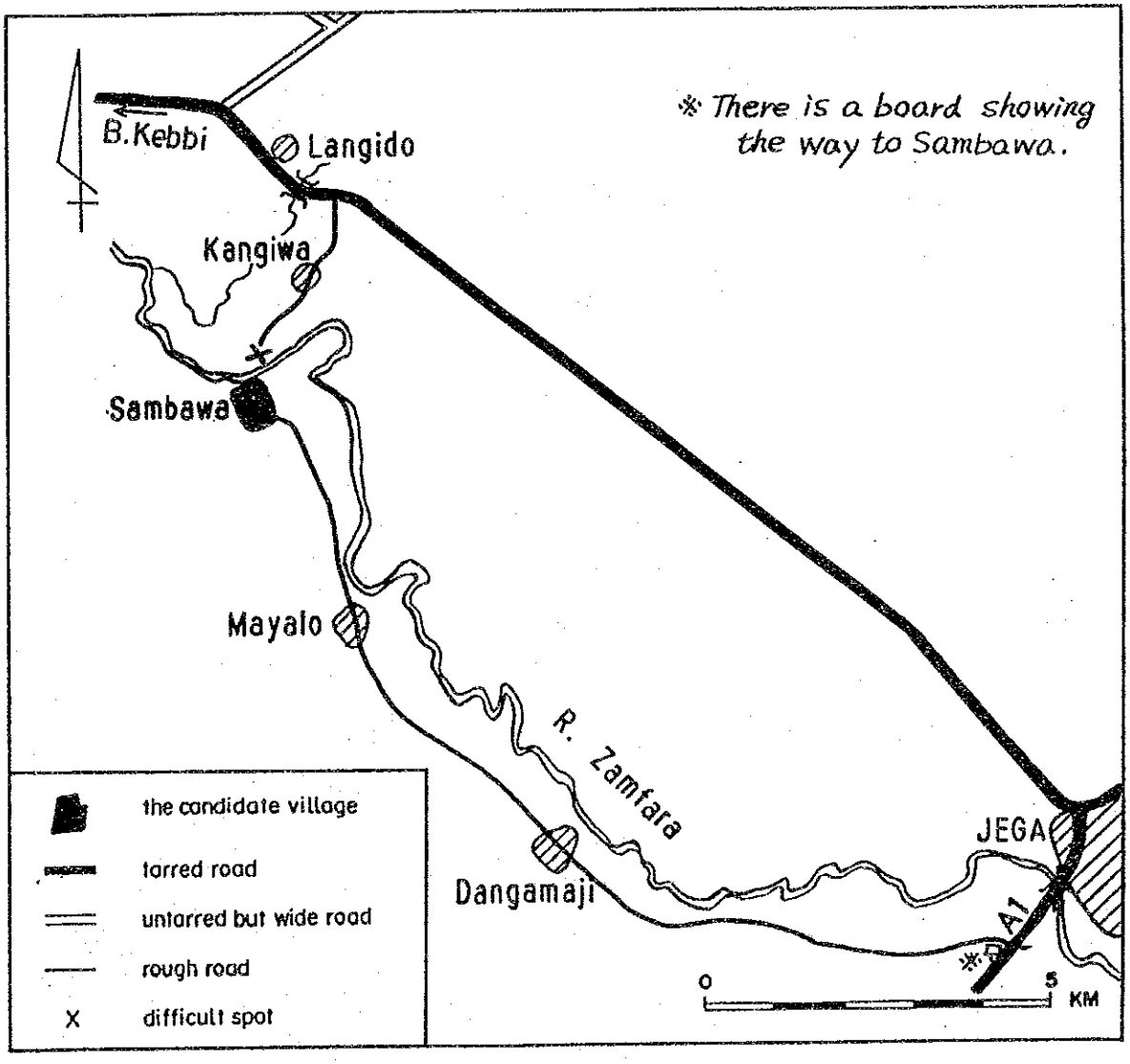
The Study for Groundwater Development in Sokoto State

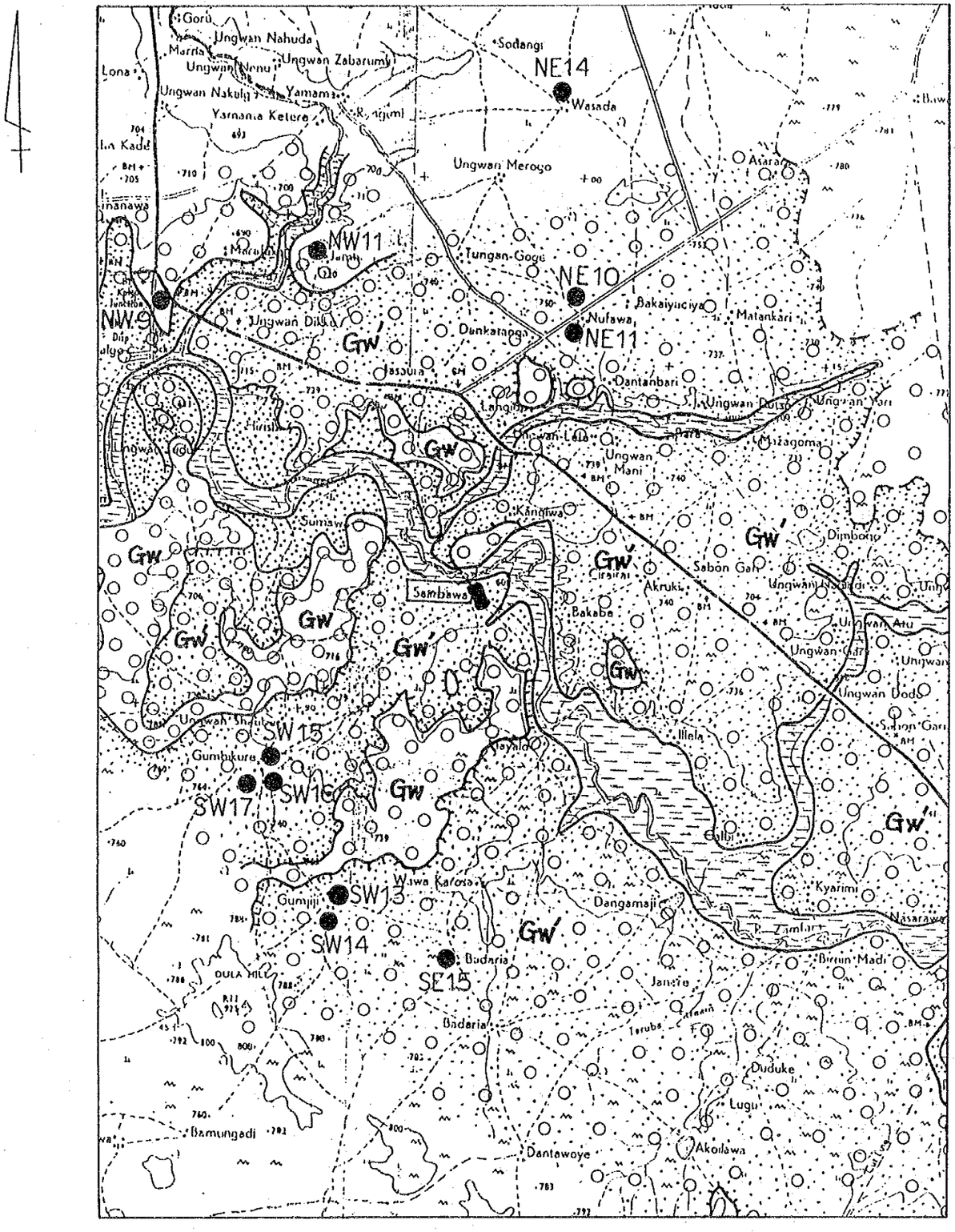
VILLAGE : Sambawa

Village No. 42



LOCATION MAP

(1/100,000 Sheet 49)



1/100,000 0 50 km

GEOLOGICAL MAP

Sambawa

f Fadama

Eroded and Recovered with Sand

Escarpment

Gw Gwandu Formation

SW16 Existing Boreholes

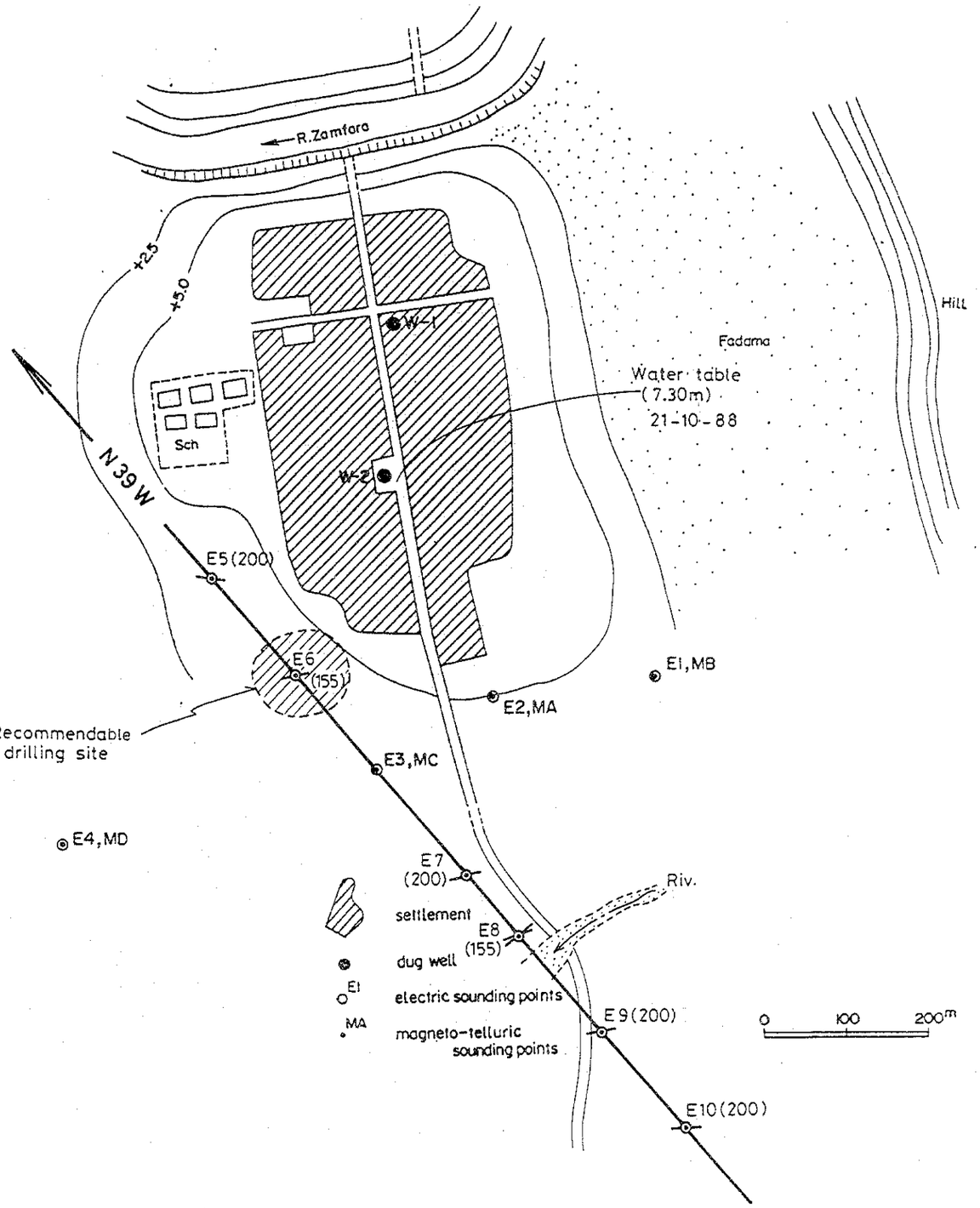
DATA OF EXISTING BOREHOLES

Borehole No.	Depth(m)	S.W.L.(m)	S.C.(m^3/d/m)
NW 9	91.0	10.90	5.78
NW 11	91.0	20.33	16.19
NE 10	91.0	26.79	2.27
NE 11	85.0	24.70	92.90
NE 14	48.0	22.82	81.00
SW 13	73.0	36.42	7.75
SW 14	66.0	36.74	1.27
SW 15	56.0	24.87	10.41
SW 16	49.0	19.88	16.10
SW 17	54.0	18.61	18.36
SE 15	72.0	27.70	3.60

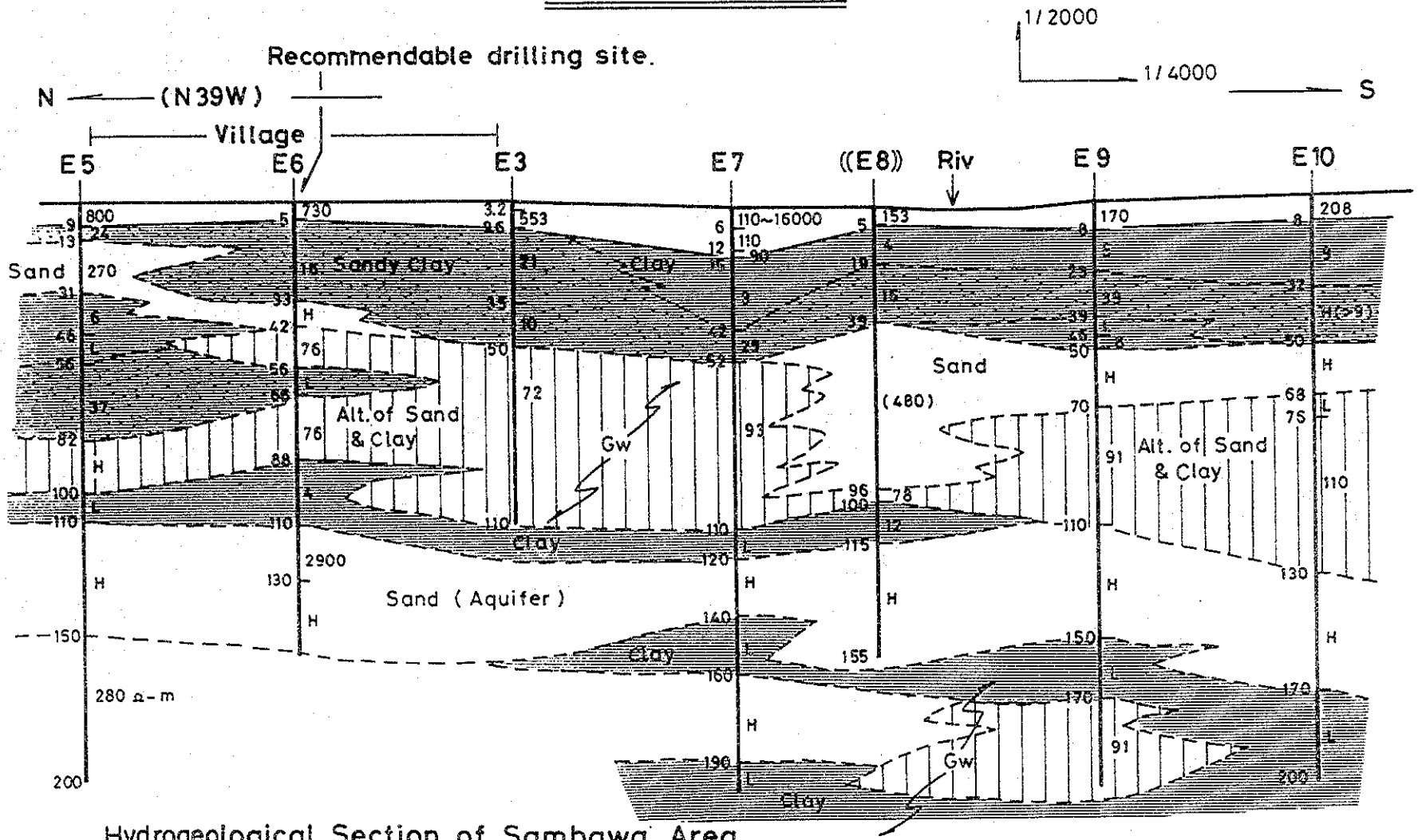
S.W.L.: Static Water Level
S.C : Specific Capacity

THE LOCATIONS OF INVESTIGATION AND THE TOPOGRAPHICAL FEATURE

No.42 Sambawa



No. 42 : Sambawa



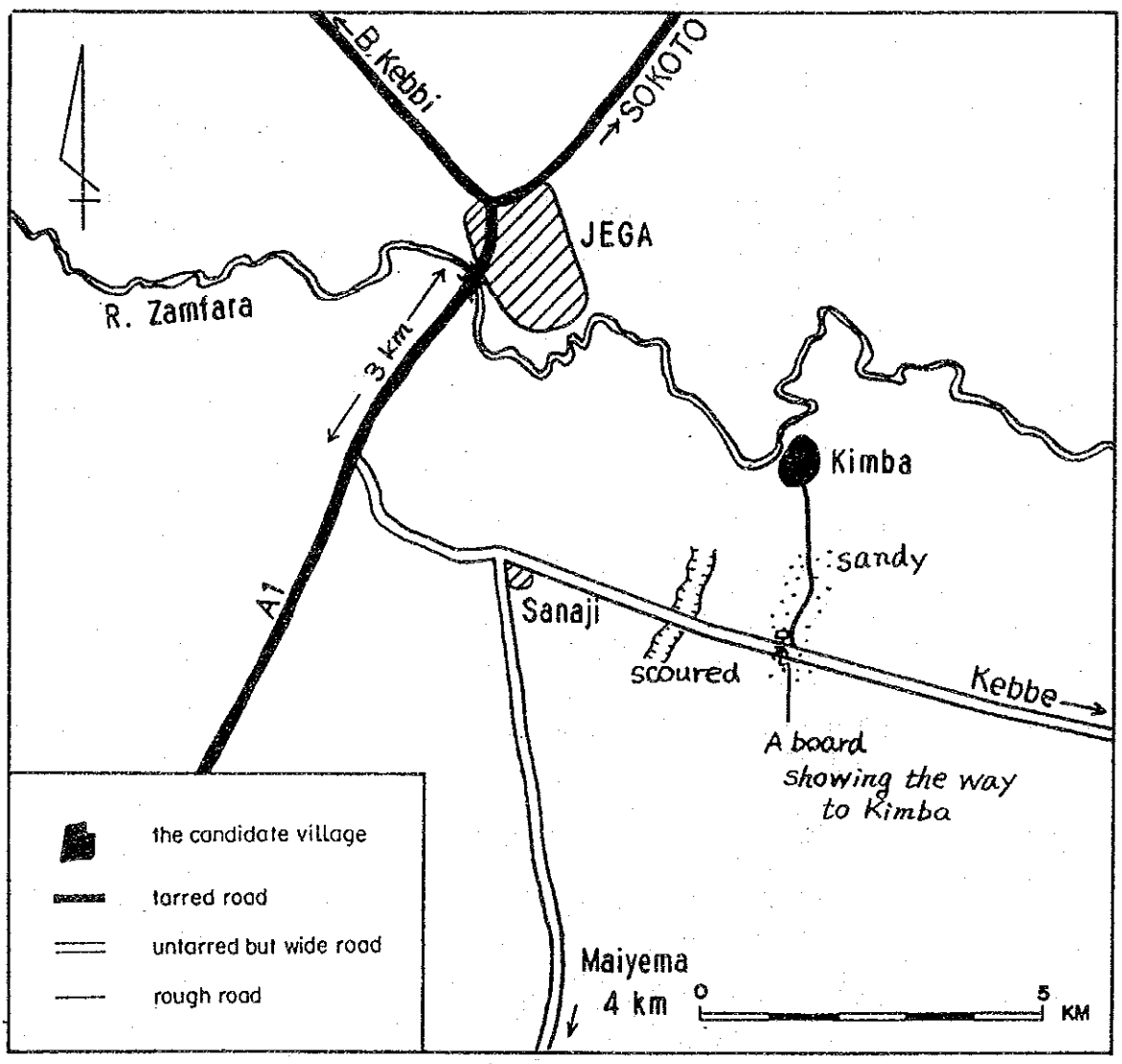
Hydrogeological Section of Sambawa Area.

