APPENDIX III

MINUTES OF DISCUSSIONS

APPENDIX-III

Minutes of Discussions
on
Rural Broadcasting Facilities Project
in
the Democratic Republic of Sudan

In response to the request by the Government of the Democratic Republic of Sudan, the Government of Japan has sent, through the Japan International Cooperation Agency, a team headed by Mr. Mototsugu KANO (Deputy Director, Radio Monitoring Division, Ministry of Posts and Telecommunications) to conduct a Basic Design Study on the Rural Broadcasting Facilities Project (hereinafter referred to as "the Project"), from February 3 to March 3, 1984.

The Team has conducted the field survey, held a series of discussions and exchanged views with the central and regional governmental authorities concerned of the Democratic Republic of Sudan.

As a result of the survey and discussions, both sides have agreed to recommend to their respective Government to examine the result of the study attached herewith towards the realization of the Project.

Khartoum, February 28, 1984

加納元次

Mototsugu KANO
Team Leader
Japanese Study Team

Hosuya Hassan Fadlalha
Director General
Sudan National Broadcasting Corporation

Minutes

1. The objective of the Project is to provide facilities and equipment for the medium wave radio broadcasting transmitting stations in order to improve the radio broadcasting service with a view to promoting education activities and improving living standards in rural areas.

2. Sudan National Broadcasting Corporation is responsible for the implementation of the Project on Sudanese side.

3. According to priority, the proposed sites and the output power for the transmitting stations are as follows;

   1) El Obeid, 5kw
   2) Wad Medani, 5kw or 10kw (*)
   3) Atbara, 5kw or 10kw (*)
   4) Kassala, 5kw
   5) Dongola, 5kw

   (*) subject to the further study in Japan

4. The Japanese Study Team will convey to the Government of Japan the intention of the Government of the Democratic Republic of Sudan that the former takes the necessary measures to cooperate in implementing the Project and provide the facilities and equipment listed in Annex I for the five radio broadcasting transmitting stations as stated in the paragraph 3 within the scope of Japanese economic cooperation in grant form.

5. The Government of the Democratic Republic of Sudan will take the necessary measures listed in Annex II on condition that the grant assistance by the Government of Japan is extended to the Project.

6. Both sides confirmed that the Japanese Study Team explained the Japanese Grant Aid Programme and Sudanese side understood it.

ANNEX I

1.	Medium Wave Radio Broadcasting Transmitter	2 sets
2.	Transmitting Antenna	1 set
3.	Dummy Load	1 set
4.	Input Equipment	1 set
5.	Transmission Control Equipment	1 set
6.	Remote Control/Supervisory System	1 set
7.	Studio-to-Transmitter Link	1 set
8.	Measuring Equipment	1 set
9.	Engine Generator	1 set
10.	Shelters	
	1 each for transmitter and engine generator	
11.	Monitoring Receiver	1 set
12.	Other related equipment, spare parts and tools	1 set

ANNEX II

1. To provide data and informations necessary for basic design.
2. To secure the lands necessary for the radio broadcasting transmitting stations.
3. To take necessary steps to ensure the reliable programme transmission to the studios of the proposed transmitter sites.
4. To carry out site preparation such as clearing, leveling and access road before commencement of construction works.
5. To provide facilities for distribution of electricity, drainage, communications and security.
6. To ensure prompt unloading, tax exemption, customs clearance at the ports of disembarkation in Sudan and prompt internal transportation of the products purchased under the grant.
7. To exempt the Japanese nationals concerned from custom duties, internal taxes and other fiscal levies imposed in Sudan with respect to the supply of the products and services for the Project.
8. To provide necessary permissions, licences and other authorizations for carrying out the Project.
9. To establish necessary operation and maintenance organizations in time for the completion of the radio broadcasting transmitting stations.

APPENDIX IV

LIST OF CONCERNED PERSONS MET BY THE SURVEY TEAM

APPENDIX-IV

LIST OF CONCERNED PERSONS MET BY THE SURVEY TEAM

1.	Ministry of Information and Culture	
	the Hon. Mr. Ismail Al-Haj Musa	Minister
	Mr. Mohamed Kgogali Sallehin	
2.	Sudan National Broadcasting Corporations (SNBC)	
	Mr. Moauya Hassan Fudlalha	Director General
	Mr. Hassan A. A. Rahman	Director General of Engineering
	Mr. Mahmoud Said Badri	Director of Planning and Projects
3.	Mr. Abdelrhman Elsated Badri	
	University of Khartoum	
	Dr. Elfaflh Mohamed Ali	Professor, Building and Read Institute
4.	KORDOFAN	
	the Hon. Mr. Alatih Bushare	Governor
	The Hon. Mr. Dalom Aikhtim	Minister of Regional and Administrative Affairs
	Mr. Salah	Deputy Director of Information & Culture
	Mr. Awad	Director of Broadcasting
	Mr. Ibrahim Mekki Dool	Director of Telecommunication
5.	ATBARA	
	the Hon. Professor Abdella Ahmed Abdella	Governor
	Mr. Wahbi	Director General of TV Station

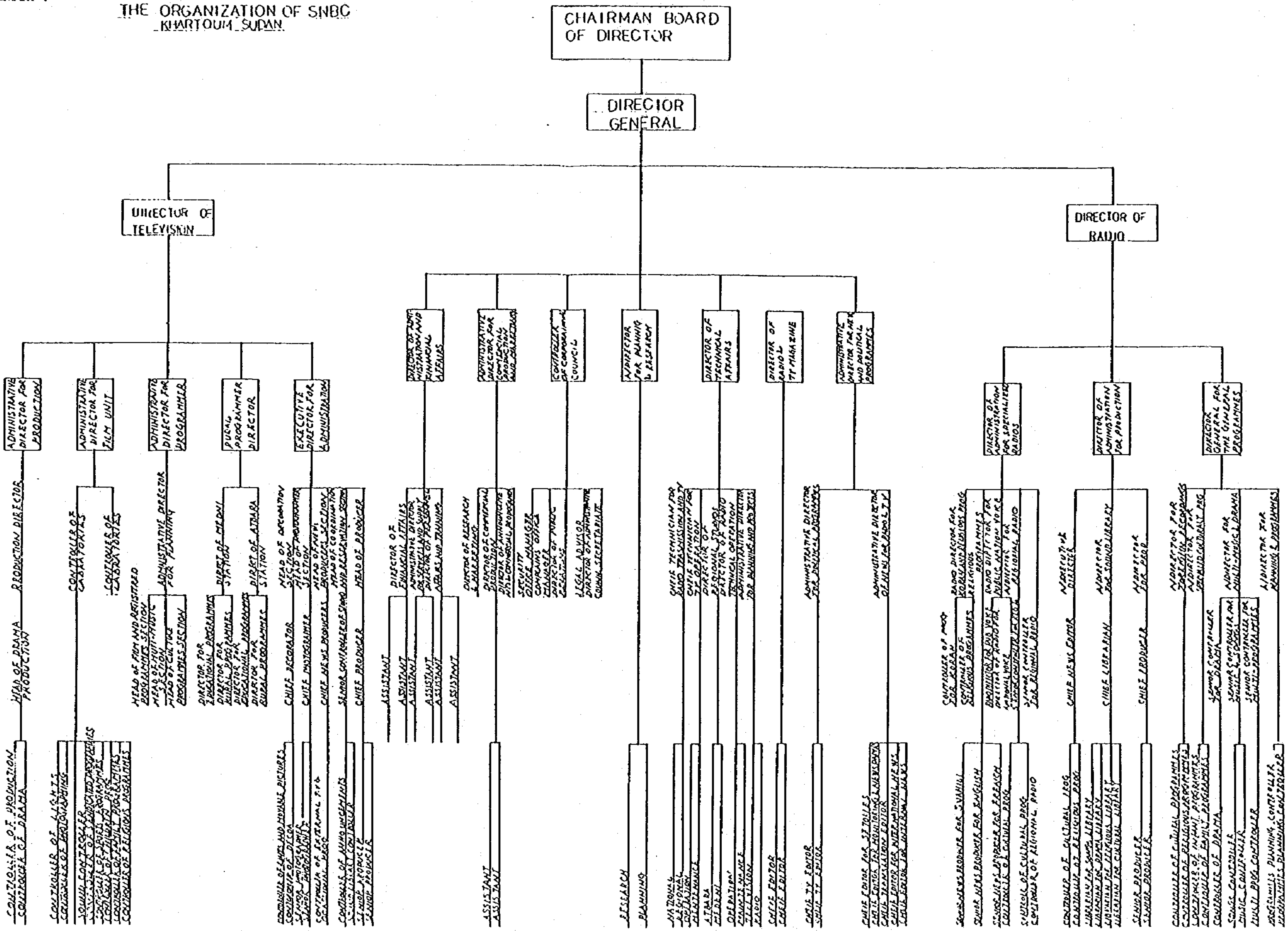
	Mr. Kamal Osman	District Manager of Telecommunication
	Mr. Mohamed Elhassan	Microwave Engineer of Telecommunication
6.	KASSALA	
	the Hon. Mr. Abdulah Ahmed El Hardula	Minister of Regional and Administrative Affairs, East Region
7.	DONGOLA	
	Mr. Osman Barri Algamas	Commissioner
	Mr. Mahgob Elsidig	Director of the Province
	Mr. Alkawad El Khalifa	Assistant Commissioner
8.	SENNAR	
	Mr. Salih El Hag El Bashier	Chief Engineer, SENNAR Transmitting Station

APPENDIX V

ORGANIZATION OF SNBC

APPENDIX-V

THE ORGANIZATION OF SNBC
KHARTOUM SUDAN



APPENDIX VI

LIST OF FREQUENCY ASSIGNMENT (WARC)

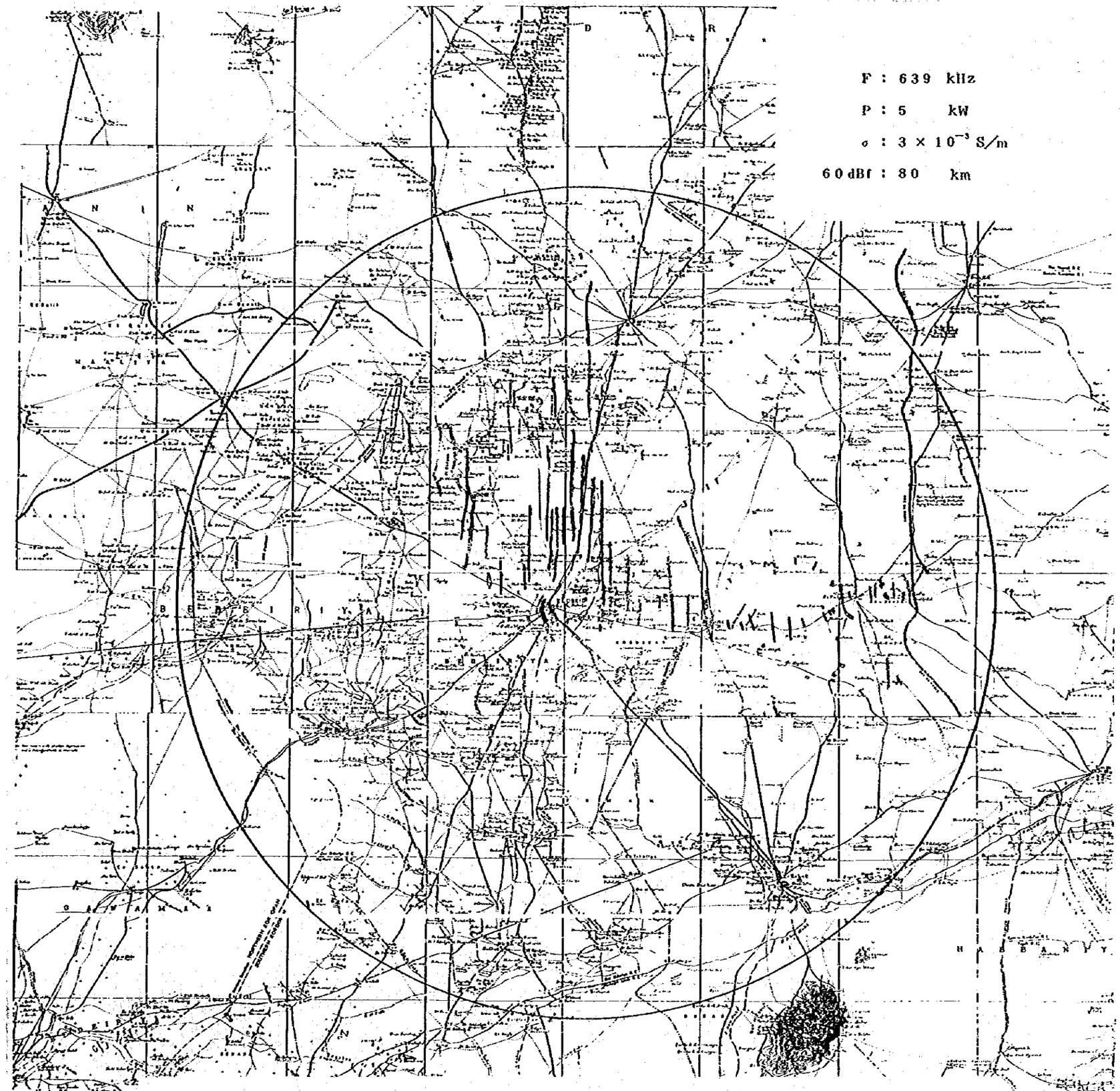
APPENDIX-VI

1	2	3	4	5	6	7	8	9	10	11	12
540(2)	NYALA	24E58	12N03	A20	250	24.6	A	221	4	0400-2200	
558(4)	EN NOHUD	28E23	12N40	A20	100	23.4	A	333	4	0400-1500	
576(6)	SOBA	32E40	15N30	A20	200	26.4	A	323	3	0400-2200	24
603(9)	RUMBEK	29E38	06N48	A20	50	20.4	A	313	3	0600-1600	24
621(11)	RASHAD	31E31	11N39	A20	100	23.4	A	304	4	0600-1600	24
639(13)	EL OBEID	30E14	13N12	A20	200	25.1	A	225	4	0400-2400	18/G LSO UGA
666(16)	KASSALA	36E22	15N23	A20	200	27.0	B		4	0400-2400	24
693(19)	JUBA	31E35	04N50	A20	200	26.4	A	276	3	0400-2200	18/TGK
729(23)	ZALINGEI	23E33	12N57	A20	200	26.4	A	247	4	0600-1600	24
747(25)	PT SUDAN	37E12	19N36	A20	100	24.0	B		4	0400-2400	24
765(27)	SOBA	32E40	15N30	A20	200	26.4	A	228	3	0400-2200	24
783(29)	ATBARA	34E00	17N30	A20	100	26.0	B		4	0400-2400	
801(31)	EL FASHER	25E30	15N38	A20	100	23.4	A	241	4	0600-1600	24
819(33)	DONGOLA	30E30	19N10	A20	100	24.0	A	235	4	0600-1600	24
837(35)	WADI HALFA	31E18	21N54	A20	50	20.4	A	230	4	0400-1500	24
855(37)	SOBA	32E40	15N30	A20	500	30.0	B		3	0400-2400	24
873(39)	BURAM	25E10	10N47	A20	250	30.0	B		4	0400-2400	24
891(41)	BABANUSA	27E48	11N21	A20	100	23.4	A	215	4	0400-1500	24
909(43)	YAMBIO	28E24	04N32	A20	50	21.0	B		3	0400-1600	24
927(45)	MALAKAL	31E40	09N32	A20	250	27.4	A	200	3	0400-2200	18/KEN 24
945(47)	ABU HAMED	33E08	15N30	A20	100	23.4	A	205	3	0500-1600	24
963(49)	SOBA	32E40	15N30	A20	200	26.4	A	181	3	0400-2400	18/CYP 24
1026(56)	PIBOR POST	33E08	06N49	A20	50	20.4	A	164	3	0400-1500	24
1071(61)	WAU	28E01	07N48	A20	200	23.0	A	266	3	0400-2200	24
1296(86)	SENNAR	33E36	13N31	A20	1500	34.0	B		3	0400-2400	23/URS 24

