資料－７　ボ-リング調査結果

GOVERNMENT OF UGANDA

RURAL ELECTRIFICATION PROJECT

GEOTECHNICAL INVESTIGATION FOR THE PROPOSED NEW POWER SUBSTATION AT KAYUNGA

CONDUCTED BY
HYDROTECH CONSULTANTS
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KAMPALA - UGANDA.

OCTOBER 1998

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List of Abbreviations

BH	-	Borehole.
BS	-	British Standard.
CH	-	Inorganic Clays of High Plasticity.
CI	-	Inorganic Clays of Intermediate Plasticity.
CL	-	Inorganic Clays of Low Plasticity.
SC	-	Clayey Sands.
D-35	-	Position of Disturbed Samples.
U-100	-	Position of Undisturbed Samples.
M	-	Meters.
SPT	-	Standard Penetration Test.
N-value	-	SPT Blows for 300 mm penetration.
NM	-	Natural Moisture Content.
SA	-	Sieve Analysis.
LL	-	Liquid Limit.
PL	-	Plastic Limit.
PI	-	Plasticity Index.
USCS	-	Unified Soil Classification System.
ρ	-	Bulk Density.
C_u	-	Shear Strength Value.
G_s	-	Specific Gravity.
q_u	-	Ultimate Compressive Strength.

1. INTRODUCTION:

M/S YACHIYO ENGINEERING CO. LTD contracted HYDROTECH Consultants to conduct a geotechnical investigation at the proposed new power substation at Kayunga.

The Investigation followed an agreed scope of work aimed at the following;

i) Confirming the location of the test holes and determination of the exact boring location.

ii) Measurement of height above mean sea level based on authorized temporary bench mark.

iii) Establishing the thickness and composition of the underlying soil profile down to a depth of 5.0 meters;

iv) Establishing the depth of the water table;

v) Evaluating the consistency of the in-situ soils using SPTs;

vi) Establishing engineering properties of the in-situ material through laboratory tests.

vii) Evaluating the soil bearing capacity and recommend the foundation system; and

viii) Compiling a technical report.

ix) Backfilling of boreholes.

The geotechnical investigation was conducted by drilling two boreholes to a maximum depth of 5.5M at the proposed test points. Disturbed and undisturbed samples were retrieved from the boreholes for laboratory testing. The field investigation was conducted between Monday October 6 and October 8, 1998.

2. THE SITE

2.1 Site Location (See Appendices)

The site is located about 75 km on Mukono – Kayunga Road. It is within one of the tributaries of the Sezibwa River which flows in to L. Kyoga (see attached map).

2.2 Site Condition

At the time of the investigation, the site was dry having been filled with murram during previous old construction activities of the Bugerere Dairy Co-operative Society Limited plant within the vicinity. The site was easily accessible to the drilling equipment.

2.3 Geology of the Site (see attached map).

Geological Maps sheets N.A. 36-14 AND North A 36/4-II Bombo indicate granitoid rocks are the parent material forming the predominant geology underlying the site. These are mainly foliated and unfoliated gneisses and granites. Geological mapping revealed topical isolated and thin laterites. The valley has alluvial deposits, mainly of sands, silts, clays and peat.

2.4 Tectonics

There are no major faulting in the area. Tremors due to earth movements, though common in Uganda, are not significant in the investigated area. The site is not associated with volcanism and is free from land slides owing to its rather flat topography.

3.0 FIELD TESTS

3.1 General

The fieldwork was conducted in accordance with BS 5930 198: "Code of Practice for Site Investigations"

The fieldwork consisted of rotary boring, conducting SPT test, recovery of disturbed and undisturbed soil samples.

3.2 Boring with Standard Penetration Tests

Two boreholes were sunk to a maximum depth of 5.5m using a rotary drilling rig mobile model 47. The rig was mounted with 100mm or 200mm diameter flight augers. Standard penetration tests were performed in boreholes using a standard split spoon sampler over a total depth of 450mm. The number of blows required to drive the spoon through the last 300mm penetration was recorded as the N-value. A logging of the soil type, and condition was prepared (see drill logs in appendices).

3.3 Disturbed and Undisturbed Soil Samples.

A total of 10 disturbed samples resulting from SPTs were collected for subsequent laboratory testing. Also using the Shelby and sampling tubes, undisturbed samples were collected at pre-identified depth and were subsequently taken for laboratory testing. A summary of test results is given in Tables 1a-b in the Appendices.

3.4 Ground Water Table

Ground water was encountered in both boreholes at a depth of 1.5m below ground level but being in the R. Sezibwa valley flooding is expected and common.

4. LABORATORY TESTING

Laboratory testing was conducted by the Central Materials Laboratory in accordance to BS 1377: 990 "Methods of Test of Soils for Engineering Purposes".

Individual tests were conducted according to the following test procedures;

Natural moisture content	Part 2: 3.2
Sieve analysis	Part 2: 9.2
Liquid Limit	Part 2: 4.3
Plastic Limit	Part 2: 5.3
Plasticity index	Part 2: 5.4
Specific gravity	Part 2: 8.3
Unconfined compression	Part 7: 7.2

5. FIELD AND LABORATORY TEST RESULTS.

5.1 Field Test Results

The soil profile at both test points in general have a thin fill/top of a thick grey clayey silty sand Gravel. The above soil rests on gray red/brown silty clay before grading into a weathered rock. In BH1 a layer of silty clay was identified between 0.3 – 1.5m. The silty clays below 3.5m depth probably a product of weathering of the in-situ rocks. The thickness of the top soil/fill averaged to 0.5m while for the silty sandy Gravel 2.5m.

The consistency of the silty clay material was ranged from stiff to very stiff while for silty sandy gravel the relative density was from dense to medium dense.