(Map showing resistivity profile and estimated lithologic distribution) Gw: Gwandu F.

The Study for Groundwater Development in Sokoto State

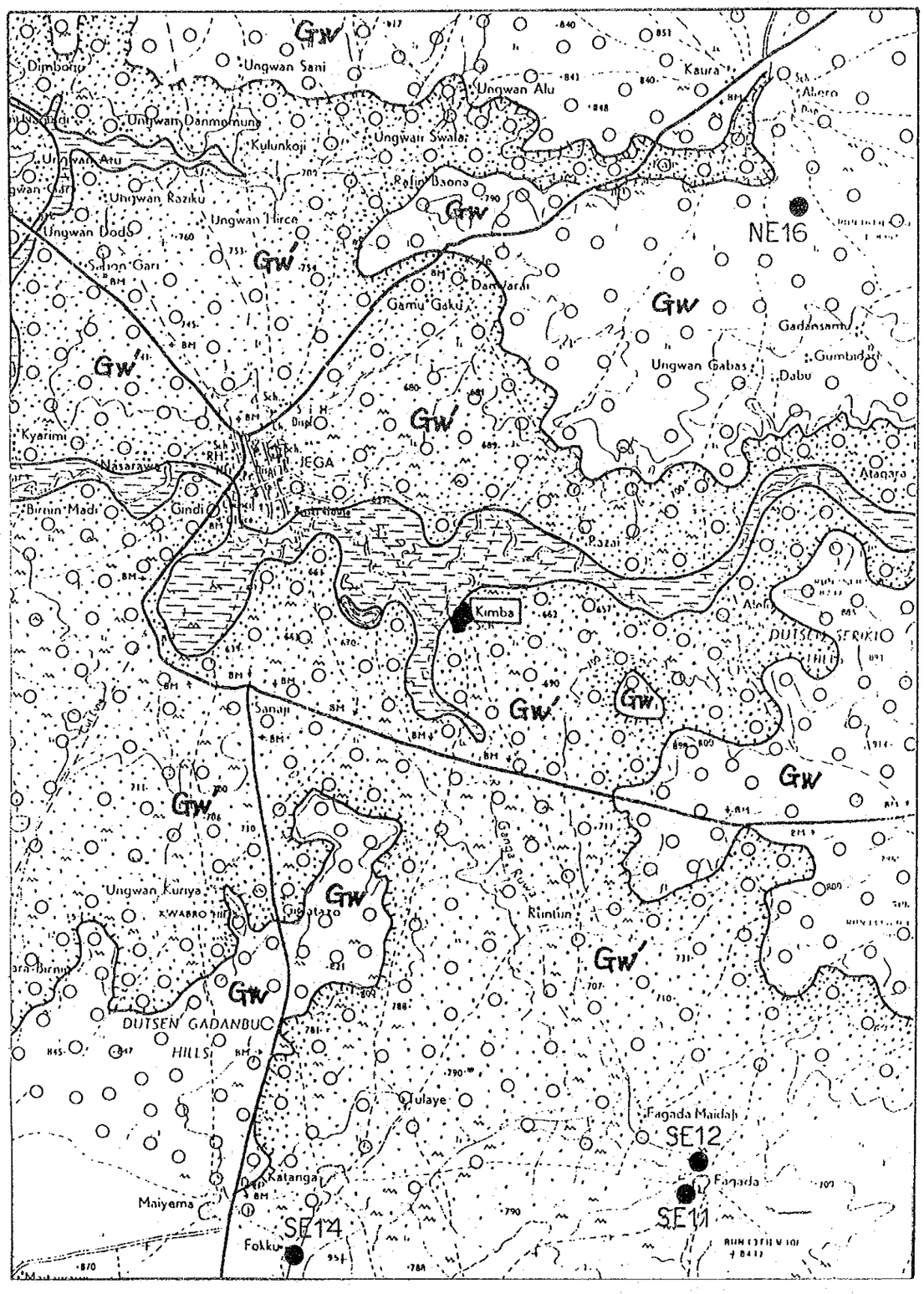
VILLAGE : Kimba

Village No. 43



LOCATION MAP

(1/100,000 Sheet 49)



GEOLOGICAL MAP

Kimba

- Fadama
- Eroded and Recovered with Sand
- Escarpment
- Gw — Gwandu Formation
- SW 16 — Existing Boreholes

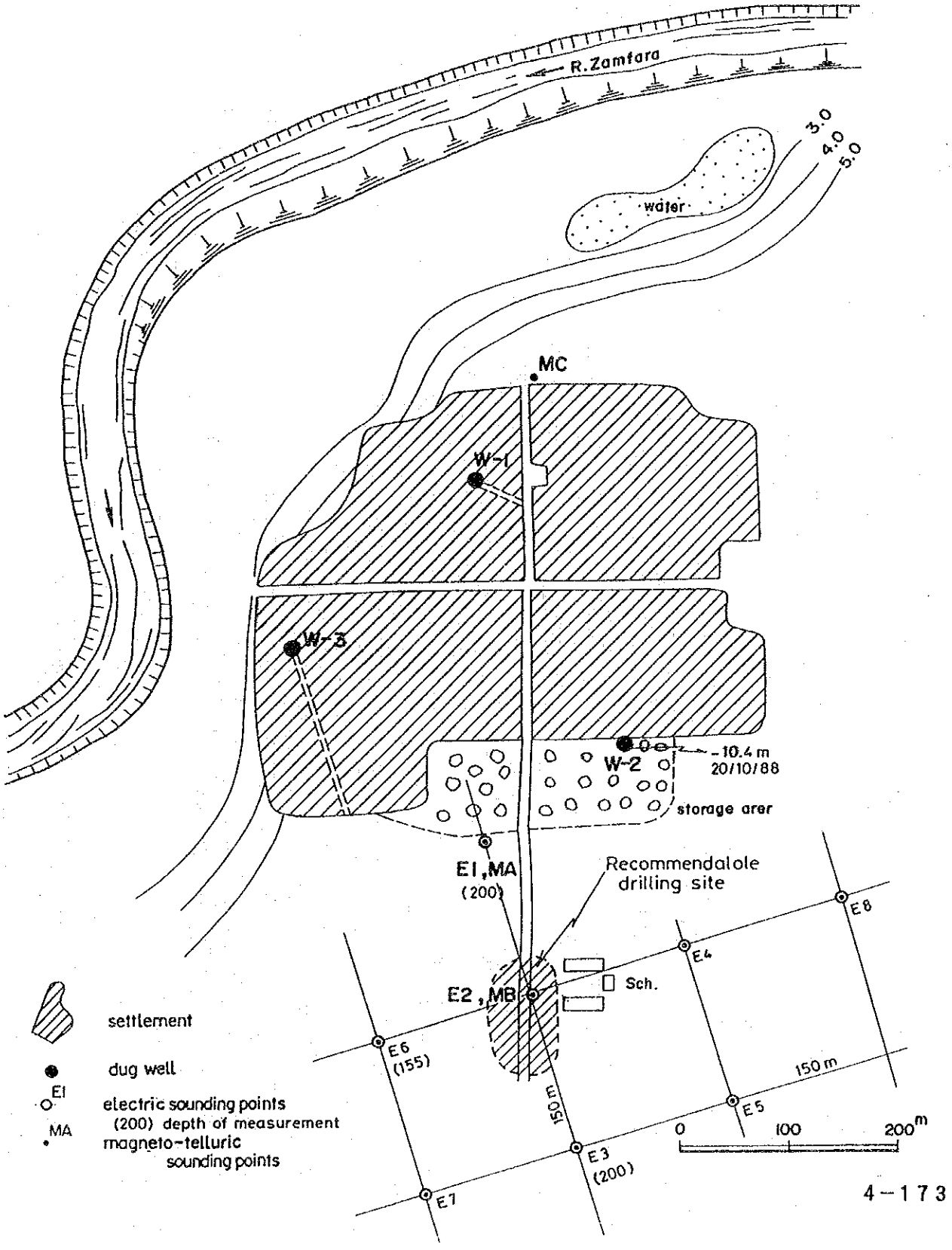
DATA OF EXISTING BOREHOLES

Borehole No.	Depth(m)	S.W.L.(m)	S.C.(m³/d/m)
NE 16	44.0	24.20	1.45
SE 11	60.0	12.25	3.17
SE 12	60.0	18.82	18.96
SE 14	73.0	51.24	42.35

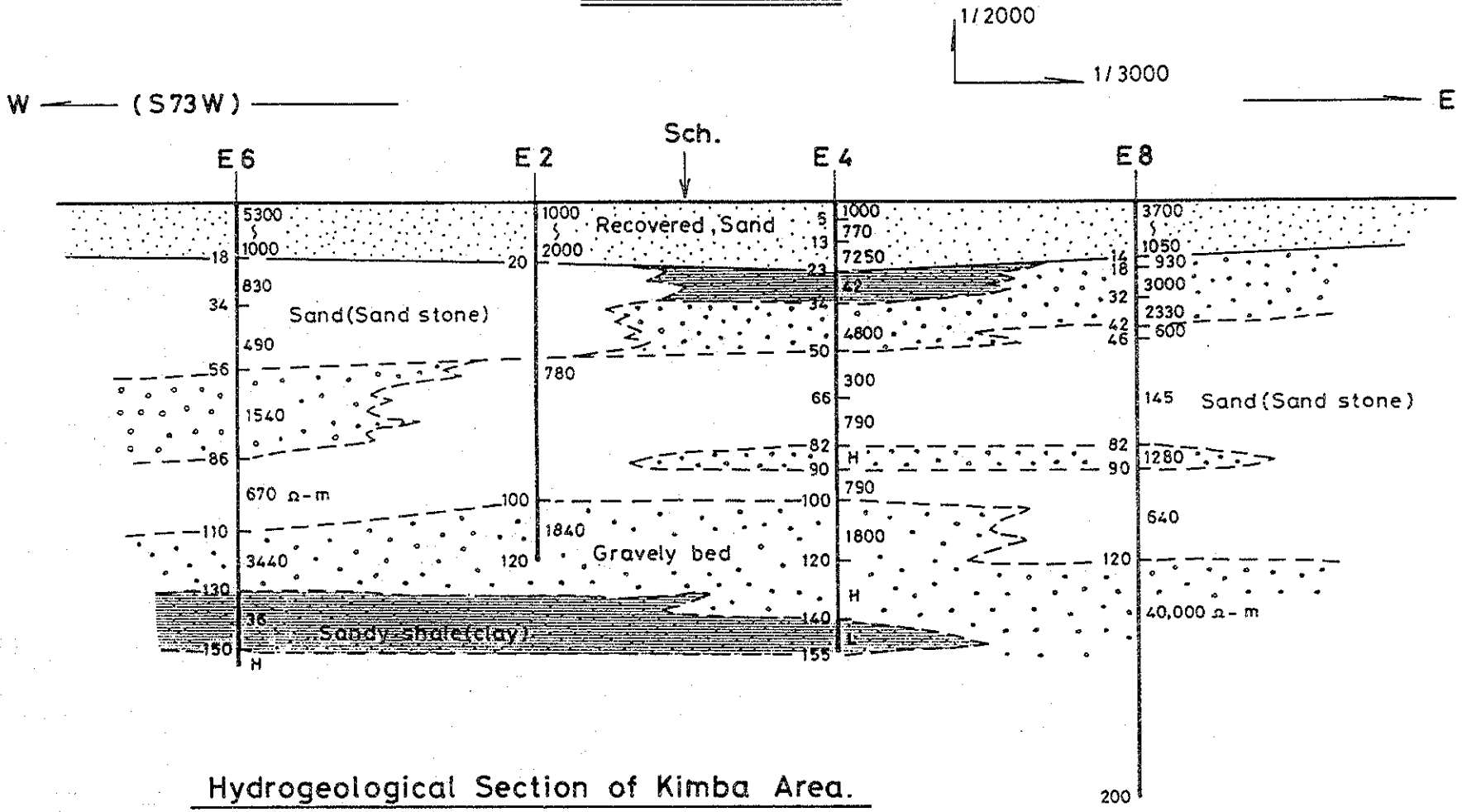
S.W.L.: Static Water Level
S.C : Specific Capacity

THE LOCATIONS OF INVESTIGATION AND THE TOPOGRAPHICAL FEATURE

No.43 Kimba



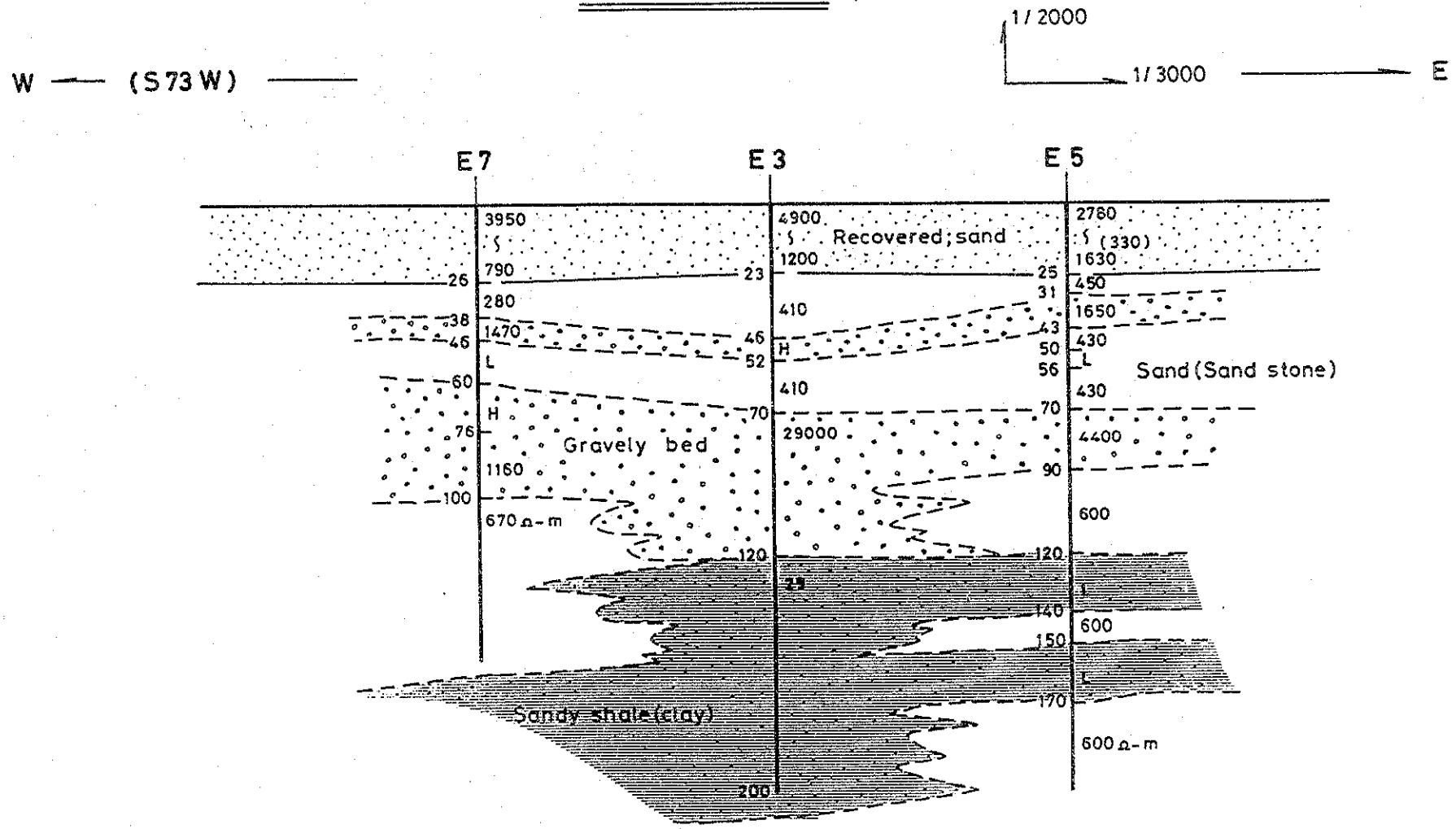
No. 43 : Kimba (1)