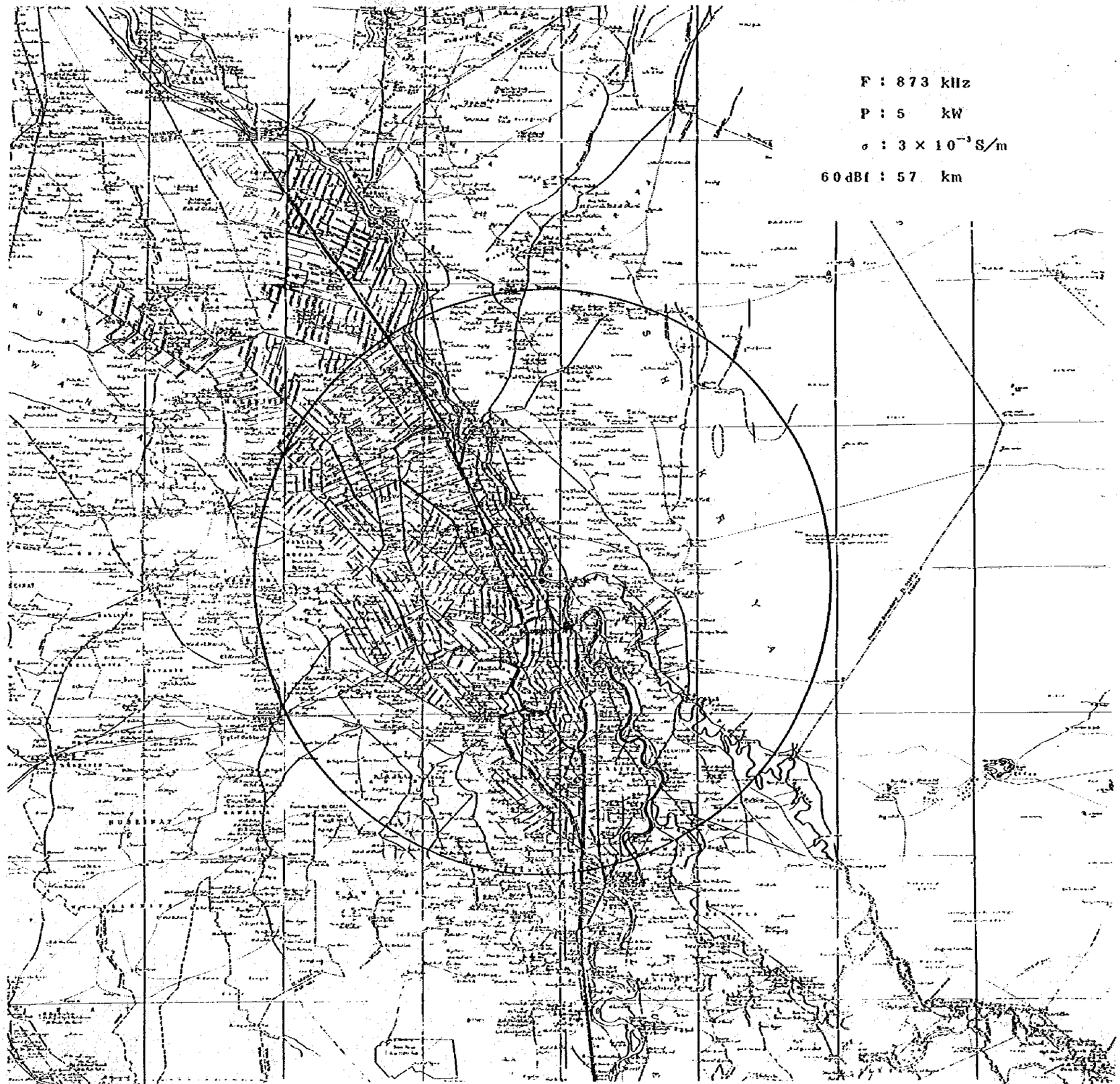
1: Assigned Frequency (kHz) (CHANNEL NUMBER)
2: Name Of Transmitting Station
3: Geographical coordinates of the transmitting stations
4: ditto
5: Necessary Bandwidth (kHz)
6: Carrier Power (kW)
7: Maximum Radiation (dB)
8: Type of Antenna
9: Height of Antenna
10: Ground Conductivity (mS/m)
11: Hours of Operation (GMT)
12: Remarks

APPENDIX Ⅶ

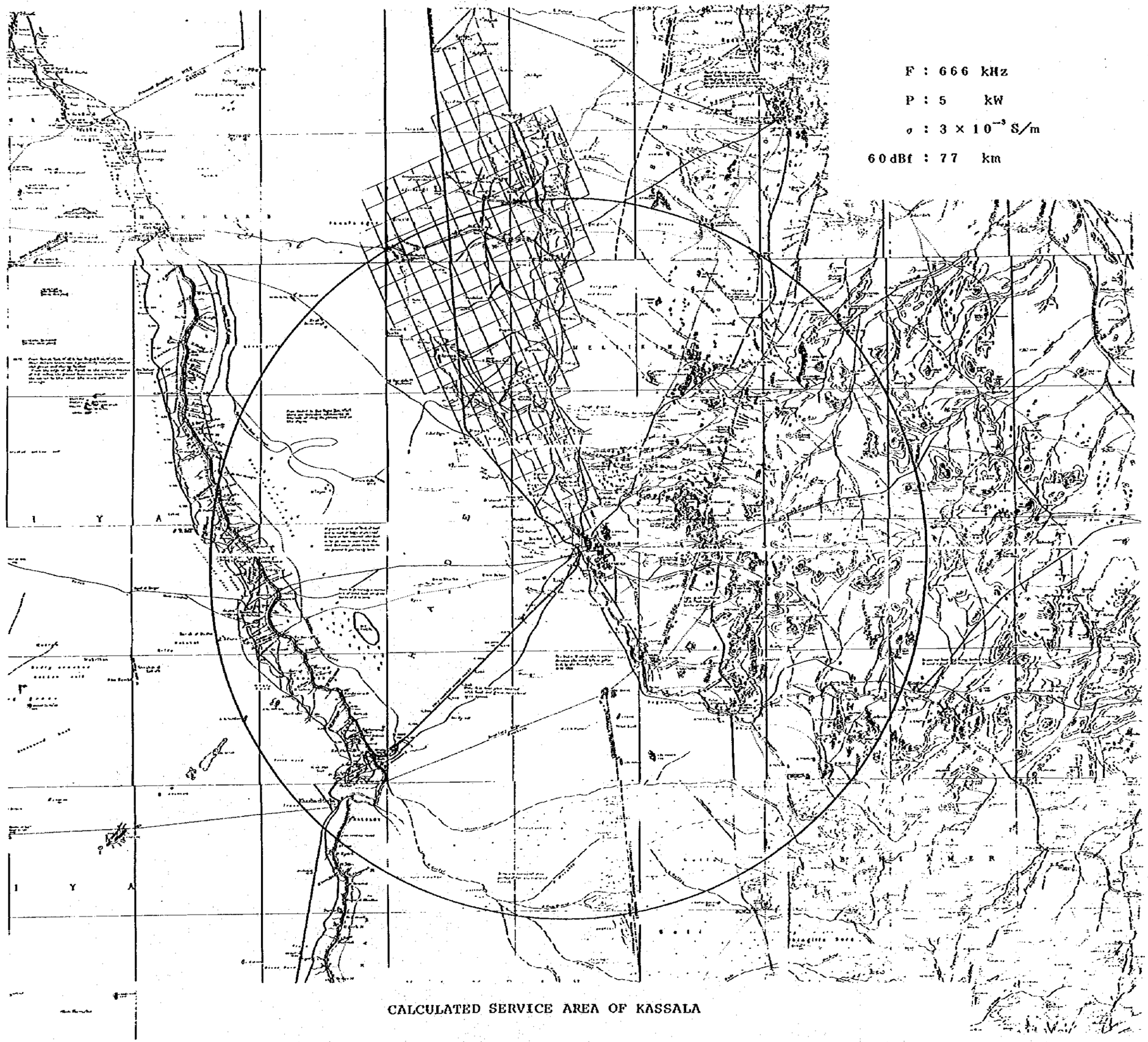
CALCULATED BROADCASTING SERVICE AREA



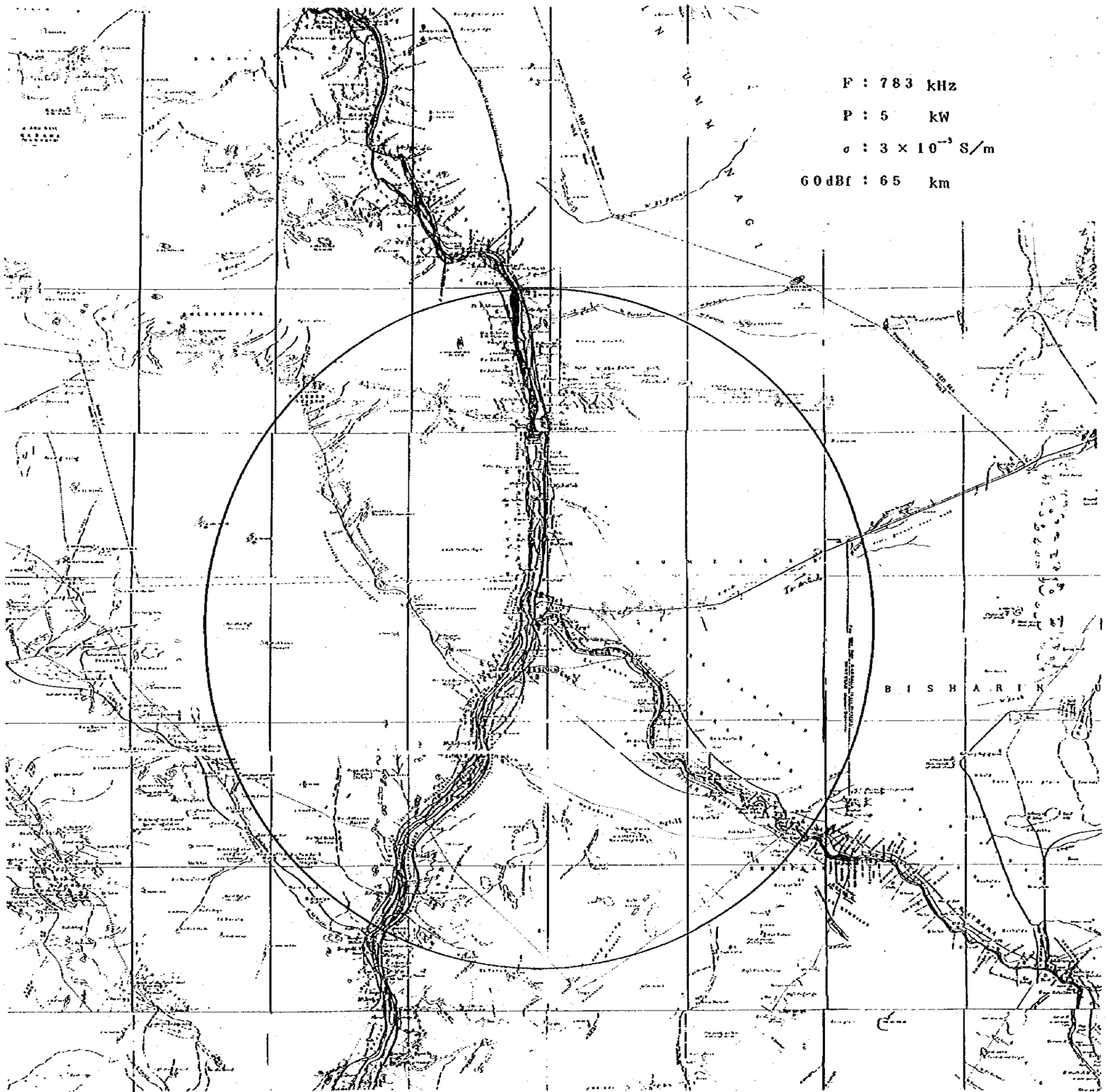
CALCULATED SERVICE AREA OF EL OBEID



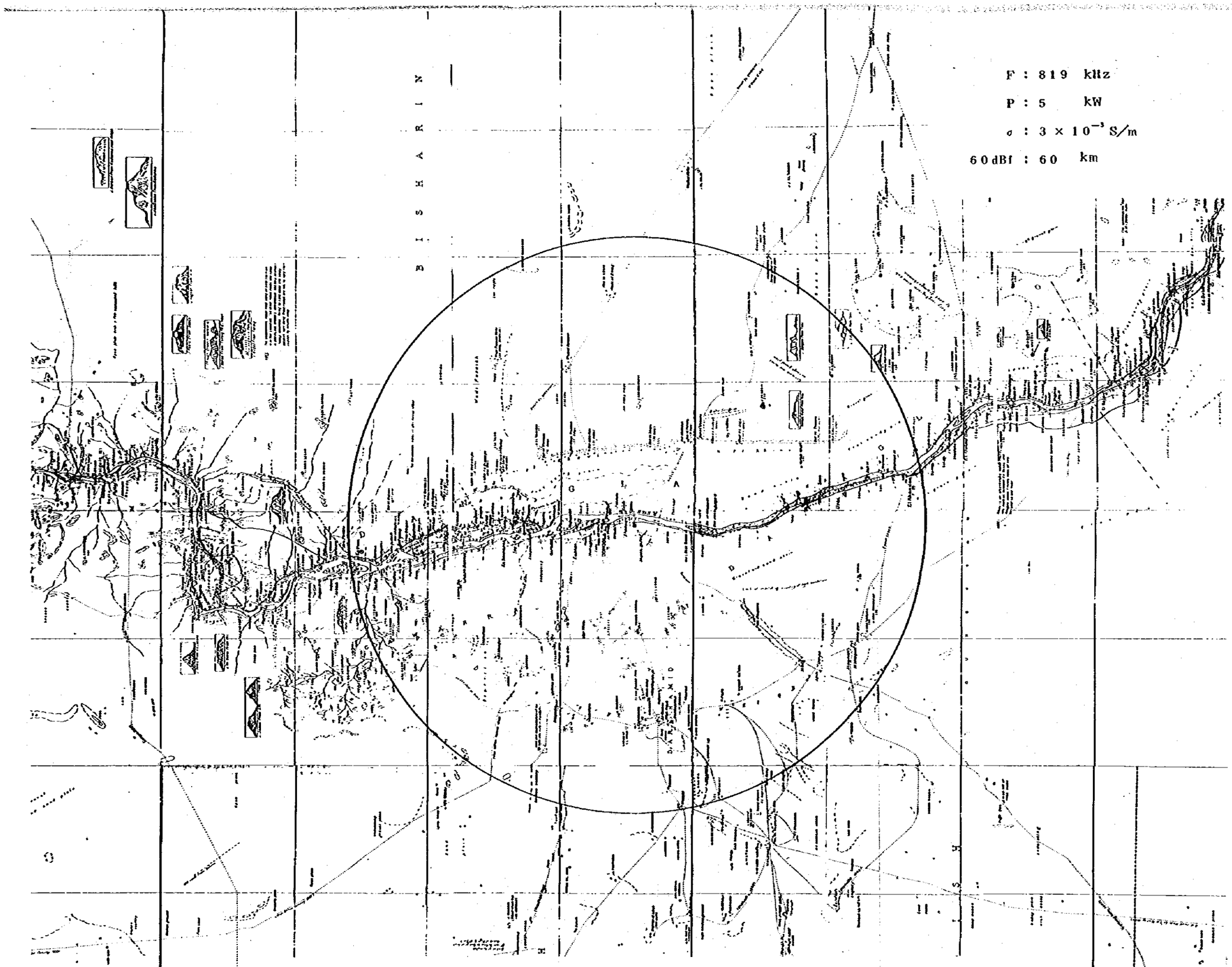
CALCULATED SERVICE AREA OF WAD MEDANI



CALCULATED SERVICE AREA OF KASSALA



CALCULATED SERVICE AREA OF ATBARA



CALCULATED SERVICE AREA OF DONGOLA

APPENDIX VIII

FIELD STRENGTH DATA

Survey of Field Strength (EL OBEID 639 kHz)

8th Feb. 1984

PLACE & TIME	FREQUENCY (kHz)	FIELD STRENGTH dB/μv	REMARKS
Site	560		ADF 2nd Harmonics
14:10 ∿	594	20	Music
	650	23	Arabic
	690		
	963	30	Music
	1,520	23	
	610	9	Noise Level
	1,000	9	Noise Level
	1,600	9	Noise Level
Centre of City (No.1)	612	40	(-27kHz) beat
	621	45	(-18kHz) Arabic
18:00 ∿	639	48	Assigned Frequency, BBC
	648	53	(+9kHz) Arabic
	657	40	(+18kHz) Music
	666	23	(+27kHz) Music
	570	25	Noise Level
	995	25	Noise Level
	1,580	20	Noise Level
Centre of City (No.2)	612	46	(-27kHz) beat
	621	51	(-18kHz) Arabic
18:30 ∿	639	56	Assigned Frequency, BBC
	648	56	(+9kHz) Arabic
	657	40	(+18kHz) music
	666	35	(+27kHz) music
	575	17	Noise Level
	990	20	Noise Level
	1,590	10	Noise Level

Survey of Field Strength (WAD MEDANI 873 kHZ) 24th Feb. 1984

PLACE & TIME	FREQUENCY (kHz)	FIELD STRENGTH dB/μv	REMARKS
Hotel 19:00 ∿	846	39-49	(-27kHz) Fading
	864	50	(-9kHz) Arabic
	873	41-51	Assigned Frequency,Fading
	882	35	(+9kHz)
	891	39	(+18kHz)
	990	34-44	(+27kHz)
	600	20	Noise Level
	875	22	"
	1,000	23	"
	1,500	<20	"
Suburb 19:45 ∿	846	34-44	(-27kHz) Fading
	855	39	(-18kHz)
	864	53	(-9kHz) Arabic
	873	45-49	Assigned Frequency,Fading
	882	37	(+9kHz)
	891	36	(+18kHz)
	900	45-55	(+27kHz) Fading
	600	20	Noise Level
	875	< 20	"
	1,000	< 20	"
	1,500	< 20	"
Site 17:00 ∿	855	25	(-18kHz)
	864	32	(-9kHz) Arabic
	900	20-30	(+27kHz) Fading
	600	<20	Noise Level
	880	<20	"
	1,000	<20	"
	1,500	< 20	"
Hotel 8:30 ∿	1,296	80	Sennar Station
Hotel 7:00 ∿	864	34	Arabic
	600	23	Noise Level
	900	22	"
	1,000	<20	"
	1,000	20	"

Survey of Field Strength (ATBARA 783 kHz)

16th-17th FEb. 1984

PLACE & TIME	FREQUENCY (kHz)	FIELD STRENGTH dB/μv	REMARKS
Site	648		Arabic
10:44 ∿	683	25	
Railway Station	765	39	(-18kHz) music
	774	46	(-9kHz) Arabic
19:00 ∿	783	51	Assigned Frequency, beat
	792	45	(+9kHz) Talk
	801	46	(+18kHz) music
	520	15	Noise Level
	1,000	24	Noise Level
	1,610	15	Noise Level
Guest house	765	46	(-18kHz)
20:00 ∿	774	47	(-9kHz)
	783	52	Assigned Frequency
	792	56	(+9kHz)
	801	57	(+18kHz)
	519	20	Noise Level
	1,044	22	Noise Level
	1,611	14	Noise Level

