示す、「マ」国の標準的な井戸仕様に沿って、現地井戸掘削企業（WATEC）に再委託して実施した。

表‐2　　試掘井戸の調査仕様

① 井戸仕上げ口径：φ6 インチ、平均掘削深度：60m
② スクリーン・ケーシング口径：φ6 インチ(外径 160mm) PVC 製
③ 帯水層部分へのスクリーン設置
④ 掘削孔とスクリーンの間に砂利充填
⑤ 井戸洗浄（Development）
⑥ 揚水試験　(段階揚水試験：各揚水 2 時間 4 段階、計 8 時間、
定流量揚水試験：連続 24 時間、回復試験：6 時間ないし水位回復 90%以上)
⑦ 水質分析（「マ」国及び WHO 飲料水水質ガイドライン準拠）して飲料水の適否を判定する。
⑧ 水質サンプリングは、大腸菌群及び一般細菌を含む分析 21 項目を「マ」国の水質分析に係る公的機関にて実施する。

(3) 調査対象サイトの水質分析の仕様

水質については WHO 飲料水水質ガイドライン及び「マ」国の飲料水深井戸基準(2005)に基づき、水質分析の公的機関である農業・灌漑・水資源省水質分析室(首都 Lilongwe)で実施した。水質分析は下表‐3 に示す「マ」国の標準 21 項目の分析を行った。水質分析結果は飲料水として問題のない水質であることが確認された。(表-15 を参照)

表-3　WHO 及び「マ」国飲料水水質ガイドライン　　（単位：mg/L)

	水質項目	WHO	Malawi		水質項目	WHO	Malawi
1	TDS	1,000	2,000	12	アルカリ度	-	-
2	濁度	-	25	13	塩化物	250	750
3	pH Value	6.5-8.5	6.0-9.5	14	硫酸塩	250	800
4	ケイ酸	-	-	15	硝酸塩	50	100
5	ナトリウム (Na)	200	500	16	炭酸塩	-	-
6	カリウム (K)	-	-	17	フッ素	1.5	3.0
7	マグネシウム (Mg)	0	200	18	電気伝導度	-	3,500
8	カルシウム(Ca)	-	250	19	大腸菌群	0/100mL	50/100mL
9	鉄 (Fe)	0.3	3.0	20	炭酸水素塩	-	-
10	全硬度	200	800	21	一般細菌	-	0
11	浮遊物質(SS)	-	-				

(4) 調査対象 4 サイトの水理地質評価

調査対象サイトは、水理地質的には小さな集水域の最上流部に位置するため、雨季の降水時のみ河川（湿地）となる小水系である。乾季において流水はなく枯れ川で、流路は南から北に流れている。試掘井は電気探査（水平探査と垂直探査）の解析結果に基づき、対象敷地内を原則として地下水賦存が高いと想定された上流部（TTC No.1）から下流部（TTC No.4）に掘削し、対象敷地内の地下水ポテンシャル、水理地質評価を行った。

調査結果は、最上流部 TTC No.1 は空井戸であったが、下流に向かって順次地下水量が増加する自然な傾向を示した。地質的には、地表に露頭が見られる風化の進行した花崗岩質片麻岩類から巨晶花崗岩類に地下水賦存が期待されたが、風化帯や不整合面にも地下水は無く、下位の新鮮な灰黒色の黒雲母片麻岩類の亀裂帯に被圧地下水が存在した。

一方、調査対象の計画水需要量は 75m^3/日であるため、動力ポンプの運転時間を 8～10 時間とした場合の揚水量は 7.5～9.4 m^3/時、ないし 2.1～2.6 L/秒が必要である。仮に複数の井戸 3 井で水需要を確保すると 1 井当り 25m^3/日となり、地下水揚水量は 2.5～3.1 m^3/時、ないし 0.7～0.9 L/秒の地下水ポテンシャルが必要である。試掘井 4 井の地下水ポテンシャルと揚水量の評価を表-5～8 に取りまとめた。

表-6 に定流量(連続)揚水試験の結果を示す。対象 TTC の試掘井 4 井のうち TTC No.3（43.2m^3/ day）と TTC No.4（20.7m^3/ day）は水量水質ともに良好で、給水施設の深井戸水源として動力ポンプの設置可能である。但し、TTC No.1 は完全な空井戸、TTC No.2 には地下水が存在したが、揚水試験の結果、少量の地下水（2.3m^3/ day）しか得られず活用はかなり困難と思われる。また、回復試験では 4 時間 30 分で TTC No.3 が 98.3%、TTC No.4 が 99.0%と良好な回復率を示したが、水位降下では前者では 34.67m、後者が 48.04m と大きな降下量を示した。

表-7 は揚水試験データを水理地質的に評価し、比湧出量及び地下水ポテンシャルでは水位降下 20m を基準として可能陽水量を試算した。TTC No.3 は 24.96m^3/ day、TTC No.4 は 14.4 m^3/ day と算定された。一方、表-5 では試掘井の具体的な井戸構造図(図-7 及び 11)に基づき、動力ポンプ設置深度を選定し、揚水水位の変動による水位降下を最大にした場合の可能揚水量を試算した結果、TTC No.3 は 21.8m^3/ day、TTC No.4 は 15.1 m^3/ day と算定された。動力ポンプの設置深度は、井戸構造と帯水層の関係から採水箇所のスクリーン前面には設置しないことが一般的であり、それぞれの設置深度を 56m と 65m と設定している。(井戸構造図については図-7 及び 11 を参照)

以上の検討結果から、現状でのサイトの成功井戸 3 井の可能揚水量は、地下水ポテンシャルを基本にすると、約 50m^3/ day となり、計画水需要量 75 m^3/ day には届かない。現状の評価では追加の井戸が必要と思料される。また、今回の試掘調査の結果から地下水賦存の高い地域は TTC No.3 から TTC No.4 の地域に絞りこまれ、水質的には飲料水に最適であることが判明している。試掘調査では地下水調査地域を原則的にサイト敷地内に限定してきたことから、実施における地下水では境界地域から北側に多少の裕度のある地域での追加井戸 2 井、平均深度 65m を実施することによってより水量の多い深井戸が建設可能と判断される。

表-4　井戸構造からのポンプ設置深度と可能揚水量

対象サイト	静水位(m)	ポンプ設置深度(m)	揚水水位(最大)(m)	水位降下(最大)(m)	比湧出量(m^3/hr/m)	揚水量(最大)(m^3/hr)	可能揚水量(m^3/ day) 8hr 揚水	水量評価
記号	E	M	O	P=O-E	H=D/G	Q=HxP	R8=Qx8hr	S
1.TTC No.1	-	-	-	-	-	-	-	×
2.TTC No.2	9.5	37m	37m	27.5	0.022	0.61	4.9	×
		47m	47m	37.5	0.022	0.83	**6.4**	△
3.TTC No.3	3.49	38m	38m	34.5	0.052	1.79	14.3	○
		56m	56m	52.5	0.052	2.73	**21.8**	◎
4.TTC No.4	1.96	32m	32m	30.0	0.03	0.9	7.2	△
		41m	41m	39.0	0.03	1.17	9.4	△
		65m	65m	63.0	0.03	1.89	**15.1**	○

注1)　井戸構造からポンプ設置深度を選定し、表-8 の水理地質評価から求めた H:比湧出量と水位降下（最大）とした場合の Q：揚水量（最大）で 1 日 8 時間運転した場合の可能揚水量（R8）を評価した。

注2)　水量評価　◎：TTC No.3 の可能揚水量（21.8m^3/ day）

○：TTC No.4 の可能揚水量（15.1m^3/ day）

△：TTC No.2 の可能揚水量（6.4m^3/ day）

表-5　　定流量(連続)揚水試験(24 時間)と回復試験結果

対象サイト	定流(連続)揚水量(m^3/hr)	揚水試験時間(hr)	揚水量(m^3)	水位降下(m)	回復試験(回復%)	回復時間(hr)	比湧出量(m^3/hr/m)	水量評価
記号	D	T	S=DxT	G=F-E	U	V	H=D/G	W
1.TTC No.1	Dry	-	-	-	-	-	-	×
2.TTC No.2	0.90	2.3	2.1	40.5	100%	4.0	0.022	△
3.TTC No.3	1.8	24	43.2	34.67	98.3%	4.5	0.052	◎
4.TTC No.４	1.48	14	20.7	48.04	99.0%	4.5	0.03	○

注1)　揚水試験（定流量連続）の結果より試掘井を評価した。

注2)　水量評価　◎：TTC No.3 の揚水試験による揚水量（43.2m^3/ day）

○：TTC No.4 の揚水量（20.7m^3/ day）

△：TTC No.2 の揚水量（2.1m^3/ day）

表-6　地下水ポテンシャルと揚水量の評価

対象サイト 井戸番号	掘削深度 (m)	井戸深度（m）	揚水量 （m^3/h）	静水位 （m）	揚水水位（m）	水位降下 （m）	比湧出量 （m^3/h/m）	地下水ポテンシャル （m^3/h）	可能揚水量 （m^3/day）	ポンプ設置深度(m)	評価
記号	B	C	D	E	F	G=F-E	H=D/G	K=Hx20m	L=Kx24hr	M	N
1.TTC No.1	53	-	-	-	-	-	-	-	-	-	×
2.TTC No.2	54	54	0.9	9.5	50	40.5	0.022	0.44	10.56	47m	△
3.TTC No.3	61	61	1.8	3.49	38.16	34.67	0.052	1.04	24.96	56m	◎
4.TTC No.4	70	70	1.44	1.96	50.0	48.04	0.03	0.60	14.4	65m	○

注1) 揚水試験結果より地下水ポテンシャルは、水位降下 20m を基準とした各井戸の可能揚水量を評価すると、10～25 m^3/日となる。

注2) 評価

◎：TTC No.3 は可能揚水量が約 25 m^3/日のため十分活用できる。

○：TTC　No.4 の可能揚水量は 14.4 m^3/日のため十分活用可能である。

△：TTC　No.2 の可能揚水量は 10.56 m^3/日で地下水ポテンシャルからは利用可能であるが、表-6 に示した揚水試験の結果、記号 S:に示す通り、実際の揚水量は 2.1(m^3)と少量であったため活用はかなり困難である。

表-7　試掘井 TTC サイトの水理地質評価

対象サイト 井戸番号	井戸口径 (mm)	掘削深度 (m)	井戸深度 (m)	揚水量 (m^3/hr)	静水位 (m)	揚水水位 (m)	水位降下 (m)	比湧出量 (m^3/hr/m)	帯水層	スクリーン設置深度 (m)
記号	A	B	C	D	E	F	G=F-E	H=D/G	I	J
1. TTC No.1	160	53	-	-	-	-	-	-	-	空井戸
2. TTC No.2	160	54	54	0.9	9.5	50	40.5	0.022	黒雲母片麻岩	24 - 36、42 - 45
3. TTC No.3	160	61	61	1.8	3.49	38.16	34.67	0.052	黒雲母片麻岩	40 - 55
4.TTC No.4	160	70	70	1.44	1.96	50.0	48.04	0.03	黒雲母片麻岩	19 – 31、34 – 40、61 - 64