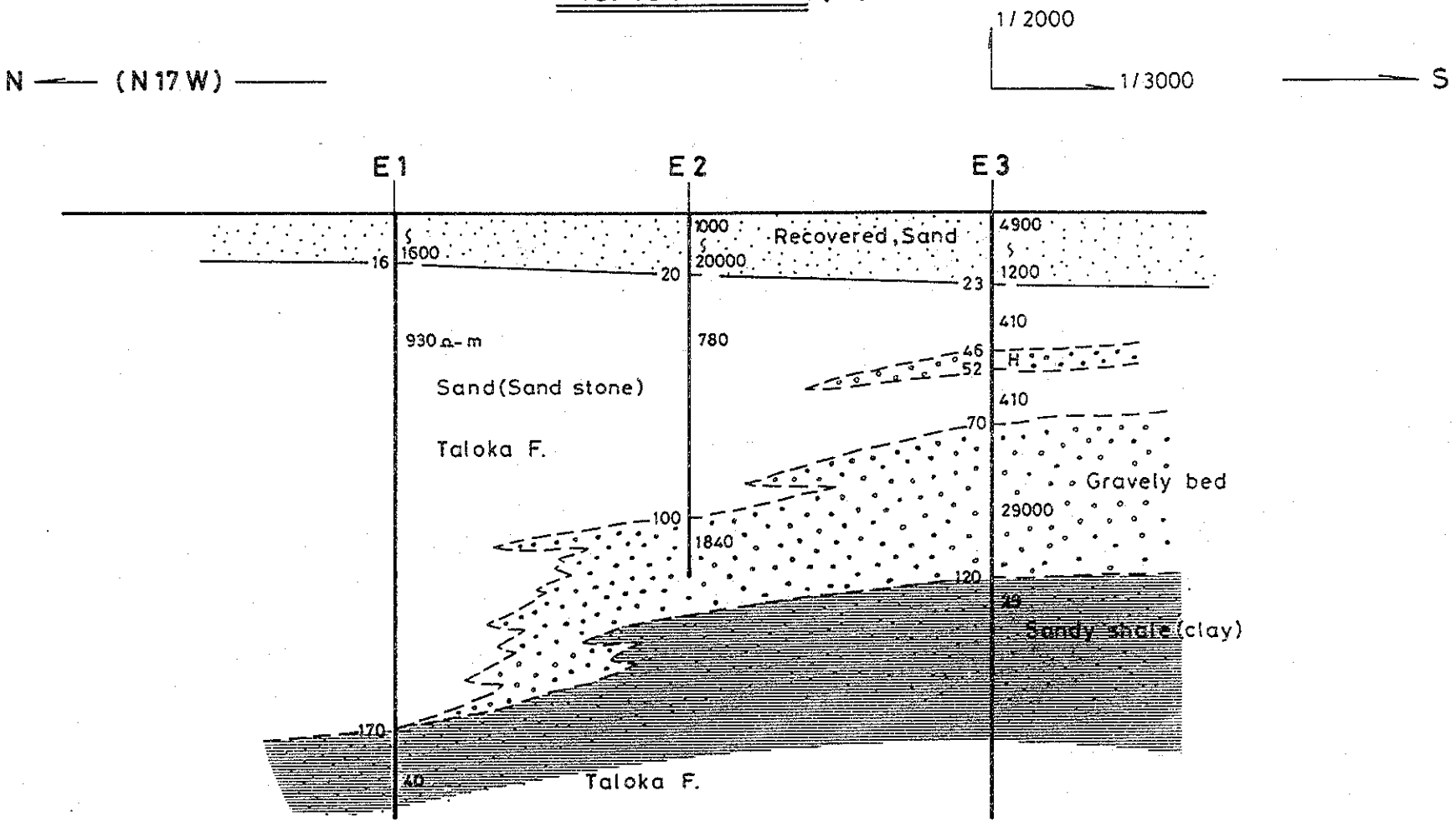
Hydrogeological Section of Kimba Area.

(Map showing resistivity profile and estimated lithologic distribution.)

No. 43 : Kimba (2)


W
(S 73 W)
E
1/2000
1/3000
E7
E3
E5
3950
S
790
26
280
38
1470
46
L
60
H
76
1160
100
670 Ω-m
4900
S
Recovered; sand
1200
23
410
46
H
52
410
70
29000
120
2780
S (330)
1630
25
450
31
1650
43
430
50
L
56
430
70
4400
90
600
120
L
140
600
150
L
170
600 Ω-m
Gravely bed
Sand (Sand stone)
Sandy shale (clay)
200

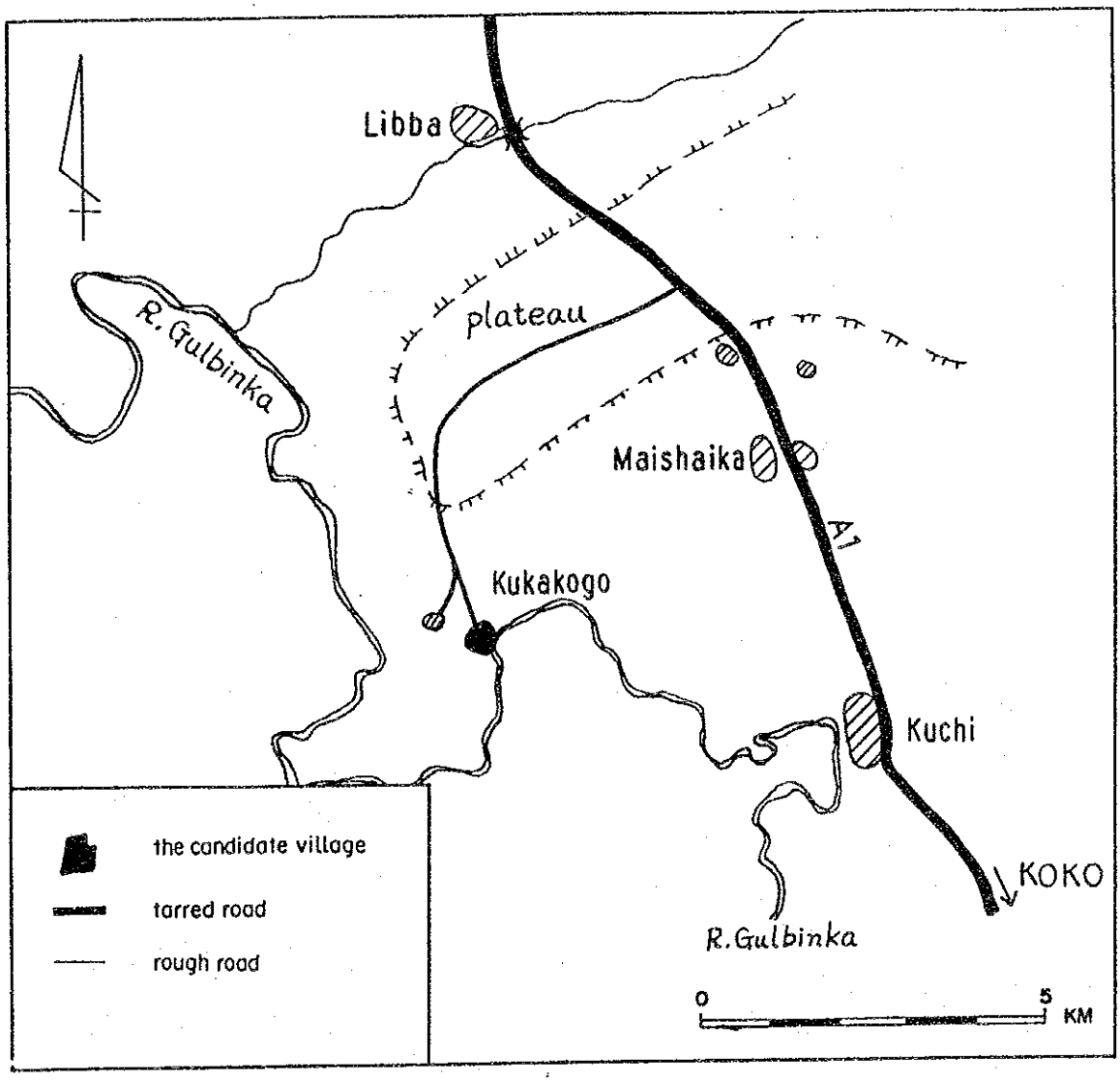
No. 43 : Kimba (3)


1/2000
1/3000
N
(N 17 W)
S
E 1
E 2
E 3
Recovered, Sand
1000
20000
4900
1200
1600
16
20
23
930 Ω-m
780
410
46
52
Sand(Sand stone)
Taloka F.
410
70
Gravely bed
29000
100
1840
120
49
Sandy shale (clay)
170
40
Taloka F.

The Study for Groundwater Development in Sokoto State

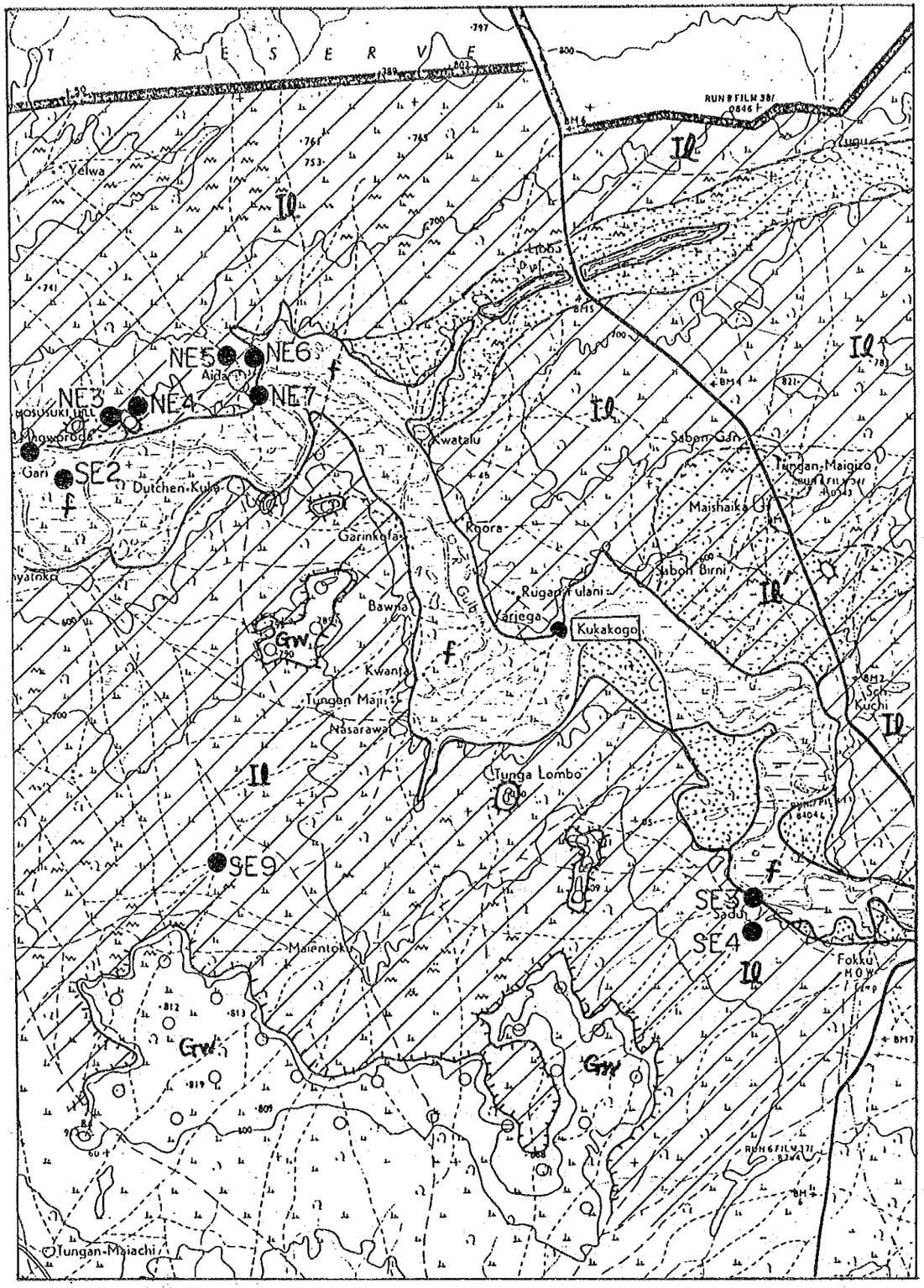
VILLAGE : Kuka Kogo

Village No. 44



LOCATION MAP

(1/100,000 Sheet 72)



GEOLOGICAL MAP

Kuka Kogo

- Lake, Pond
- River
- Fadama
- Eroded and Recovered with Sand
- Escarpment
- Il — Illo Formation
- SW 16 — Existing Boreholes

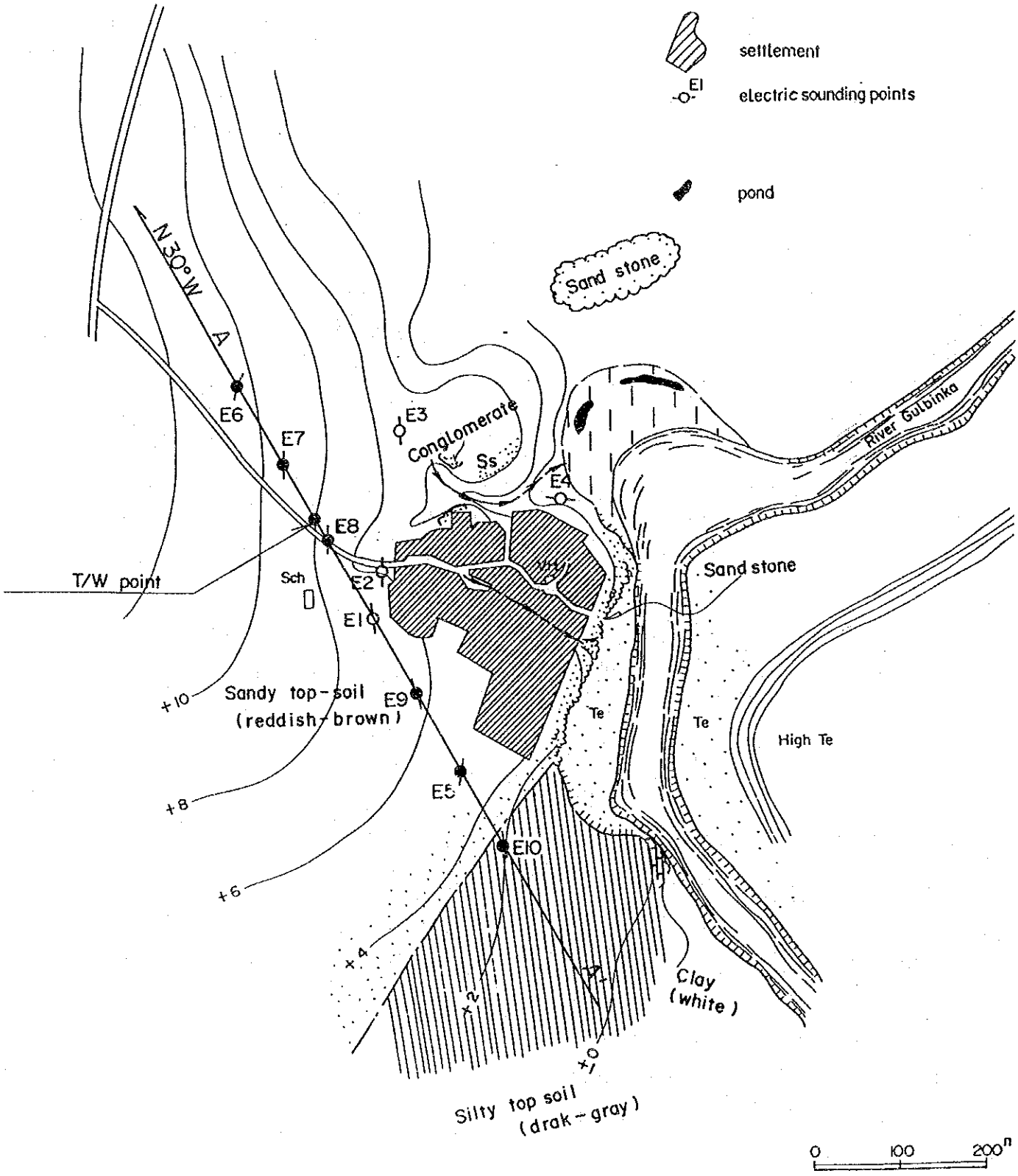
DATA OF EXISTING BOREHOLES

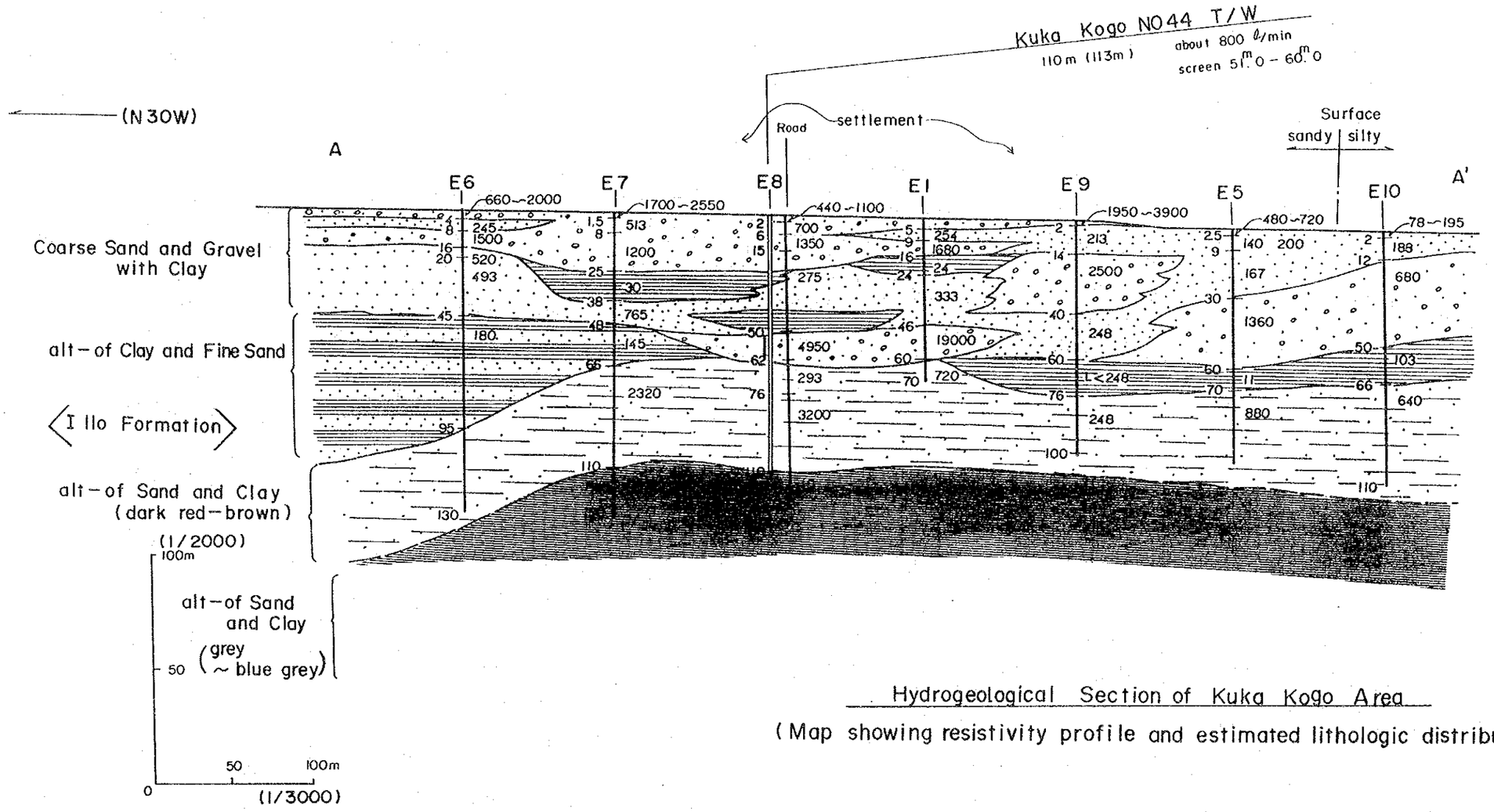
Borehole No.	Depth(m)	S.W.L.(m)	S.C.(m³/d/m)
NE 2	84.0	68.75	69.73
NE 3	36.0	22.39	115.20
NE 4	26.0	17.31	6.97
NE 5	36.0	22.68	45.00
NE 6	36.0	17.45	18.89
NE 7	31.0	16.63	48.00
SE 3	42.0	13.11	159.41
SE 4	30.0	15.14	130.91
SE 9	54.0	35.91	106.11