Survey of Field Strength (KASSALA 666kHz)

16th-17th Feb. 1984

PLACE & TIME	FREQUENCY (kHz)	FIELD STRENGTH dB/μv	REMARKS	
Hotel 19:00 ∿	639	58	(-27kHz)	BBC
	648	61	(-18kHz)	Rabic
	657	54	(-9kHz)	
	666	55	Assigned Frequency	
	675	53	(+9kHz)	
	684	45-47	(+18kHz)	Fading
	693	45	(+27kHz)	
Suburb 20:00 ∿	639	62	(-27kHz)	BBC
	648	76	(-18kHz)	Arabic
	657	50	(-9kHz)	
	666	57	Assigned Frequency	
	675	48	(+9kHz)	
	684	55 - 57	(+18kHz)	Fading
	693	58	(+27kHz)	
	520	20	Noise Level	
	660	22	"	
	980	22	"	
	1,450	20	"	
	1,540	21	"	
Centre of City 20:30 ∿	520	20	Noise Level	
	660	24	"	
	980	25	"	
	1,540	22	"	
Site 12:30 ∿	648	39	(-18kHz)	Arabic
	684	21	(+18kHz)	
	520	20	Noise Level	
	660	20	"	
	980	20	"	
	1,540	20	"	

Survey of Field Strength (DONGOLA 819kHz)

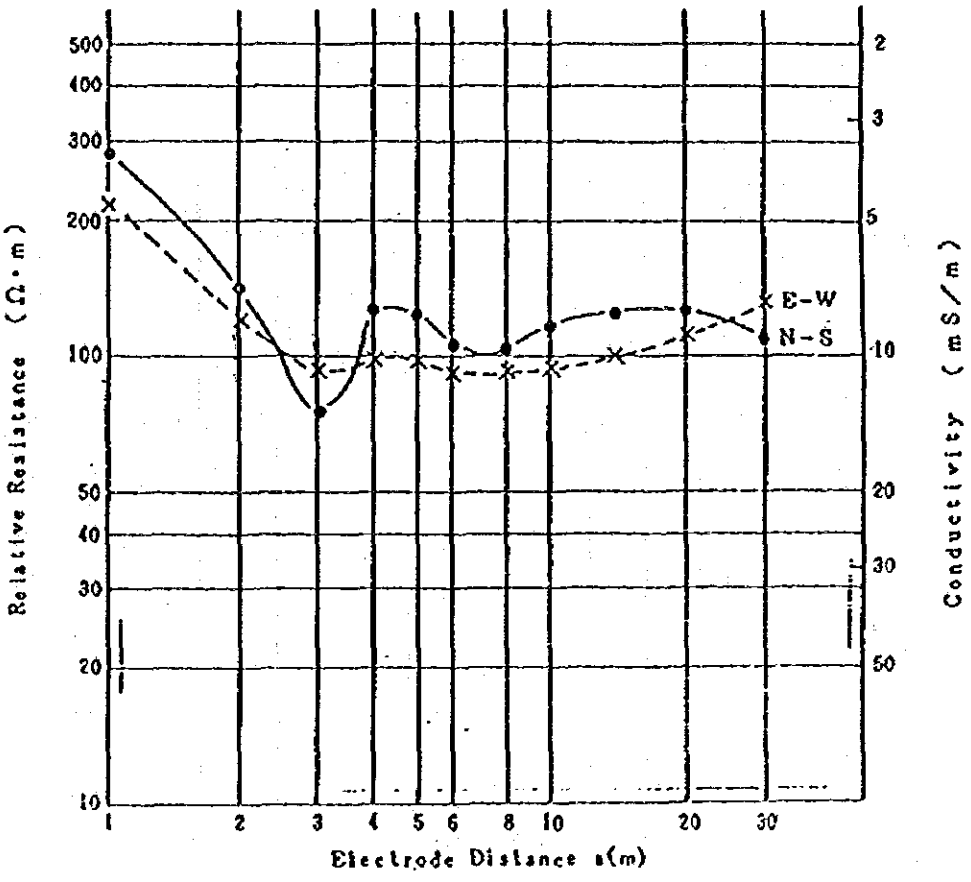
23rd-26th Feb. 1984

PLACE & TIME	FREQUENCY (kHz)	FIELD STRENGTH dB/μv	REMARKS
Guest House 7:20 ∿	819	30	Assigned Frequency, Arabic
Site 17:00 ∿	819	30	Assigned Frequency, Arabic
	505	13	Noise Level
	1,000	10	Noise Level
	1,550	15	Noise Level
Guest House 20:00 ∿	801	52	(-18kHz) Arabic
	810	34	(-9kHz)
	819	53	Assigned Frequency, Arabic
	828	44	(+9kHz) Beat
	837	42	(+18kHz) Beat
	500	23	Noise Level
	975	28	Noise Level
	1,650	15	Noise Level

APPENDIX IX

GROUND CONDUCTIVITY DATA

EL-OBEID

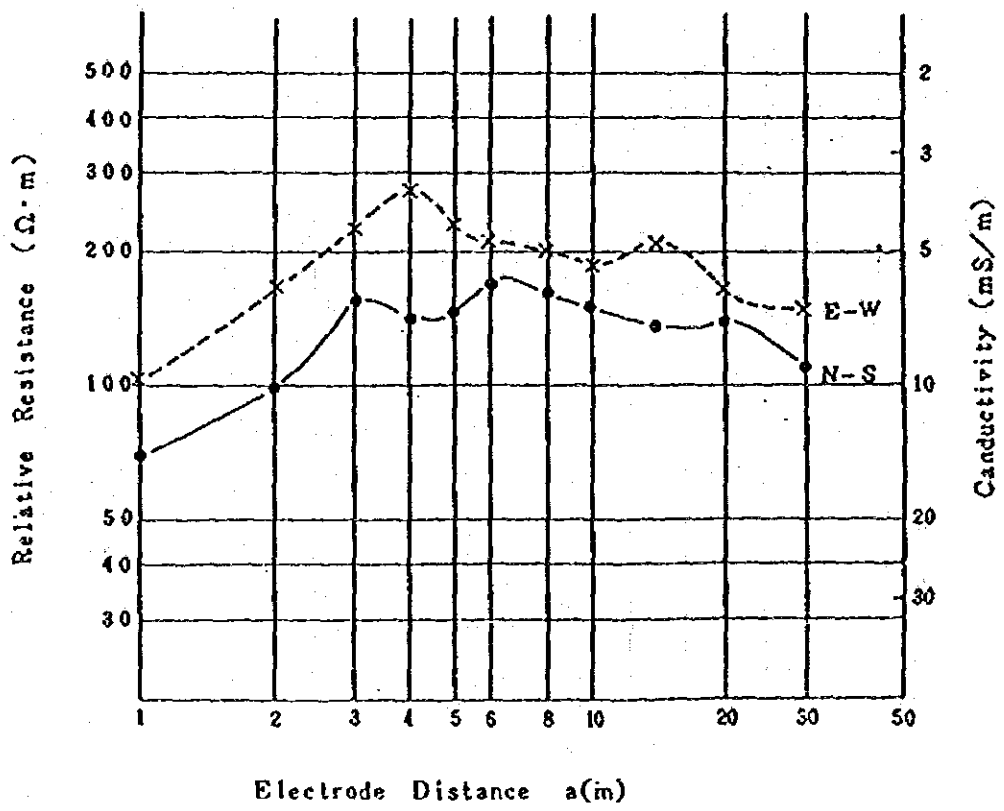


Note:

Measurement Instrument : Type L-10 (Yokogawa Electric Co.,)

Result of Ground Conductivity Measurement

WAD - MEDANI

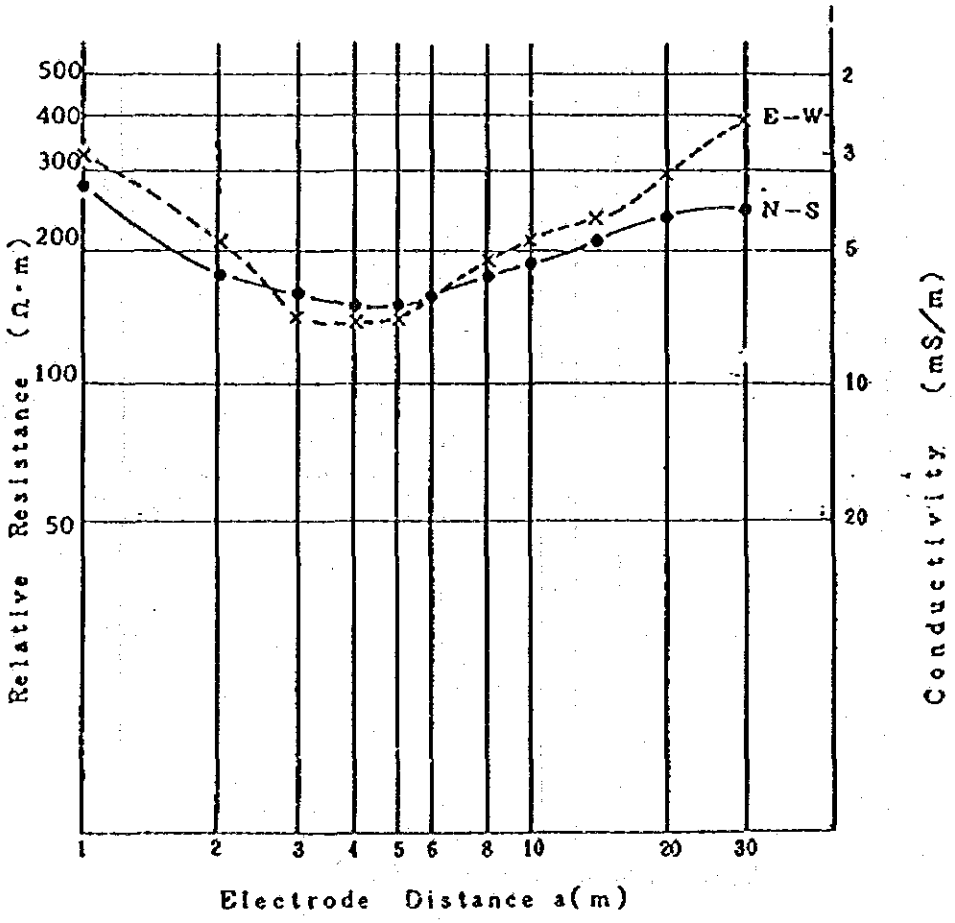


Note:

Measurement Instrument : Type 3244 (Yokogawa Electric Co.,)

Result of Ground Conductivity Measurement

ATBARA

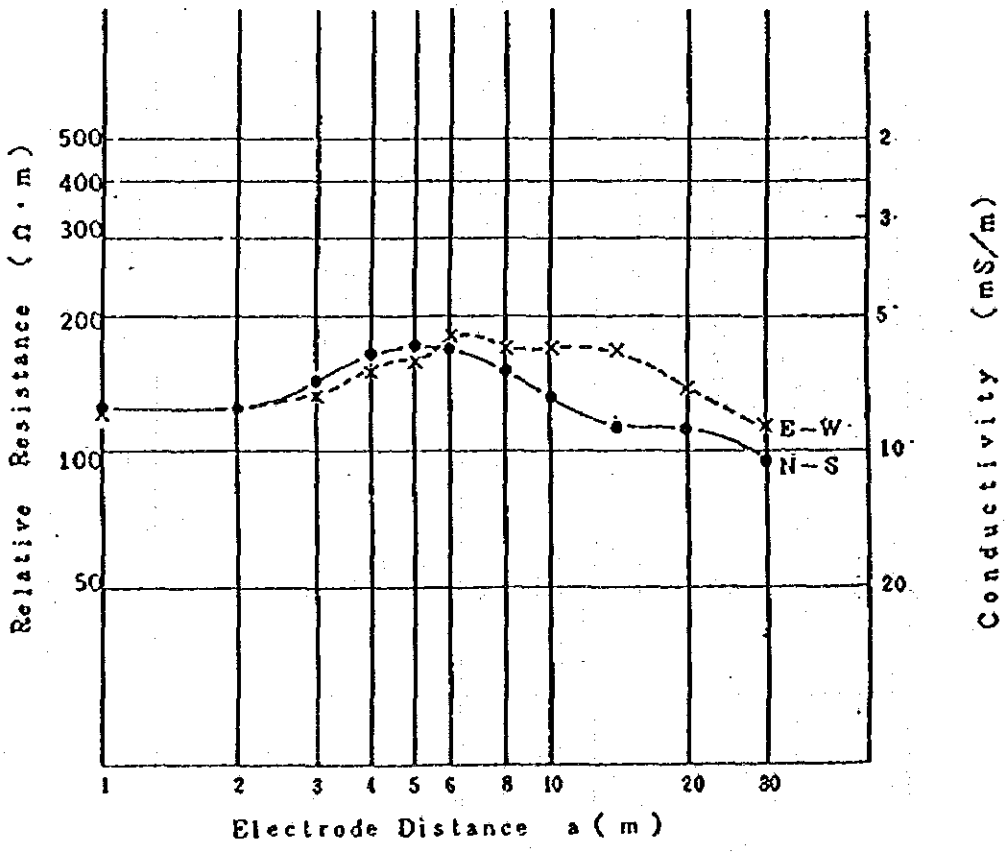


Note :

Measurement Instrument : Type L-10 (Yokogawa Electric Co.,)

Result of Ground Conductivity Measurement

KASSALA

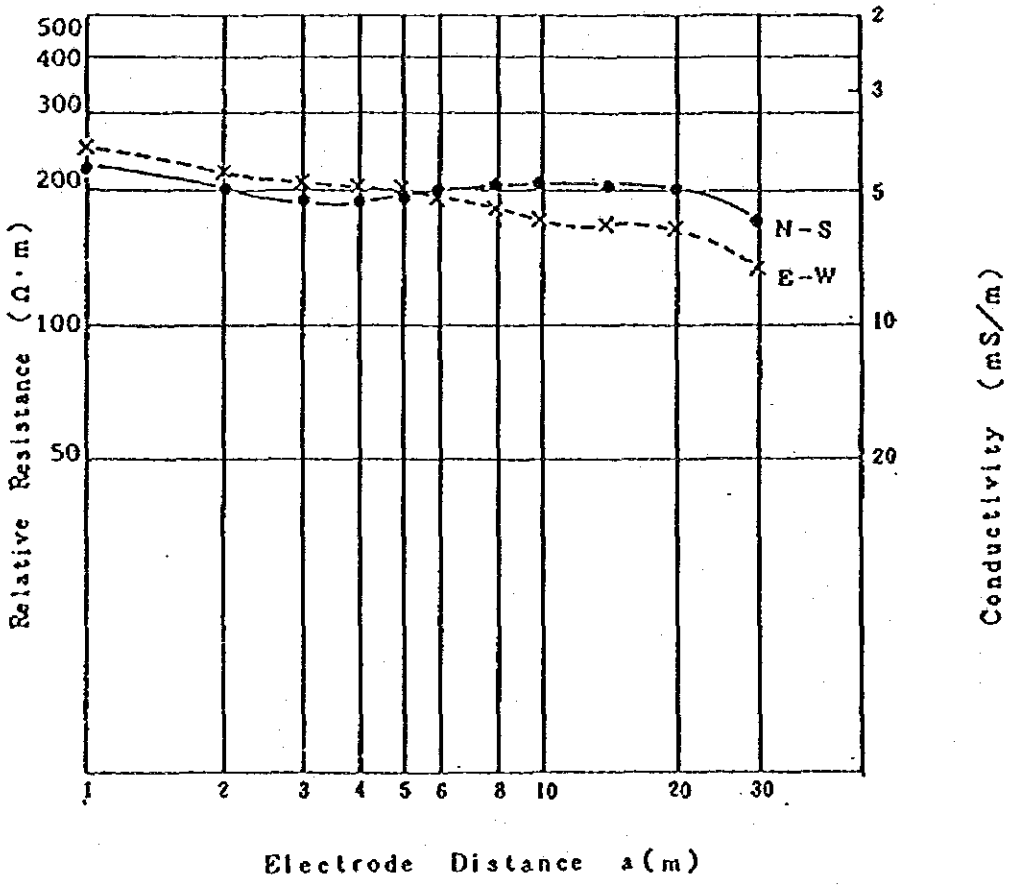


Note :

Measurement Instrument : Type 3244 (Yokogawa Electric Co.,)

Result of Ground Conductivity Measurement

DONGOLA



Note :

Measurement Instrument : Type 2-10 (Yokogawa Electric Co.,)

Result of Ground Conductivity Measurement

APPENDIX X

RESULT OF SURFACE EXPLORATION

INDEX

1. Preface

This report handles the reconnaissance work in Sudan from February 5 to March 1, 1984, and examination result done after arriving in Japan, as well as the investigations on soil yield strength of each spot, based upon the above result.

2. Outline of the Topographic Features and Geology in Sudan

Outline

Firstly, the topographic features as well as geology of African continent is very monotonous. Except the Atlas Mountain Range, which is a young fold mountains of the northern tertiary era layer, most of the land is the plateau area, which has not got the fold since old geographical age. It is based on the old crystal rock gneiss, granite, etc.), and the rocks of each geographical era, which cover it, are mostly terrigenous layer, except the sea coast area. (Fig. 1) The feature of the Continent is that the sea cost plane is narrow, the inner area is a huge basin, as well as high swells, which surround it (Fig. 2).

Secondary, the topographic features and geology of Sudan will be mentioned. Sudan is situated on from nearly 4°N, and its main part is in the Sudan Basin, which occupies the basins of the White and Blue Nile (Fig. 2). It consists of the plateau, which is divided into various natural scenic views, such as the tropical rain forests, marshes, the subtropical savannas and deserts, etc. In the south, rainfalls are abundant, and the characteristic swampland called Sad, which is the area of high temperatures and high humidities, mostly occupied by swamps and forests.