2. 試掘調査データ

2-1. 試掘井 TTC No.1

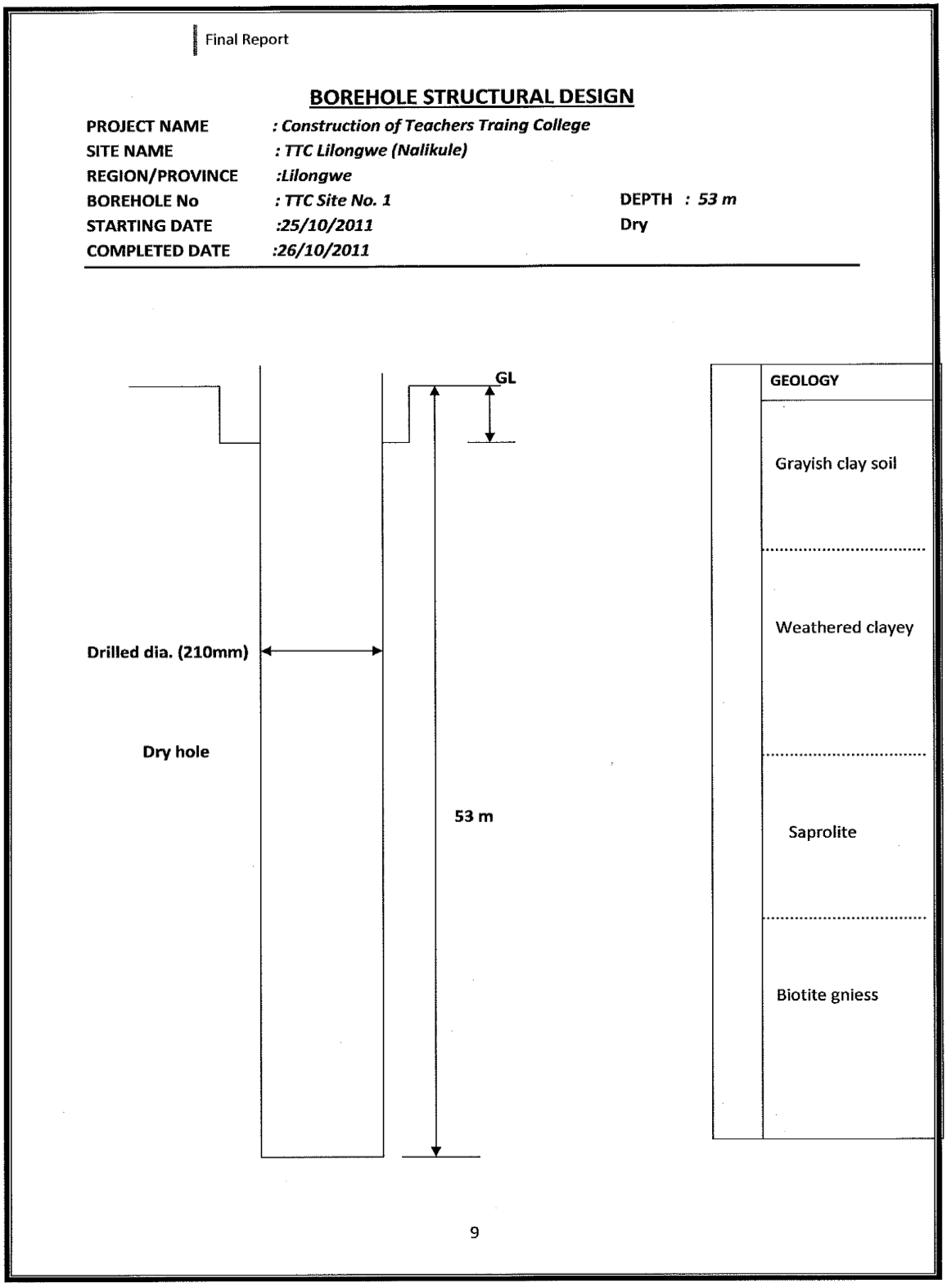


図-2 TTC No.1 試掘井戸柱状図 (Dry：空井戸)

2-2.　試掘 TTC No.2

(1)　試掘井戸

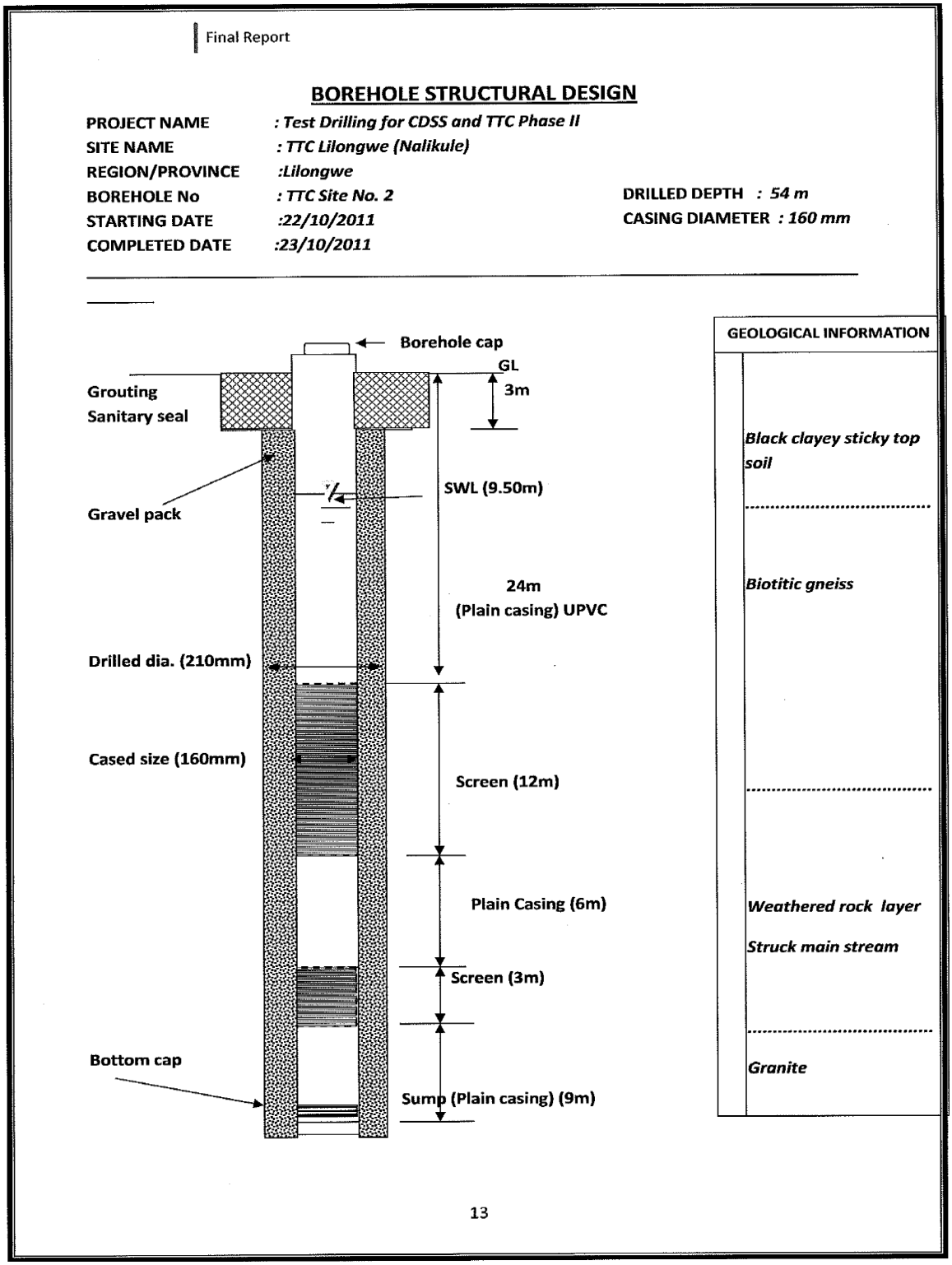
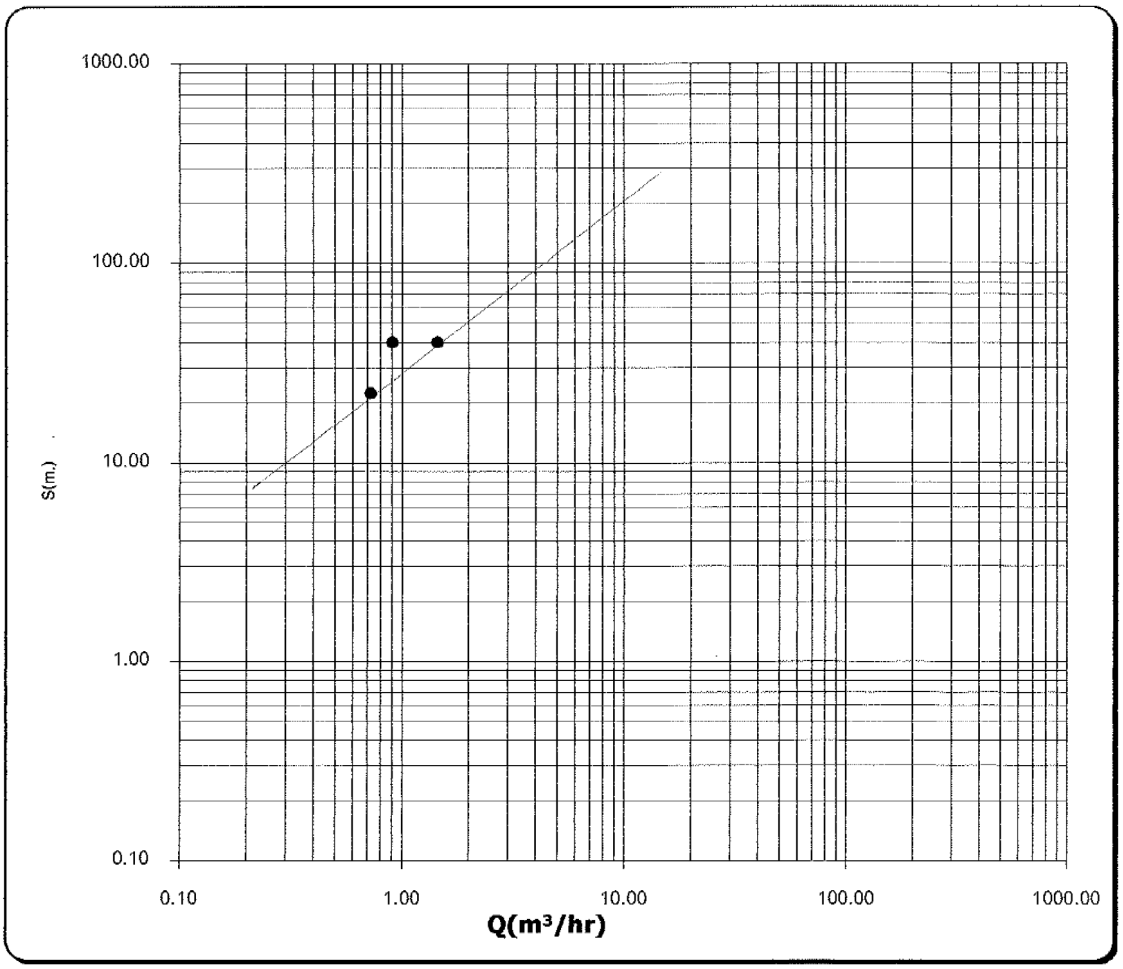