The in-situ moisture regime was predominantly found below liquid limits in all tested samples and in for BH1 depth 1.5 – 3.5m where the natural moisture was below the plastic limit. The uncorrected SPT value of 11 was obtained in BH1 for the silty clay while for the silty sandy Gravel 22.

5.2 Laboratory Test Results.

5.2.1 Soil classification

The soil directly below the existing fill are silty clays with intermediate plasticity indices in BH1. Then a rather thick silty sandy gravel in both BH1 and BH2. Then silty clays of intermediate to high plasticity were identified below 3.5m depth.

According to the unified Soil Classification System, the silty clay soils can be classified as either CI or CH while for the clayey silty sandy (GC).

The soils proposed to directly support the loads (clayey silty sandy gravel) have the following average composition.

- Gravel 42%
- Sand 24%
- Silty and Clay 32%

5.2.2 Shear Strength

Unconfined strength test was only possible for the silty clays and the compressive strength qu ranged from 230 kN/m^2 to 500 kN/m^2 . The shear strength Cu thus, vary from 115 kN/m^2 to 250 kN/m^2. The average bulk density was 19kN/m^3.

6. EVALUATION OF THE BEARING CAPACITY

6.1 General

In absence of information regarding the foundation type, size and depth, an accurate bearing capacity evaluation for in-situ soils cannot be made. The evaluation presented here is based on assumptions in order to guide the design engineer.

6.2 Assumptions

The following assumptions have been made;

i) Two alternative foundation types may be used:

- Strip continuos foundation of minimum width of 1.0m and
- Single square footings of 2.0

ii) The foundation depth will not exceed 1.5m

iii) Below 1.5m the soil profile to be affected by the proposed construction is the silty sandy gravel and generally the relevant SPT value are those to a depth of from 1.5m-3.5m. The minimum SPT value in this range was 22.

For N = 22; $\varnothing^{o} = 34^{o}$ from Charts
b = 20.7 kN/m^3

iv) Terzaghi's bearing capacity equations and the theory on which they are based are valid.

v) The most likely failure mechanism is by general shear.

vi) The allowable bearing capacity safety factor is 3.

6.3 Allowable Bearing Capacity

Based on the laboratory test results and assumptions outlined in 6.2, the following allowable bearing values were determined;

FOUNDATION TYPE	BEARING CAPACITY (kNm^2)
A 1.0M wide strip footing at 1.5M depth	**375**
A single square footing 2.0M wide placed at 1.5M depth.	**422**

From the above table a load of about 8MN can be supported by 2x2 single square footing at 1.5m depths.

7. CONCLUSIONS

i) The proposed site for construction of the proposed New Power Substation at Kayunga was investigated using two boreholes drilled down to a depth 5.5 meters.

ii) The site generally has top soil/fill on top of thick clayey silty sandy gravels. Top soil/fill averaging 0.5m thick. This will need to be stripped to spoil in the preparation for a founding system.

iii) The top silty clay and the clayey sandy gravel on alluvial products resulting from erosional deposition materials is product within the land system. It was evident from the logs that residual soils from weathering in in-situ rocks start at a depth of about 3.5m.

iv) The in-situ moistures are significantly below liquid limit and the proposed 1.5m deep excavations are expected to be wet due to a high water level. The use of pumping or any dewatering system is not ruled out.

v) The silty clay material was found with a substantial fraction passing Bs sieve 0.063mm (between 54% - 92%). Within the recommended construction depth of 2.0m the predominant material shall be clayey silty sandy gravels with average passing Bs sieve 0.063mm of 32%.

vi) The liquid limit was found to range from 34% to 53% while the minimum plasticity index was 14%. These values are high and the soils are likely to be sticky. However, at the construction depth, considerable volume changes are not expected.

vii) The shear parameters recommended for bearing capacity evaluation Cu = $\varnothing kNm^2$ and $\varnothing=34^0$ for a general shear failure mechanism. This was got from the minimum SPT value of 22.

viii) The bearing capacity was evaluated to be 375 kNm^2 for 1.0m wide strip footing and 422 kNm^2 for 2.0m square footing at a depth of 1.5m, a load up to 8MN shall be supported on a 2m x 2m square footing.

ix) Ground water level was encountered at 1.5m in the investigated depth and is likely to be permanent as water level measurements taken after 25 hours was 0.5m below ground surface. Although the investigations were conducted during the dry season the site is susceptible to seasonal flooding and the foundations engineer must take this into account. If the substation is very sensitive to water, rock fill should be considered. The idea is to raise sensitive parts out of reach of flood levels.

x) The site is free of any geological structural discontinuity like faults and is tectonically stable. No land slides are expected.

xi) The information provided in this report about the site soil conditions is considered adequate for foundation design and analysis.

BIBLIOGRAPHY

i) BRITISH STANDARDS INSTITUTION. British Standards 1377:1975 and British Standard 1377:1990. Methods of test for Soils for Civil Engineering Purposes London, 1990.

ii) BRITISH STANDARDS INSTITUTION. British Standard 5930:1981. Code of Practice for site investigations. London, 1981.

iii) BRAIN VICKERS. Laboratory work in Civil Engineering Soils Mechanics. Granada Publishers, London, 1978.

iv) G. BRYEN. J.P. EVERETT, K. SCHWARTZ. A guide to Practical Geotechnical Engineering in Southern Africa. Frankipile SA, Third Edition, 1995.

v) JOSEPH E. BOWLES. Foundation Analysis and Design, Second edition, McGraw Hill Kogukusha Ltd. Tokyo, 1977.

vi) SHENBAGA R. KANIRAJ. Design Aids in soils Mechanics and Foundation Engineering. Tata McGraw Publishing Co. Ltd. New Dehli, 1995.