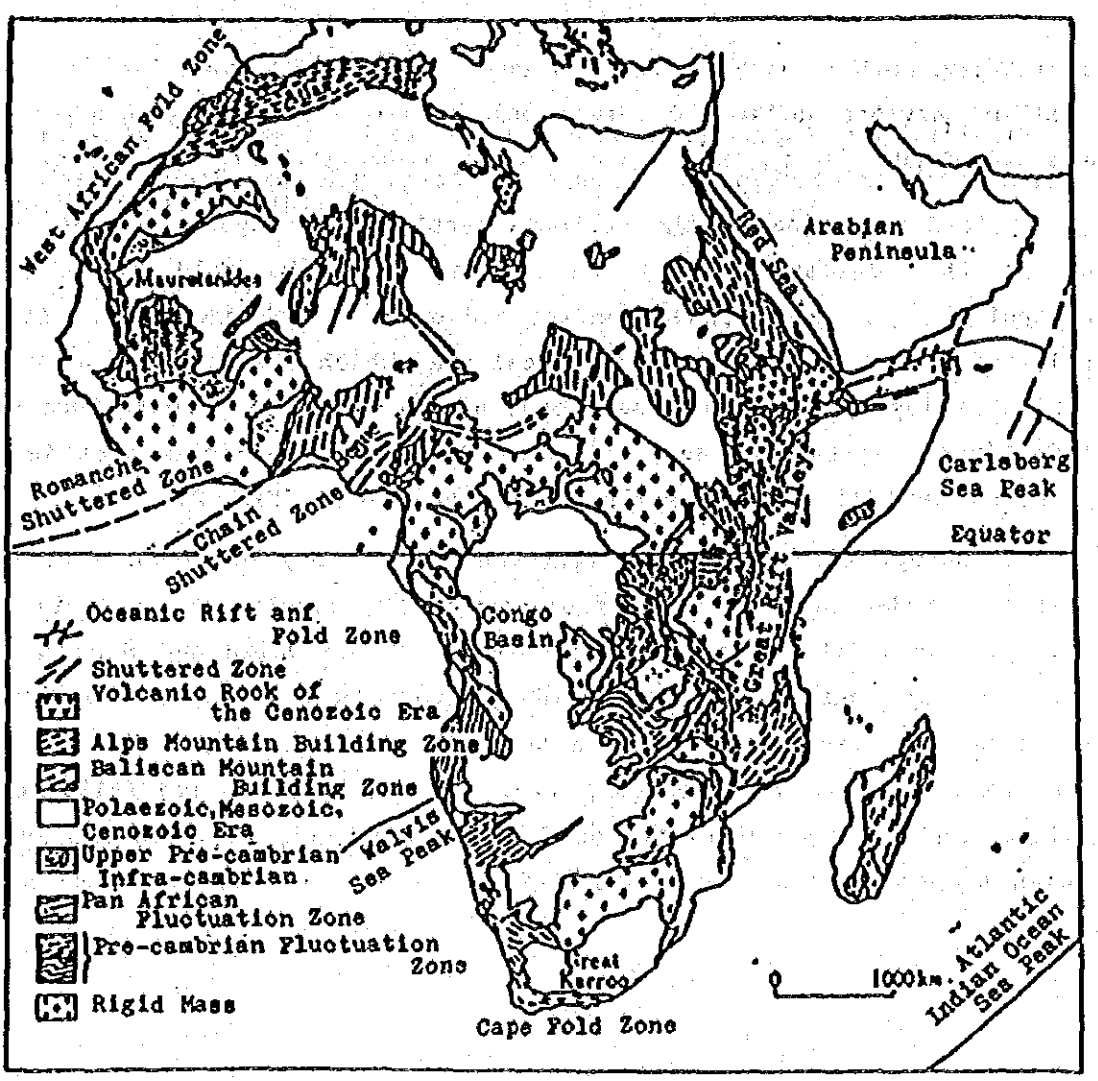
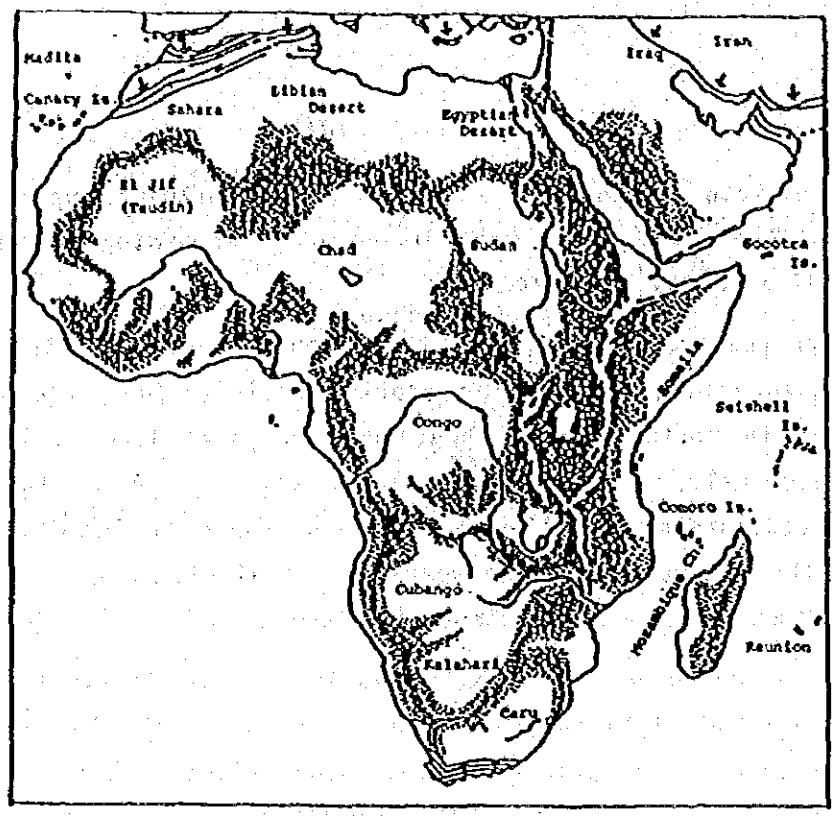


Fig. 1 Geographical Structure of the Africa Continent complied and simplified from 'International Tectonic Map of Africa (1968) and Geological Atlas,UNESCO (1975)



Reference 2

Fig.2 Basin and Swell Structures of African Continent

Survey spot

The survey spot are geographically classified in Table 1.

Table 1 Geography of the Survey Spots

Servey Spot	Above Sea Level (m)*	Remarks
KASSARA	495	EAst end of SUDAN Along the Ethiopian border East of ATBARA River, a tributary of Nile. Eastward from here, it reaches to the plateau. Just east of KHARTOUM.
ATBARA	350	North of KHARTOUM. Diverging point of Nile and ATBARA tributary.
DONGOLA	227	North of SUDAN and riverside of Nile. Nubia Desert is near its north.
EL OBEID	570	West of White Nile. Small plateau.
WAD MEDANI	405	Just north of KHARTOUM. Central city of Gezird area, a cotton plantation. Along Blue Nile.

* Average altitude of African Continent is about 670m.

Climate

The olimate in the dry land has great influence upon the soils. Among them, the rainfall is most important. According to Reference 3, the rainfall in SUDAN is as follows:

"Under the tropical climate, the intense heat covers the whole year espeotialy in centre part. The yearly preoipitation widely changes, under 100mm in north Egyptian boarder, and above 1,200mm in the south end. Consequently, the dry season lasts for as long as ten months in ATBARA, northeastern part, while only one month in MONGOLLA, southern part. In the central part, the yearly preoipitation changes widely from 100mm to 500mm, and the rainy season is short".

Temperature of Gezird area, including KHARTOUM, WAD MEDANI, etc., of which cotton plantations are the treasures of SUDAN, is not below 30°C through the year. The rainfall becomes smaller from south to north. That of WAD MEDANI, THE CENTRAL PRTS, IS ABOUT 380mm per year, AND IN KHARTOUM, only about 180mm.

In addition, the rain concentrates mostly in two months, July and August, and scarcely from November to April. The rainfalls in EL OBEID and DONGOLA, which are not indicated, can be antioipated.

SOIL

In the land, the cohesive soils are widely distributed. The penetration of water into the soil in the irrigation area is small, and almost all rainfall stay on the surface and evaporate.

Black Cotton Soils

This is a speoial soil, noteworthy in SUDAN. It is black olay soil, and called Badole.[4] It's distribution in Africa is shown in Fig. 3[5].

It is olearly observed that the soil is distributed from centre to south-east, as well as south in Sudan.

This soil belongs to the speoial soil and shows remarkable swelling according to the change of the water content percentage.

According to Reference 6, 'this black-gray soil becomes clay-like by rain, and is very trouble something, which obstructs the automobile traffic. Accordingly, the season of field survey in INGESANA HILLS area, east-southeast of EL OBEID, is limited from around October to March'. This soil is deposited on the surface course in the area. By another Reference 4, the layer thickness of the soil is about 1 M in average, when the basic layer is shallow. Consequently, the depth of embedment base should be decided avoiding this soil.

The reason of swelling is Monmolinite, the main component of the clay minerals in the soil.

Fig. 4[5)] shows the comparison on the plasticity chart between the black cotton soils and the samples collected in each survey spots, mentioned later.

All references are shown in Annex-2.

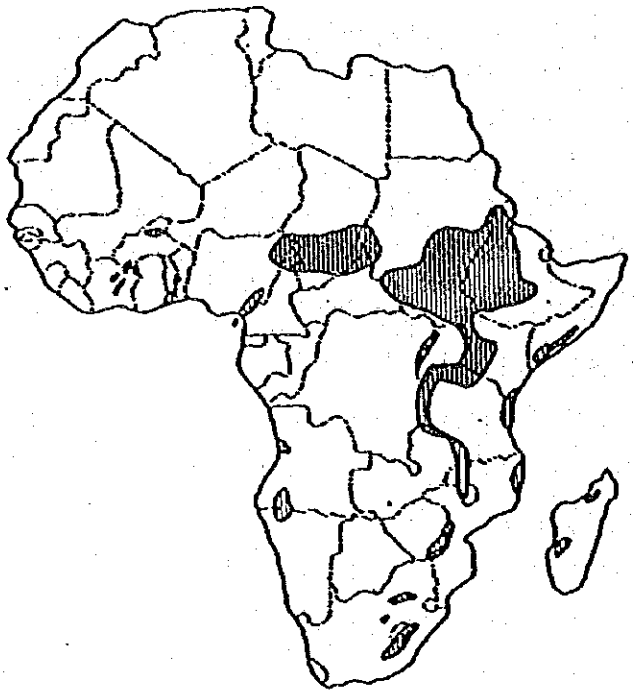


Fig 3 DISTRIBUTION OF BLACK CLAY SOILS IN AFRICA

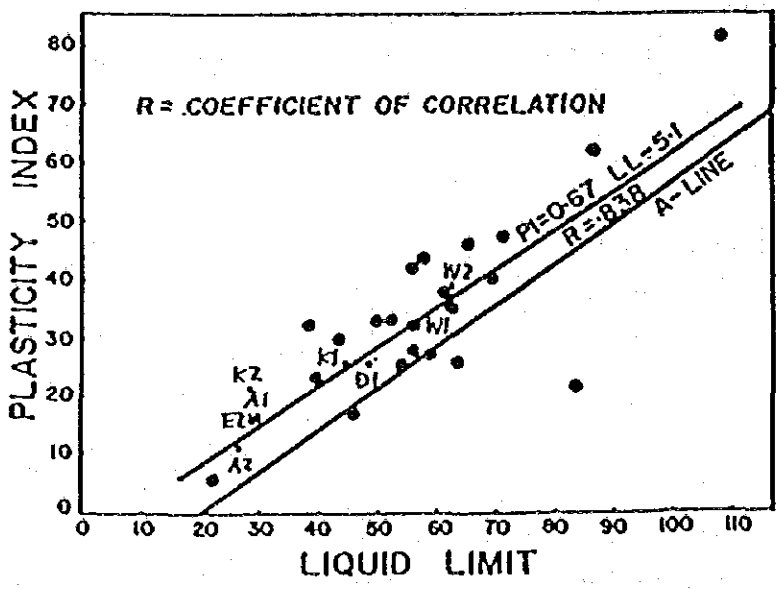


Fig 4 PLASTICITY CHART, AFRICAN BLACK CLAYS

3. Outline of Exploration

Explorations were conducted at five spots shown in Fig. 5. The items are as follows:

i) Investigation of the outcrop on the spot, and the sample collecting.

At each spot, the outcrop is observed, and the samples are collected at G.L. -1.0m and -2.0m by digging the test pits.

ii) Static Cone Penetration Test at in-site
Only in KASSARA

iii) Observation of Samples and Physical Test

After arriving in Japan, the collected samples were carefully observed, and physical test was conducted. The items of the test and the standards[7] in conformity are as follows:

* Special Gravity Test of Soil Particles	JIS A 1202
* Water Content Test	JIS A 1203
* Grading Test	JIS A 1204
* Liquid Limit Test	JIS A 1205
* Plastic Limit Test	JIS A 1206

Solid yield strength at each spots were examined based on i) to iii) and materials from KHARTOUM University, Annex 1.

4. Exploration Result in KASSARA

4.1 Observation of Outcrop

Situation of Site

It is situated on the outskirts of farm land, spreading westward of the city and along the river of GASH. Contemporary, a vacant ground. Flat and no vegetation. A well, of which water depth is G.L.-42m, is one km far eastern of the site.

Situation of Surface Soil

Blackish clay soil. Hard, under 2 to 3 cm. Water penetration is good. When water is spilt, the surface comes down and a hole is made.

Observation of Excavation Pit Wall

Considerably hard. A mark of excavation by the pick is engraved on the pit wall. The harder, the lower. The soil is same down to 200 cm.

4.2 Observation of Collected Samples

Samples were collected at G.L. about -1.0m and 02.0m.

Samples from G.L. -1.0m

They were collected as hard cores. Apparently, volcanic rock, but so strong as expected by the appearance. Some parts collapse easily by the fingers. Dark brown. Soil lump, in the water, collapses and becomes fine grained soils.

Samples from G.L. -2.0m

Apparently, the solid silt or sand stone. When crashed the fingers, mostly becomes fine grained (remains as grains, but diameter is very small, like silt). Some parts remains as small lump. They has light ocher colour.

4.3 Pysical Test

The list of test is shown in Table2, as follows:

Table 2. List of Physical Test (KASSARA)

Table-2 List of Physical Test

Soil Texture \ Name of Sample			K-1(G.L.-1.0m)	K-2(G.L.-2.0m)
Gravity	G		2.745	2.765
Water Content *	Wn (%)		11.0	5.4
Consistency	Liquid Limit Wl (%)		43.4	27.5
	Plastic Limit Wp (%)		17.9	6.8
	Plasticity Index Ip		25.5	20.7
Grading ** Characteristic	Gravel (%)		0.7	2.2
	Sand (%)	Coarse Sand	11.6	4.2
		Fine Sand	14.4	40.5
	Silt (%)		47.7	30.8
	Cley (%)		25.6	22.3
Classification	Japanese Standard Soil Classification		CL	CL
	Triangle Axis Presentation		F	F

* Due to the aridity during the transportation, these water content percentage will be smaller than that of the original condition.

** Gravel 2,000μ <, Sand 74 - 2,000μ (Coarse Sand 420 - 2,000μ, Fine Sand 74 - 420μ), Silt (5 - 74μ), Clay 5μ >

4.4 Dutch Cone Penetration Test

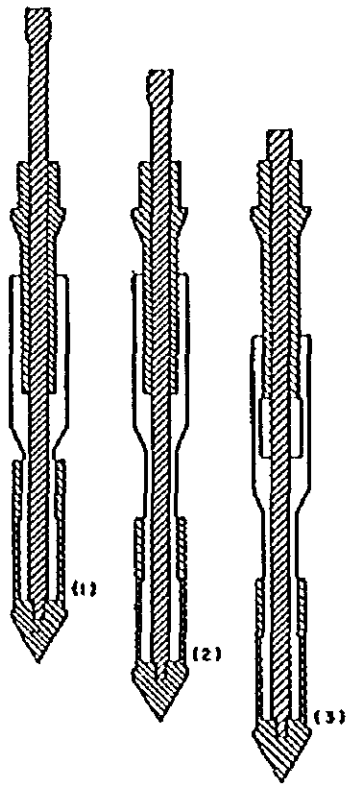
Dutch Cone Penetration Test was conducted at the Building and Road Research Institute of KHARTOUM University. The test equipment used is a mechanical friction cone penetrator (Begemann Cone) for 10 tons. The cone resistance (q_c) and the friction on the jacket (f_g) were measured at 15 cm deep at intervals of 20 cm. Fig. 6 shows the process of measurement.