図-3　TTC No.2　試掘井戸柱状図

(2)　試掘井戸(TTC No.2)の揚水試験結果を図-4～図-6に示す。

STEP DRAWDOWN TEST

PROYECT NAME	Malawi CDSS & TTC Phase 2		
BOREHOLE No.	TTC No.2	STATIC WATER LEVEL	9.50 m.
SITE	TTC Nalikule	DATE	25/10/11

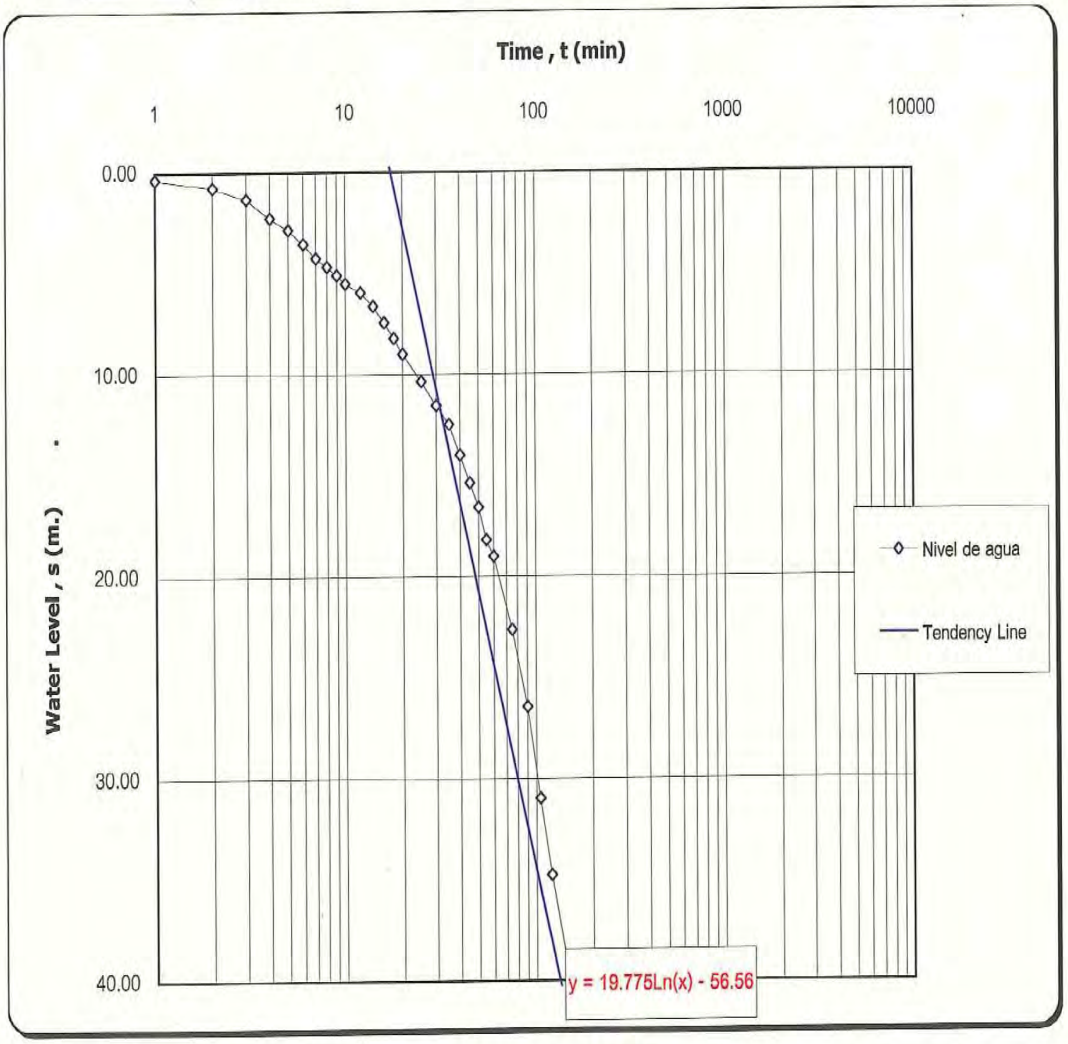


STEP	DISCHARGE Q (m^3/hr.)	DYNAMIC LEVEL N.D. (m.)	DRAWDOWN S (m.)	SPECIFIC CAPACITY Q/S (m^3/hr/m.)
FIRST(1st)	0.72	32.05	22.55	0.0319
SECOND(2nd)	1.44	50.00	40.50	0.0356
THIRD(3rd)				
FORTH(4th)				
FIFTH(5th Constant)	0.90	50.00	40.50	0.0222

図-4　TTC No.2　段階揚水試験結果

CONSTANT DISCHARGE TEST

PROYECT NAME	Malawi CDSS & TTC Phase 2		
BOREHOLE No.	TTC No.2	STATIC WATER LEVEL	9.50 m.
SITE	TTC Nalikule	DATE	26/10/11



DESCRIPTION	
Discharge, Q (m^3/hr.)	0.90 m^3/hr.
water Level ,ΔS (m.)	40.50 m.
Transmissivity , T (m^2/hr.) T = (2.30 Q)/(4πΔS)	0.004 m^2/hr.
Screen Length , b (m.)	15.00 m.
Hydraulic Gradient , K (m./hr.) K = T/b	2.712E-04 m./hr.

図-5　TTC No.2　　定流量揚水試験結果

表-9　TTC No.2　　定流量揚水試験結果表

CONSTANT DISCHARGE TEST

NAME OF PROJECT		Malawi CDSS and TTC PHASE 2		
No.		TTC – No. 2	BOREHOLE DEPTH	54 m
NAME OF LOCATION		NALIKULE T.T.C	YIELD(L/sec)	0.25 L/S
DISTRICT		LILONGWE	STATIC WATER LEVEL	9.50 m
		T.A. CHIMUTU	DYNAMIC WATER LEVEL	50 m
DATA		26th /10/2011	PUMP SET	50 m

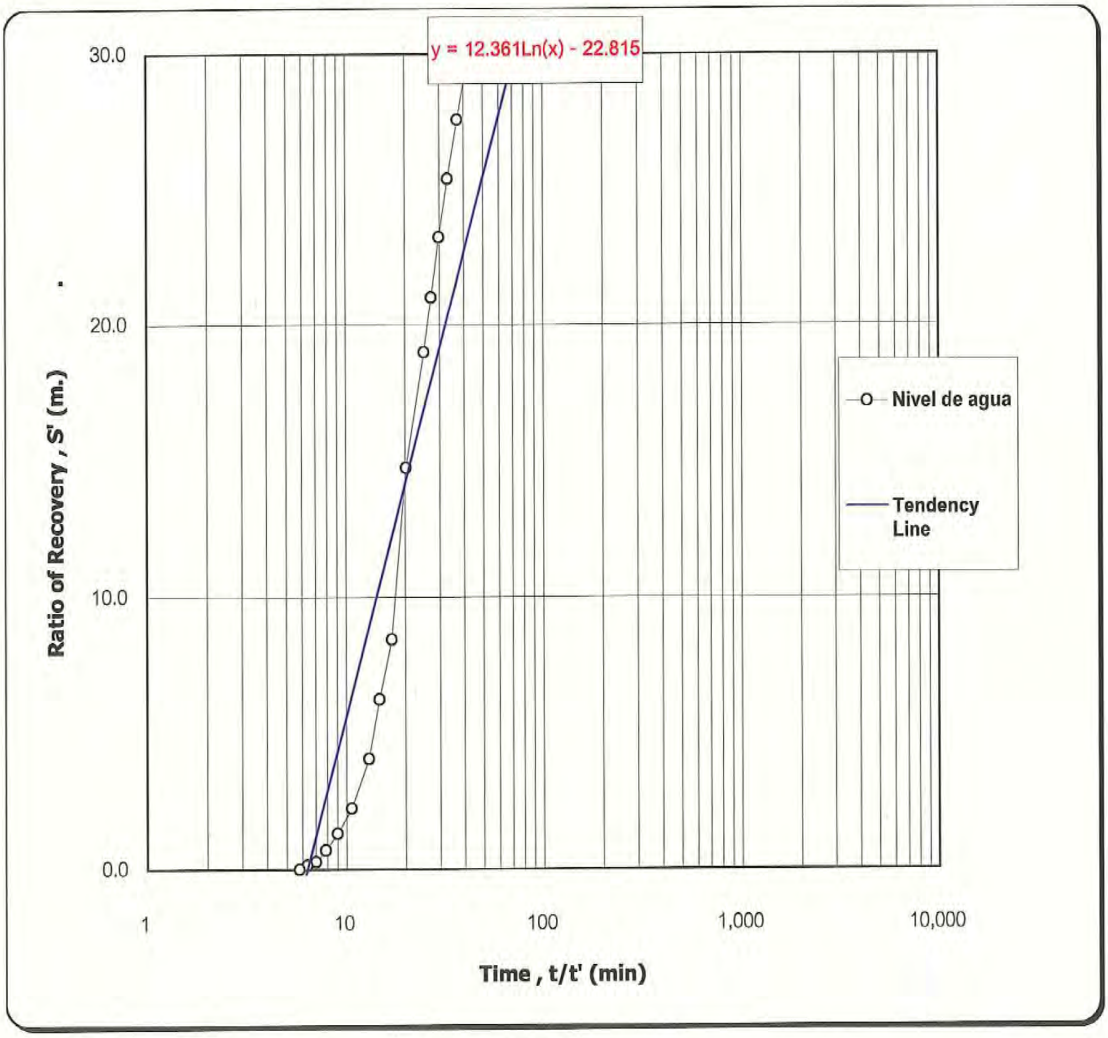
ACTUAL (Hour: Minute)		TIME t(min)	DISCHARGE (Lit/min)	DYNAMIC (m)	DRAW DOWN (m)	REMARKS
07 00	0	0	0.25L/sec	9.50	0.00	
: 01	1	1	0.25L/sec	9.85	0.35	
: 02	1	2	0.25L/sec	10.25	0.75	
: 03	1	3	0.25L/sec	10.82	1.32	
: 04	1	4	0.25L/sec	11.75	2.25	
: 05	1	5	0.25L/sec	12.33	2.83	
: 07	2	7	0.25L/sec	13.74	4.24	
: 10	3	10	0.25L/sec	15.00	5.50	
: 13	3	13	0.25L/sec	15.68	6.18	
: 15	2	15	0.25L/sec	16.54	7.04	
: 20	5	20	0.25L/sec	18.50	9.00	
: 25	5	25	0.25L/sec	19.85	10.35	
: 30	5	30	0.25L/sec	21.05	11.55	
: 35	5	35	0.25L/sec	21.98	12.48	
; 40	5	40	0.25L/sec	23.50	14.00	
: 45	5	45	0.25L/sec	24.87	15.37	
: 50	5	50	0.25L/sec	26.08	16.58	
: 55	5	55	0.25L/sec	27.70	18.20	
08 : 00	5	60	0.25L/sec	31.10	21.60	
: 10	10	70	0.25L/sec	33.16	23.66	
; 20	10	80	0.25L/sec	35.93	26.43	
: 30	10	90	0.25L/sec	39.30	29.80	
: 40	10	100	0.25L/sec	41.67	32.17	
: 50	10	110	0.25L/sec	44.26	34.76	
09 : 00	10	120	0.25L/sec	49.02	39.53	
: 20	20	140	0.25L/sec	50.00	40.50	