APPENDICES

HYDROTECH CONSULTANTS

LEVELLING BOOKING FORM

Date: 6th October, 98 **Observer: KENNETH OTIM**

Project: RURAL ELECTRIFICATION **Booker: RICHARD ENEN**

Location: KAYUNGA. **Staffman: HERBERT**

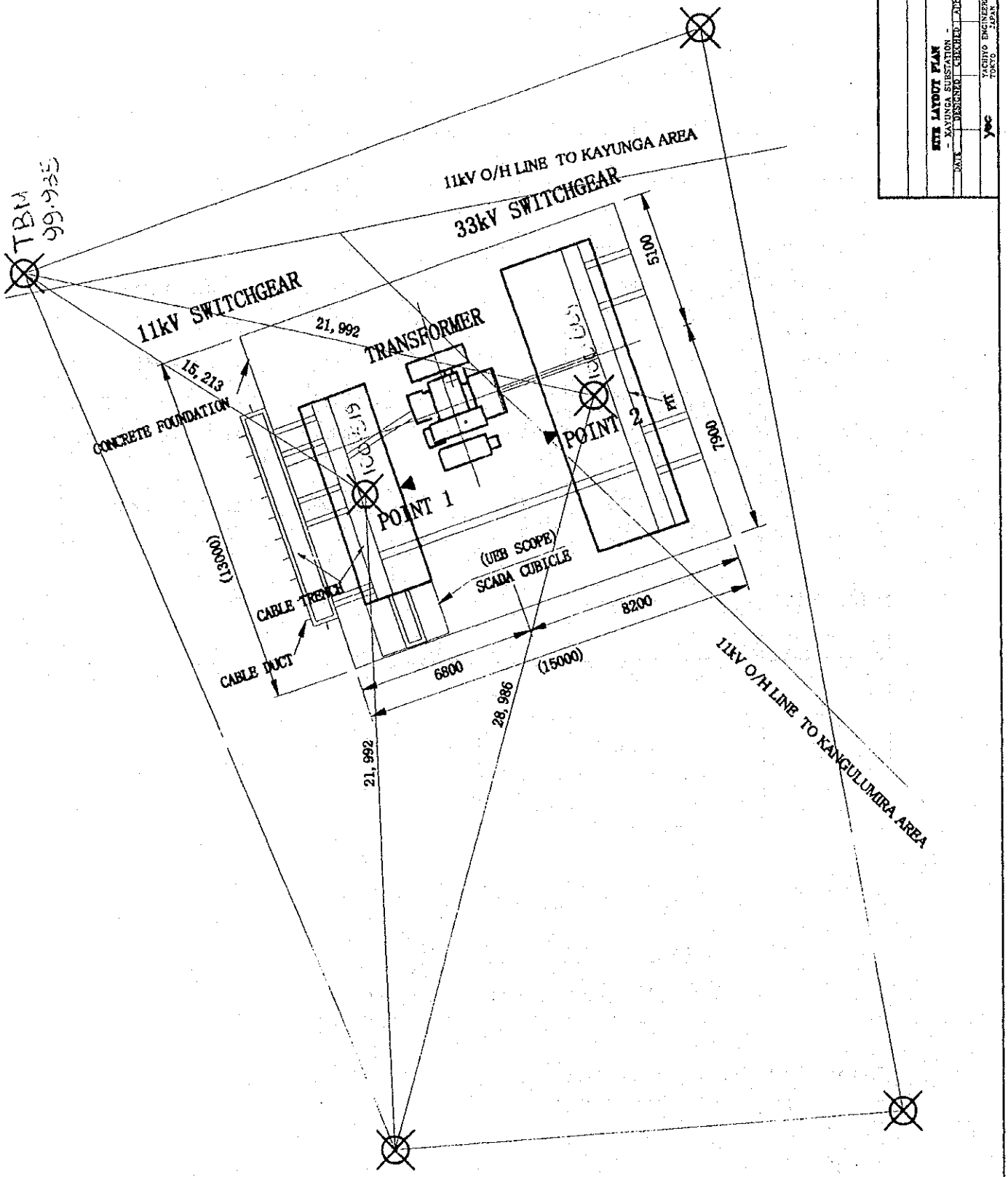
BS	IS	FS	RISE	FALL	REDUCED LEVEL	REMARKS
2.184					99.935	Sta. A. TBM
	1.600		0.584		100.519	Sta. B. Point 1
		1.450	0.150		100.669	Sta. C. Point 2
ΣBS = 2.184		ΣFS = 1.450				

CHECKS: ΣBS - ΣFS = RLL Point – RL TBM

∴ 2.184 - 1.450 = 0.734

and 100.669 - 99.935 = 0.734

CONCLUSION : No field error.


SCALE 1/200
DWG. No. E-1
SITE LAYOUT PLAN
- KAYUNGA SUBSTATION -
DESIGNED CHECKED APPROVED REVISION
DATE
YACHIYO ENGINEERING CO., LTD
TOKYO JAPAN
TBM 99.935
11kV O/H LINE TO KAYUNGA AREA
33kV SWITCHGEAR
11kV SWITCHGEAR
21,992
TRANSFORMER
15,213
CONCRETE FOUNDATION
POINT 1
POINT 2
5100
7900
(13000)
CABLE TRENCH
CABLE DUCT
(UEB SCOPE)
SCADA CUBICLE
8200
6800
(15000)
28,986
21,992
11kV O/H LINE TO KANGULUMIRA AREA