Fig. 7 shows the result of test. The unit, MN/m^2, in the figure, has the following relations to kgf/cm^2:

$$1MN/m^2 = 1{,}000\ KN/m^2 = 10\ kgf/cm^2$$

Fig. 6 Measuring Process of the Mechanical Friction Cone Penetrometer (Begemann Cone)

Fig. 7 Result of Dutch Cone Penetration Test (KASSARA)



(1) Cone and friction sleeve retracted

(2) Cone in extended position

(3) Cone and friction sleeve both advanced

Fig. 6 Measurement Process of Mechanical Friction Cone Penetration Test(KASSARA)

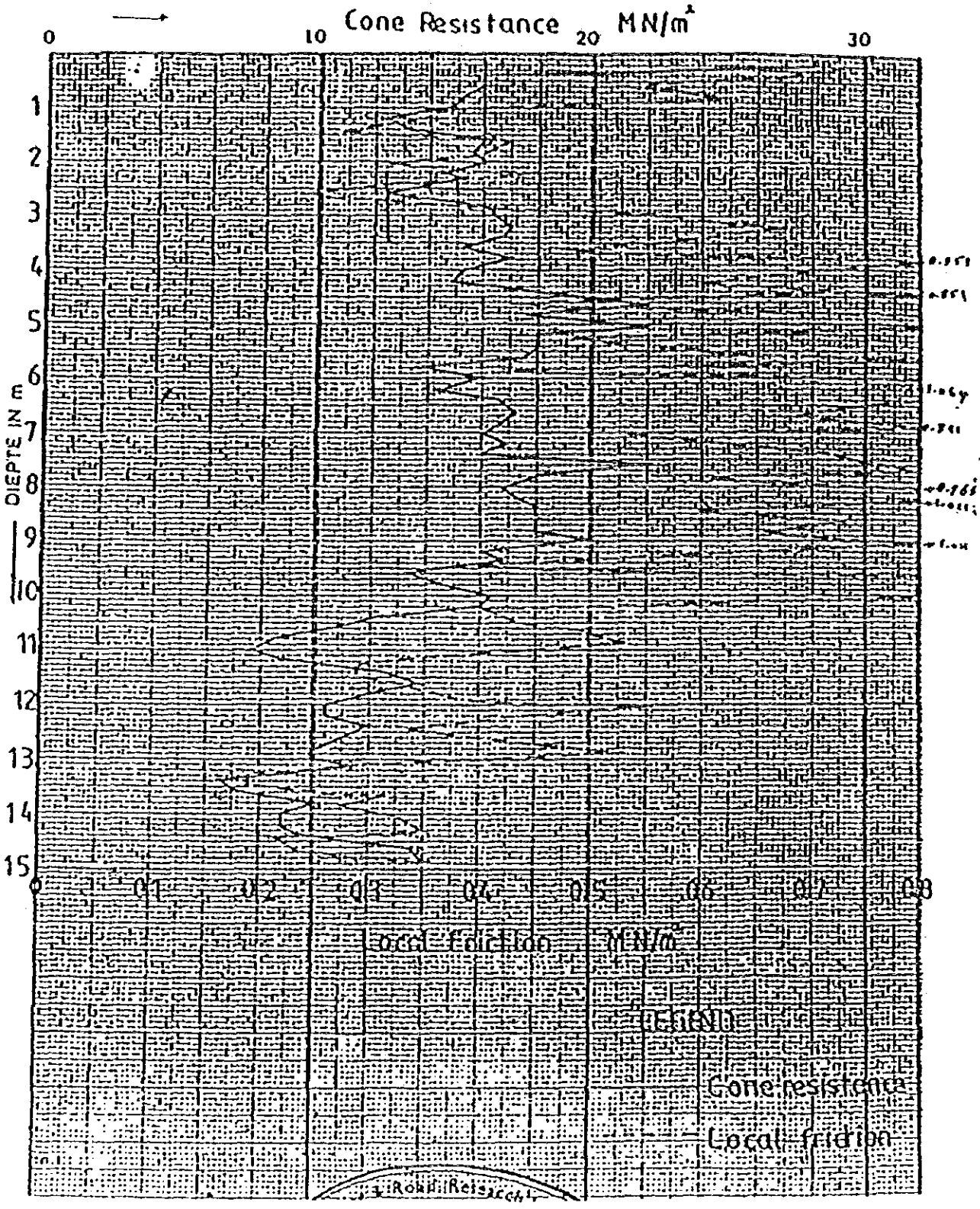


Fig.7 Result of Dutch Cone Penetration Test (KASSARA)

4.5 Investigation on Soil Yield Strength

In the soil analysis, this soil is regarded as cohesive soil, because it is CL (sandy clay or silty clay).

According to the result of Dutch cone penetration test, mentioned in Section 4.4,

	$F_R = \frac{\bar{f}_s}{q_c} \times 200$	q_c (q_c)	f_c($\bar{f}_s$)
G.L. - -10m	4.1	13 - 20(17)	0.5 - 1.0(0.7)
G.L. - -15m	3.2	8 - 13(11)	0.2 - 0.5(0.35)

(Unit: MN/m^2)

q_c is larger in the upper layer than in the lower layer. Judging from these low F_R values, the sand is increased in the lower layer.

If the surface is supposed to be cohesive soil, the relations between the non-drainage shearing strength (C_u) and q_c is as follows:

$$Cu = \frac{q_c}{N}$$

here, N: cone coefficient
: upper ridden stress (negligible, because it is too smaller than q_c.)

Concerning N, the following proposals are Submitted:

(i) Sanglerat[10)]

$q_c < 20kgf/cm^2$ $\quad 15 < N < 18$ (Normally Consolidated Clay)

$q_c > 25kgf/cm^2$ $\quad 22 < N < 26$ (Over Consolidated Clay)

(ii) By Soil Exploration Methods of Soil Engineering Society[1)]

$14 < N < 17$

(iii) By Standard of Basic Architectural Construction Design and Comment of Architectural Engineering society[12)]

$10 < N < 20$

When q_c = 17 MN/m^2 and N=30 for the safty's sake,

$$C_u = 5.7 \text{ kgf/cm}^2 \qquad (1)$$

If the strength of basic bottom becomes low by inundation C_u value becomes one half:

$$C_u = 2.8 \text{ kgf/cm}^2 \qquad (2)$$

The allowable bearing power will be, using above C_u, as follows:

$$q_a = \frac{1}{3} (CN_c + {}_1BN_r + r_2D_fN_q) \qquad \text{(Long term)} \qquad (3)$$

here, $= 1.3$ $N_c = 5.3$ ($\phi = 0^\circ$), $N_r = 0$

$_2 = 1.69$, $\frac{1}{2} = 0.69$, $N_q = 3$

The allowable bearing power (q_a) without the influence of water is as follows:

$$q_a = \frac{1}{3} \quad (1.3 \times 57 \times 5.3 + 1.69 \times 3 \times D_f)$$

If the influence of D_f is negligible for its small value,

$$q_a = \frac{1}{3} \times 392 = 131 \text{ t/m}^2 \qquad (4)$$

$$q_a = \frac{1}{3} (1.3 \times 28 \times 5.3) = 64 \text{ t/m}^2 \qquad (5)$$

In conclusion, the allowable bearing power in KASSALA will be determined for the safty's sake, as follows:

q_a = 50 t/m^2 (Long term) (6)

q_a = 100 t/m^2 (Short term) (7)

In the above investigation, the allowable bearing power is regarded to be equal to the permissible soil pressure.

5. Exploration Result in ATBARA

5.1 Observation of Outcrop

Situation of Site

Desert area, about 5 km south from the city. The site is dotted with sandy hills with about 2m high. To ATBARA River, 1 km north and 5m to the water level.

Situation of Surface Soil

Sand, mixed by small gravels. Poured water is absorbed quickly.

Observation of Excavation Pit Wall

Black soil down to G.L. -70cm, and white soil underneath. Very hard. It can not be excavated without a pick.

5.2 Observation of Collected Samples

Samples were collected at G.L. about -1.0m and -2.0m.

Samples from G.L. -1.0m

Samples were collected as cores. Light brown, a little blackish comparing with that of from G.L. -2.0m. Clods can be easily collapsed by hands. Partly white small particles. All samples can be grained finely by hands.

Samples from G.L. -2.0m

Nearly the same as above. A little white.

5.3 Physical Test

The list of physical test is shown in Table 3.

Table 3 List of Physical Test (ATBARA)

Table-3 List of Physical Test

Soil Texture \ Name of Sample			A-1 (G.L.-1.0m)	A-2 (G.L.2.0m)
Gravity	G		2.735	2.724
Water Content *	Wn (%)		4.9	4.8
Consistency	Liquid Limit Wl (%)		28.7	24.8
	Plastic Limit Wp (%)		12.0	13.9
	Plasticity Index Ip		16.7	10.9
Grading ** Characteristic	Gravel (%)		13.7	29.4
	Sand (%)	Coarse Sand	18.0	17.0
		Fine Sand	38.6	33.7
	Silt (%)		22.1	14.2
	Cley (%)		7.6	5.7
Classification	Japanese Standard Soil Classification		SC	SC
	Triangle Axis Presentation		SF	SF

* Due to the aridity during the transportation, these water content percentage will be smaller than that of the original condition.
* Gravel 2,000μ < Sand 74 - 2,000μ (Coarse Sand 420 - 2,000μ Sand 74 - 2,000μ (Coarse Sand 420 - 2,000μ , Fine Sand 74 - 420μ), Silt (5 - 74μ), Clay 5μ >.

5.4 Investigation on Soil Yield Strength

The soil of this area, north of KHARTOUM, contains much sand. In soil analysis, it is classified as silty sand or hefty sand. It does not considerably contain black cotton soils.

If the soil is considered as sand, the conversion equation between q_a and N is, by *Reference* 4,

$$N = q_a/4 = 170/4 = 42 \qquad (1)$$

If $6\sqrt{20N} + 15 = \sqrt{20 \times 42} + 15 = 43^\circ \longrightarrow 40^\circ$

$\alpha = 1.3$, $C = 0$, $\beta = 0.4$, $\gamma_1 = 1.69$ ($\gamma_1' = 0.69$)

$N_r = 114$. $\gamma_2' = 1.69$ ($\gamma_2 = 0.69$), $N_q = 3$

If the above values are put into equation (3) in Section 4.5,

$$q_a = \frac{1}{3}(0.4 \times 1.69 \times 114 \times B + 1.69 \times 3 \times D_f)$$

$$= \frac{1}{3}(77B + 5.0\, D_f) \text{ .....Without influence of water} \qquad (2)$$

$$q_a = \frac{1}{3}(0.4 \times 0.69 \times 114 \times B + 0.69 \times 3 \times D_f)$$

$$= \frac{1}{3}(31.5B + 2.0\, D_f) \text{ .....With influence of water} \qquad (3)$$

Consequently, if $D_f = 0$, for the safty's sake,

$f_e = q_a = 10.5B$ (Long term)

$f_e = q_a = 21.0B$ (short term) With influence of water

6. Exploration Result in DONGOLA

6.1 Observation of Outcrop

Situation of Site

Desert area, along Nile River, about 7 km south of the city. In the east of the site, hills of 4m high extend to the city.

Situation of Surface Soil

Fine grained white sand

Observation of Excavation Pit Wall

Blackish soil down to G.L. -160cm, underneath white soil mixed with small gravels.

6.2 Observation of Collected Samples

Samples were collected from G.L. about -1.0m and -2.0m.

Samples from G.L. -1.0m

Hard soil grains, not collapsed easily by hands. It resembles the samples in WAD MEDANI in colour and shape. In the water, it collapses into fine grains. Gray colour.

Samples from G.L. -2.9m

Roundish gravels with the diameter of under 3cm and fined silt of light brown (white) colour. Silt is not hard solid as in the upper layer.

6.3 Physical Test

The list of physical test is shown in Table 4.

Tabke 4 List of Physical Test (DONGOLA)

Table- 4 List of Physical Test

Soil Texture \ Name of Sample			W-1(G.L.-1.0m)	W-2(G.L.-2.0m)
Gravity	G		2.701	2.734
Water Content *	Wn (%)		9.6	10.5
Consistency	Liquid Limit Wl (%)		55.4	61.1
	Plastic Limit Wp (%)		24.1	23.0
	Plasticity Index Ip		31.3	38.6
Grading ** Characteristic	Gravel (%)		2.2	3.1
	Sand (%)	Coarse Sand	3.3	2.5
		Fine Sand	17.3	28.7
	Silt (%)		57.4	52.0
	Cley (%)		19.8	13.7
Classification	Japanese Standard Soil Classification		CH	CH
	Triangle Axis Presentation		F	F

* Due to the aridity during the transportation, these water content percentage will be smaller than that of the original condition.

** Gravel 2,000μ <, Sand 74 - 2,000μ (Coarse Sand 420 - 2,000μ, Fine Sand 74 - 420μ), Silt (5 - 74μ), Clay 5μ >.

6.4 Investigation on Soil Yield Strength

Because this site is located in the northern SUDAN, and near the desert, the soil contains much sadgravels. Precipitation is considerably little.

The bearing power is found by Equation (2). Section 5.4, as follows:

$$q_a = \frac{1}{3}(77B + 5.0D_f) \text{ Without influence of Water} \quad (1)$$

For the safty's sake, if $D_f = 0$,

$f_e = q_a = 25.6B$ (Long term)
$f_e = q_a = 51.3B$ (Short term) Without influence of Water (2)

7. Exploration Result in EL OBEIDO

7.1 Observation of Outcrop

Situation of Site

Desert area, about 10km east of the city. The whole site inclines slightly to the south. It is dotted with thorns, around where the surface sand soil is heaped up.

Situation of Surface Soil

Fine grained red sand, mixed by white ones. Poured water is absorbed quickly.

Observation of Excavation Pit Wall

Solidified red sand, seen on the surface, makes the layer down to 30 - 50cm, and underneath a sandstone layer, slightly softer than bricks, with little moisture.

7.2 Observation of Collected Samples

Samples were collected from G.L. about -1.0m and -2.0m.

Samples from G.L. -1.0m

Small clods in brick colour. Clods can be easily collapsed by hands into fine grain (like silt).

samples from G.L. -2.0m

Water content is probably higher than other samples. However, the feeling by fingers is same as clay. Ocher colour.

7.3 Physical Test

The list of physical test is shown in Table 5.

Table 5 List of Physical Test (EL OBEID)

Table-5 List of Physical Test

Soil Texture \ Name of Sample			E-1 (G.L.-1.0m)	E-2 (G.L.-2.0m)
Gravity	G		2.637	2.665
Water Content *	Wn (%)		1.8	11.8
Consistency	Liquid Limit Wl (%)		N.P.	27.2
	Plastic Limit Wp (%)		N.P.	11.4
	Plasticity Index Ip		N.P.	15.8
Grading ** Characteristic	Gravel (%)		0	0.6
	Sand (%)	Coarse Sand	3.5	2.2
		Fine Sand	76.5	73.2
	Silt (%)		11.2	12.7
	Cley (%)		8.8	11.3
Classification	Japanese Standard Soil Classification		SC	SC
	Triangle Axis Presentation		SF	SF

* Due to the aridity during the transportation, these water content percentage will be smaller than that of the original condition.

** Gravel 2,000μ <, Sand 74 - 2,000μ (Coarse Sand 420 - 2,000μ, Fine Sand 74 - 420μ), Silt (5 - 74μ), Clay 5μ >.

7.4 Investigation of Soil Yield Strength

Down to G.L. -1.0m, it is considered as laterite layer. Underneath clayed soil or silt sand grain. Therefore, the strength can be found as in ATBARA, Section 5.4.

$$\left.\begin{aligned} f_e &= q_a = 10.5B \quad \text{(Long term)} \\ f_e &= q_a = 21.0B \quad \text{(Short term)} \end{aligned}\right\} \text{ With the influence of water (1)}$$

8. Exploration Result in WAD MEDANI

8.1 Observation Outcrop

Situation of Site

The site is located about 13 km north of the city, on the left bank of Nile River, and about 800m from the bank. Undulations probably due to the rain. Whole site inclines into the river. 7m high from the water level.

Situation of Surface Soil

Clayey soil mixed by small gravels. Hard in 1 -2cm deep. With water it becomes clay-like.

Observation of Excavation Pitt Wall

Very hard. Only by a pick, excavation is possible. Harder in the lower layer. An iron bar is stuck barely with a hammer. However, it is unexpectedly fragile, when a force is applied.

8.2 Observation of Samples Collected

Samples were collected from G.L. about -1.0m and -2.0m.

Samples from G.L. -1.0m

Small clods in dark brown or grey colour. They can not be collapsed into grains by fingers. In the water, they turn to fine grains.

Samples from G.L. -2.0m

Nearly same as the above. The part of clods is more.

8.3 Physical Test

List of Physical Test is shown in Table 6.

Table 6 List of Physical Test (WAD MEDANI)

Table-6 List of Physical Test

Soil Texture \ Name of Sample			D-1 (G.L.-1.0m)	D-2 (G.L.-2.0m)
Gravity	G		2.771	2.658
Water Content *	Wn (%)		7.6	1.4
Consistency	Liquid Limit Wl (%)		48.0	N.P.
	Plastic Limit Wp (%)		24.0	N.P.
	Plasticity Index Ip		5.4	----
Grading ** Characteristic	Gravel (%)		2.4	44.2
	Sand (%)	Coarse Sand	18.7	16.9
		Fine Sand	57.6	24.9
	Silt (%)		15.9	10.5
	Cley (%)		CL	3.5
Classification	Japanese Standard Soil Classification		F	G-C
	Triangle Axis Presentation			C-F

* Due to the aridity during the transportation, these water content percentage will be smaller than that of the original condition.

** Gravel 2,000μ <, Sand 74 - 2,000μ (Coarse Sand 420 - 2,000μ, Fine Sand 74 - 420μ), Silt (5 - 74μ), Clay 5μ >.

8.4 Investigation of Soil Yield Strength

According to the plasticity chart (Fig. 4) and the value of W_L, this is considerably the black cotton soils. Therefore, the foundation should be placed where the black cotton soil does not exist. If the situation is not allowed, the following idea is found:

If the sensitivity ratio of this cohesive soil is 1/10, q_c in KASSALA

$q_c = 170$ kg/cm^2 will be $\qquad q_c = \frac{170}{10} = 17$ kg/cm^2

If $C_u = q_c/15$ is adopted,

$C_u = 1.1$ kg/cm^2 (2)

Just as equations (3) and (4) in Section 4.5,

$f_e = q_a = \frac{1}{3}(1.3 \times 17 \times 5.3) = 25$ t/m^2 (long term) with influence

$f_e = q_a = 50$ t/m^2 (short term) water (3)

9. Summary

(1) Considering the inundation at each site, the long-term soil yield strength is proposed as follows: (in case of a direct foundation)

KASSALA	50	t/m^2
ATBARA	10.5B	t/m^2
DONGOLA	25.6B	t/m^2
EL OBEID	10.5B	t/m^2
WAD MEDANI	25	t/m^2

The above figures were obtained on the analogy of only Dutch cone penetration test in KASSALA, therefore, overestimation should be avoided.