Temperature :　　PH:

Conductivity :

WATER LEVEL RECOVERY TEST

PROYECT NAME	Malawi CDSS Phase II		
BOREHOLE No.	Ezondweni No.2	STATIC WATER LEVEL	9.50 m.
SITE	Ezondweni CDSS	DATE	27/09/11



DESCRIPTION	
Discharge, Q (m^3/hr.)	0.90 m^3/hr.
Water Level ,ΔS (m.)	40.50 m.
Transmissivity , T (m^2/hr.) T = (2.30 Q)/(4πΔS)	0.00 m^2/hr.
Screen Length , b (m.)	15.00 m.
Hydraulic Gradient , K (m./hr.) K = T/b	2.712E-04 m./hr.

図-6　TTC No.2　　回復試験結果

表-10　TTC No. 2　　回復試験計測表

DISCHARGE TEST (RECOVERY)

NAME OF PROJECT		Malawi CDSS and TTC PHASE 2		
No.		TTC – No. 2	BOREHOLE DEPTH	54m
NAME OF LOCATION		NALIKULE TTC	YIELD (L/sec)	0.25 l/s
DISTRICT		LILONGWE	STATIC WATER LEVEL	9.50m
		T.A. CHIMUTU	DYNAMIC WATER LEVEL	
DATA		26/10/2011	PUMP SET	50 m

TIME (Hour: Minute)		Elapsed Time t(min)	Accumulated time (Lit/min)	Water Level (m)	Recovery (m)	Remarks
10 : 20	0	0	1440	50.00	40.50	Clean water
: 21	1	1	1441	49.20	39.70	
: 22	1	2	1442	48.65	39.15	
; 23	1	3	1443	47.25	37,75	
: 24	1	4	1444	46.28	36.78	
: 25	1	5	1445	45.84	36.34	
: 29	2	7	1447	44.94	35.44	
: 30	3	10	1450	44.04	34.54	
: 33	3	13	1453	43.20	33.70	
: 25	2	15	1455	42.30	32.80	
: 40	5	20	1460	41.85	32:35	
; 45	5	25	1465	41.30	31.80	
: 50	5	30	1470	39.40	29.90	
: 55	5	35	1475	37.08	27.58	
11 : 00	5	40	1480	34.90	25.40	
: 05	5	45	1485	32.76	23.26	
: 10	5	50	1490	30.54	21.04	
: 15	5	55	1495	28.50	19.00	
: 20	5	60	1500	26.00	16.50	
: 30	10	70	1510	17.94	8.44	
; 40	10	80	1520	16.57	7.07	
: 50	10	90	1530	14.93	5.43	
12 : 00	10	100	1540	13.56	4.06	
: 10	10	110	1550	12.68	3.18	
: 20	10	120	1560	11.74	2.24	
: 35	15	135	1575	11.27	1.77	
: 50	15	150	1590	10.82	1.32	
13 : 05	15	165	1605	10.50	1.00	
: 20	15	180	1620	10.21	0.71	
: 35	15	195	1635	9.78	0.28	
: 50	15	210	1650	9.74	0.24	
14 : 05	15	225	1665	9.65	0.15	
: 20	15	240	1680	9.55	0.05	
: 35	15	255	1695	9.50	0.	100%

2-3 試掘 TTC No.3

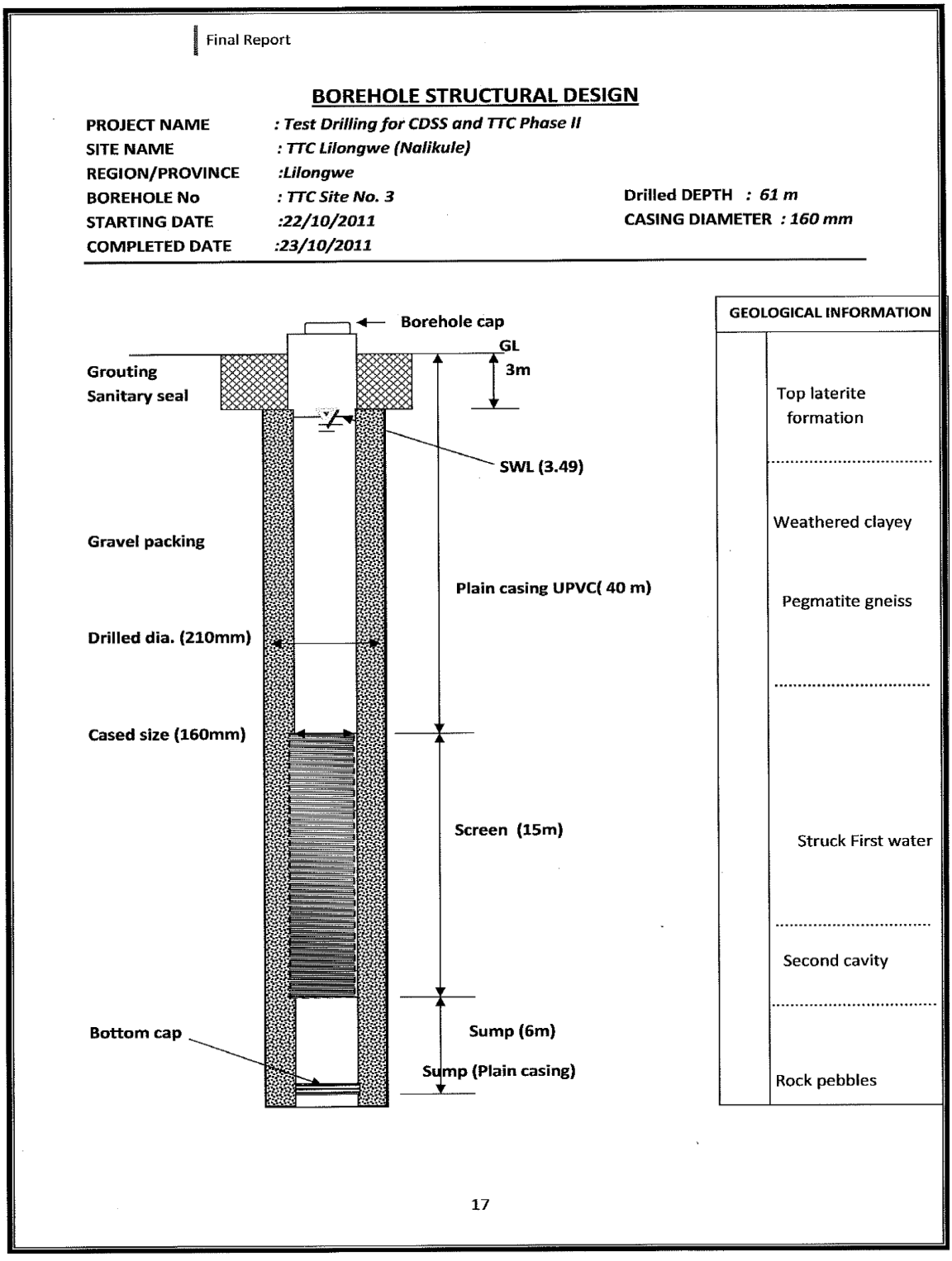
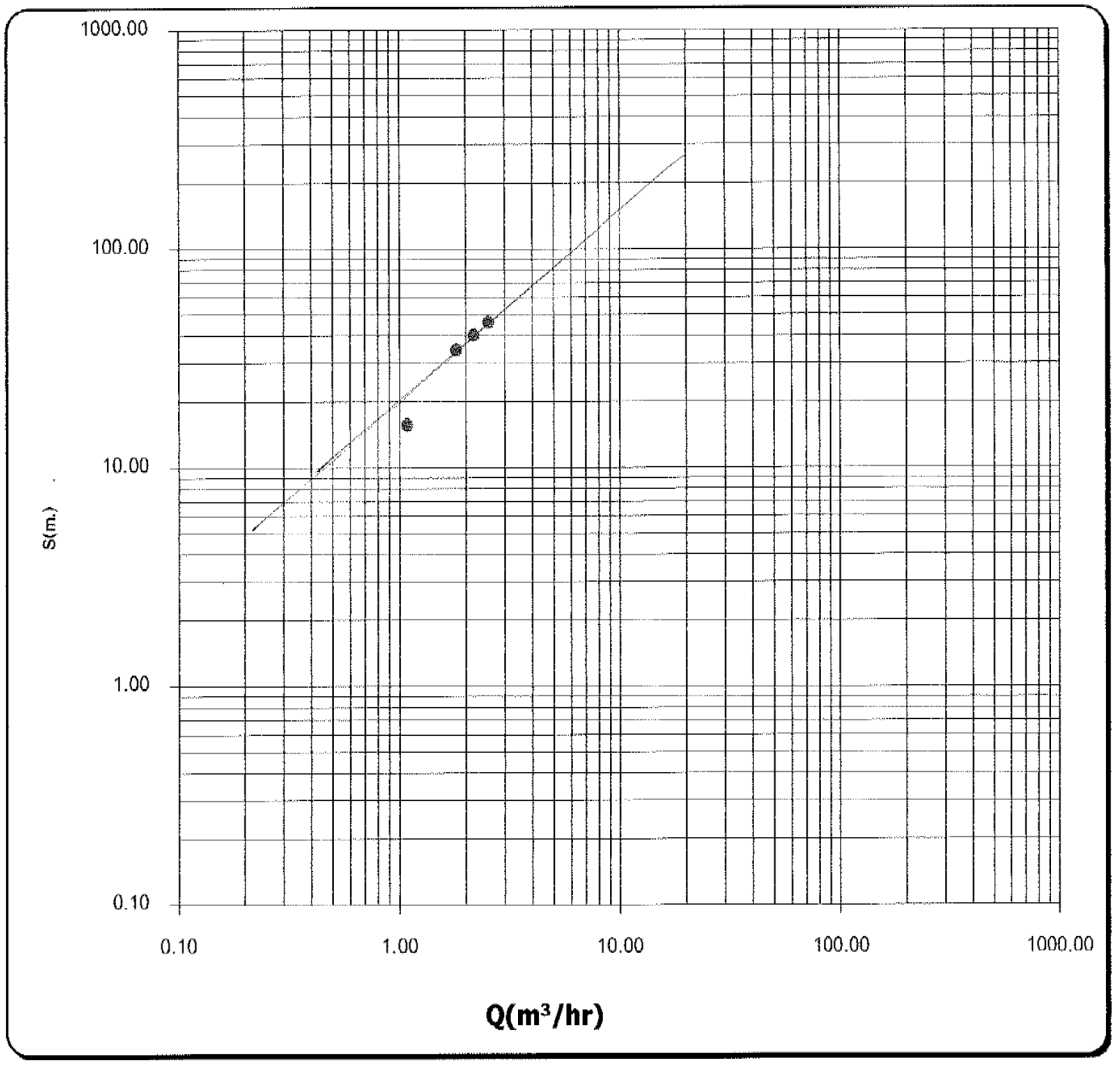