HYDROTECH CONSULTANTS

SOIL FIELD TESTS

Project: Rural Electrification Project

Location: Kayunga

Ground Elevation: 100.519

Borehole No. B/H2

Size of Hole/Pit: 75 mm diameter

Drilling Equipment used: Mobile Drill F700

Date Started: 7.10.1995 Date completed: 7.10.1998

Depth of Water Table: 100.019M after 25 hours

SAMPLE				FIELD TESTS		DESCRI-PTION	GROUP SYMBOL	REMARKS
SAMPLE TUBE NO.	DEPTH	DISTUR BED	UNDIST-URBED	SPT	WATER TABLE	TOP SOIL		
	100.519 100.219							
	100.219 99.519				100.019	GREY BROWN SILTY SAND		
B/H1 1 – 1.45 D3	99.519 99.069	[redacted]	UD	5 6 5(11)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H1 2 – 2.45 D3	98.519 98.069	[redacted]		7 10 12(22)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H1 3-3.45 D3	97.519 97.069	[redacted]		21 15 17(32)		GREY BROWN RED SILTY SAND	GM	DENSE
B/H1 4-4.45 D.3	96.519 96.069	[redacted]		12 14 14(28)		GREY BROWN RED SILTY SAND	GM	VERY STIFF
B/H1 5-5.45 D3	95.519 95.069	[redacted]		7 10 12(22)		WEATH-ERED ROCK	ML	MEDIUM DENSE

HYDROTECH CONSULTANTS

SOIL FIELD TESTS

Project: Rural Electrification Project

Location: Kayunga

Ground Elevation: 100.669

Borehole No. B/H2

Size of Hole/Pit: 75 mm diameter

Drilling Equipment used: Mobile Drill F700

Date Started: 7.10.1995 Date completed: 7.10.1998

Depth of Water Table: 100.169M after 25 hours

SAMPLE				FIELD TESTS		DESCRI-PTION	GROUP SYMBOL	REMARKS
SAMPLE TUBE NO.	DEPTH	DISTUR BED	UNDIST-URBED	SPT	WATER TABLE	TOP SOIL		
	100.669 100.269							
	100.269 99.669				100.169	GREY BROWN SILTY SAND		
B/H2 1 – 1.45 D3	99.669 99.219	▮		5 6 5(11)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H3 2 – 2.45 D3	98.669 98.219	▮		7 10 12(22)		GREY BROWN SILTY SAND	GM	MEDIUM DENSE
B/H2 3-3.45 D3	97.669 97.219	▮		21 15 17(32)		GREY BROWN RED SILTY SAND	GM	DENSE
B/H2 4-4.45 D.3	96.669 96.219	▮		12 14 14(28)		GREY BROWN RED SILTY SAND	GM	VERY STIFF
B/H2 5-5.45 D3	95.669 95.219	▮		7 10 12(22)		WEATH-ERED ROCK	ML	MEDIUM DENSE

CENTRAL MATERIALS LABORATORY

PROJECT : PROPOSED NEW POWER SUBSTATION AT KAYUNGA
CLIET : M/S HYDROTECH CONSULTANTS
DATE : 7/10 98

SUMMARY OF SOIL LABORARORY TESTS

DEPTH	FIELD SPT VALUE	N-VALUE	LOG	SOIL DESCRIPTION	N.M	ATTERBERG LIMITS			GRADING% PASSING										G_s	q_u	Remarks
					%	LL %	PL %	PI %	10.0 mm	6.3 mm	5.0 mm	2.0 µm	6.0 µm	0.425 µm	3.0 µm	0.212 µm	0.50 µm	0.63 µm		kPa	
0m00				Top soil (Fill)																	
1.00	3,3,8	11		Dark grey silty clay (stiff)u-100	17.1	43	16	27	100	98	97	94	84	79	72	67	61	54	2.69	230	Groundwater level 1.5m
2.00	34,24,18	42		Grey brown clayey silty sandy Gravel (dense) (D-35)	9.1	38	17	21	90	82	76	56	40	36	34	31	28	25	2.65		
3.00	24,30,18	48		Grey brown clayey silty sandy gravel(dense)(D-35)	10.1	34	20	14	90	79	73	59	44	40	37	35	32	28	2.64		
4.00	7,8,9	17		Grey brown very silty clay (very stiff) u-100)	25.0	46	23	23	96	88	87	81	79	78	77	76	74	69	2.68	350	
5.00	6,10,16	26		Weathered rock (medium dense) (D-35)	38.5	46	24	22		100	98	95	90	88	87	86	83	78	2.69		