The depth of embedment should be more than 2m at each site, and specifically in WAD MEDANI, the foundation in the black cotton soil, G.L. -2.0m, should be avoided as possible.

(2) Though the amount of settlement was not mentioned in this report, for sand soil, $E = 2q_c$, and for clay soil, $E = 480\ C_u$ will be proposed.

(3) The black cotton soil in SUDAN is a special expanded clay. The possibility of low bearing power, as well as high settlement can be considered at inundation of different types in each site. It is necessary to obtain useful information at KHARTOUM University and so on.

(4) Surface soils of all sites are considered as good, according to the samples collected and the result of test pit (note that the test was done in the dry season). However, the fall of strength during water-containing or inundation is worrying. Samples collected at the site without disturbing the situation, as well as the inundation loading test at the original site are recommended.

SOIL TESTING RESULTS

Title of Job _____

Bore Hole No. _____

				ATBARA-1	ATBARA-6	DONGOLA-1	DONGOLA-2	ELOBEID 1	ELOBEID 2
Sample No.									
Depth of Sample (m)									
Grain-Size Analysis	Gravel-Size Fraction (2000μ<)		%	13.7	29.4	5.4	44.2	0	0.6
	Sand-Size Fraction (74~2000μ)		%	56.6	50.7	21.1	41.8	80	25.4
	Silt-Size Fraction (5~74μ)		%	22.1	14.2	57.6	10.5	11.2	12.7
	Clay-Size Fraction (5μ>)		%	7.6	5.7	15.9	3.5	8.8	11.3
	Max. Grain Size		mm	9.52	9.52	4.76	25.4	2.000	4.760
	Uniformity Coefficent	U_c		38.5	35.5	23.2	83.1	21.7	56.1
	Coefficent of Curvature	U'_c		2.5	2.8	1.8	0.3	8.4	20.3
Consistency	Liquid Limit	w_L	%	28.7	24.8	48.0	NP	NP	27.2
	Plastic Limit	w_P	%	12.0	13.9	24.0	NP	N.P	11.4
	Plasticity Index	I_P		16.7	10.9	24.0	NP	N.P	15.8
Classification of Soil	Japanese Unified Soil Classification			SC	SC	CL	C-C	SC	SC
Specific Gravity of Soil Particle		G_s	t/cm³	2.735	2.724	2.771	2.658	2.637	2.665
Natural	Natural Moisture Content	w	%	4.9	4.8	7.6	1.4	1.8	11.8
	Bulk Density	ρ_t	g/cm³						
	Natural Void Ratio	e_0							
	Degree of Saturation	S_r							
Unconfined Compression Test	Uncon. Comp. Strength	q_u	kg/cm²						
	Sensitivity Ratio	S_t							
	Modulus of Elasticity	E_{50}	kg/cm²						
Triaxial Compresson Test	※ Testing Method								
	Cohesion	C	kg/cm²						
	Angle of Internal Friction	ϕ	deg.						
Direct Shear Test	※ Testing Method								
	Cohesion	C	kg/cm²						
	Angle of Internal Friction	ϕ	deg.						
Consolidation Test	Preconpression Intensity	P_c	kg/cm²						
	Compression Index	C_c							
	Coefficient of Consolidation	C_v	cm²/d						
	Coefficient of Volume Compressibility	m_v	cm²/kg						

※ Unconsolidation – Undrained Shear Test UU
Consolidation – Undrained Shear Test CU, $\overline{CU}$
Consolidation – Drained Shear Test $\overline{CD}$

SOIL TESTING RESULTS

Title of Job _____

Bore Hole No. _____

				WADMEDANI -1	WADMEDANI -2	KASSARA-1	KASSARA-2
Sample No.							
Depth of Sample (m)							
Grain-Size Analysis	Gravel-Size Fraction (2000μ<)		%	2.2	3.1	0.7	2.2
	Sand-Size Fraction (74~2000μ)		%	20.6	31.2	26.0	44.7
	Silt-Size Fraction (5~74μ)		%	57.4	52.0	47.7	30.8
	Clay-Size Fraction (5μ>)		%	19.8	13.7	25.6	22.3
	Max. Grain Size		mm	4.76	4.76	4.76	4.76
	Uniformity Coefficient	U_c		37.4	22.3	—	116.3
	Coefficient of Curvature	U'_c		1.9	2.4	—	1.0
Consistency	Liquid Limit	w_L	%	55.4	61.6	43.4	27.5
	Plastic Limit	w_P	%	24.1	23.0	17.9	6.8
	Plasticity Index	I_P		31.3	38.6	25.5	20.7
Classification of Soil	Japanese Unified Soil Classification			CL	CL	CL	CL
Specific Gravity of Soil Particle		G_s	g/cm³	2.701	2.734	2.745	2.765
Natural	Natural Moisture Content	w	%	9.6	10.5	11.0	5.4
	Bulk Density	ρ_t	g/cm³				
	Natural Void Ratio	e_0					
	Degree of Saturation	S_r					
Unconfined Compression Test	Uncon. Comp. Strength	q_u	kg/cm²				
	Sensitivity Ratio	S_t					
	Modulus of Elasticity	E_{50}	kg/cm²				
Triaxial Compresson Test	※ Testing Method						
	Cohesion	C	kg/cm²				
	Angle of Internal Friction	ϕ	deg.				
Direct Shear Test	※ Testing Method						
	Cohesion	C	kg/cm²				
	Angle of Internal Friction	ϕ	deg.				
Consolidation Test	Precompression Intensity	P_c	kg/cm²				
	Compression Index	C_c					
	Coefficient of Consolidation	C_v	cm²/d				
	Coefficient of Volume Compressibility	m_v	cm²/kg				

※ Unconsolidation – Undrained Shear Test UU

Consolidation – Undrained Shear Test CU, $\overline{CU}$

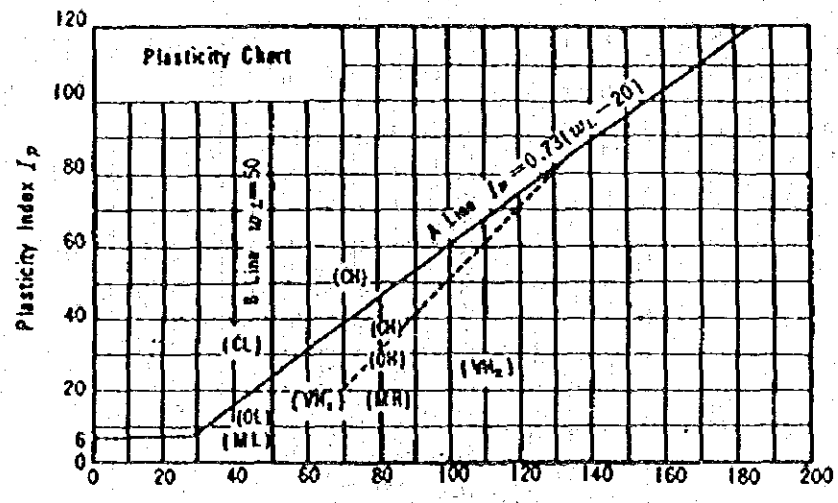
Consolidation – Drained Shear Test CD

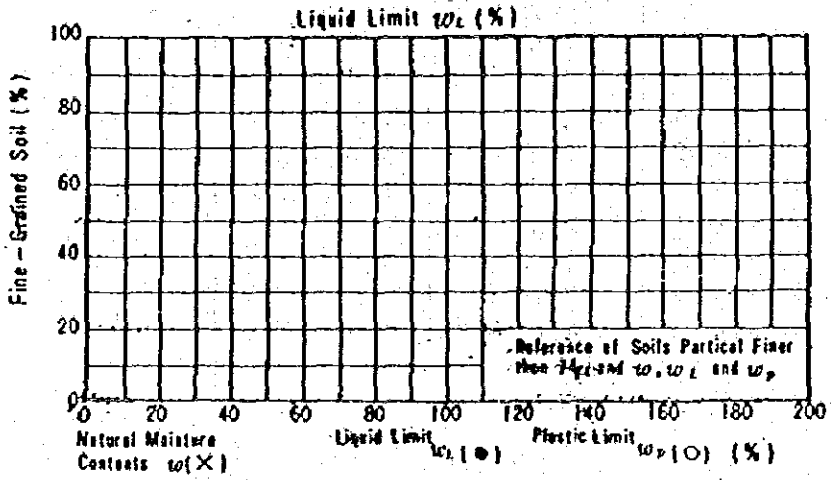
CLASSIFICATION OF SOIL.

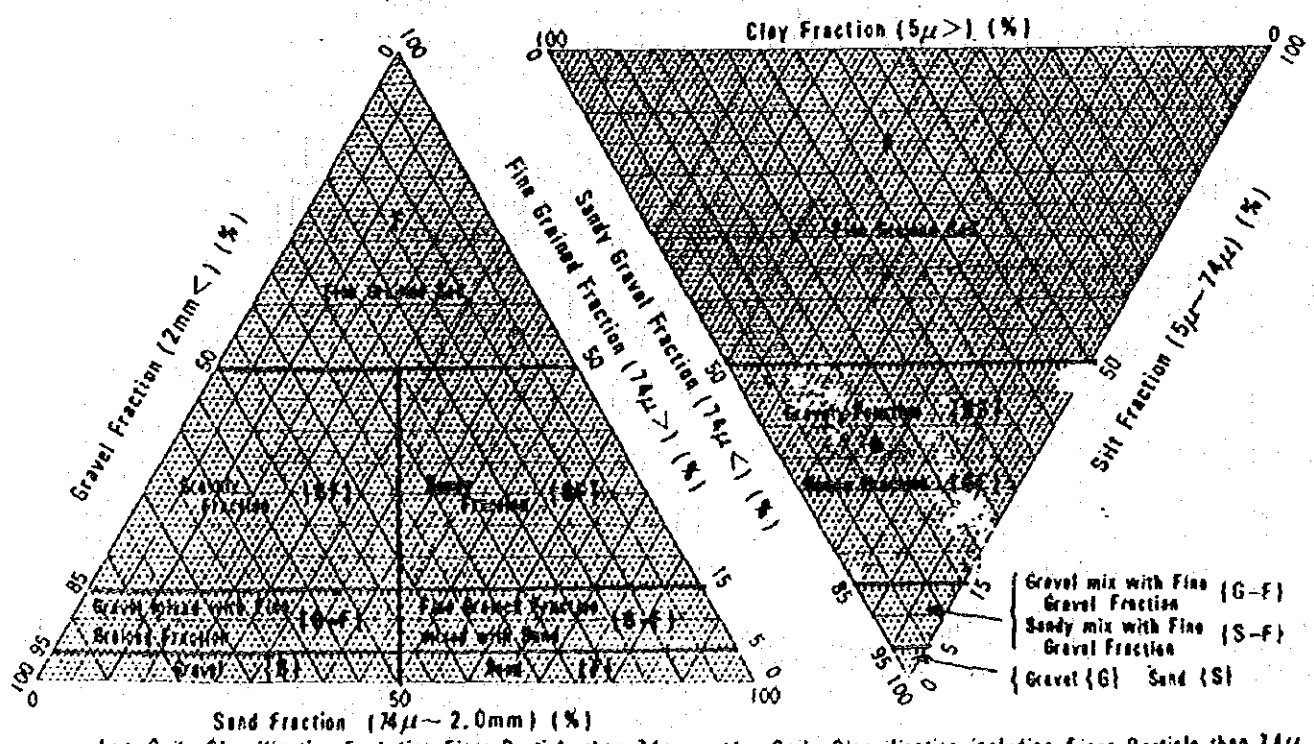
Title of Job _____

Bore Hole No. _____

Sample No. _____ (m~ m)







(a) Soils Classification Excluding Finer Particle than 74μ (b) Soils Classification including Finer Particle than 74μ

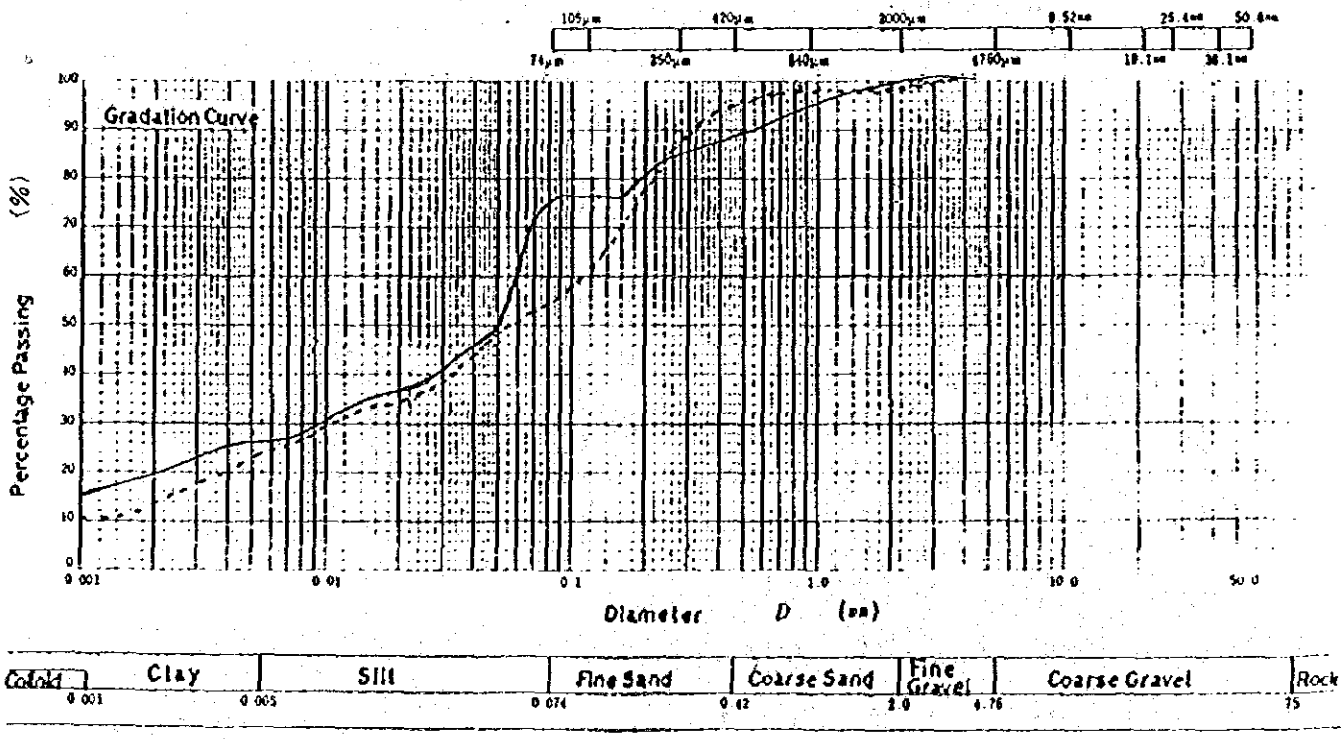
TOKYO SOIL RESEARCH CO., LTD

JIS A 1204 | GRAIN SIZE ANALYSIS

Title of Job ..... Date: .....