S.W.L.: Static Water Level
S.C. : Specific Capacity

THE LOCATIONS OF INVESTIGATION AND THE TOPOGRAPHICAL FEATURE

No.44 Kuka Kogo





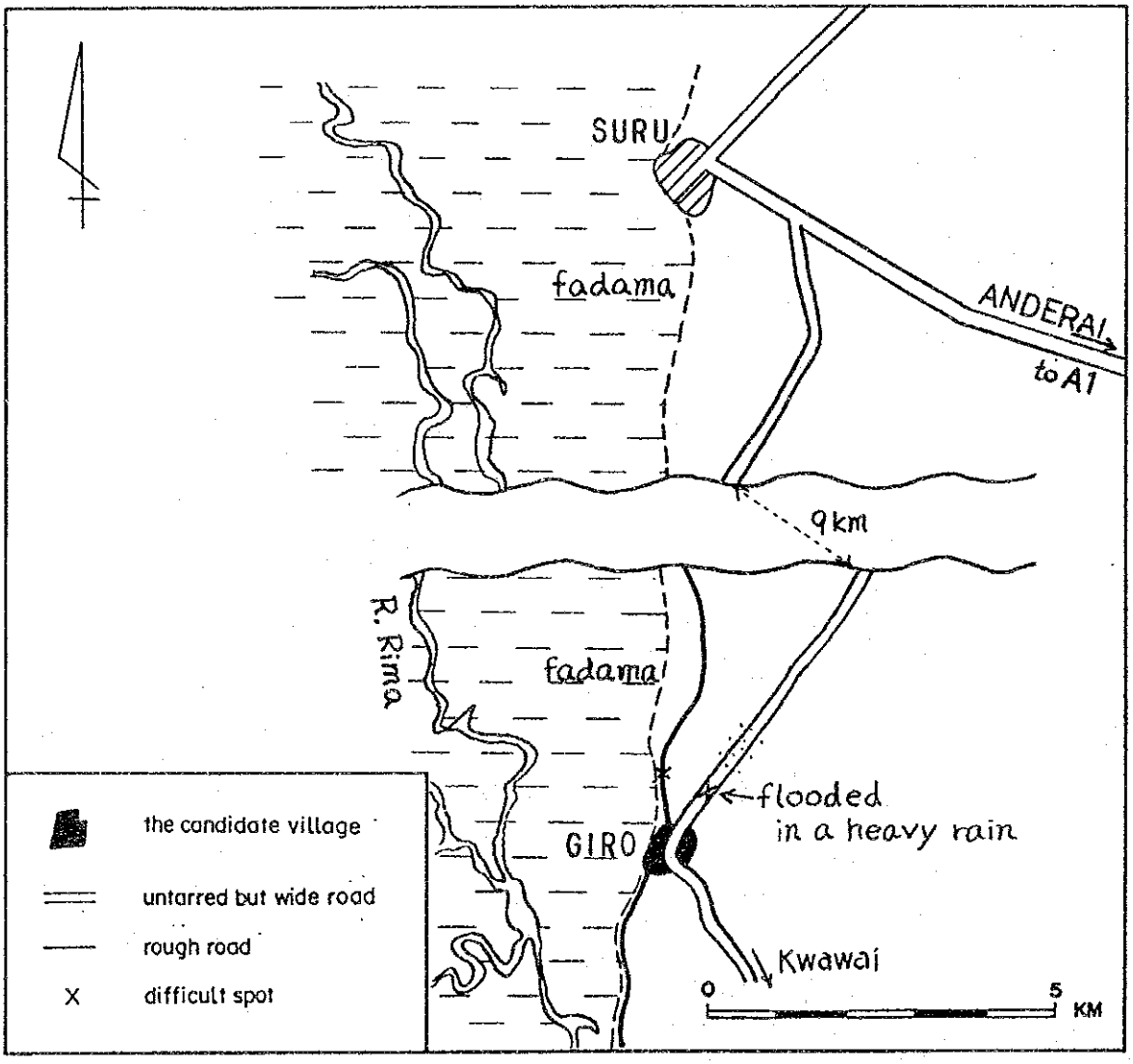
Hydrogeological Section of Kuka Kogo Area

(Map showing resistivity profile and estimated lithologic distribution)

The Study for Groundwater Development in Sokoto State

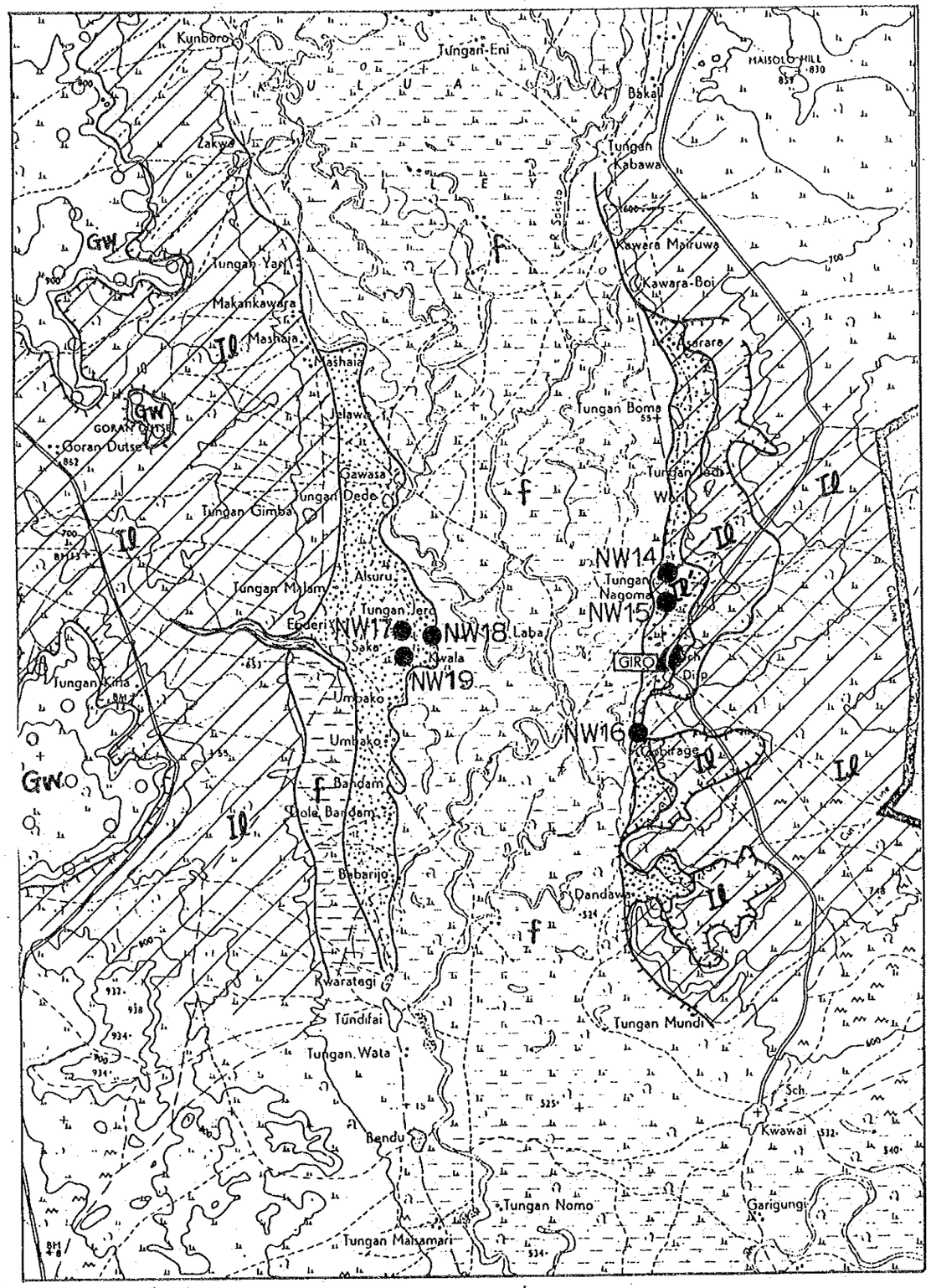
VILLAGE : Giro

Village No. 45



LOCATION MAP

(1/100,000 Sheet 72)



1/100,000 0 50 km

GEOLOGICAL MAP

Giro

- f Fadama
- Eroded and Recovered with Sand
- Escarpment
- Il Illo Formation
- SW 16 Existing Boreholes

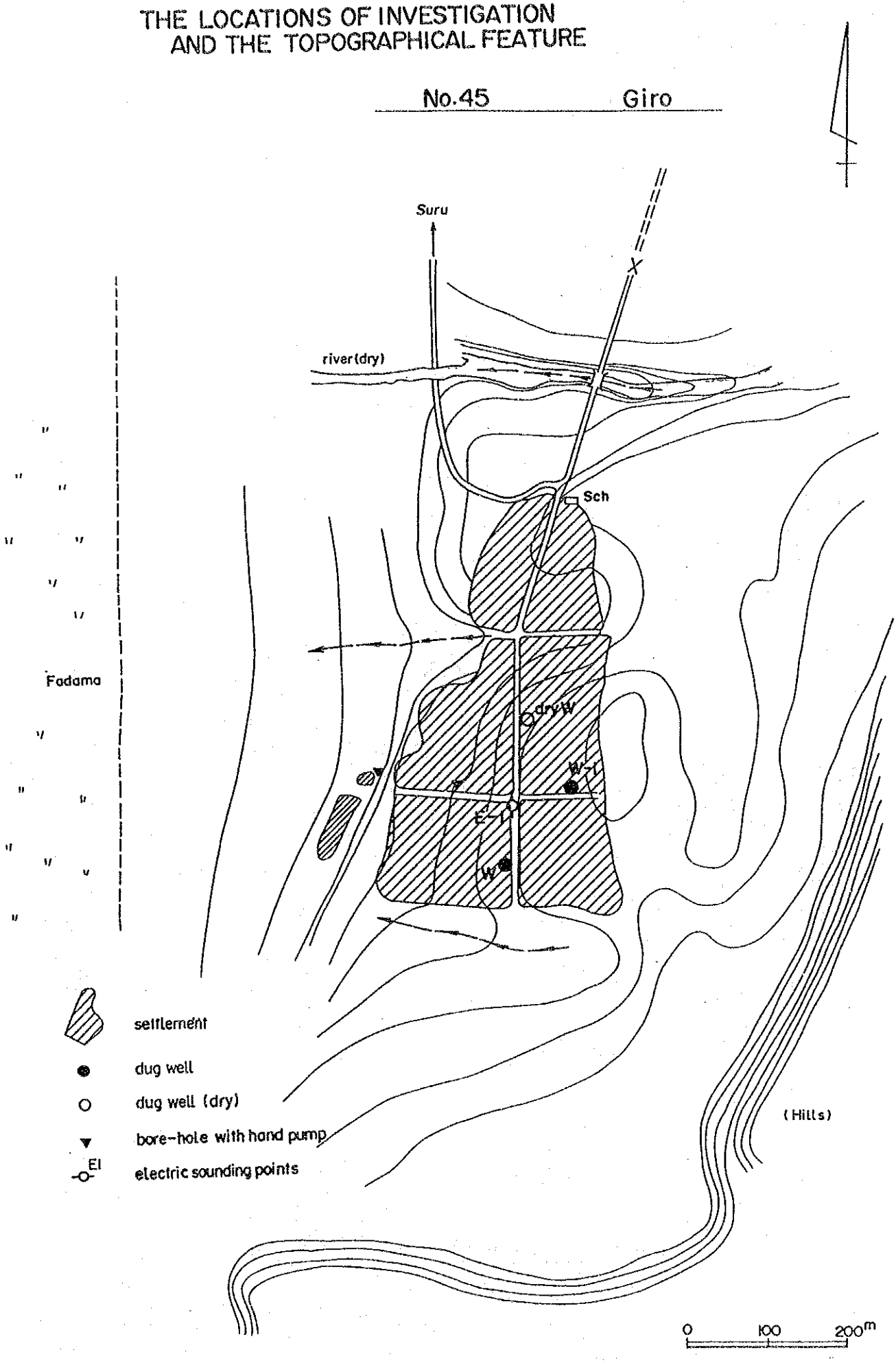
DATA OF EXISTING BOREHOLES

Borehole No.	Depth(m)	S.W.L.(m)	S.C.(m^3/d/m)
NW 14	36.0	3.92	4.54
NW 15	30.0	7.20	12.46
NW 16	24.0	7.72	36.92
NW 17	30.0	2.26	11.95
NW 18	30.0	2.23	14.87
NW 19	30.0	2.36	15.32