図-7 TTC No.3 井戸柱状図(適正水量を得た)

STEP DRAWDOWN TEST

PROYECT NAME	Malawi CDSS and TTC Phase II		
BOREHOLE No.	TTC No.3	STATIC WATER LEVEL	3.49 m.
SITE	TTC No.3	DATE	2011/110/23

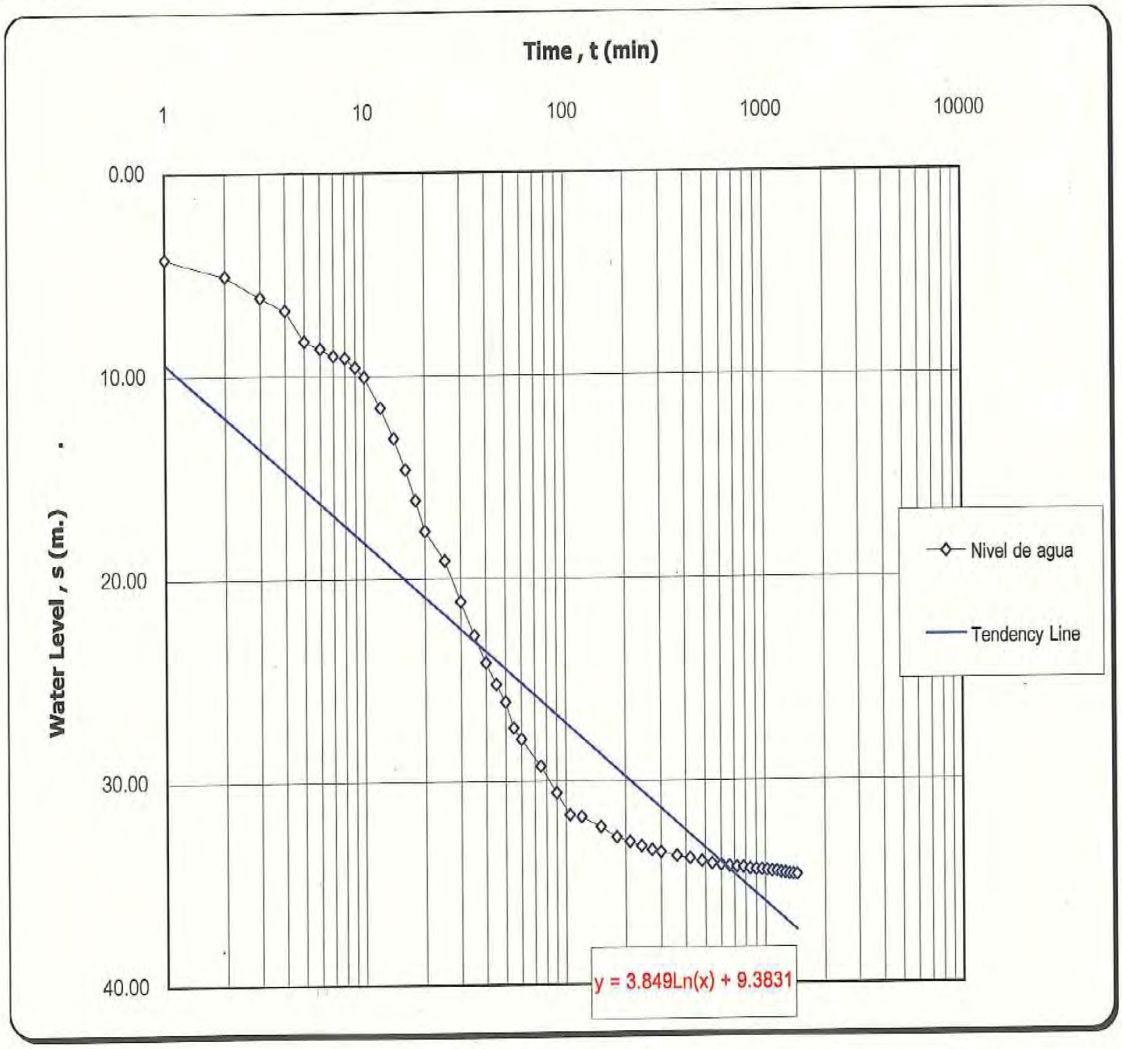


STEP	DISCHARGE Q (m^3/hr.)	DYNAMIC LEVEL N.D. (m.)	DRAWDOWN S (m.)	SPECIFIC CAPACITY Q/S (m^3/hr/m.)
FIRST(1st)	1.08	19.30	15.81	0.0683
SECOND(2nd)	2.16	44.14	40.65	0.0531
THIRD(3rd)	2.52	50.00	46.51	0.0542
FORTH(4th)				
FIFTH(5th: Constant)	1.80	38.16	34.67	0.0519

図-8 TTC No.3 段階揚水試験結果

CONSTANT DISCHARGE TEST

PROYECT NAME	Malawi CDSS Phase II Malawi DSS Phase II		
BOREHOLE No.	TTC No.3	STATIC WATER LEVEL	3.49 m.
SITE	TTC Nalikule	DATE	23/10/11



DESCRIPTION	
Discharge, Q (m^3/hr.)	1.80 m^3/hr.
water Level ,ΔS (m.)	34.67 m.
Transmissivity , T (m^2/hr.) T = (2.30 Q)/(4πΔS)	0.010 m^2/hr.
Screen Length , b (m.)	15.00 m.
Hydraulic Gradient , K (m./hr.) K = T/b	6.335E-04 m./hr.

図-9 TTC No.3 定流量揚水試験結果

表-11　TTC No.3　　定流量揚水試験計測表

CONSTANT DISCHARGE TEST

NAME OF PROJECT	Malawi CDSS and TTC PHASE 2		
No.	TTC – No. 3	BOREHOLE DEPTH	61m
NAME OF LOCATION	NALIKULE T.T.C	YIELD (L/sec)	0.5L/S
DISTRICT	LILONGWE	STATIC WATER LEVEL	3.49m
	T.A. CHIMUTU	DYNAMIC WATER LEVEL	38.16 m
DATE	23 /10/2011	PUMP SET	54 m