BH NO. 1
FINAL DEPTHS AT 5.5m
SUMMARY FORM NO. 1a

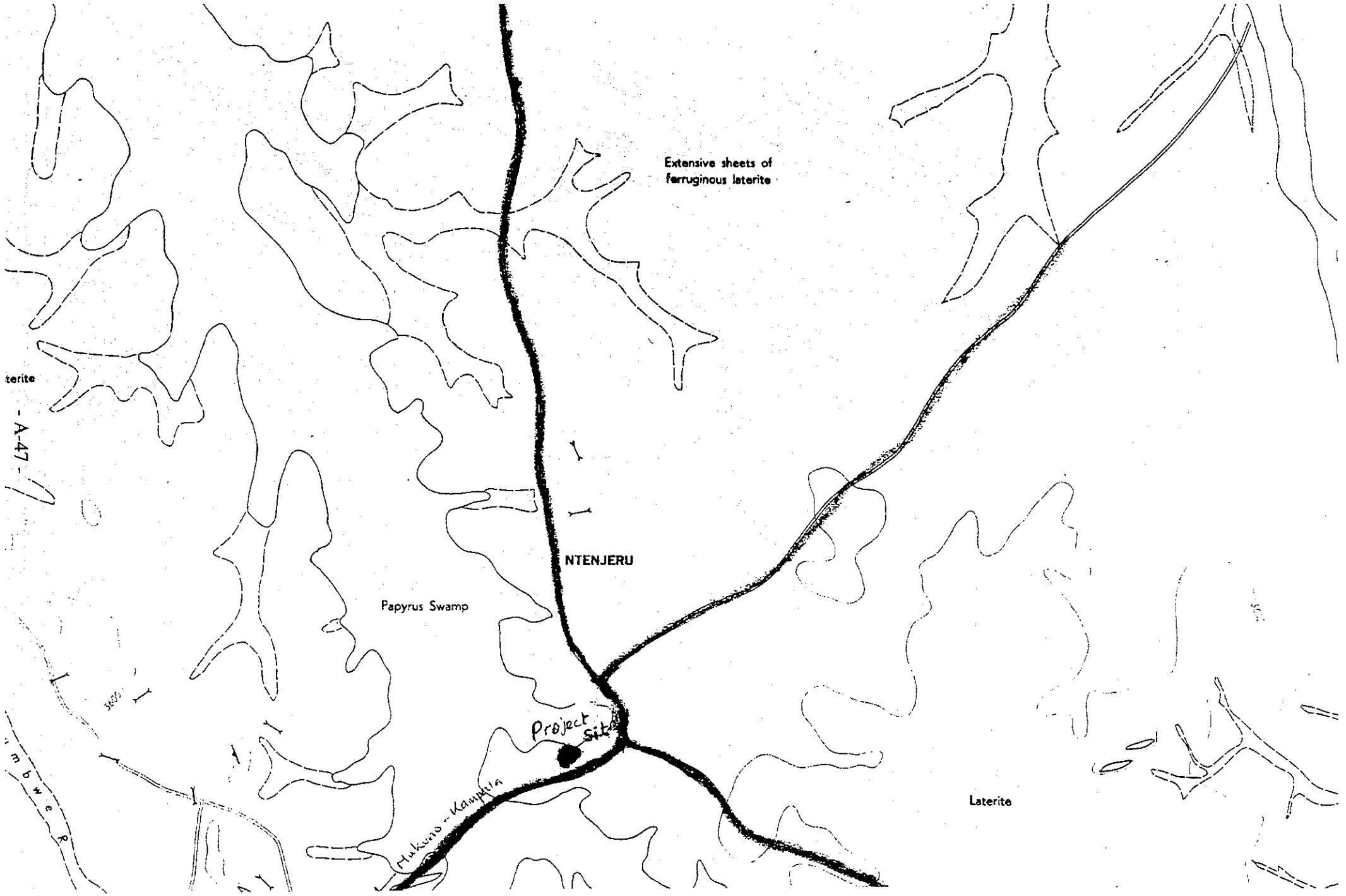
CENTRAL MATERIALS LABORATORY

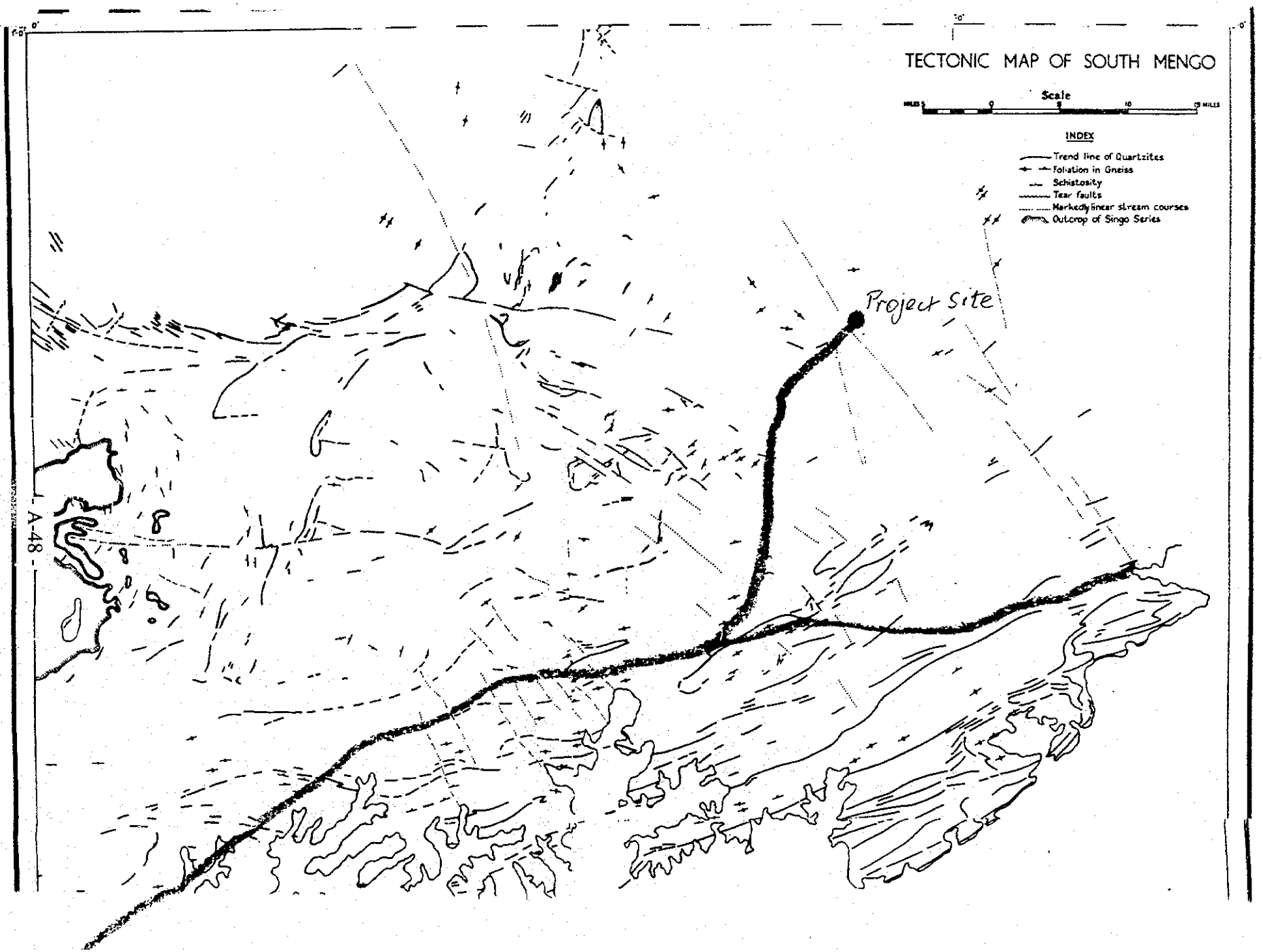
PROJECT : PROPOSED NEW POWER SUBSTATION AT KAYUNGA
CLIET : M/S HYDROTECH CONSULTANTS
DATE : 7/10 98