S.W.L.: Static Water Level
S.C : Specific Capacity

THE LOCATIONS OF INVESTIGATION AND THE TOPOGRAPHICAL FEATURE

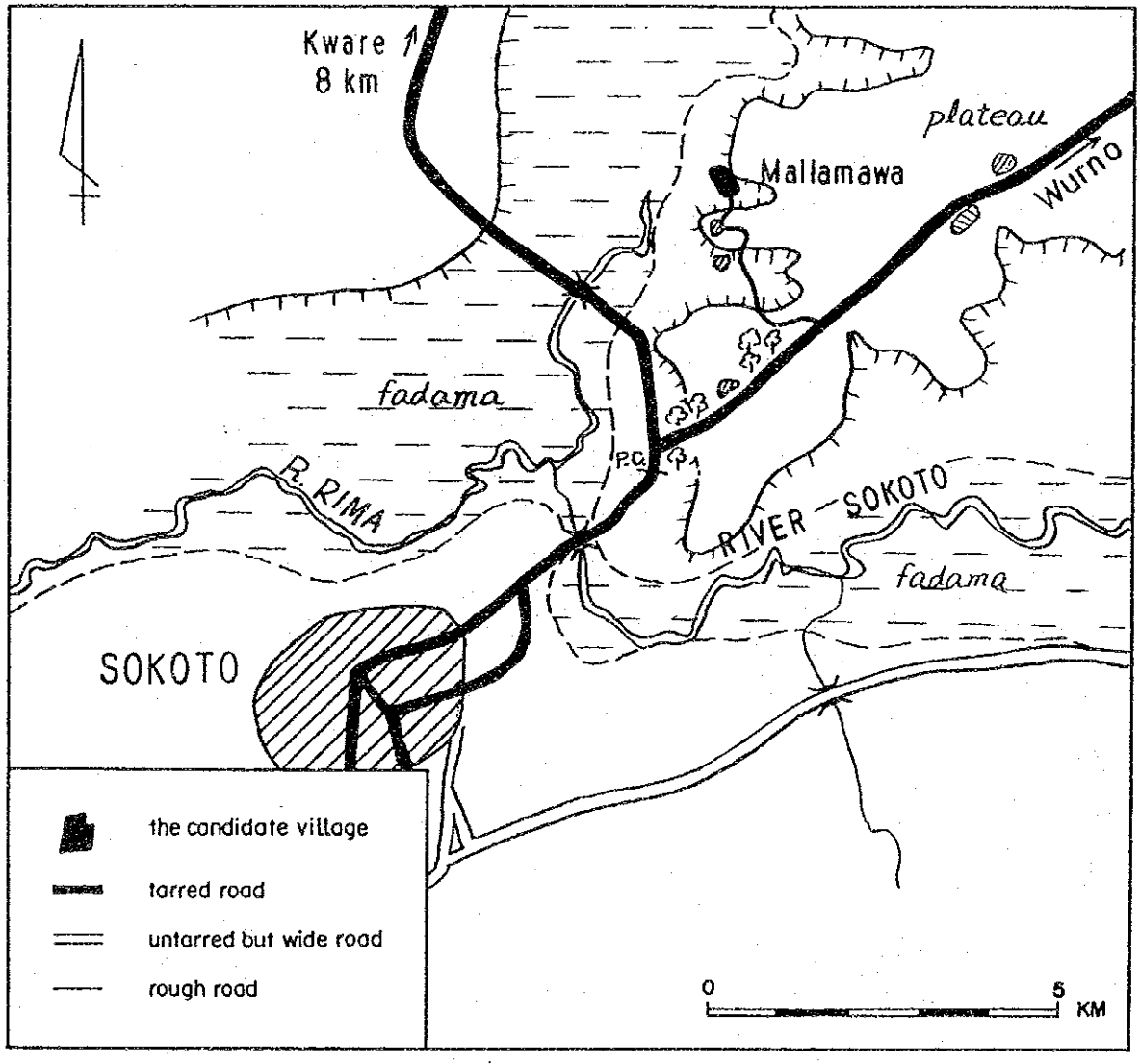
No.45 Giro



The Study for Groundwater Development in Sokoto State

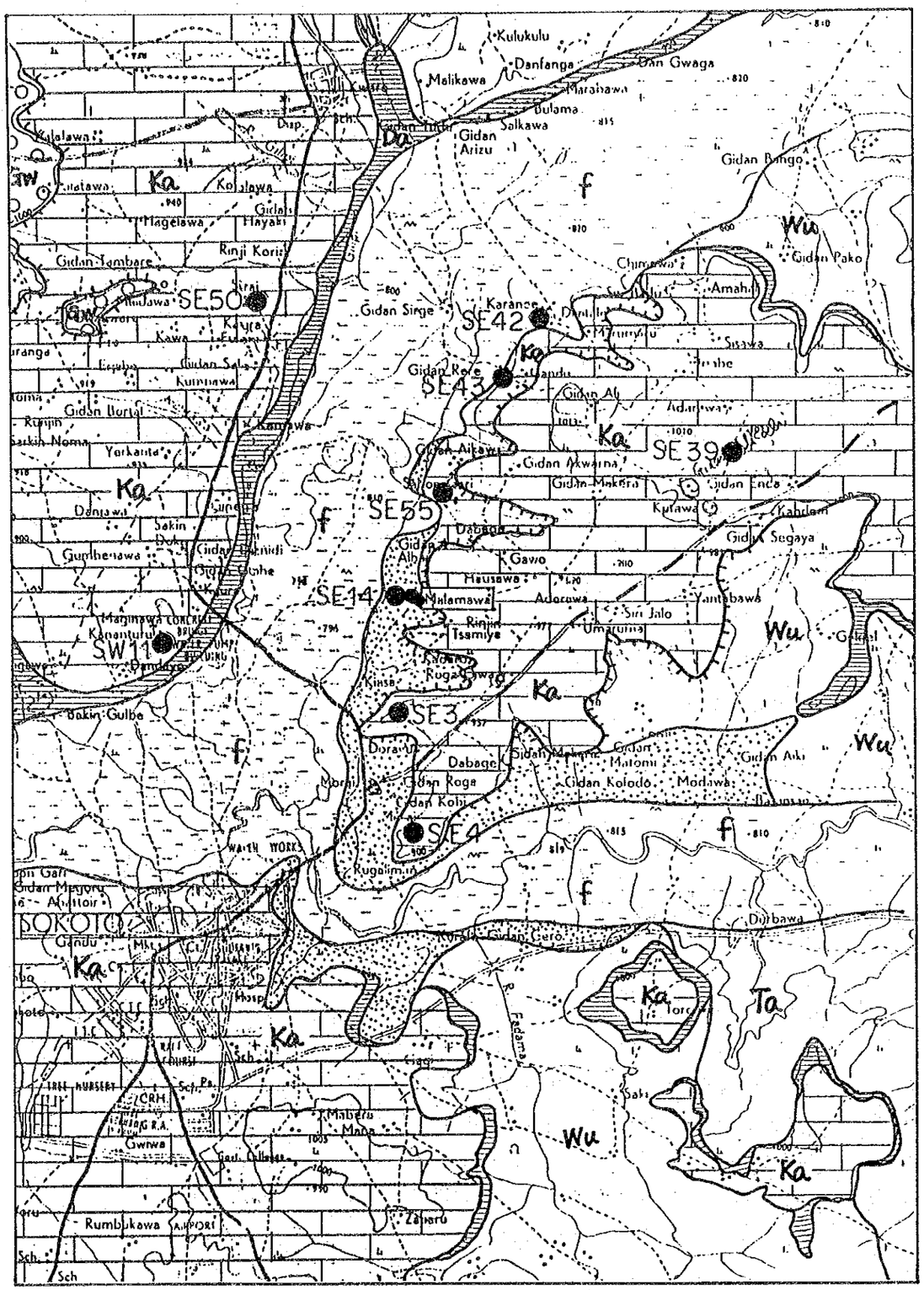
VILLAGE : Mallamawa

Village No. 46



LOCATION MAP

(1/100,000 Sheet 10)



1/100,000 0 50 km

GEOLOGICAL MAP

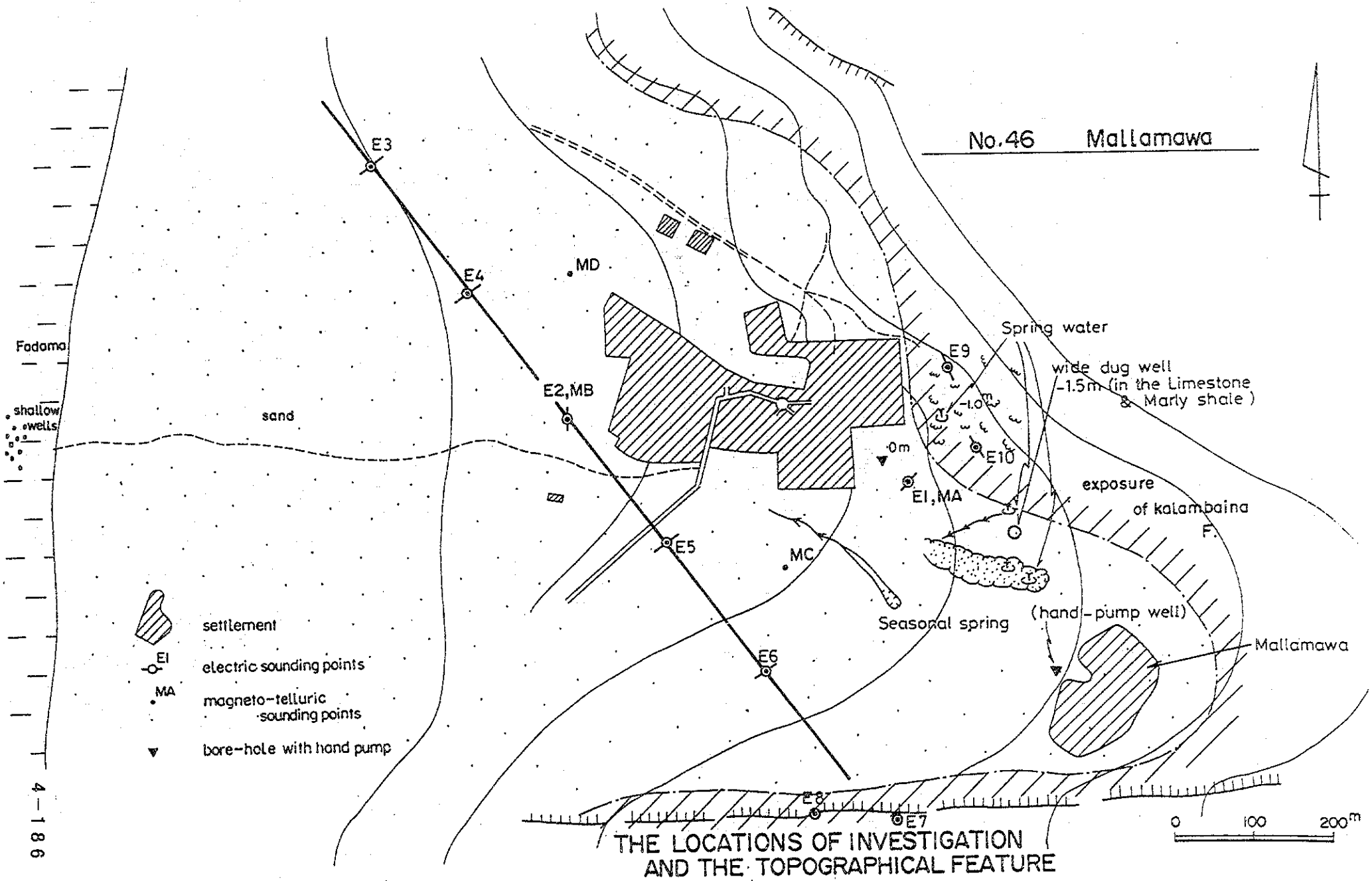
Mallamawa

- Lake, Pond
- River
- f — Fadama
- Eroded and Recovered with Sand
- Escarpment
- Gw — Gwandu Formation
- Ka — Kalambaina Formation
- Da — Dange Formation
- Wu — Wurno Formation
- Ta — Taloka Formation
- SW 16 — Existing Boreholes

DATA OF EXISTING BOREHOLES

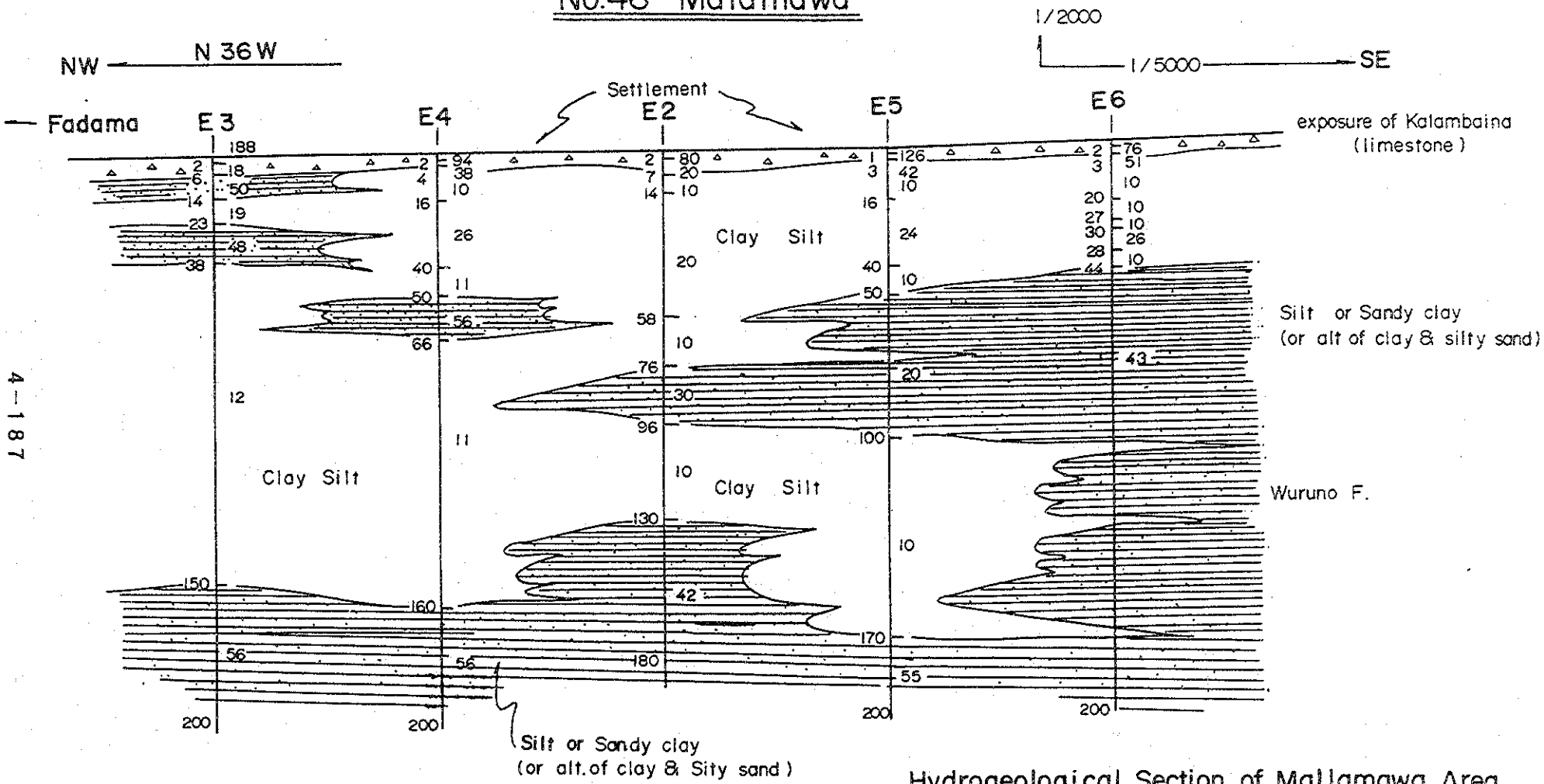
Borehole No.	Depth(m)	S.W.L.(m)	S.C.(m³/d/m)
SW 11	56.0	28.55	15.83
SE 3	97.0	35.52	3.44
SE 4	94.0	32.23	0.71
SE 14	73.0	17.70	1.73
SE 42	58.0	13.24	1.54
SE 43	83.0	15.50	5.06
SE 50	66.0	15.43	1,872.00
SE 55	66.7	12.74	1.84

S.W.L.: Static Water Level
S.C. : Specific Capacity



THE LOCATIONS OF INVESTIGATION AND THE TOPOGRAPHICAL FEATURE

No.46 Malamawa

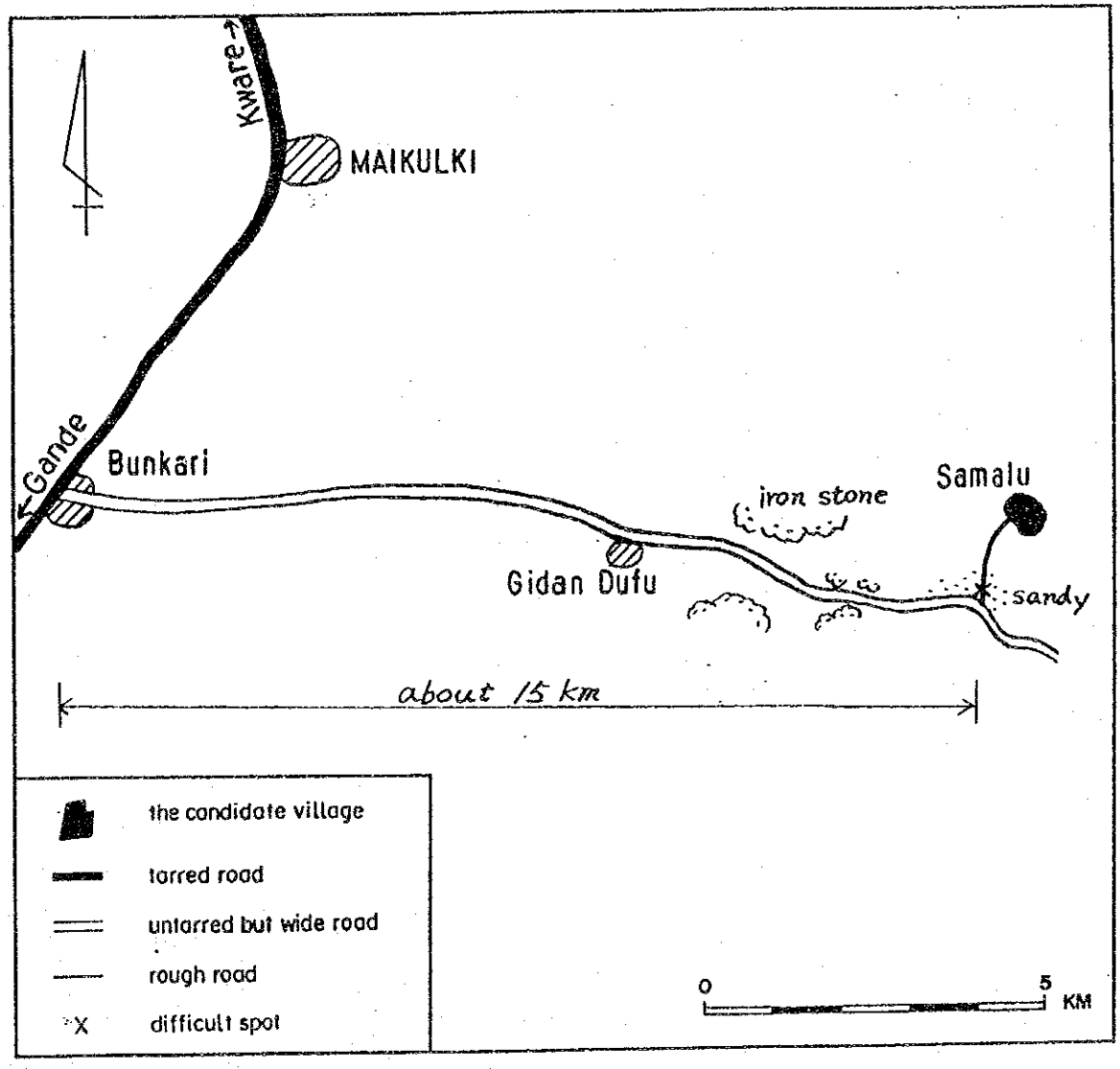


Hydrogeological Section of Mallamawa Area
(Map showing resistivity profiles & lithologic distribution)

The Study for Groundwater Development in Sokoto State

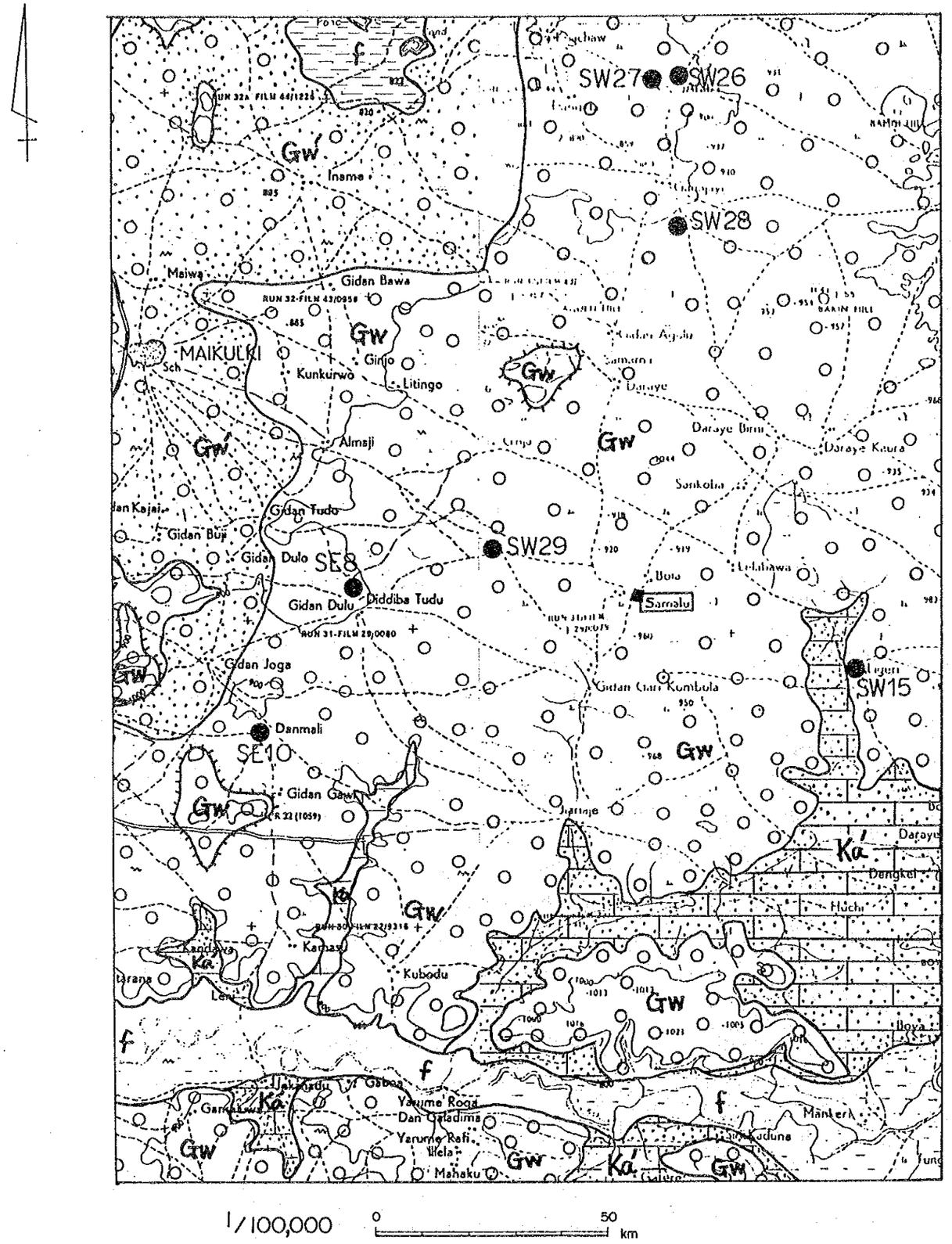
VILLAGE : Samalu

Village No. 47



LOCATION MAP

(1/100,000 Sheet 10)