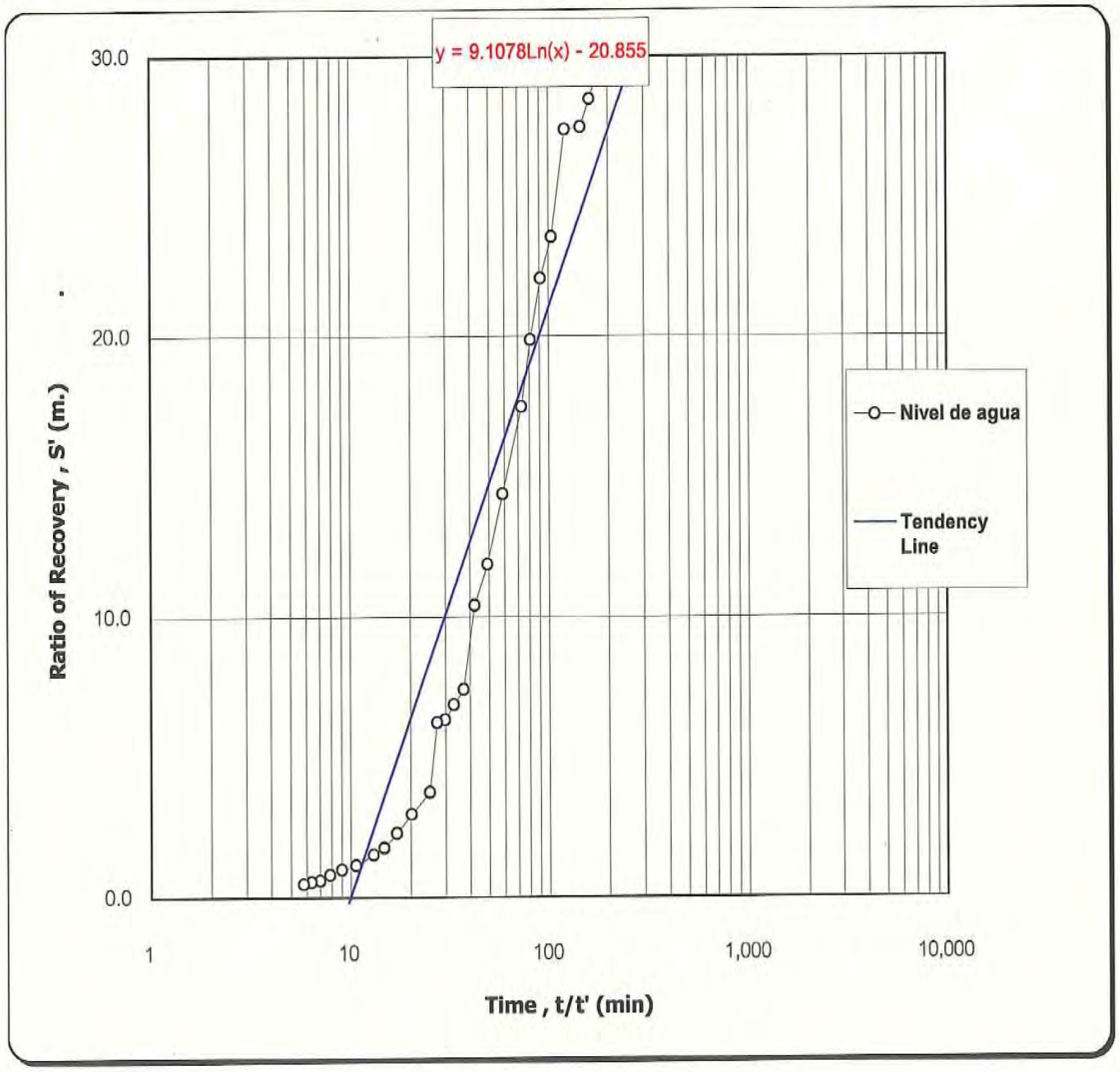
ACTUAL TIME (Hour: Minute)		TIME t(min)	YIELD (Lit/min)	DYNAMIC (m)	DEPTH (m)	REMARKS
8 : 10	0	0	5L/10sec	3,49	0	
: 11	1	1		7,73	4.24	
: 12	1	2		8.56	5.07	
: 13	1	3		9.60	6.11	
: 14	1	4		10.25	6.76	
: 15	1	5		11.78	8.29	
: 17	2	7		12.50	9.01	
: 20	3	10		13.55	10.06	
: 23	3	13		16.58	13.09	
: 25	2	15		18.49	15.00	
: 30	5	20		21.15	17.66	
: 35	5	25		22.60	19.11	
: 40	5	30		24.62	21.13	
: 45	5	35		26.30	22.81	
: 50	5	40		27.04	23.55	
: 55	5	45		28.71	25.22	
9 : 00	5	50		29.58	26.09	
: 05	5	55		30.86	26.93	
: 10	5	60		31.42	27.93	
: 20	10	70		32.58	29.09	
: 30	10	80		33.32	29.83	
: 40	10	90		34.05	30.56	
: 50	10	100		35.24	31.75	
10 : 00	10	110		35.74	32.25	
: 10	10	120		36.02	32.53	
: 30	20	140		36.26	32.77	
: 50	20	160		36.49	33.00	
11 : 10	20	180		36.68	33.19	
: 30	20	200		36.72	33.23	
: 50	20	220		36.90	33.41	
12 : 10	20	240		37.02	33.53	
:40	30	270		37.14	33.65	
13 : 10	30	300		37.20	33.71	
: 40	30	330		37.25	33.76	
14 : 10	30	360		37.32	33.83	
: 40	30	390		37.47	33.98	
15 : 10	30	420		37.60	34.11	
16 : 10	60	480		37.65	34.16	
17 :10	60	540		37.72	34.23	
18 : 10	60	600		37.76	34.27	
19 : 10	60	660		37.78	34.29	
20 : 10	60	720		37.85	34.36	
21: 10	60	780		37.89	34.40	
22: 10	60	840		37,92	34.43	
23: 00	60	900		37.94	34.45	
00: 10	60	960		37.96	34.47	
01; 10	60	1020		37.99	34.50	
02: 10	60	1080		38.04	34.55	
03: 10	60	1140		38.08	34.59	
04: 10	60	1200		38.12	34.63	
05 ;10	60	1260		38.14	34.65	
06 ;10	60	1320		38.16	34.67	

Temperature :　　PH:

Conductivity :

WATER LEVEL RECOVERY TEST

PROYECT NAME	Malawi CDSS Phase II		
BOREHOLE No.	TTC No.3	STATIC WATER LEVEL	3.49 m.
SITE	TTC Nalikule	DATE	24/10/11



DESCRIPTION	
Discharge, Q (m^3/hr.)	1.80 m^3/hr.
Water Level ,ΔS (m.)	34.67 m.
Transmissivity , T (m^2/hr.) T = (2.30 Q)/(4πΔS)	0.01 m^2/hr.
Screen Length , b (m.)	15.00 m.
Hydraulic Gradient , K (m./hr.) K = T/b	6.335E-04 m./hr.

図-10　TTC No.3　　回復試験結果

表-12　TTC No.3　　回復試験計測表

DISCHARGE TEST (RECOVERY)

NAME OF PROJECT	Malawi CDSS and TTC PHASE 2		
No.	TTC – No. 3	BOREHOLE DEPTH	61.0 m
NAME OF LOCATION	NALIKULE TTC	YIELD (L/sec)	0.5 l/s
DISTRICT	LILONGWE	STATIC WATER LEVEL	3.49 m
	T.A. CHIMUTU	DYNAMIC WATER LEVEL	38.16
DATE	24/10/2011	PUMP SET	54.0m

Time (Hour: Minute)		Elapsed Time t(min)	Accumulated time (Lit/min)	Water Level (m)	Recovery (m)	Remarks
8 : 14	0	0	1440	38.16	34.67	Clean water
: 15	1	1	1441	36.33	32.84	
: 16	1	2	1442	35.55	32.06	
: 17	1	3	1443	34.42	30.93	
: 18	1	4	1444	33.14	29.65	
: 19	1	5	1445	31.96	28.47	
: 21	2	7	1447	29.92	26.43	
: 24	3	10	1450	27.04	23.55	
: 27	3	13	1453	24.08	20.59	
: 33	2	15	1455	22.67	19.18	
: 37	5	20	1460	19.30	15.81	
: 44	5	25	1465	16.48	12.99	
: 49	5	30	1470	14.24	10.75	
: 54	5	35	1475	12.55	9,06	
: 59	5	40	1480	11.18	7.69	
09 : 04	5	45	1485	10.03	6.54	
: 09	5	50	1490	9.01	5.52	
: 14	5	55	1495	7.54	4.05	
: 24	5	60	1500	7.00	3.51	
: 34	10	70	1510	6.55	3.06	
: 44	10	80	1520	5.98	2.49	
: 54	10	90	1530	5.58	2.09	
10 : 04	10	100	1540	5.30	1.81	
: 14	10	110	1550	5.12	1.63	
: 29	10	120	1560	4.90	1.41	
: 44	15	135	1575	4.73	1.24	
: 59	15	150	1590	4.60	1.11	
11 : 14	15	165	1605	4.52	1.03	
: 29	15	180	1620	4.48	0.99	
: 44	15	195	1635	4.37	0.88	
: 59	15	210	1650	4.30	0.81	
12 : 14	15	225	1665	4.23	0.74	
: 29	15	240	1680	4.20	0.71	
: 44	15	255	1695	4.12	0.63	
: 59	15	270	1710	4.08	0.59	

2-4 試掘 TTC No.4

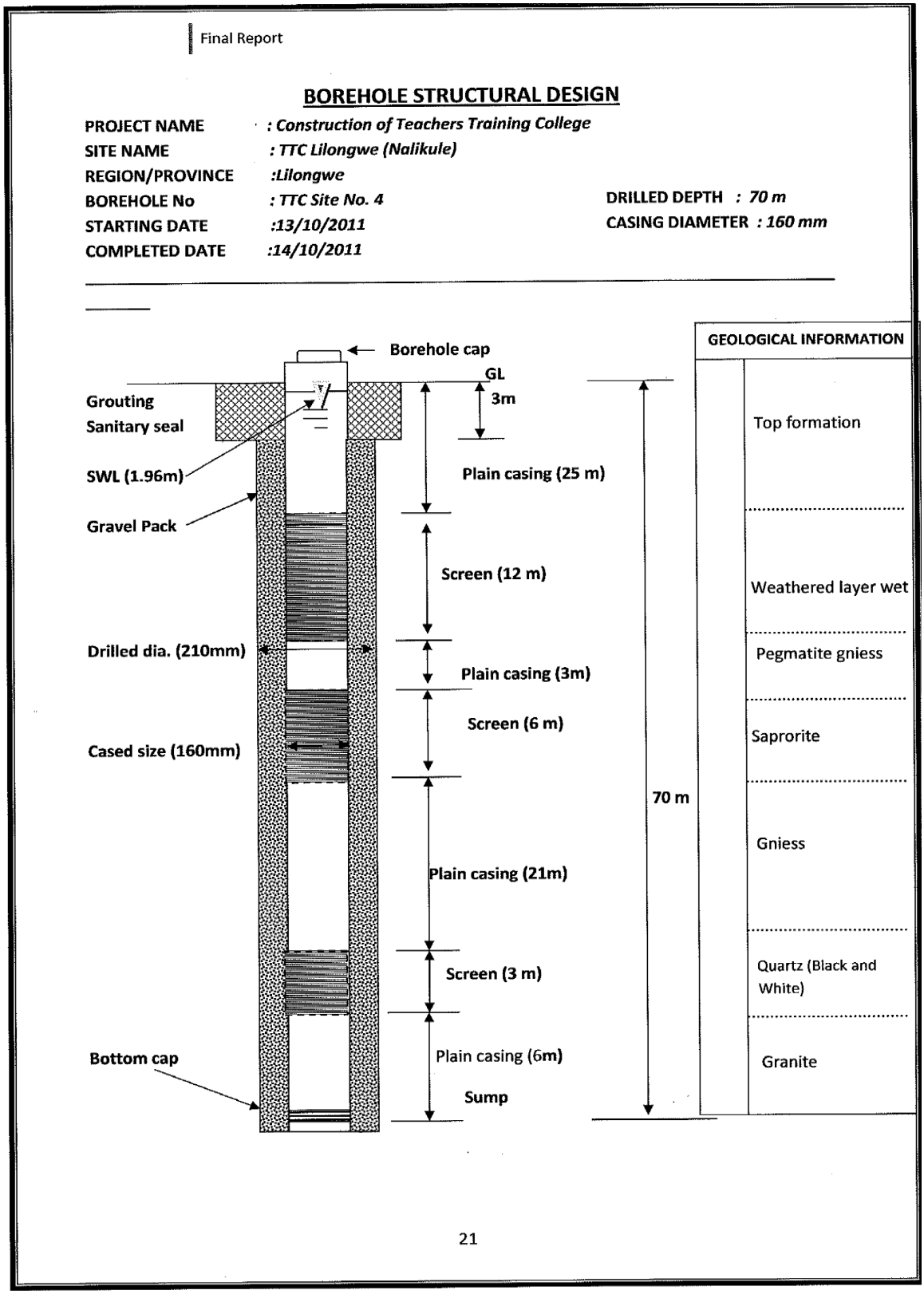
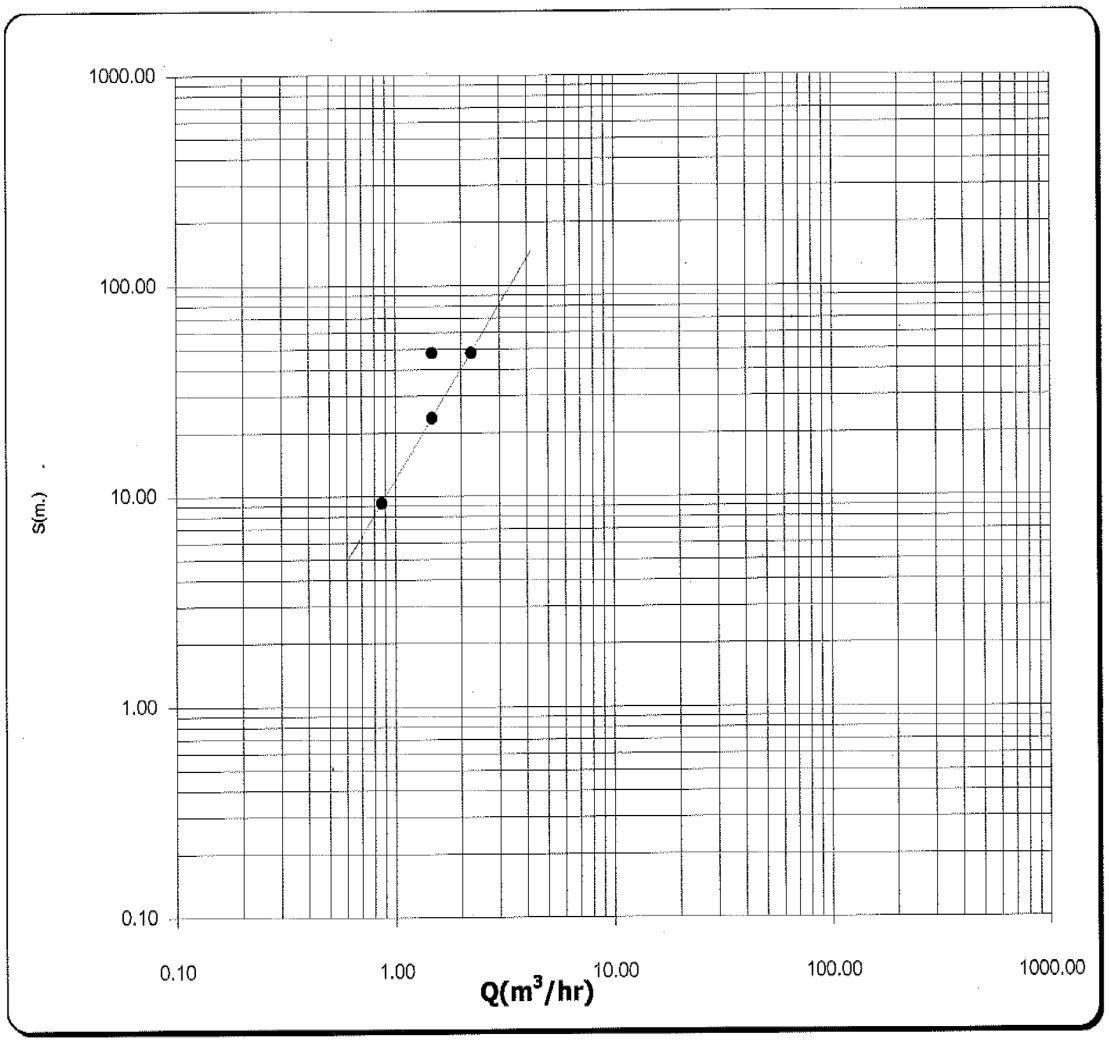