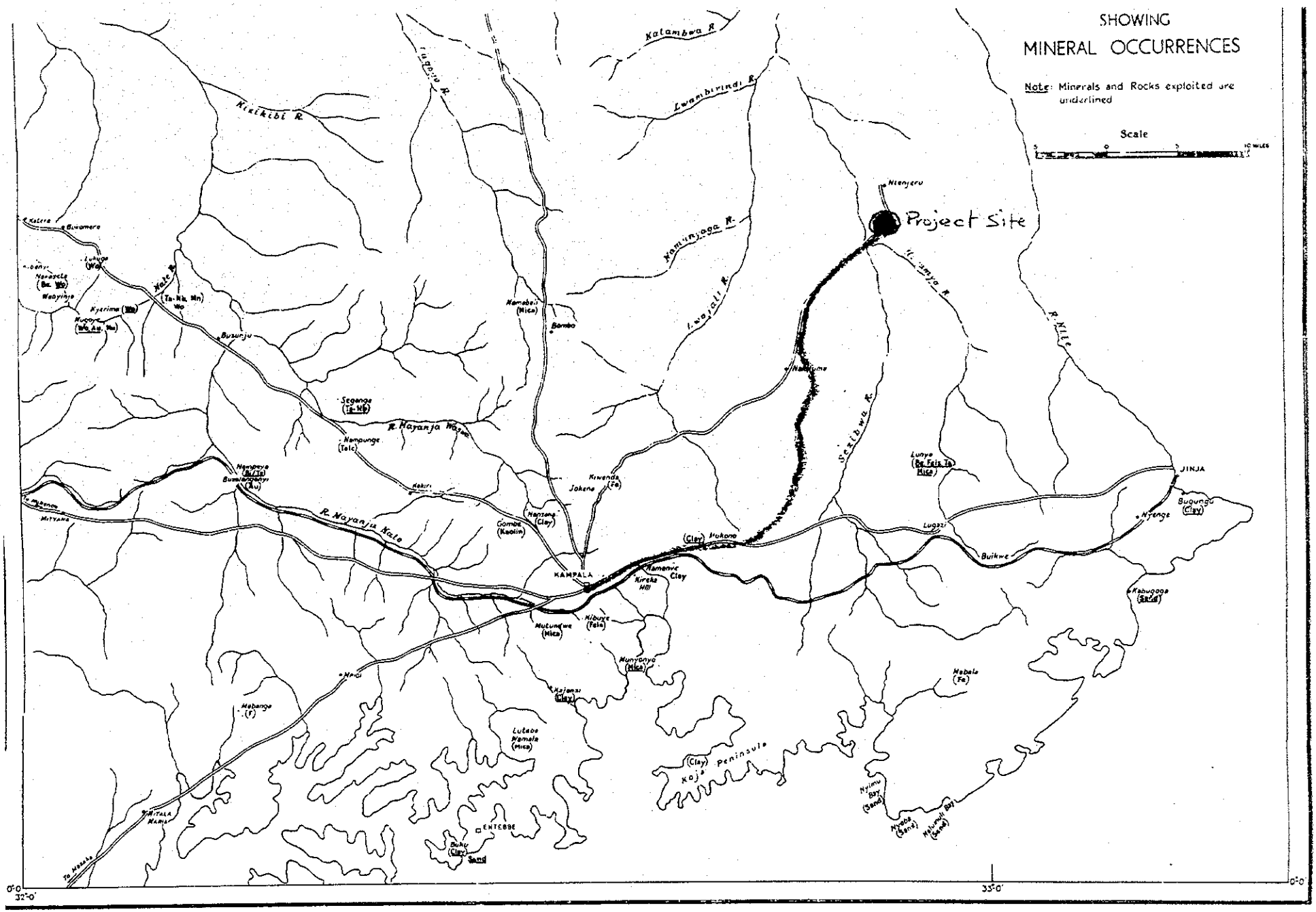
SUMMARY OF SOIL LABORARORY TESTS

DEPTH	FIELD SPT VALUE	N-VALUE	LOG	SOIL DESCRIPTION	N.M	ATTERBERG LIMITS			GRADING% PASSING										G_s	q_u	Remarks
					%	LL %	PL %	PI %	10.0 mm	6.3 mm	5.0 mm	2.0 µm	6.0 µm	0.425 µm	3.0 µm	0.212 µm	0.50 µm	0.63 µm		kPa	
0m00 0.4m				Top Soil (Fill)																	
1.00	5,6,5	11		Grey Brown silty sand (medium dense)(D-35)	15.1	38	14	24	92	68	62	52	46	45	43	41	39	36	2.65		Groundwater level 1.5m
2.00	7,10,12	22		Grey brown clayey silty sandy Gravel (dense) (D-35)	16.3	44	16	28	81	65	60	50	45	45	44	43	42	38	2.65		
3.00	21,15,17	32		Grey red brown Red clayey silty sandy gravel (dense) (D-35)	16.4	38	16	22	91	86	78	69	58	56	54	53	51	47	2.67		
4.00	12,14,14	28		Grey -red brown very silty clay (verystiff) u-100	25.4	45	23	22		100	99	97	94	94	93	92	91	86	2.70	500	
5.00	7,10,12	22		Weathered rock (very stiff) (D-35)	32.2	53	26	27			100	99	98	98	97	97	95	92	2.72		