GEOLOGICAL MAP

Samalu

- River
- f — Fadama
- Eroded and Recovered with Sand
- Escarpment
- Gw — Gwandu Formation
- Ka — Kalambaina Formation

● SW 16
Existing Boreholes

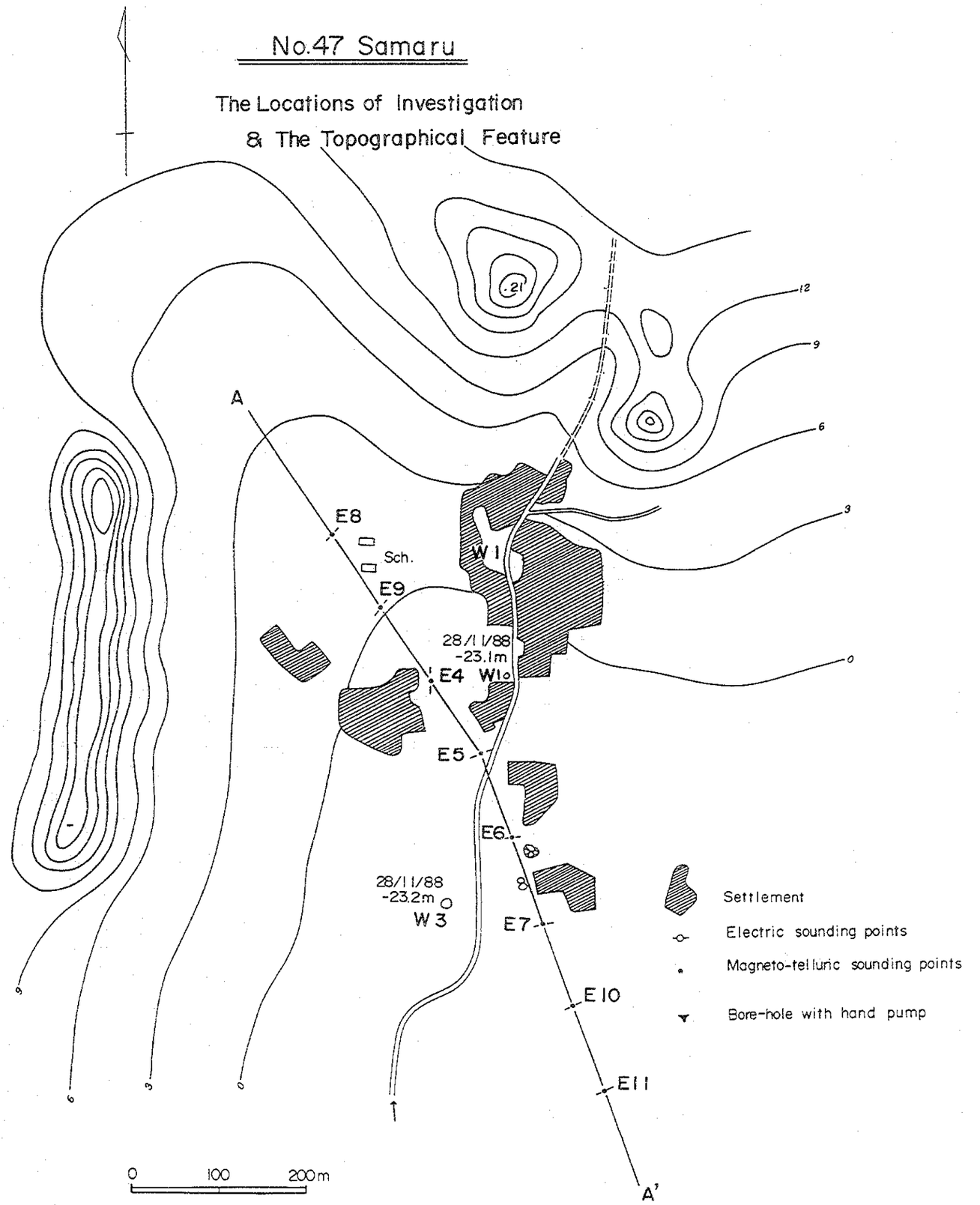
DATA OF EXISTING BOREHOLES

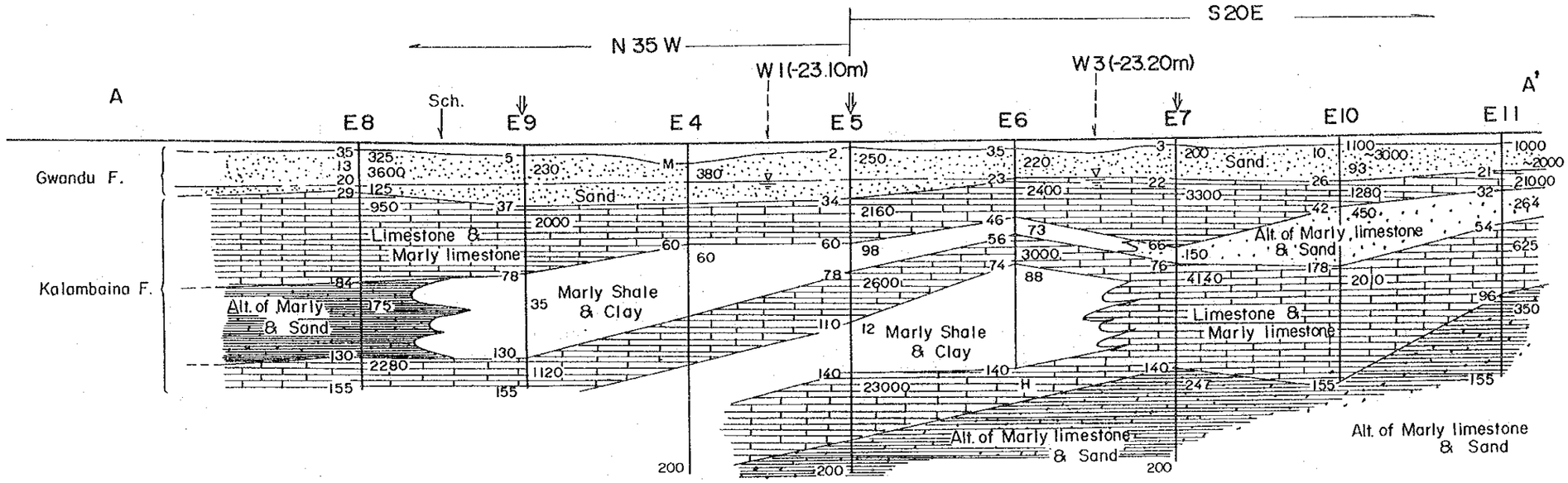
Borehole No.	Depth(m)	S.W.L.(m)	S.C.(m³/d/m)
SW 15	46.0	23.25	1.71
SW 26	36.0	5.94	79.29
SW 27	38.0	5.94	48.19
SW 28	43.0	23.56	64.42
SW 29	61.0	27.32	43.13
SE 8	42.0	17.02	38.43
SE 10	42.0	29.12	50.14

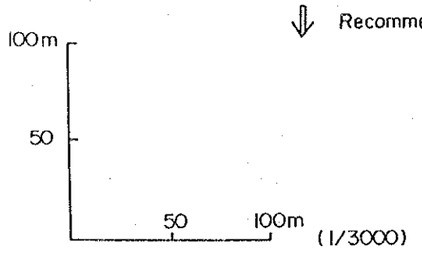
S.W.L. : Static Water Level
S C : Specific Capacity

No.47 Samaru

The Locations of Investigation
& The Topographical Feature







Hydrogeological Section of Samalu Area

(Map showing resistivity profile & estimated lithologic distribution)

APPENDIX

1. List of Data Collected

Appendix 1. List of Data Collected
(Reports, Documents, Data and Information)

1-1 Meterology and Hydrology

1) F.M.W.R. (1980) : Hydrological Year Book 1977-78
2) S.R.R.B.D.A.( ) : Hydrological Year Book 1981-82
3) F.M.W.R. : Monitoring and Management of Hydrometric Stations,Wells and Borekales in Sokoto-Rima Basin Zone A
   - 1st Progress Reoprt 1983 -
   - 2nd Progress Report 1984 -
   - 3rd Progress Report 1984 -
   - Final Report (Apperdices) 1984 -

   Zone B
   - 2nd Progress Report 1984 -

4)F.M.W.R. : Re-activation of Hydrological Stations, Sokoto-Rima Basin
   - Appendix 1981 -

· Hydrometric Stations in Hydrological Area 1:2,000,000
· Location Map of Hydrometerological Stations in Sokoto State 1:563,380

1-2 Geology and Hydrogeology

1) Geological Survery of Nigeria (1965): Geological Map (1/250,000 Series)
   1. TANGAZA 2. SOKOTO 3. SHINKAFE
   6. BIRNIN KEBBI 7. GUMMI 8. GUSAU

2) Geological Survey Div., F.M. of Mine and Power (1974) : Geological Map of Nigeria scale : 1 /2,000,000

3) Jones, B. (1948) : The Sedimentary rocksa of Sokoto Province Geolo. Surv. Nig. Bulletin No.18

4) du Preez J.W. and W. Barber (1965) : The Distribution and Chemical Quality of Groundwater in Northern Nigeria

5) Kogbe C.A. (1978) : Geology of Nigeria

6) Ogilbee W. and H.R.Anderson (1965) : Exploratory Drilling for Groundwater in Western sokoto Province, Nigeria, with particular reference to artrsian aquifers in the Gwando Formation

7) Ogilbee W. and H.R. Auderson (1973) : Aquifer in the Sokoto basin, Northern Nigeria, with a Description of the General Hydrogelogy of the Region

8) Barbour K.M. et al. : Nigeria In Maps

9) Russ W., ph. D., F.G.S. (1957) : The Geology of Parts of Nigeria, Zaria and Sokoto Provinces, with Special Reference to the Occurance of Gold. Geol. Nig. Bulletin No.27

10) F.D.W.R. (1980) : Assessment and Rehabilitaticion of abandoned Boreholes in Nigeria Zone A (Final Report)

11) F.D.W.R. (1982) : Geophysical Investigations for the Location of suitable Sites for drilling of Productive Boreholes, in the Basement Complex Area of Sokoto State

12) S.A.R.D.A. (1986) : Summary of Hydrogeological Data, Borehole Location Map (1200 Borehole Project, Final Report)

13) F.M.O.H. and UNICEF (1987) : Present Status and Future Requirements of the FMOH/UNICEF (fit.) Rural Clinic, Water and Sanitation Project

14) UNICEF (1987) : From a Pilot Project to a National Strategy UNICEF Nigeria Water And Sanitation Programme (1981-1986)

15) FAO (1986) : National Water Resources Plan

16) B.N.C.U. (1981) : Groundwater Development in Nigeria in the Eighties

17) Haughton S.H. (1963) : Stratigraphic History of Africa - South of the Sahara-

18) Reyment R.A. (1965) : Aspects of the Geology of Nigeria

1-3 Socio-economy and others

1) S.S.W.B. (1978) Report on Water Supplies for Kalmalo Lake Area

2) Ministry of Economic Planning Sokoto State : Programmes of Sokoto State in the 4th National Development Plan 1981-85

3) Ministry of Economic Planning Sokoto State : A Survey of Settlements in Sokoto State,. 1981

4) The Daily Times of Nigeria Limites (1986) : Nigeria Year Book 1987

5) Budget Planning Department of Sokoto State : Recurrent and Capital Estimates of The Government of Sokoto State of Nigeria
1978/1979, 1979/1980, 1983, 1986, 1987

6) Economic Planning Department of Sokoto State :
Sokoto State Water and Electricity Statistics 1980,1985
Sokoto State Statisticcal Handbook 1976
Population Estimates 1987
Quarterly Report on The Prices of Selected Commodities in Sokoto Town
Jan. - Mar. 1977
Jan. - Mar. 1980
Apr. - Jun. 1980
Jul. - Sep. 1980
Jul. - Sep. 1986

7) Nigeria 1982 Official Handbook

8) Federal Office of Statistics
Nigeria Trade Summary Dec. 1987
Review of External Trade 1987
Annual Abstract of Statistics 1986 Edition
Economic and Social Statistics Bulletin 1986 Edition
Digest of Statistics Dec. 1985
National Integrated Survey of Households Jun. 1980 - May 1981
Social Statistics in Nigeria 1979
Statistical News No.51-56 29th Oct. 1985 - 29th Apr. 1986

9) World Bank : Staff Apraisal Report Nigeria Sokoto Agriculture Development Project May 24, 1982

10)S.A.R.D.A. : Achievements to Date Mar. 1982 - Dec. 1988

11)Task Force Committee on Water Resources Development and Management Report Nov. 1986

12)Topographical Maps

Nigeria Road Map 1:1,500,000	1 Sheet
Topographical map 1:500,000	5 Sheets
Sheet No.6	
Sheet No.7	
Sheet No.8	
Sheet No.10	
Sheet No.15	
Topographical map 1:250,000	26 Sheets
Sheet No.1 : KURDULA	(2)
Sheet No.2 : SOKOTO	(2)
Sheet No.6 : ARGUNGU	(2)
Sheet No.6A: ZOGIRMA	(1)
Sheet No.7 : GUMMI	(2)
Sheet No.8 : GUSAU	(1)
Sheet No.17: KAMBA	(1)
Sheet No.18: SHANGA	(1)
Sheet No.29: YELWA	(1)
Sheet No.29A: BABANA	(1)
Sheet No.30: KONTAGORA	(1)
Sheet No.31: TEGINA	(1)
Sheet No.42: MINNA	(3)
Sheet No.43: ABUJA	(3)
Sheet No.51: LAFIAGZ	(2)
Sheet No.52: BARO	(2)
Topographical map 1:100,000	58 Sheets

Sheet No.1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 26, 27, 28, 29, 30, 31, 32, 48, 49, 50, 51, 52, 53, 54, 55, 71, 72, 73, 74, 75, 76, 77, 78, 94, 95, 96, 97, 98, 99, 100, 117, 118, 119, 120, 121, 122, 138, 139, 142, 143, 163, 164, 165, 203, 204, 205, 206,

2. Previous Investigation

and

Relevant Groundwater Development Project

Appendix 2. Previous Investigation and Relevant Groundwater Development Project

In 1948, Jones published and explanation and map of the sedimentary rocks of Sokoto Province in which the general pattern of the distribution of groundwater was outlined. This geologic work was the first important stratigraphic study in the Sokoto region.

More recently (1965), D.H. Parker of the Geological Survey of Nigeria updated part work and mapped the geology of a large segment of Sokoto Province. The water resources of the Sokoto region were first described by Raeburn and Tattam (1930) and more recently by du Preeg and Barber (1965).

Test drilling in Niger between 1948 and 1956 first revealed the presence of artesian water in the Gwandu Formation. In 1961, from this evidence the Ministry of work of Nigeria drilled exploratory borehole (GSN2481) at Birnin Kelbi and found artesian water in the lower part of the Gwandu Formation. Subsequently, groundwater exploration project in the Sokoto Basin, begun in March 1963 and completed in May 1967, was carried out by the U.S. Agency for International Development (AID). The result of investigations of the project are covered in the reports by William Ogilbee and Henry R. Anderson U.S. Geological Survey, titled "Exploratory Drilling for Groundwater in Western Sokoto Province, Nigeria with particular reference to artesian aquifers in the Gwandu formation " (July 1965) and "Aquifers in the Sokoto Basin, Northwestern Nigeria, with a Description of the General Hydrogeology of the Region" (1973). At the same time with above the project, in 1962, the Food and Agriculture organization (FAO) began to conduct a hydrologic study of the Sokoto-Rima drainage basin, and the annual reports (FAO, 1963,1964,1965) were published, which included water level in wells and data of stream flow and precipitation. In recent years, following investigation and projects for groundwater development have been carried out in the Sokoto region:

- Assessment and Rehabilitation of abandoned Boreholes in Nigeria Zone A (FDWR, 1980)
- Monitoring and management of Hydrometric stations, wells and boreholes in Sokoto-Rima Basin Zone A (FDWR, 1983-1984)
- Geophysical Investigations for the Location of suitable Sites for drilling of Productive Boreholes in the Basement Complex Area of Sokoto State (FDWR, 1982)
- National Borehole Project (FDWR, 1981-1983)

· 1,200 Borehole Project (SARDA, 1983-1985)
· Sokoto Agricultural Development Project - 1,500 Borehole Project - (SARDA, 1987-1989)

3. Questionnaire Sheet Used in the Field Survey

Questionnaire Sheets

Questionnaire

Condition of Existing Water Supply System

- Village Name:_____Area:_____km^2
- Location:_____
- Population: total _____ Male _____ Female _____

  generation 0 - 10 _____ 11 - 40 _____over 40_____
- Population served with public water supply:_____
- Average water supply above:_____liter/capita/day
- Population dependent only on private or natural water source:_____
- Approximate amount of water for domestic use above:____L/C/D

Name/Position of responsible person
for management of water supply: _____

Name/Position of the person
who filled this form: _____

Date:_____, 1988

A. IN Case water source is power-pumped tube well;

- Number of the well:_____wells

	drilled depth	casing diameter	daily pumpage	population served	year constructed
Well I	_____m	____inch	_____m^3	_____	19_____
Well II	_____m	_____inch	_____m^3	_____	19_____

- Type of reservoir tank:_____capacity:_____m^3
- Pumpage:_____i/min.
- Pumping time:_____hours/day from _____to_____
- Elevation of tank:_____m above ground surface
- Distribution system type:_____
- Diameter/Length of distribution pipe:Ø =_____"total length_____m

  Ø =_____"total length_____m
- Number of communal faucet:_____pcs.
- Distance from faucet: average_____m farthest_____m
- Water quality: ☐ Satisfactory ☐ Unsatisfactory

  major reason of latter:_____
- Water rate: ₦_____/m^3 or ₦_____per month per family
- Condition of rate collection: ☐ over 90% ☐ 70-90% ☐ less than 70%
- Working condition of facilities:_____

  _____
- Major problem or difficiency on operation and maintenance;

  _____

  _____
- Organization or body concerned with above facility construction:

  _____
- Other water sources in this village (type and number)

  _____ _____

  _____ _____

B. In case water source is the well with/without manual pump

- Type and number of existing source

	number	population served
a. Dug well without pump shallower than 5m	_____	_____
b. -do- 5 - 10 m deep	_____	_____
c. -do- deeper than 10m	_____	_____
d. Dug well with manual pump 5m	_____	_____
e. -do- 5 - 10 m deep	_____	_____
f. -do- 10 m	_____	_____
g. Tube well with manual pump 10 m	_____	_____
h. -do- 10 - 30 m	_____	_____
i. -do- 30 - 60 m	_____	_____
j. -do- 60 m	_____	_____

- Water quality: good in wells of ( )
  poor but bearable in wells of( )
  not potable water from ( )

  major reason of poor quality:_____

- Do you have water association in your village? ☐yes, ☐no

  If yes, is management/operation of the association going well?