Sample No & Depth	No KASSARA-1 (m ~ m)		No KASSARA-2 (m ~ m)	
	Grain Size mm	Percentage % Passing	Grain Size mm	Percentage % Passing
Sieve Analysis	50.8		50.8	
	38.1		38.1	
	25.4		25.4	
	19.1		19.1	
	9.52		9.52	
	4.76	100.0	4.76	100.0
	2.00	99.3	2.00	97.8
	0.84	93.3	0.84	96.8
	0.42	87.7	0.42	93.6
	0.25	83.5	0.25	85.2
	0.105	74.4	0.105	57.6
	0.074	73.3	0.074	53.1
Hydrometer	0.0538	52.0	0.0535	49.1
	0.0386	45.0	0.0383	42.5
	0.0247	38.0	0.0246	35.9
	0.0144	34.5	0.0143	32.6
	0.0102	31.0	0.0102	29.3
	0.0073	27.5	0.0072	26.0
	0.0037	24.0	0.0037	19.4
	0.0030	22.3	0.0030	17.8
	0.0015	17.1	0.0015	11.2

Sample No. & Depth		No KASSARA-1 (m ~ m)		No KASSARA-2 (m ~ m)	
4.76mm <	%	0.0		0.0	
Fine Gravel (4.76 ~ 2mm)	%	0.7	0.7	2.2	2.2
Coarse Sand (2 ~ 0.42mm)	%	11.6		4.2	
Fine Sand (0.42 ~ 0.074mm)	%	14.4	26.0	40.5	44.7
Silt (0.074 ~ 0.005mm)	%	47.7		30.8	
Clay (0.005mm >)	%	25.6		22.3	
Colloid (0.001mm >)	%	15.0		10.0	
2000μm Percentage Passing	%	99.3		97.8	
420μm Percentage Passing	%	87.7		93.6	
74μm Percentage Passing	%	73.3		53.1	
Max. Grain Size	mm	4.7600		4.7600	
60 % Grain Size	mm	0.0606		0.1163	
30 % Grain Size	mm	0.0094		0.0109	
10 % Grain Size	mm	———		0.0010	
Uniformity Coefficient	U_c	———		116.28	
Coefficient of Curvature	U_c'	———		1.02	
Specific Gravity	G_s	2.75		2.75	

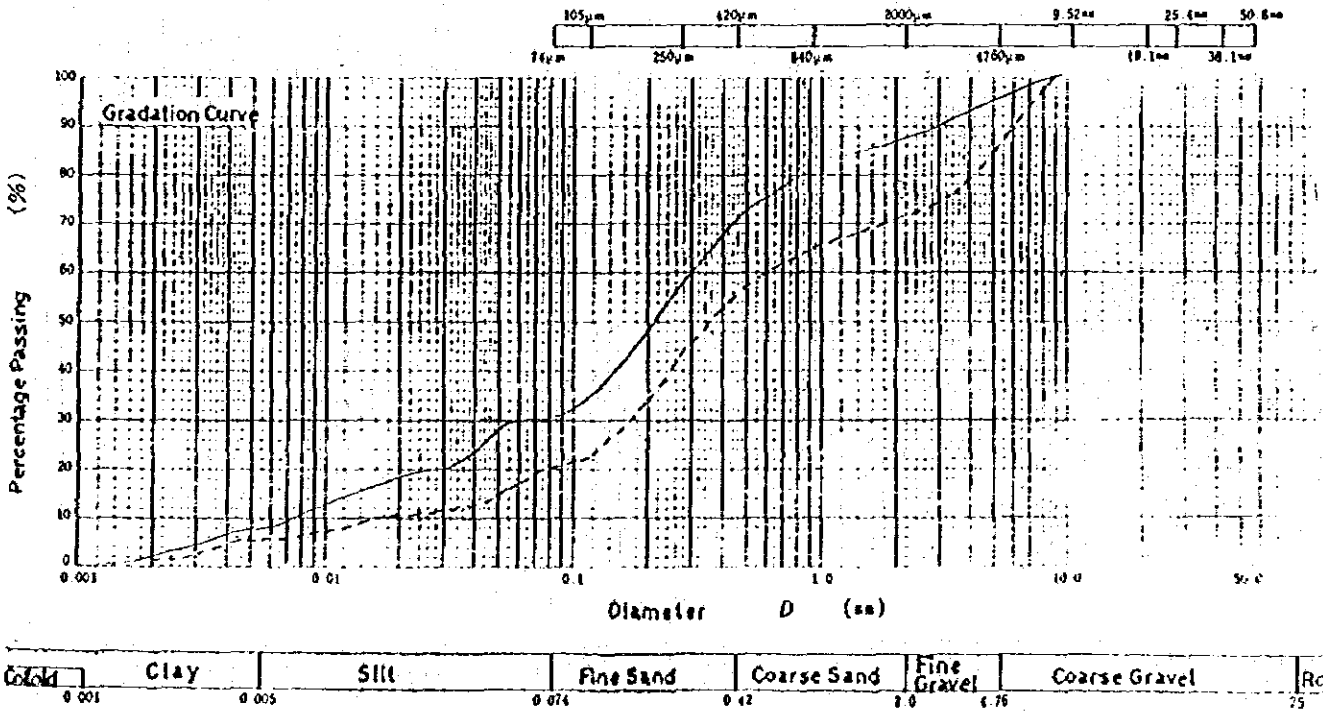


JIS A 1204 | GRAIN SIZE ANALYSIS

Title of Job ..... Date: .....

Sample No & Depth	No ATBARA-1 (m ~ m)		No ATBARA-6 (m ~ m)	
Sieve Analysis	Grain Size mm	Percentage Passing %	Grain Size mm	Percentage Passing %
	50.8		50.8	
	38.1		38.1	
	25.4		25.4	
	19.1		19.1	
	9.52	100.0	9.52	100.0
	4.76	93.9	4.76	82.1
	2.00	86.3	2.00	70.6
	0.84	77.8	0.84	63.7
	0.42	68.3	0.42	53.6
	0.25	54.6	0.25	40.0
	0.105	33.0	0.105	21.8
	0.074	27.7	0.074	19.9
Hydrometer	0.0446	23.4	0.0470	16.2
	0.0293	22.8	0.0406	12.9
	0.0240	19.4	0.0248	11.2
	0.0146	16.1	0.0149	8.4
	0.0104	12.8	0.0106	7.9
	0.0074	8.4	0.0074	6.2
	0.0037	6.2	0.0038	4.6
	0.0031	4.6	0.0031	2.9
	0.0014	2.3	0.0016	1.3

Sample No & Depth	No ATBARA-1 (m ~ m)		No ATBARA-6 (m ~ m)	
4.76mm < %	6.1		17.9	
Fine Gravel (4.76 ~ 2mm) %	7.6	13.7	11.4	29.4
Coarse Sand (2 ~ 0.42mm) %	18.0		17.0	
Fine Sand (0.42 ~ 0.074mm) %	38.6	56.6	23.7	40.7
Silt (0.074 ~ 0.005mm) %	22.1		11.2	
Clay (0.005mm >) %	7.6		1.7	
Colloid (0.001mm >) %	0.4		0.4	
2000μm Percentage Passing %	86.3		70.6	
420μm Percentage Passing %	68.3		53.6	
74μm Percentage Passing %	27.7		19.9	
Max. Grain Size mm	9.4200		9.4200	
60 % Grain Size mm	0.3030		0.6081	
30 % Grain Size mm	0.0778		0.1718	
10 % Grain Size mm	0.0079		0.0171	
Uniformity Coefficient U_c	38.41		34.47	
Coefficient of Curvature U_c'	2.44		2.83	
Specific Gravity G_s	2.734		2.724	

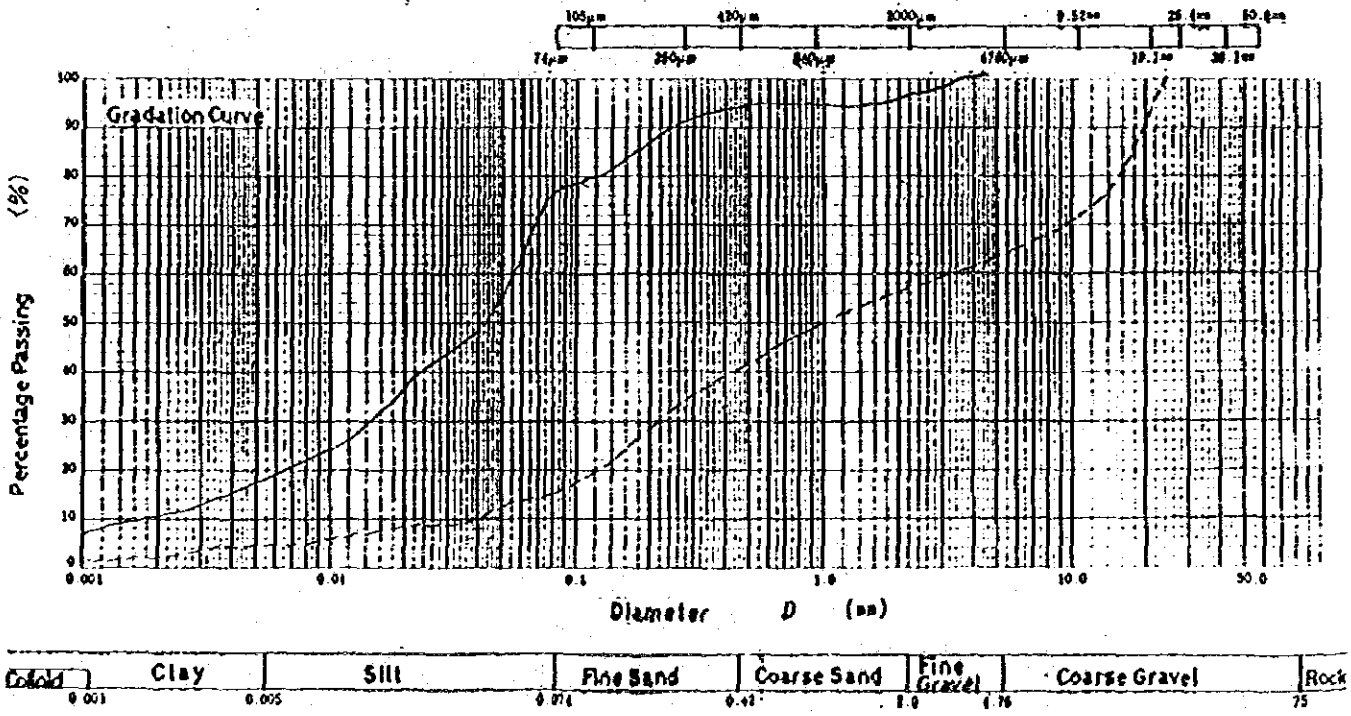


JIS A 1204 | GRAIN SIZE ANALYSIS

Title of Job..... Date:.....

Sample No. & Depth	No. DONGOLA-1 (m ~ m)		No. DONGOLA-2 (m ~ m)	
	Grain Size mm	Percentage Passing %	Grain Size mm	Percentage Passing %
Sieve Analysis	50.8		50.8	
	38.1		38.1	
	25.4		25.4	100.0
	19.1		19.1	84.8
	9.52		9.52	67.3
	4.76	100.0	4.76	52.3
	2.00	94.6	2.00	44.8
	0.84	93.4	0.84	42.4
	0.42	92.2	0.42	38.9
	0.25	89.2	0.25	31.7
	0.105	77.6	0.105	16.9
	0.074	73.4	0.074	14.0
Hydrometer	0.0431	46.8	0.0468	12.8
	0.0384	46.7	0.0408	9.4
	0.0246	40.0	0.0260	7.9
	0.0144	28.2	0.0141	6.3
	0.0104	23.2	0.0108	4.7
	0.0074	18.8	0.0077	3.8
	0.0037	13.1	0.0038	3.0
	0.0031	11.4	0.0031	2.2
	0.0014	8.0	0.0016	0.6

Sample No. & Depth		No. DONGOLA-1 (m ~ m)		No. DONGOLA-2 (m ~ m)	
4.76mm <	%	0.0		52.7	
Fine Gravel (4.76 ~ 2 mm)	%	4.4	4.4	6.4	44.2
Coarse Sand (2 ~ 0.42 mm)	%	2.4		16.9	
Fine Sand (0.42 ~ 0.074 mm)	%	18.7	21.1	24.4	41.8
Silt (0.074 ~ 0.005 mm)	%	52.6		10.4	
Clay (0.005 mm >)	%	14.9		3.4	
Colloid (0.001 mm >)	%	6.0		0.2	
2000μm Percentage Passing	%	94.6		44.8	
420μm Percentage Passing	%	92.2		38.9	
74μm Percentage Passing	%	73.4		14.0	
Max. Grain Size	mm	4.7600		26.4000	
60 % Grain Size	mm	0.0464		3.4690	
30 % Grain Size	mm	0.0148		0.2263	
10 % Grain Size	mm	0.0024		0.0429	
Uniformity Coefficient	U_c	23.14		83.12	
Coefficient of Curvature	U_c'	1.81		0.33	
Specific Gravity	G_s	2.721		2.648	

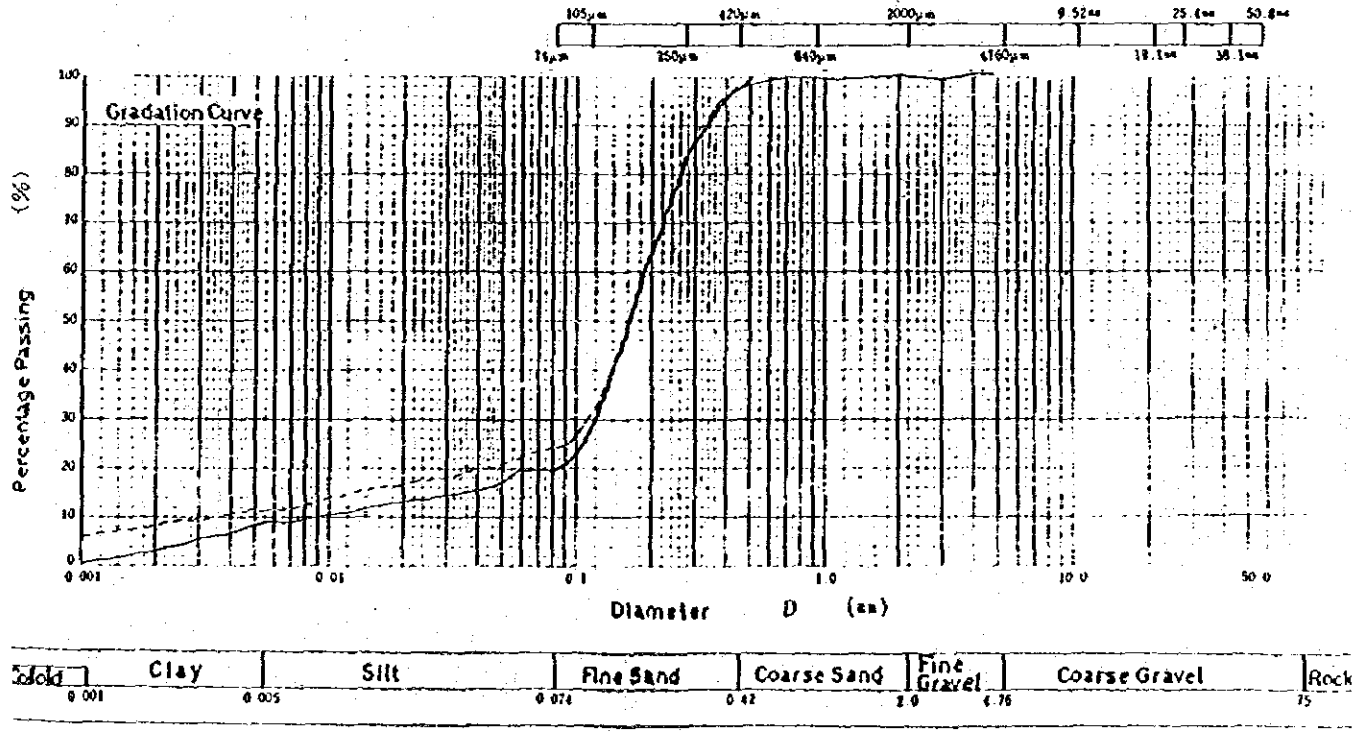


JIS A 1204 | GRAIN SIZE ANALYSIS

Title of Job ..... Date: .....

Sample No. & Depth	No. ELOBELD-1 (m ~ m)		No. ELOBELD-2 (m ~ m)	
Sieve Analysis	Grain Size mm	Percentage Passing %	Grain Size mm	Percentage Passing %
	50.8		50.8	
	38.1		38.1	
	25.4		25.4	
	19.1		19.1	
	9.52		9.52	
	4.76		4.76	100.0
	2.00	100.0	2.00	99.4
	0.84	98.9	0.84	98.7
	0.42	96.4	0.42	97.2
	0.25	77.2	0.25	78.4
	0.105	24.6	0.105	28.0
	0.074	20.0	0.074	24.0
Hydrometer	0.0484	18.3	0.0443	21.2
	0.0423	16.9	0.0387	18.4
	0.0268	14.4	0.0247	17.7
	0.0144	12.7	0.0144	14.8
	0.0110	11.1	0.0103	14.1
	0.0078	9.4	0.0073	12.3
	0.0039	7.8	0.0037	10.4
	0.0032	6.2	0.0030	9.6
	0.0016	2.9	0.0014	7.8

Sample No. & Depth		No. ELOBELD-1 (m ~ m)		No. ELOBELD-2 (m ~ m)	
4.76mm <	%	0.0		0.0	
Fine Gravel (4.76 ~ 2mm)	%	0.0	0.0	0.6	0.6
Coarse Sand (2 ~ 0.42mm)	%	3.4		2.0	
Fine Sand (0.42 ~ 0.074mm)	%	76.4	80.0	73.2	75.4
Silt (0.074 ~ 0.005mm)	%	11.2		12.7	
Clay (0.005mm >)	%	8.8		11.3	
Colloid (0.001mm >)	%	1.0		4.0	
2000μm Percentage Passing	%	100.0		99.4	
420μm Percentage Passing	%	96.4		97.2	
11μm Percentage Passing	%	20.0		24.0	
Max. Grain Size	mm	2.0000		4.7600	
60 % Grain Size	mm	0.1922		0.1841	
30 % Grain Size	mm	0.1200		0.1113	
10 % Grain Size	mm	0.0089		0.0033	
Uniformity Coefficient	U_c	21.66		46.04	
Coefficient of Curvature	U_c'	8.44		20.26	
Specific Gravity	G_s	2.637		2.664	

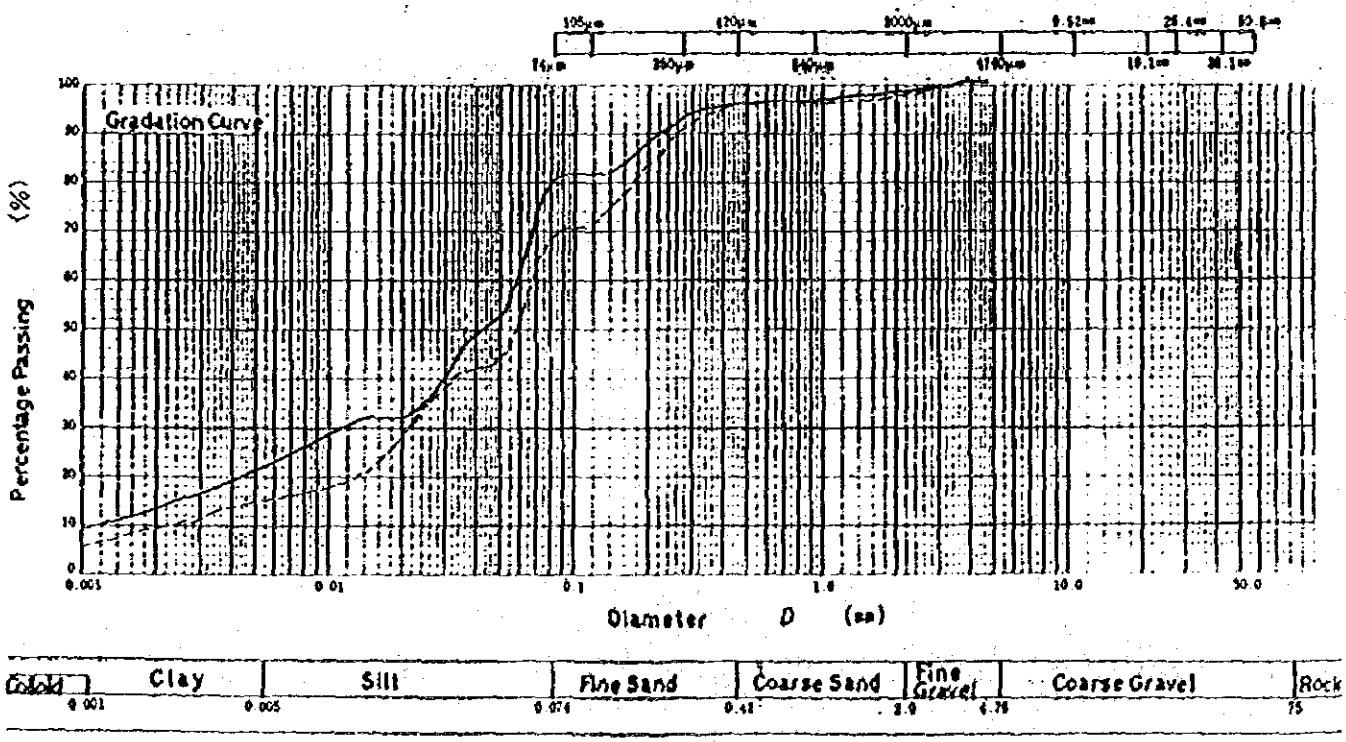


JIS A 1204 | GRAIN SIZE ANALYSIS

Title of Job..... Date:.....