BH NO. 2
FINAL DEPTHS AT 5.5m
SUMMARY FORM NO. 1b


Extensive sheets of ferruginous laterite
terite
NTENJERU
Papyrus Swamp
Project Site
Mukuno - Kamputa
Laterite
- A-47 -


TECTONIC MAP OF SOUTH MENGO
Scale
INDEX
Trend line of Quartzites
Foliation in Gneiss
Schistosity
Tear faults
Markedly linear stream courses
Outcrop of Singo Series
Project Site


SHOWING
MINERAL OCCURRENCES
Note: Minerals and Rocks exploited are underlined
Scale
Project Site
Ntenjeru
Kalambwa R.
Lwambirindi R.
Kamunyaga R.
Lwajali R.
Kiyanja R.
R. Nile
Kikekibi R.
Kaleera
Buwamera
Lunga (Wo)
Nakaseke (Bx, Wo)
Wabyinya
Kyerima (Wo)
Kuyora (Wo, Au, Mn)
Kafe R.
(Ta-Nb, Mn) Wo
Busunju
Namebeli (Mica)
Bombo
Nabusuna
Seganga (Ta-Nb)
R. Nayanja Waya
Namaunga (Talc)
Nakiri
Kiwenda (Fe)
Jakana
Sezibwa R.
Lunya (Ba, Fels, Ta) Mica
JINJA
Bugungu (Clay)
Nyenga
Lugazi
Buikwe
Kabugaga (Sand)
Mawanga (Ta) Bumbaddeyi (Au)
R. Mayanja
Mityana
R. Nayanja Kafe
Gombe (Kaolin)
Hanjeng (Clay)
(Clay) Prokana
KAMPALA
Namanve Clay
Kireka Hill
Mutundwe (Mica)
Kiburye (Fels)
Munyonyo (Mica)
Nkozi
Kajansi (Clay)
Mabanga (r)
Lutaba Namala (mica)
Mabala (Fe)
(Clay) Koja Peninsula
Nyimu Bay (Sand)
Nkoba (Sand)
Kituuti Bay (Sand)
MITALA MARIA
To Masaka
ENTEBBE
Buku (Clay) Sand
0°0'
32°0'
33°0'
0°0'