図-11　TTC No.4　井戸柱状図(適正水量を得た)

STEP DRAWDOWN TEST

PROYECT NAME	Malawi CDSS & TTC Phase 2		
BOREHOLE No.	TTC No. 4	STATIC WATER LEVEL	1.96 m.
SITE	TTC Nalikule	DATE	27/10/11

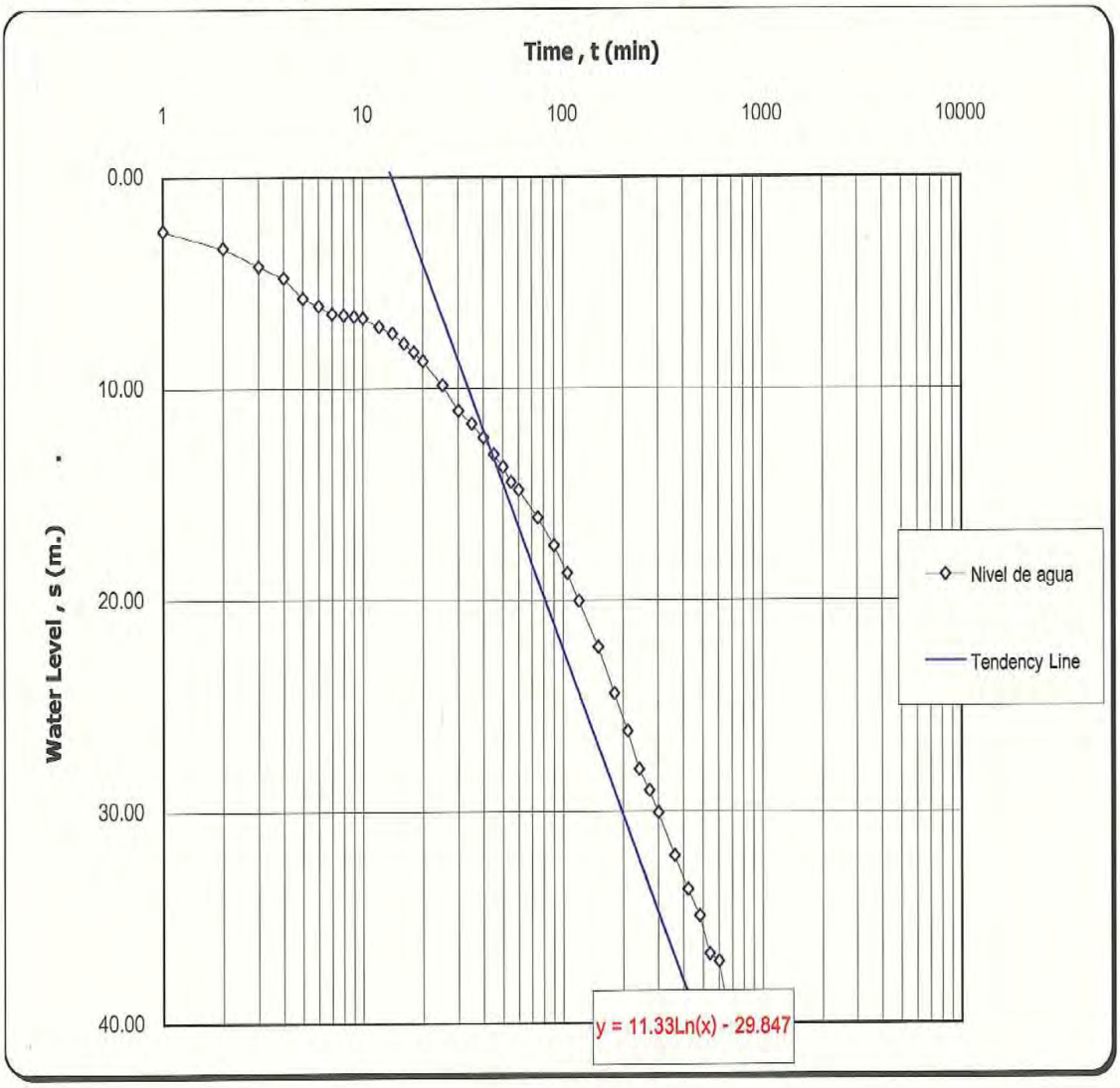


STEP	DISCHARGE Q (m^3/hr.)	DYNAMIC LEVEL N.D. (m.)	DRAWDOWN S (m.)	SPECIFIC CAPACITY Q/S (m^3/hr/m.)
FIRST(1st)	0.86	11.24	9.28	0.0931
SECOND(2nd)	1.48	25.50	23.54	0.0627
THIRD(3rd)	2.23	50.00	48.04	0.0465
FORTH(4th)				
FIFTH(5th Constant)	1.48	50.00	48.04	0.0307

図-12　TTC No. 4　　段階揚水試験結果

CONSTANT DISCHARGE TEST

PROYECT NAME	Malawi CDSS & TTC Phase 2		
BOREHOLE No.	TTC No.4	STATIC WATER LEVEL	1.96 m.
SITE	TTC Nalikule	DATE	29/10/11



DESCRIPTION	
Discharge, Q (m^3/hr.)	1.48 m^3/hr.
water Level ,ΔS (m.)	48.04 m.
Transmissivity , T (m^2/hr.) T = (2.30 Q)/(4πΔS)	0.006 m^2/hr.
Screen Length , b (m.)	21.00 m.
Hydraulic Gradient , K (m./hr.) K = T/b	2.678E-04 m./hr.

図-13　TTC No.4　定流量揚水試験結果

表-13　TTC No. 4　定流量揚水試験計測表

Final Report

CONSTANT DISCHARGE TEST

NAME OF PROJECT	Malawi CDSS and TTC PHASE 2		
No.	[redacted]	BOREHOLE DEPTH	70M
NAME OF LOCATION	NALIKULE T.T.C	YIELD (Lit/sec)	0.41L/S
DISTRICT	LILONGWE	STATIC WATER LEVL	1.96m
	T.A. CHIMUTU	DYNAMIC WATER LEVEL	50M
DATE	28 /11/2011	PUMP SET	50M