Sample No & Depth	No. WADMEDNI-1 (m ~ m)		No. WADMEDANI-2 (m ~ m)	
Sieve Analysis	Grain Size mm	Percentage % Passing	Grain Size mm	Percentage % Passing
	50.8		50.8	
	38.1		38.1	
	25.4		25.4	
	19.1		19.1	
	9.52		9.52	
	4.76	100.0	4.76	100.0
	2.00	97.8	2.00	96.9
	0.84	96.2	0.84	94.7
	0.42	94.4	0.42	94.4
	0.25	91.8	0.25	89.1
	0.105	79.8	0.105	68.9
	0.074	72.2	0.074	64.7
Hydrometer	0.0448	54.3	0.0432	44.8
	0.0321	48.3	0.0327	41.4
	0.0244	34.4	0.0244	30.7
	0.0148	30.9	0.0146	20.4
	0.0104	27.4	0.0101	17.0
	0.0074	24.0	0.0074	14.3
	0.0038	12.0	0.0037	11.8
	0.0031	14.3	0.0030	10.1
	0.0016	10.0	0.0014	6.6

Sample No & Depth		No. WADMEDANI-1 (m ~ m)		No. WADMEDANI-2 (m ~ m)	
4.76mm <	%	0.0		0.0	
Fine Gravel (4.76 ~ 2mm)	%	2.2	2.2	3.1	3.1
Coarse Sand (2 ~ 0.42mm)	%	3.4		2.4	
Fine Sand (0.42 ~ 0.074mm)	%	17.3	20.6	28.7	31.2
Silt (0.074 ~ 0.005mm)	%	47.4		43.0	
Clay (0.005mm >)	%	19.8		19.7	
Colloid (0.001mm >)	%	8.0		4.0	
2000μm Percentage Passing	%	97.8		96.9	
120μm Percentage Passing	%	94.4		94.4	
74μm Percentage Passing	%	72.2		64.7	
Max. Grain Size	mm	4.7600		4.7600	
60 % Grain Size	mm	0.0484		0.0671	
30 % Grain Size	mm	0.0132		0.0222	
10 % Grain Size	mm	0.0016		0.0030	
Uniformity Coefficient	U_c	37.43		22.34	
Coefficient of Curvature	U_c'	1.89		2.44	
Specific Gravity	G_s	2.701		2.734	



JIS A 1205 1206	LIQUID LIMIT AND PLASTIC LIMIT	

Title of Job ..... Date .....

Sample No. & Depth No. ATBARA-1 (m ~ m)

Liquid Limit Test			Plastic Limit Test	
No.	Number of Blows	Water Content %	No.	Water Content %
1	42	27.6	1	12.1
2	34	28.0	2	11.8
3	29	28.8	3	12.3
4	23	28.7		
5	13	30.8		
6	8	31.3	AV	12.0

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
28.7	12.0	16.7	5.1

Sample No. & Depth No. ATBARA-b (0.00 m ~ 0.00 m)

Liquid Limit Test			Plastic Limit Test	
No.	Number of Blows	Water Content %	No.	Water Content %
1	44	24.0	1	14.2
2	35	24.4	2	14.0
3	28	24.5	3	13.7
4	23	25.0		
5	14	25.9		
6	9	26.3	AV	13.9

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
24.8	13.9	10.9	3.3

Sample No. & Depth No. DONGORA-1 (0.00 m ~ 0.00 m)

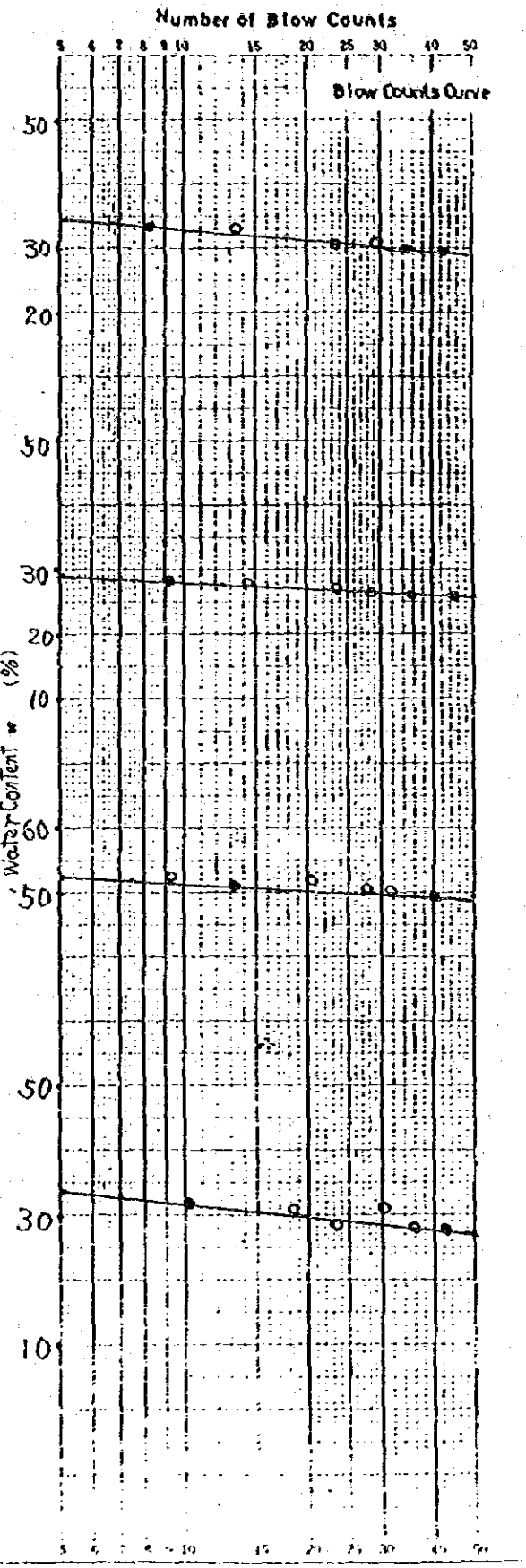
Liquid Limit Test			Plastic Limit Test	
No.	Number of Blows	Water Content %	No.	Water Content %
1	40	47.4	1	24.1
2	31	47.9	2	24.3
3	27	48.3	3	23.7
4	20	49.4		
5	13	49.1		
6	9	50.3	AV	24.0

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
48.0	24.0	24.0	3.4

Sample No. & Depth No. ELOBEID-2 (0.00 m ~ 0.00 m)

Liquid Limit Test			Plastic Limit Test	
No.	Number of Blows	Water Content %	No.	Water Content %
1	42	25.8	1	11.5
2	35	26.2	2	11.7
3	30	29.1	3	11.1
4	23	26.4		
5	18	28.5		
6	10	29.8	AV	11.4

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
27.2	11.4	15.8	6.4



JIS A 1205 1206	LIQUID LIMIT AND PLASTIC LIMIT	

Title of Job ..... Date .....

Sample No.& Depth No WEDMEDANI-1 (m ~ m)

Liquid Limit Test

No	Number of Blows	Water Content %
1	45	51.6
2	36	52.6
3	30	53.7
4	23	56.0
5	18	57.3
6	13	59.6

Plastic Limit Test

No	Water Content %
1	24.2
2	24.3
3	24.0
AV	24.1

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
55.4	24.1	31.3	14.8

Sample No.& Depth No WEDMEDANI-2 (m ~ m)

Liquid Limit Test

No	Number of Blows	Water Content %
1	45	59.5
2	36	60.5
3	28	60.7
4	23	62.0
5	20	62.3
6	11	64.9

Plastic Limit Test

No	Water Content %
1	23.3
2	23.0
3	22.7
AV	23.0

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
61.6	23.0	38.6	8.5

Sample No.& Depth No KASSARA-1 (m ~ m)

Liquid Limit Test

No	Number of Blows	Water Content %
1	43	41.2
2	36	42.0
3	27	41.9
4	18	45.2
5	13	45.6
6	8	48.2

Plastic Limit Test

No	Water Content %
1	18.0
2	18.2
3	17.7
AV	17.9

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
43.4	17.9	22.5	9.5

Sample No.& Depth No KASSARA-2 (m ~ m)

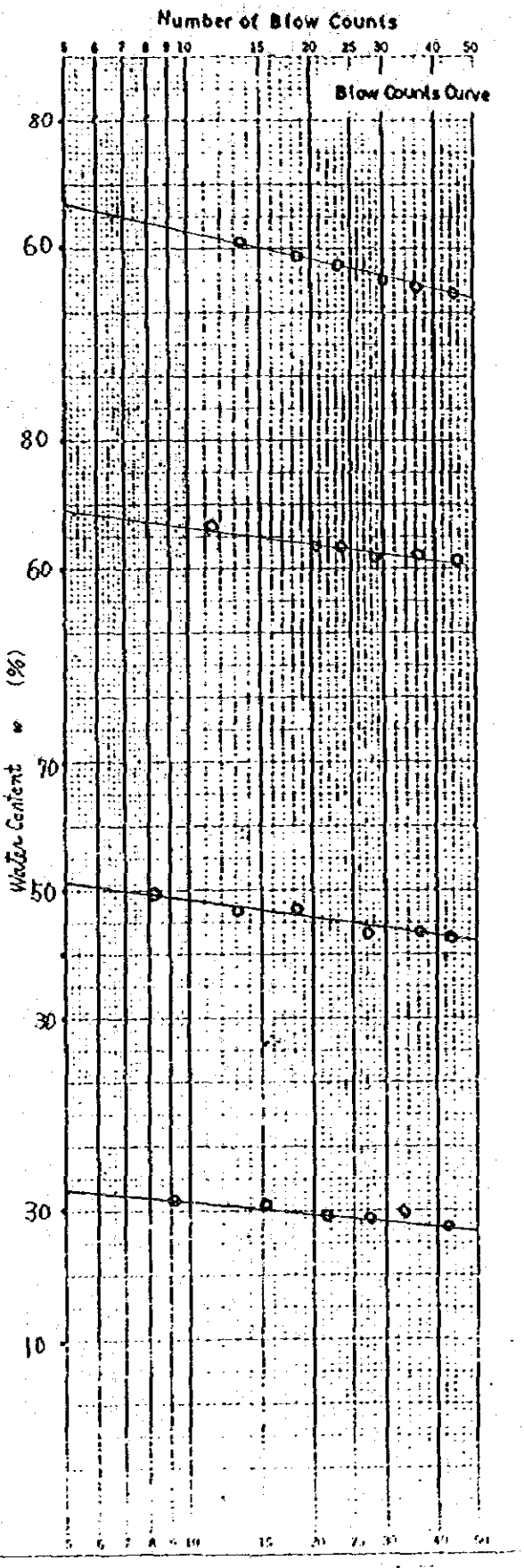
Liquid Limit Test

No	Number of Blows	Water Content %
1	42	26.0
2	33	28.4
3	27	27.6
4	21	28.1
5	15	29.6
6	9	30.5

Plastic Limit Test

No	Water Content %
1	6.5
2	6.7
3	7.2
AV	6.8

Liquid Limit w_L %	Plastic Limit w_P %	Plasticity Index Ip	If
27.5	6.8	20.7	6.7



BUILDING AND ROAD RESEARCH INSTITUTE
UNIVERSITY OF KHARTOUM

The National Borad Casting Corporation
Khartoum.

The Building and Road Research Institute of the University of Khartoum was invited by the National Broad-Casting Corporation to carry out soil investigation at Kassala.

A 10 ton capacity Dutch static cone penetrometer handled with an adhesion jacket cone type was used in this investigation.

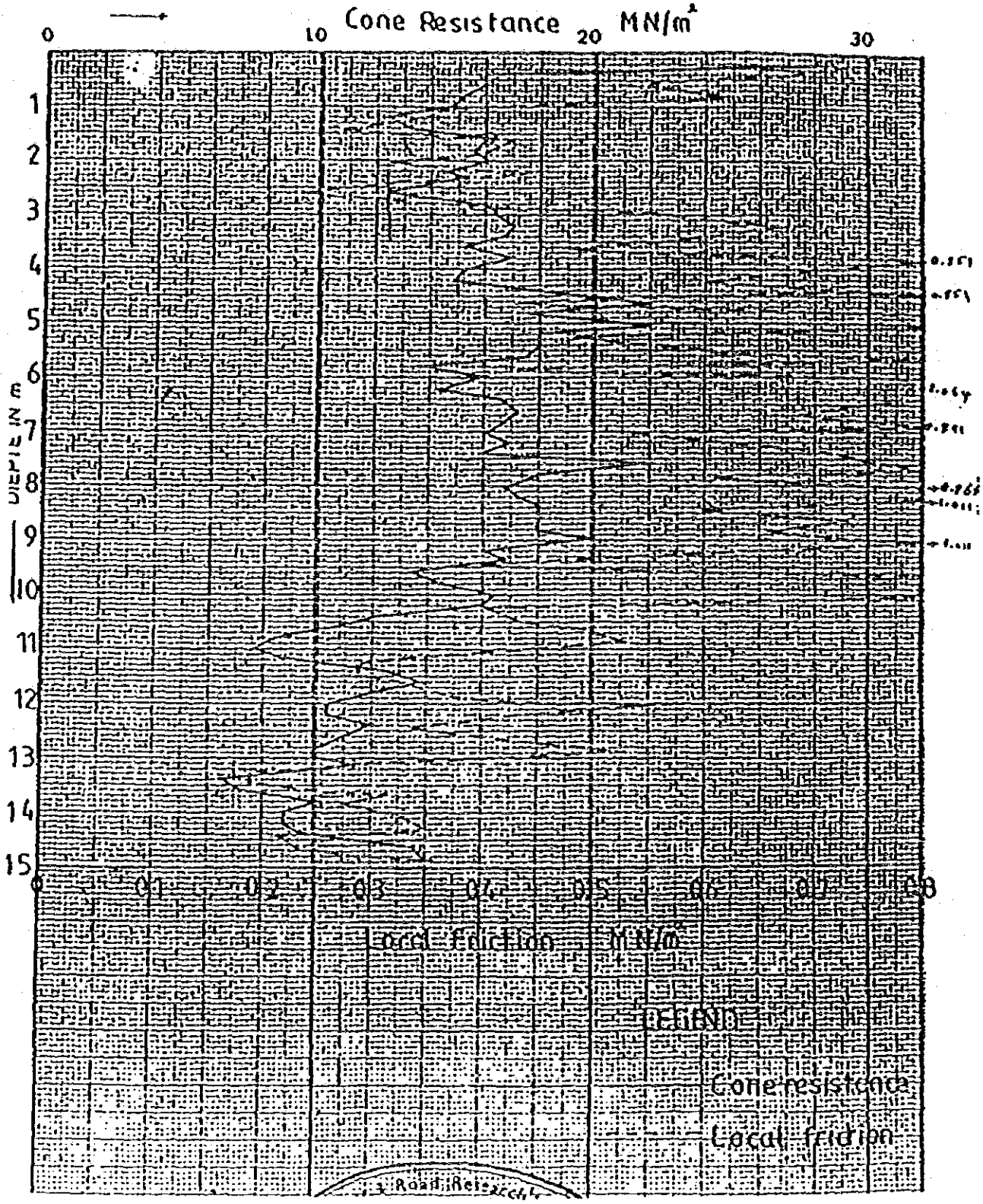
A single cone penetration test sounding (C.P.T.) was conducted at the location allocated by the client's representative.

The cone resistance and the friction on the jacket were recorded at 0.2m interval, and the total depth penetrated was 15m.

The given graph shows the cone resistance $q_c (MN/m^2)$ as well as the friction on the jacket f_s (MN/m^2), plotted against the depth penetrated in (m).

Building & Road Research Institute
28 FEB 1984 BR
University of Khartoum

Elfatih M.Ali P.E
I , Univ. of Khartoum
28-2-84


Cone Resistance MN/m²
0
10
20
30
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
Local friction MN/m²
Cone resistance
Local friction

ANNEX-2

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12) Designing standard on Architectural Foundation Structure and detail explanation Construction society.
(Page 222)

13) Same as 7) Page 692

14) Same as 11) Page 237

15) Same as 9) Page 131