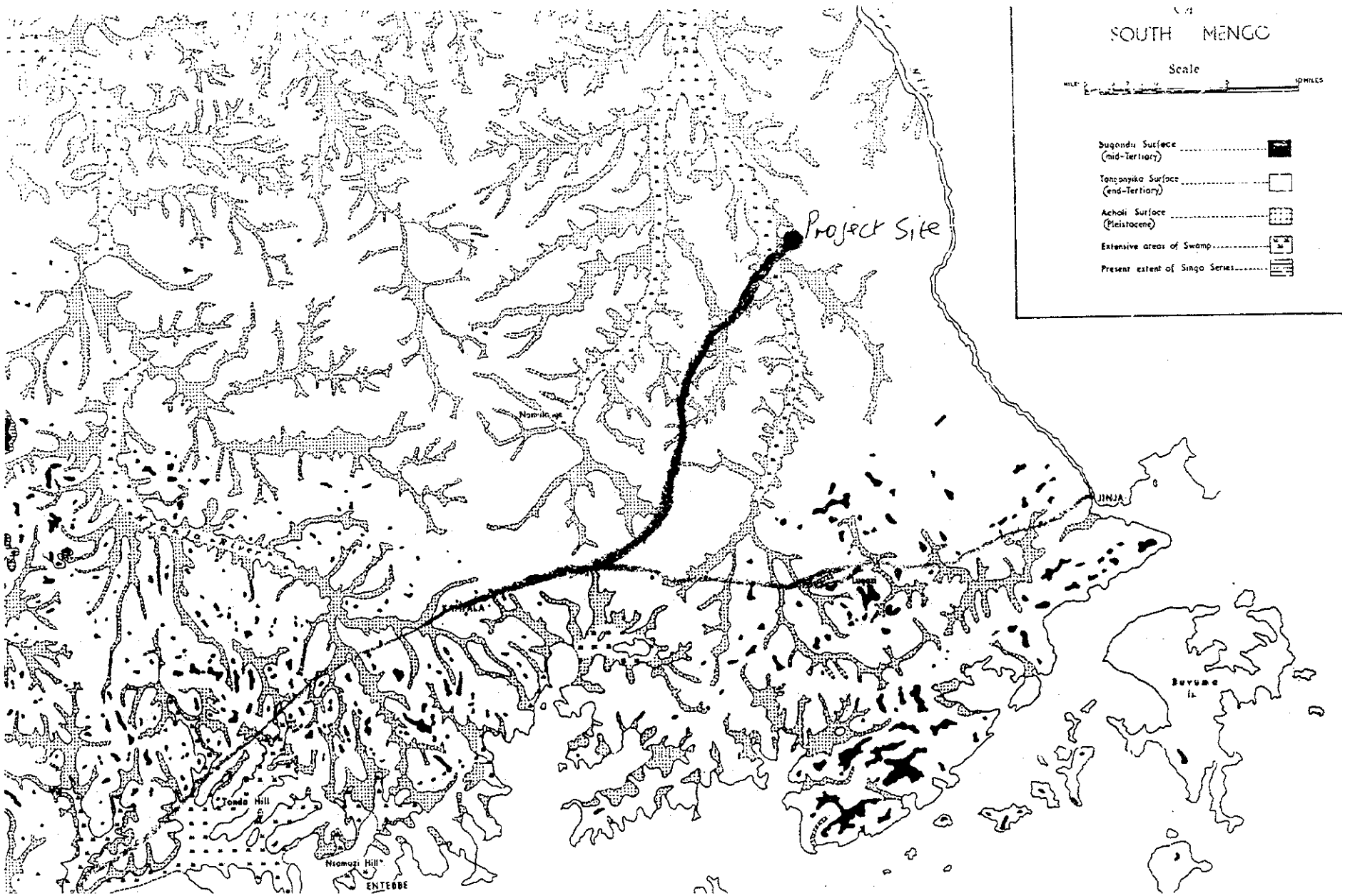

SOUTH MENGO
Scale
Project Site
Buganda Surface (mid-Tertiary)
Tanganyika Surface (end-Tertiary)
Acholi Surface (Pleistocene)
Extensive areas of Swamp
Present extent of Singo Series
JINJA
Buvuma Is.
Tonda Hill
Nsamazi Hill
ENTEBBE

Plate 1
Drilling in progress

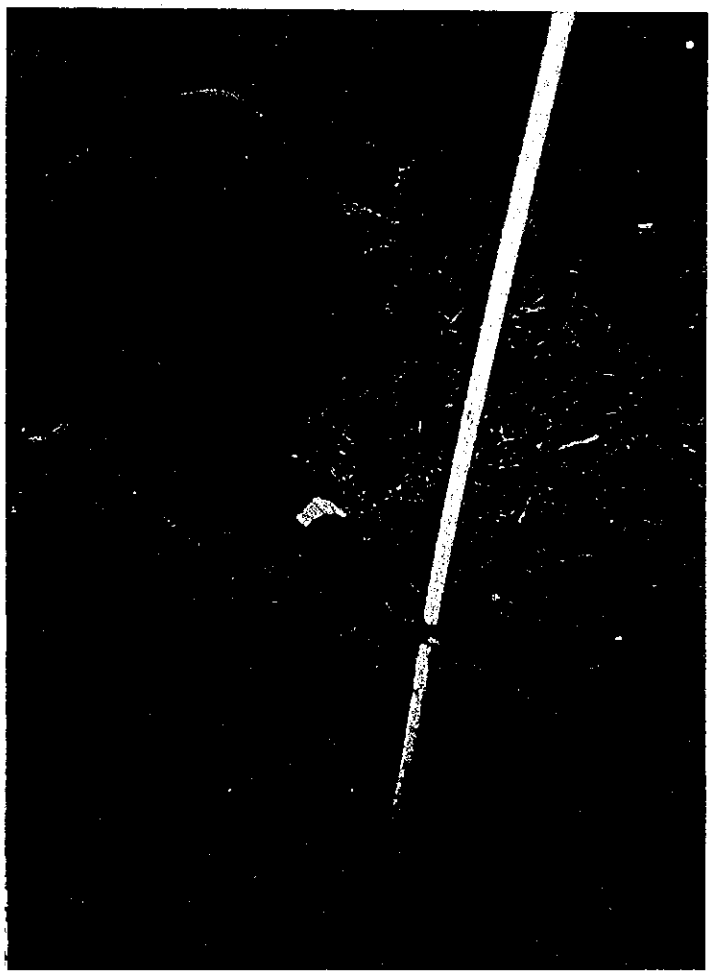


Plate 2
Determining the GWT level after 25 hours

Plate 3
Laboratory Tests in progress at the Central Materials Laboratory, Kireka

Plate 4
Backfilling the holes

資料－８　参考資料リスト

収集資料リスト

調査名　ウガンダ共和国地方電化計画基本設計調査団

番号	名　称	形態 図書・ビデオ・地図・写真等	オリジナル・コピー	発 行 機 関	発行年
1	POVERTY ERADICATION ACTION PLAN (A NATIONAL CHALLENGE FOR UGANDA) JUNE 1997	図書	コピー	MINISTRY OF PLANNING AND ECONOMIC DEVEROPMENT	1997 年
2	UGANDA YEARLY REVIEW 1997/98	図書	コピー	UGANDA NOW LTD.	1998 年
3	UGANDA'S DECADE OF REFORMS 1986-1996	図書	コピー	FOUNTAIN PUBLISHERS	1996 年
4	BACKGROUND TO THE BUDGET 1998/99 (BUDGETING FOR POVERTY ERADICATION) JUNE 1998	図書	コピー	MINISTRY OF FINANCE, PLANNING AND ECONOMIC DEVEROPMENT	1998 年
5	UGANDA DISTRICTS INFORMATION HANDBOOK 1997/98 EDITION	図書	コピー	FOUNTAIN PUBLISHERS	1997 年
6	UGANDA TRAVELLER'S MAP	地図	オリジナル	MACMILAN EDUCATION LTD.	1997 年
7	MEDIUM TERM PLAN FOR 1998-2002 PROGRAMME : THE UGANDA ELECTRICITY SUPPLY	図書	コピー	UEB	1998 年
8	UGANDA ELECTRICITY BOARD ACCOUNTS FOR THE YEAR ENDED 31ST DECEMBER 1997, TOGETHER WITH THE AUDITOR'S REPORT AND OPINION THEREON	図書	コピー	UEB	1998 年
9	UGANDA ELECTRICITY BOARD FEASIBILITY STUDY : SCADA PHASE II	図書	コピー	UEB	1995 年
10	THE THIRTYTHIRD REPORT AND ACCOUNTS OF UGANDA ELECTRICITY BOARD	図書	コピー	UEB	1996 年
11	GOVERNMENT OF THE REPUBLIC OF UGANDA MINISTRY OF NATURAL RESOURCES STRATEGIC PLAN FOR THE UGANDA POWER SECTOR OCTOBER '97	図書	コピー	UEB	1997 年