  If no, do you have any idea to form an association in future for the higher level water supply system to be properly operated?

- Desirable water supply system type

  _____

  _____

  _____

- Willingness and payability for inhabitants' share of operation and maintenance cost.

  a. more than _____% of the families in this village are willing to pay water rate.

  b. Most of the families can pay more or less ₦_____per month.

4. Technical Transfer Program

Appendix 4. Technical Transfer Program

(1) Method of Technical Transfer

During the study work in Nigeria, every member of the JICA Study Team has paid special attention to the transfer of technology to the personnel of the Nigerian Team. On-the job training and the periodic seminars have been given regarding geophysical prospecting, LANDSAT image/aerial photograph interpretation, hydrological observation methods and other techniques of hydrogeological/ hydrological investigation. Since all of the Nigerian engineers habe been very eager to learn the technology or to brush up on their skills, the effectiveness of the program is believed to be considerably high.

On-the job training was given during the actual field work of the resistivity sounding, magnetotelluric surveying, discharge measurement, water level observation and other work. It should be noted, however, that in most of the field work, the work itself was concentrated on rather than training, because most of Nigerian team members possessed a high level of professional technique and knowledge in their respective field. The JICA team members gave these professionals just a few small suggestions. But, for those who wished to extent their technical field, attention was paid and basic training was given in each field.

(2) Seminar

During the study period, the JICA team occasionally gave short seminars during intervals between work. These seminars dealt with the following:

a. Method of interpreting topographic and geological features on LANDSAT images, stressing-

- interrelation of topography with geology
- outline of LANDSAT data

b. Resistivity sounding method in Wenner's electrode configuration including

- field process of resistivity data acquisition
- analytic procedure of depth-resistivity determination through standard curve matching method
- interpretation of resistivity layers

c. Magnetotelluric method, its principles and the difference between PL-MT , ELF-MT, and TEM

d. Outline of water balance analysis method, and factors and techniques of field survey necessary for analysis

e. Hydrogeological characteristics and hydrogeological structures in Sokoto State

f. Seismic refraction method, its principles and operation

5. Survey Equipment / Materials Supplied by JICA

List of equipment / material supplied by JICA

Equipment Name	Type/Spec.	Number	Remarks	Time of arrival in Sokoto
Electric Resistivity Survey Equipment	OYO M_C-OHM	2 sets	Resistivity Spontaneous Potential	Apr., 88
Geophysical Logging Apparatus	OYO GEOLOGER 3030	1 set	Resistivity logging S-P logging Temperature logging Gamma ray logging	May, 88
Automatic Water Level Gauge	Float Type ADR-104 WP	3 sets	One month recording	June, 88
Automatic Water Level Gauge	Pressure type EMA-120	2 sets	One month recording, with 120m cable	Apr., 88
Water Level Indicator	Portable type TOSHIN-ST	15 rolls	100m long wire	Apr., 88
Current Meter	TOA CM-BM	3 sets	For river flow measure-ment	June, 88
Water Quality Checker	TOA WQC-2A	5 sets	Electric conductivity pH Temperature	Apr., 88
Water Quality Analysis Kit	KYORITSU WAS-D2	1 set	Drinking Water Inspcetion Set 18 items with reagent good for 50 samples	May, 88
Stereoscope	Mirror type REFLECTION-III	2 sets	For aerial photograph interpretation (Stereoscopic observation)	May, 88
Personal Computer	NEC 9801 VX41 GRAPHTEC KD4600(Plotter) MP 3100(Digitizer)	1 set	CPU, 16 bit	June, 88
Copying Machine	XEROX 1012 R/E	1 set	RANK XEROX SOKOTO Free maintenance service for one year(up to 22/5/89)	May, 88
Electro-Magnetic Survey Equipment	GEONICS EM37-3 TOSHIBA J3100 (Analizer)	1 set		Oct., 88
Vehicle	TOYOTA LANDCRUISER with Spare parts	2 sets		Oct., 88
Automatic Level	Nicon AS-C	3 sets	With tripod	Dec., 88
Staff		6 pcs		Dec., 88
Seismic Refraction Survey equipment	Type of Signal enhancement by stacking 12 channel	1 set	Geophone (12 pcs), Take-out cable (1 roll), Battery(2 pcs), Recording paper (L.S.), Trigger with connecing cable(L.S.), Bluster (2 sets)	March, 89

6. Specification for Test Drilling

and

Test Well Construction

A. Specification for Test Well (Subject to utilize as production well) Construction

1. Drilling Diameter

The diameter of drilled hole shall not be less than eight (8") inches from top to bottom for the six (6") or four (4") inches casing and screen to be properly installed.

2. Target Depth of Drilling

The depth of drilling will vary from place to place ranging from 60 to 200 meters with estimated average depth of 150m in the sedimentary area and 80m in the area of basement rocks. The target depth for each site will be determined after conducting geo-resistivity sounding by the consultant before drilling of each hole.

3. Equipment and Materials to be prepared by the Contractor

The drilling equipment and accessories shall be capable of drilling at 8" diameter up to 200m deep in any geological formation encountered.
For effective drilling in a limited period, the equipment shall be equipped with both rotary drilling system with direct mud water circulation and down-the-hole hammer drilling system with enough capacity of air compressor.

The materials to be prepared for completion of seven (7) test wells is listed in the table below;

Table 1. Material List for Test Well Construction

	3 wells for sedimentary area	4 wells for basement rock area
Presumed total depth of the test wells (average)	450m (150m)	320m (80m)
1. GI blind casing 5.5m long	390m (6" in diameter)	256m (4" in diameter)
2. Johnson or similar type of stainless steel screen with openning ratio of more than 15%	60m (with open space of 0.25-0.5mm)	64m (with open space of 0.5-1.0mm)
3. GI blind casing with bottom plug, 3 to 5m long	3 pcs	4 pcs
4. Gravel and coarse sand to be packed in annular space	$15m^3$ (mostly 1-2mm coarse sand)	$11m^3$ (mostly 2-3mm gravel)
5. centralizer	25 pcs	18 pcs
6. Cement grout for surface portion	adequate for seven (7) places	
7. Concrete base material 0.4 x 0.4 x 0.3m each	adaquate for seven (7) pcs	
8. Temporary cap for casing top	7 pcs	
9. Shelter for automatic water level gauge	4 places	

4. Logging

In order to determine number and location of the screen, the following three (3) types of geophysical logging shall be taken prior to casing installation;

a. Spontaneous Potential Logging
b. Electrical Resistivity Logging
c. Gamma-gamma Logging

Measurement shall be continuously done from near to the ground surface down to the bottom of the hole, or at least every one (1) meter, if continuous measuremnet is not available.
Logging data shall be attached to the drilling record.

5. Casing/Screen Installation

A sand trap, screens and blind casings are to be lowered into the drilled hole with centralizer after determination of screen settings. The location of the screen will be instructed by the consultant.

6. Gravel Packing

Immediately after installation of casing/screen, the sieved gravel and coarse sand shall be packed in the annular space between screen/casing and the drilled hole. The packing shall be done very carefully to ensure full packing of the space. The volume of the gravel packing used in each well will be checked by the consultant.
The gravel pack shall cover the entire screen length and rise a minimum of 3m above the top of the uppermost screen.

7. Well Development

The well development shall be continued until water from the well turns apparently clean. Any type of development method such as bailing, air lifting/surging or by motor pumping can be selected.

8. Pumping Test

The following three (3) types of pumping test shall be carried out at each test well under the direction of consultant.

a. Step draw down test: Five (5) steps with pumping duration of three (3) hours or more for each step.

b. Continuous draw down test: This test will be accompanied by (a). The last stage of (a) shall be continued at least 24 hours.

c. Recovery test: After continuous pumping, the recevery of water level is to be measured.

9. Well Completion

The well completion procedure shall comprise the following items;

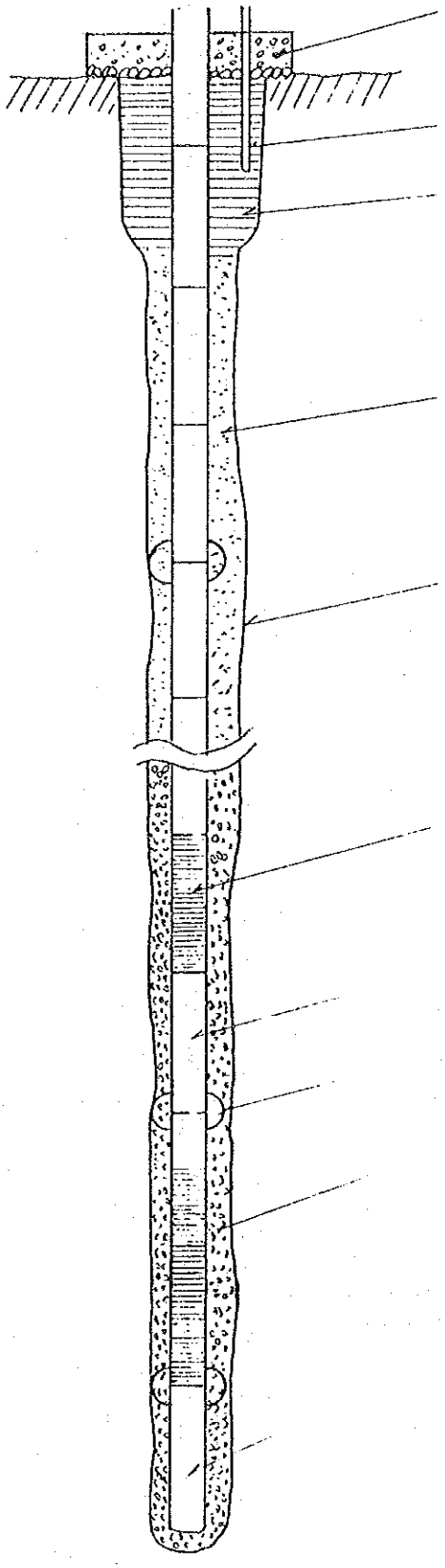
a. Back filling of the annular space between casing and drilled hole with drill cuttings to within 5m of the ground surface.

b. Cement grouting for 5m section below ground surface.

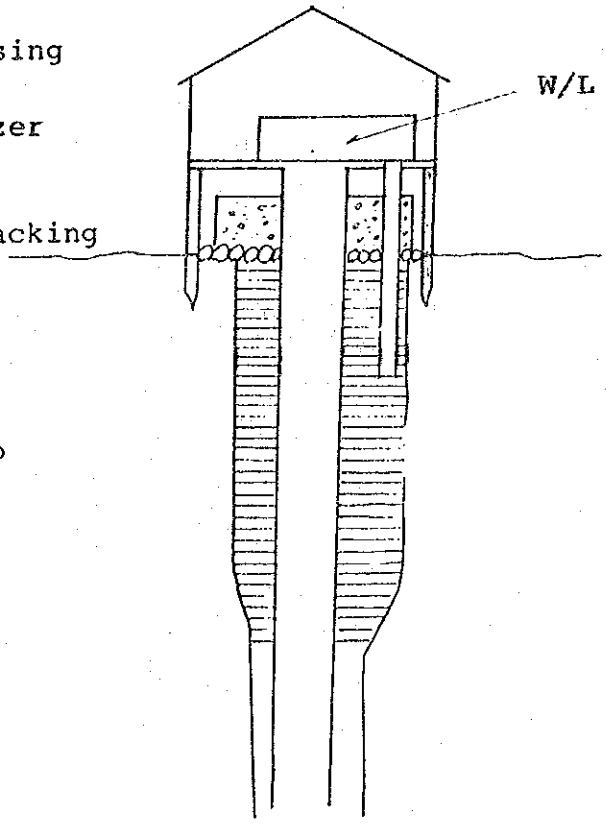
c. Construction of concrete base at a dimension of 40cm each for length and width, and 30cm in height for the firm fixing of well casing.

d. Installation of 1m length of PVC pipe, 2-1/2" in diameter, adjacent and parallel to the well casing prior to (b) and (c) to accomodate the weight of automatic water gauge.

e. Construction of a small wooden shelter for installation of automatic water gauge.



The small shelter for installation of automatic water level gauge



B. Specification for Test Drilling Work

1. Purpose of the Work

The purpose of the test drilling is to confirm the geological/ hydrogeological condition of the Study Area concerned by collecting the core sample and by measuring the groundwater level in the drilled hole.

2. Number, Target Depth, Diameter and Location of the Test Drillings

The exact locations and individual depths are to be determined by the Consultant in the first stage of the Study, that is, by middle of August. Followings are the temporary instruction to estimate the approximate drilling cost;

Location	Number	Target Depth	Diameter
a. In the area of sedimentary formation (cosely near to the Pumping well)	1	150m each	Any drilling diameter is available, which is good enough for installation of perforated PVC pipes with 2" inner diameter
b. In the area of basement rock exposure	4	80m each	
Total	5	470m	

3. Core Sampling

Twenty (20) centi-meter long rock/soil core sample with a diameter of bigger than 1-1/2" shall be taken from the depth of every ten (10) meter along with progress of drilling. In addition, the same dimensioned core sample shall be taken when change of formation is encountered. The core sample shall be arranged in order in a sample box with a note of depth taken.

4. Installation of perforated PVC pipes

Immediately after completion of drilling, a series of PVC pipes with inner diameter of two (2) inches or more shall be lowered up to the bottom of the drilled hole. When lowered, the perforated and blind pipes shall be alternately connected so that same water level is kept between inside and out side of the pipes.

7. Specification for Test Well Construction

and

Hand Pump Installation

AGREEMENT

OF

TEST WELL CONSTRUCITON AND HAND PUMP INSTALLATION

FOR

THE STUDY FOR GROUNDWATER DEVELOPMENT

SOKOTO STATE, NIGERIA

JULY, 1989

BETWEEN

JICA STUDY TEAM

AND

CONDITIONS OF ENGAGEMENT

1. GENERAL PROVISIONS

1.1 Terms of Reference

The Works to be perfomed by the Contractor under this Agreement are described in the Technical Specification set forth in Appendix "A".

1.2 Payment and Cost

Payment conditions and test well construciton and hand pump installation are described in Appendix "B" and "C" respectively.

1.3 Type of Contract

The work shall be perfomed on the Drilling
Cost basis:
There shall be no rise and fail variations allowed for escalation, inflation or any other reason.

2. COMMENCEMENT, COMPLETION AND ALTERNATION OF THE AGREEMENT

2.1 Agreement in Force

The Agreement is considered to have come into force immediately upon the signing of the agreement.

2.2 Commence Date

The Contractor shall commence the works (as described in Appendix "A") within 2 days after the Agreement has come into force.

2.3 Completion date

The works shall be completed by the 31th of August, 1989.

2.4 Alternations

Should circumstances arise which call for modifications of the Ageement these may be by mutual consent given in writing.
Proposals in the respect form one party shall be given due consideration by the other party.

3. INSURANCE

The Contractor shall obtain all insurances required by all relevant NIGERIAN Government regulations.

4. DUTIES OF CONTRACTOR

4.1 The Contractor shall exercise all reasonable skill, care and diligence in the discharge of his duties under the Agreement. The Contractor, his staff, employees shall respect the laws and customs of Nigeria and shall carry out all his responsibilities of his profession.

4.2 The Contractor shall not disclose any information which has been obtained through the construction, without the permission of the Client, during the time of construction and after the termination of the Agreement.

4.3 Subletting

The Contractor shall not assign or sublet whole or any portion of the works without prior consent of the Client to that effect.

5. PAYMENT TO THE CONTRACTOR

5.1 The Client shall effect payments to the Contractor in accordance with Appendix "B" and the construction cost set forth in Appendix "C".

5.2 All payment to the Contractor shall be in US dollar.

6. FORCE MAJEURE

"FORCE MAJEURE" includes wars, riots, or the like beyond control of the Client and the Contractor. In case of such circumstance, the Client may consider to extend the Agreement.

AGREEMENT

This Agreement (hereinafter, with the Conditions of Engagement and the Appendices and all Documents annexed hereto and forming an integral part hereof, called "the Agreement") made in duplicate on the day of July in the year Nineteen Hundred and Eighty Nine (1989) between the JICA Study Team (hereinafter called "the Client" of the one part) and (hereinafter called "the Contractor" of the other part.)

The Client is desirous that test well construction and hand pump installation works are rendered by the Contractor for the following project:

The Study for Groundwater Development in Sokoto State.

It is hereby agreed and declared between the parties as follows: The Client hereby appoints the Contractor and the Contractor accepts the appointment on the conditions as laid down in the Conditions of Engagement and Appendices anexed hereto and made a part hereof.

Appendix A	:	Technical Specification
Appendix B	:	Payment
Appendix C	:	Breakdown of Cost
Appendix D	:	Site Location

The parties sign :

The Client

The contractor

Dr. Akira Kamata
JICA Team Leader,
Study for Groundwater Developemnt
in Sokoto State

Appendix A Specification for Test Well Construction and Hand pump Installation

A. Specification for Test Well (Subject to utilitize as production well) Construction

The location of drilling site is shown in Appendix D. The exact drilling points shall be determined and indicated by the JICA study team.

1. Drilling Diameter

The diameter of drilled hole shall not be less than eight (8") inches from top to bottom for the six (6") or four (4") inches casing and screen to be properly installed.