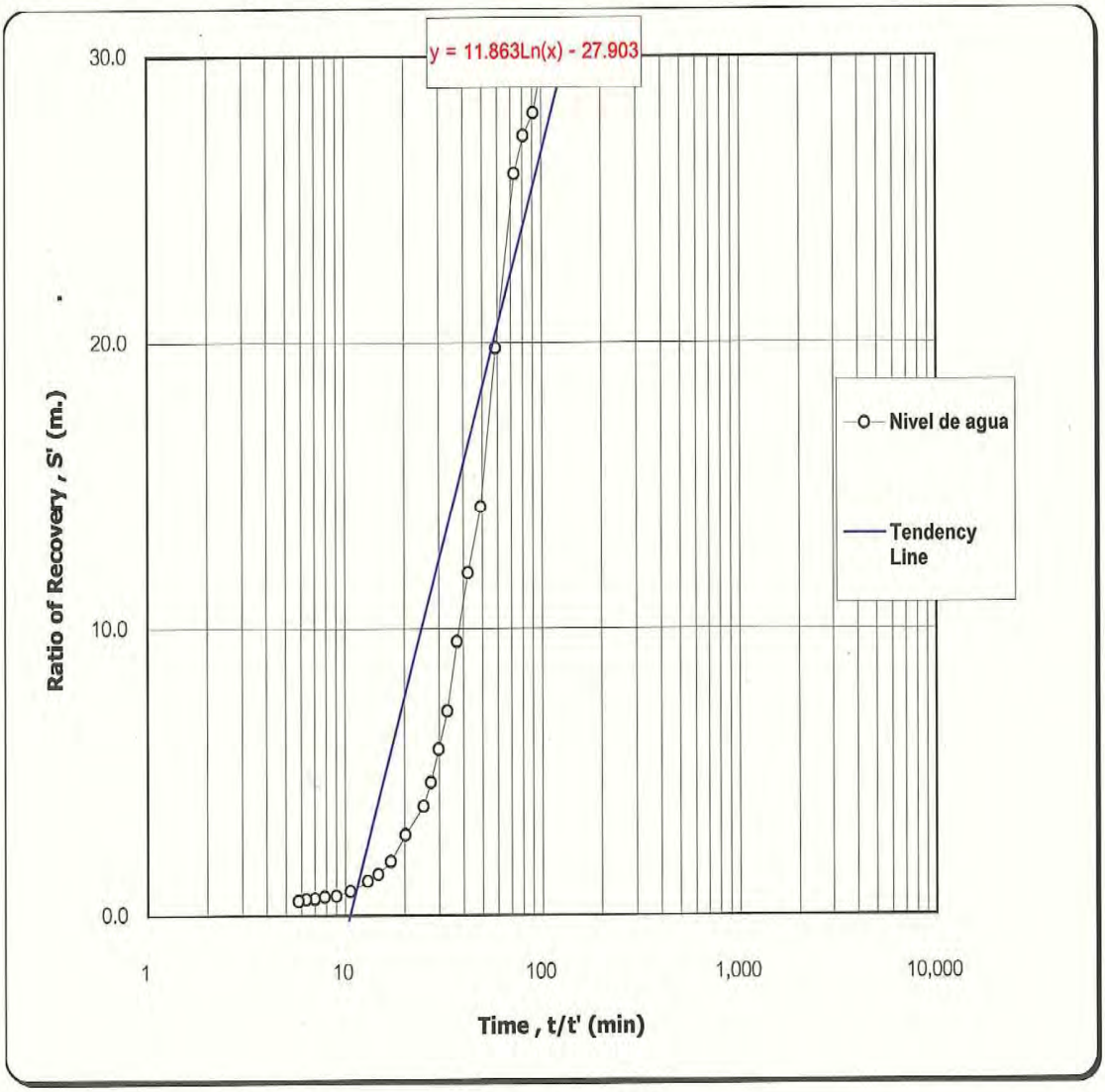
ACTUAL TIME (Hour: Minute)		TIME t(min)	YIELD (Lit/min)	DYNAMIC (m)	DRAWDOWN (m)	REMARKS
08: 55	0	0	5L/12sec	1.96	0	
: 56	1	1		4.50	2.54	
: 57	1	2		5.30	3.34	
: 58	1	3		6.17	4.21	
: 59	1	4		6.72	4.76	
09: 00	1	5		7.68	5.72	
: 02	2	7		8.42	6.46	
: 05	3	10		8.62	6.66	
: 08	3	13		9.01	7.05	
: 10	2	15		9.49	7.53	
: 15	5	20		10.66	8.70	
: 20	5	25		11.80	9.84	
: 25	5	30		13.62	11.66	
: 30	5	35		14.27	12.31	
; 35	5	40		15.07	13.11	
: 40	5	45		15.67	13.71	
: 45	5	50		16.75	14.79	
: 50	5	55		17.60	15.64	
: 55	5	60		18.38	16.42	
10 : 05	10	70		19.37	17.41	
; 15	10	80		20.24	18.28	
: 25	10	90		21.20	19.24	
: 35	10	100		22.00	20.04	
: 45	10	110		23.57	21.61	
: 55	10	120		24.92	22.96	
11 : 15	20	140		26.37	24.41	
: 35	20	160		27.34	25.38	
: 55	20	180		28.52	26.56	
12 : 15	20	200		29.54	27.58	
: 35	20	220		30.95	28.99	
; 55	20	240		31.99	30.03	
13 :25	30	270		32.94	30.98	
; 55	30	300		34.03	32.07	
14 : 25	30	330		35.01	33.05	
; 55	30	360		35.63	33.67	
15: 25	30	390		36.87	34.91	
: 55	30	420		38.67	36.71	
16 : 55	60	480		39.02	37.06	
17 :55	60	540		41.27	39.31	
18 : 55	60	600		43.08	41.12	
19 ; 55	60	660		46.52	44.56	
20 ; 55	60	720		48.04	46.08	
21: 55	60	780		49.18	47.22	
22: 55	60	840		50.00	48.04	

Temperature :　　PH:

Conductivity :

WATER LEVEL RECOVERY TEST

PROYECT NAME	Malawi CDSS & TTC Phase II		
BOREHOLE No.	TTC No.4	STATIC WATER LEVEL	1.96 m.
SITE	TTC Nalikule	DATE	29/10/11



DESCRIPTION	
Discharge, Q (m^3/hr.)	1.48 m^3/hr.
Water Level ,ΔS (m.)	48.04 m.
Transmissivity , T (m^2/hr.) T = (2.30 Q)/(4πΔS)	0.01 m^2/hr.
Screen Length , b (m.)	21.00 m.
Hydraulic Gradient , K (m./hr.) K = T/b	2.685E-04 m./hr.

図-14　TTC No.4　回復試験結果

表-14　TTC No.4　回復試験結果

DISCHARGE TEST (RECOVERY)

NAME OF PROJECT	**Malawi CDSS and TTC PHASE 2**		
No.	[redacted]	BOREHOLE DEPTH	70m
NAME OF LOCATION	NALIKULE TTC	YIELD (Lit/sec)	0.41 l/s
DISTRICT	LILONGWE	STATIC WATER LEVL	1.96m
	T.A. CHIMUTU	DYNAMIC WATER LEVEL	50M
DATE	29/10/2011	PUMP SET	50M

Time (Hour: Minute)		Elapsed Time t(min)	Accumulated time (Lit/min)	Water Level (m)	Recovery (m)	Remarks
00 : 06	0	0	1440	50.00	48.04	Clean water
: 07	1	1	1441	48.50	46.54	
: 08	1	2	1442	47.28	45.32	
; 09	1	3	1443	46.50	44,54	
: 10	1	4	1444	45.72	43.76	
: 11	1	5	1445	44.18	42.22	
: 13	2	7	1447	40.52	38.56	
: 15	3	10	1450	37.00	35.04	
: 20	3	13	1453	33.74	31.78	
: 21	2	15	1455	30.52	28.56	
: 26	5	20	1460	27.86	25.90	
; 30	5	25	1465	21.77	19.81	
: 35	5	30	1470	16.80	14.54	
: 40	5	35	1475	13.91	11.95	
: 50	5	40	1480	11.50	9.54	
: 55	5	45	1485	9.07	7.11	
: 01	5	50	1490	7.75	5.79	
: 05	5	55	1495	6.59	4.63	
: 16	5	60	1500	5.75	3.79	
: 23	10	70	1510	3.09	3.13	
; 30	10	80	1520	4.46	2.50	
: 46	10	90	1530	3.83	1.87	
: 36	10	100	1540	3.44	1.48	
02 : 06	10	110	1550	3.32	1.36	
: 21	10	120	1560	3.15	1.19	
: 36	15	135	1575	2.92	0.96	
: 51	15	150	1590	2.80	0.84	
: 36	15	165	1605	2.72	0.76	
: 51	15	180	1620	2.64	0.68	
03 : 06	15	195	1635	2.60	0.64	
: 21	15	210	1650	2.58	0.62	
: 36	15	225	1665	2.54	0.58	
: 51	15	240	1680	2.53	0.57	
04 : 06	15	255	1695	2.52	0.56	
: 21	15	270	1710	2.50	0..54	
: 36	15	285	1725	2.46	0.50	99%

表-15　TTC No.2～TTC No.4サイトの水質分析結果

Final Report

FORM No. WQPC 12/1

MINISTRY OF AGRICULTURE, IRRIGATION & WATER DEVELOPMENT

WATER QUALITY TEST RESULTS

LAB No.	814	821	822	
DATE SAMPLED	28/10/2011	28/10/2011	28/10/2011	
WATER RESOURCE UNIT				
MAP SHEET/GRID REF.				
SOURCE IDENTITY/LOCATION	**NALIKULE TTC BOREHOLE (BH No.3) T/A CHIMUTU, LILONGWE DISTRICT**	**NALIKULE TTC BOREHOLE (BH No.4) T/A CHIMUTU, LILONGWE DISTRICT**	**NALIKULE TTC BOREHOLE (BH No.2) T/A CHIMUTU, LILONGWE DISTRICT**	**MALAWI DRINKING WATER STANDARDS FOR BOREHOLE WATER (MS733:2005)**
pH Value	6.89	7.84	7.64	**6.0-9.5**
CONDUCTIVITY (µS/cm at 25°C)	311	390	460	**3, 500**
TOTAL DISSOLVED SOLIDS, mg/l	160	175	182	**2, 000**
CARBONATE (as CO_3^{2-}), mg/l	0.00	30	42	**-**
BICARBONATE (as HCO_3^{2-}), mg/l	132	90	119	**-**
CHLORIDE (as Cl^-), mg/l	26.2	28	21	**750**
SULPHATE (as SO_4^{2-}), mg/l	5.18	4.49	6.96	**800**
NITRATE (as NO_3^-), mg/l	0.003	0.199	0.013	**100**
FLUORIDE (as F^-), mg/l	-	-	-	**3.0**
SODIUM (as Na^+), mg/l	11	19	15	**500**
POTASSIUM (as K^+), mg/l	3.7	4.4	5.5	**-**
CALCIUM (as Ca^{++}), mg/l	29	35	41.6	**250**
MAGNESIUM (as Mg^{++}), mg/l	12.3	9.2	13.4	**200**
IRON (Fe^{++}), mg/l	0.153	0.309	0.140	**3.0**
TOTAL HARDNESS (as $CaCO_3$), mg/l	123	125	159	**800**
TOTAL ALKALINITY (as $CaCO_3$), mg/l	108	123	167	**-**
SILICA (as SiO_2), mg/l	19	20	17	**-**
TURBIDITY, NTU	<0.01	<0.01	2.0	**25**
SUSPENDED SOLIDS, mg/l	<0.10	<0.10	<0.10	**25**
Faecal coliform (FC), Count ml/100 ml	3	0	0	**50**
Faecal streptococci (FS), Count/100 ml	0	0	0	**0**

Analysis conducted by Central Water Laboratory

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1.　井戸掘さく中　　(TTC No.1)

2.　ケーシングの設置(口径 160mm)　TTC No.3

3. 現場水質分析(一般細菌及び大腸菌群)
水資源省水質分析係官 (TTC No.3)

4.　地質サンプル(深度 3m～61m)　TTC No.3

5.　井戸洗浄　TTC No.4

６．揚水試験　(水量と水位計測)　　TTC　No.3

図-15　TTC サイト(No.1～No.4)試掘調査記録写真　(2011 年 10 月)