2. Target Depth of Drilling

The depth of drilling will vary from place to place ranging from 100 to 200 meters with estimated average depth of 125m in ZUGU. The target depth for each site will be determined after conducting geo-resistivity sounding by the JICA Study Team before drilling of each hole.

3. Equipment and Materials to be prepared by the Contractor

The drilling equipment and accessories shall be capable of drilling at 8" diamter up to 200m deep in any gelogical formation encountered. For effective drilling in a limited period, the equipment shall be equipped with both rotary drilling system with direct mud water circulation and down-the-hole hammer drilling system with enough capacity of air compressor.

The materials to be prepared for completion of two (2) test wells is listed in the table below;

Table 1. Material List for Test Well Construction
(Two (2) well in Zugu)

	2 wells for basement rock area
Presumed total depth of the test wells (average)	250m (125m)
1. GI blind casing 5.5m long	200m (4" in diameter)
2. Johnson or similar type of stainless steel screen with openning ratio of more than 15%	50m (with open space of 0.5-1.0mm)
3. GI blind casing with bottom plug, 3 to 5m long	2 pcs
4. Gravel and coarse sand to be packed in annular space	$6m^3$ (mostly 2-3mm gravel)
5. centralizer	10 pcs
6. Cement grout for surface portion	adequate for two (2) places
7. Concrete base material 0.4 x 0.4 x0.3m each	adequate for two (2) pcs
8. Temporary cap for casing top	2 pcs
9. Sheleter for automatic water level gauge	not necessary

4. Logging

In order to determine number and location of the screen, the following three (3) types of geophysical logging shall be taken prior to casing installation;

a. Spontaneous Potential Logging
b. Electrical Resistivity Logging
c. Gamma-gamma Logging

Measurement shall be continuously done from near to the ground surface down to the bottom of the hole, or at least every one (1) meter, if continuous measurement is not avilable.
Logging data shall be attached to the drilling record.

5. Casing/Screen Installation

A sand trap, screens and blind casings are to be lowered into the drilled hole with centrailizer after determination of screen settings. The location of the screen will be instructed by the JICA study team.

6. Gravel Packing

Immediately after installtion of casing/screen, the sieved gravel and coarse sand shall be packed in the annular space between screen/casing and the drilled hole. The packing shall be done very carefully to ensure full packing of the space.
The volume of the gravel packing used in each well will be checked by the JICA study team.
The gravel pack shall cover the entire screen length and rise a minimum of 3m above the top of the uppermost screen.

7. Well Developmet

The well development shall be continued until water from the well turns apparently clean. Any type of development method such as bailing, air lifting/surging or by motor pumping can be selected.

8. Pumping Test

The following three (3) types of pumping test shall be carried out at each test well under the direction of the JICA study team.

a. Step draw down test: Five (5) steps with pumping duration of three hours or more for each step.

b. Continuous draw down test: This test will be accompanied by (a). The last stage of (a) shall be continued at least twenty four 24 hours.

c. Recovery test: After continuous pumping, the recevery of water level is to be measured.

9. Well Completion

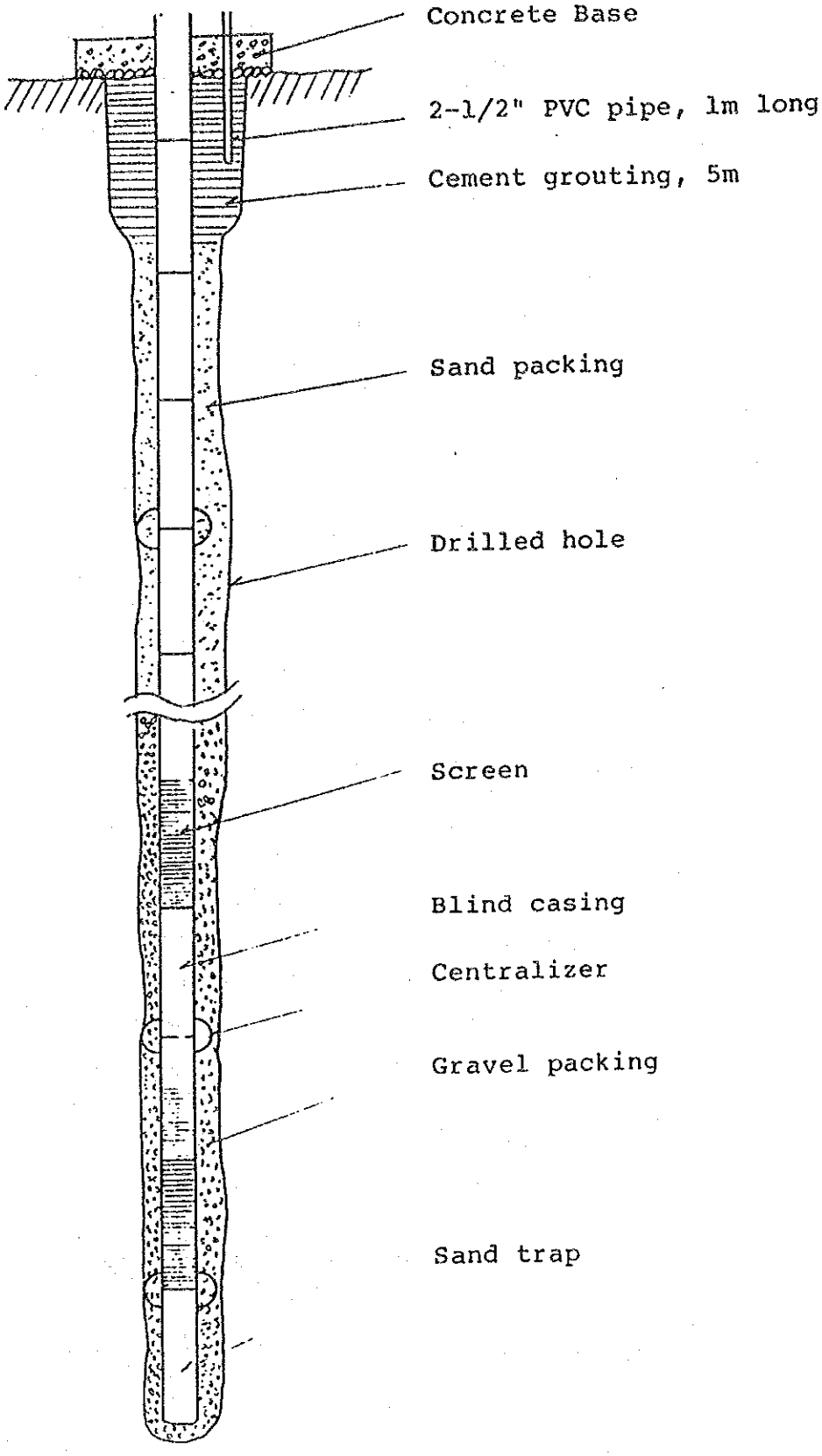
The well completion procedure shall comprise the following items;

a. Back filling of the annular space between casing and drilled hole with drill cuttings to within 5m of the ground surfaces.

b. Cement grouting for 5m section below ground surface.

c. Construction of concrete base at a dimension of 40cm each for length and width, and 30cm in height for the firm fixing of well casing.

Fig.1 Test Well Design



B. Specification for hand pump installation

1. GENERAL

This specification covers the technical requirements for materials, workmanship, installation and testing of deep well pumping units, using the hand pumps.

2. SUMMARY OF PUMP ISTALLATION WORKS

The pump installation works shall be done at 10 sites using the hand pumps. The site location is shown in Appendix D.

3. Hand pump

The deep well hand pump shall be designed for use by inhabitants commonly living in rural areas where the water level is comparatively low, particulaly taking into consideration the durabity, sanitation and less labour for that even small infant can operate easily.

Principal Requirements

Power transmiision	: Rod drive type.
Operation	: By hand.
Pumping water level	: More than 50 meters. by human power

Discharge rate :

Water level	Discharge rate
50m	15 lit/min

Cylinder diameter : max. 3-1/2"

Drop pipe and pump rod shall be suitable for the existing test wells.

Required number of the deep well hand pump shall be ten sets.

Each hand pump shall be supplied complete of suitable pump stand for deep well and manufacturer recommended tool kit for installation and maintenance.

4. INSTALLATION WORK

The pump shall be installed at the most adequate depth which shall be determined according to the result of air-lifting.

The final design for pump installation shall be capable of pumping up not less than 300 lit per hour or otherwise approved by the JICA study team.

5. TEST OPERATION

a. After installation, the effectiveness of the pumping unit shall be satisfactorily demonstrated to the JICA study team if requested.

b. Water Samples

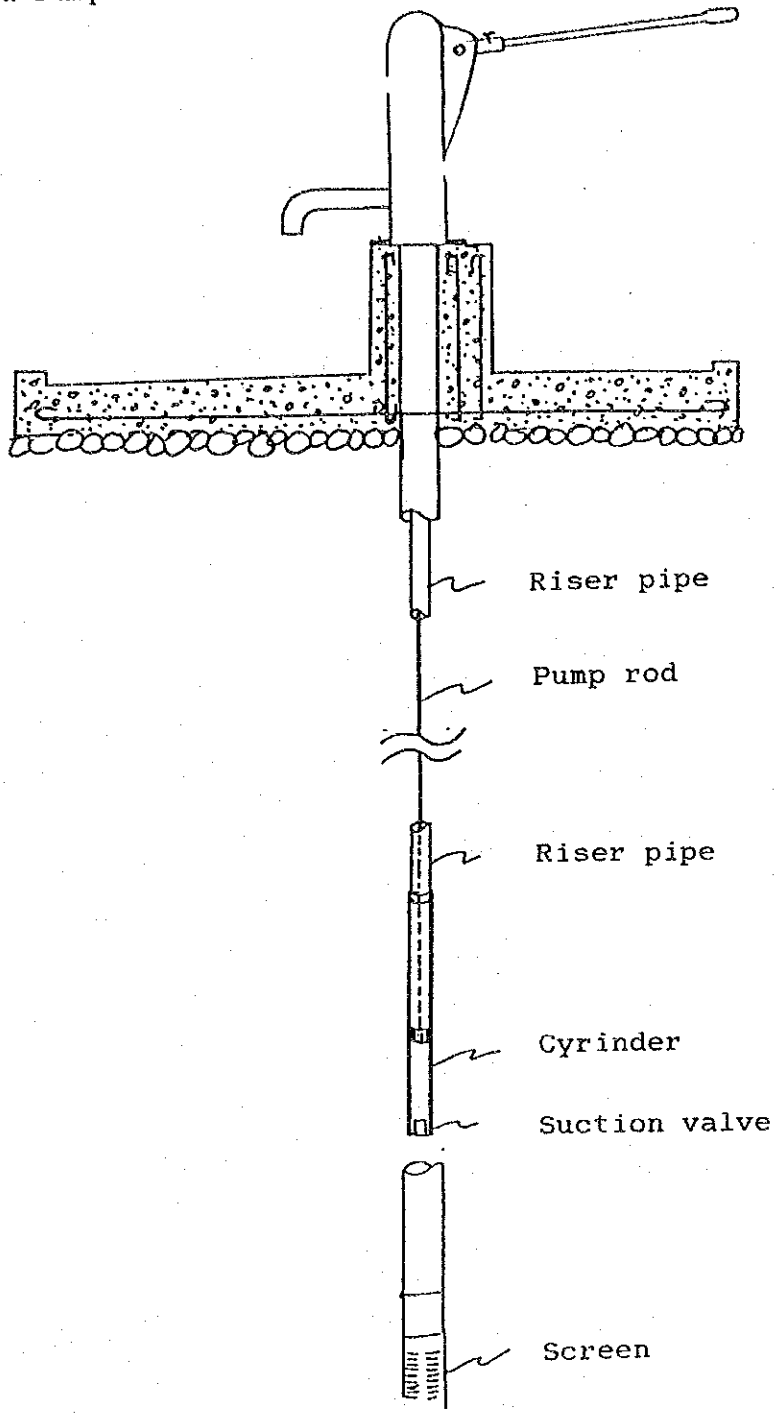
1) Samples of water shall be taken during pumping tests as and when directed by the JICA study team. The number of samples to be taken at each production hole will be determined by the JICA study team. The temperature and electrical conductivity of each sample shall be measured at the time of sampling.

2) Each sample shall be placed in a suitable plastic bottle. All water samples shall be clearly and securely labelled. The labels shall show the well reference number, site name, date and time at which the sample was taken, depth of the well and water level in the well at the time of sampling and any otehr information which the JICA study team may require.

3) The Contractor shall be responsible for storing the water samples and shall, when instructed by the JICA study team, carry out such mineralogical, chemical and physical analysis and tests of these samples using by water analysis kit to be supplied by the JCIA study team.

4) The results of the analysis and tests shall be presented in a form approved by the JCIA study team.

Fig.2 Hand Pump Installation



Appendix B

PAYMENT

1. The Client shall pay an amount of
hereafter refered to as Cost,
to the Contractor.

2. The cost include remuneration, company profits, equipment and material cost, overhead cost social charge, insurance, tax and others.

3. There shall be no rise and fail variations allowed for escalation, inflation or any othere reason.

4. The payment of the cost shall be made by the Client to the Contractor as follows;

a) Twenty (20) percents of the total contract price shall be paid after the progress of the work reach over Twenty (20) percents.

US dollars :

b) Twenty (20) percents of the total contract price shall be paid after the progress of the work reach over Forty (40) percents.

US dollars :

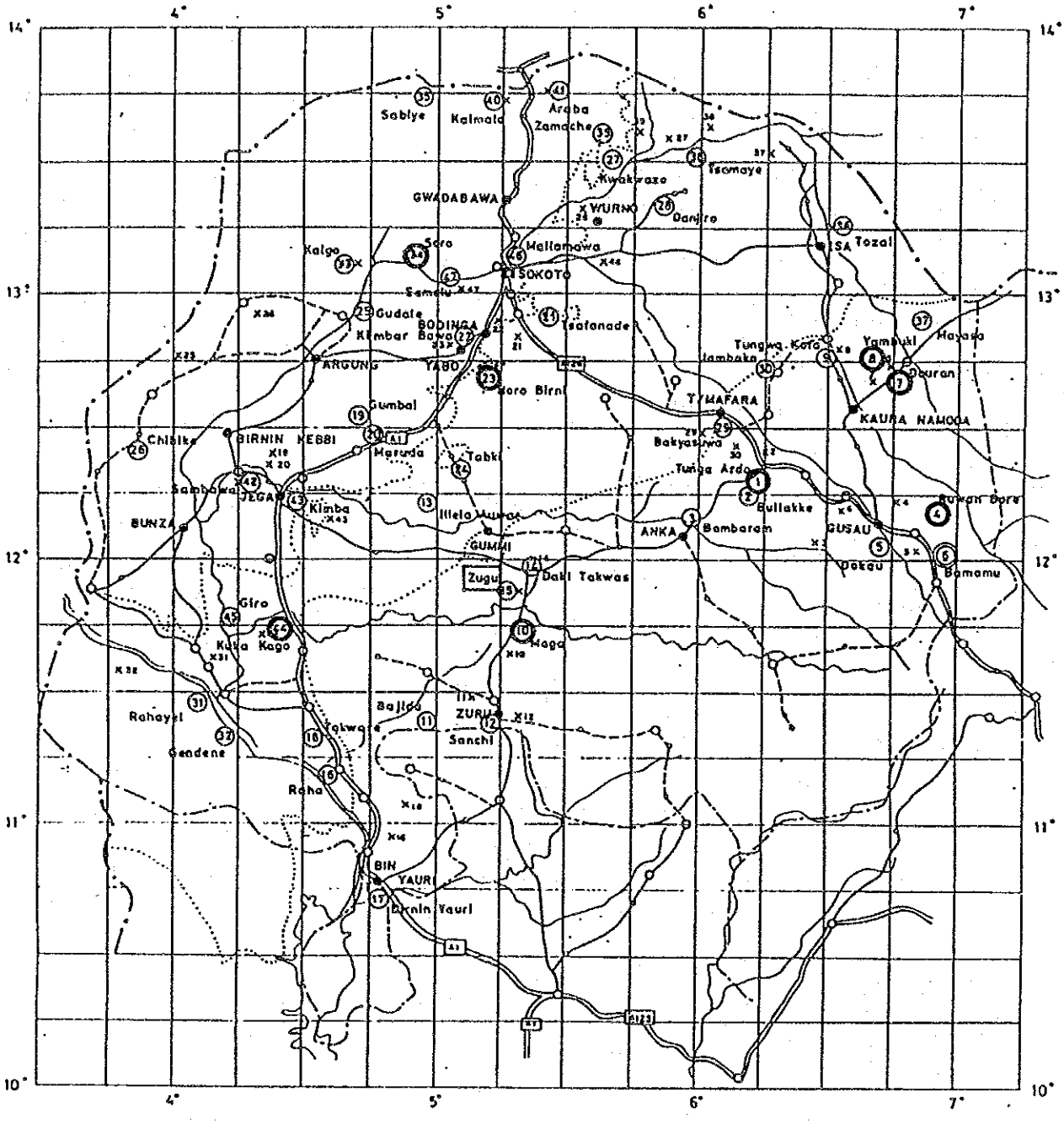
c) The remaining of Sixty (60) percetns of the total contract price shall be paid after completion of the work and all documents required in this cotnract submit to the Client.

US dollars :

Total US dollars :

BREAKDOWN OF COST

ITEM	DESCRIPTION	UNIT	Q'TY	RATE (NAIRA)	AMOUNT (NAIRA)
1.0	Test Well for Base-ment rock area	Nos.	2		
2.0	Installation of hand pump	Nos.	10		



Location map of the candidate villages for test well construction and pump installation

8. Specification for Levelling Survey

TERMS OF REFERENCES

1. GENERAL

1.1 All measurement in the survey shall be recorded in metric system.

1.2 The Contractor is responsible for providing all survey equipment and materials relating to the work, except the equipment procured by the Client.

1.3 Any other Terms of Reference required shall be discussed by the Client and the Contractor.

1.4 The progress of the survey work shall be reported to the Client every week.

2. Detailed Description of Survey

2.1 Area of Survey

The area of survey work is shown in the attached "Location Map".
The exact location will be shown on site to the Contractor by the Client before commencement of the work.

2.2 Content of Work

The determination of level of the casing-top of sixty five (65) boreholes and establishment of bench marks close to each of the same 65 boreholes.

2.3 Personnel to be Engaged

The Contractor shall select or hire skilled and well-trained personnel for the work, and submit to the Client their curricula vitae for acceptance by the Client. The Client has the right to reject and direct the replacement of the Contractor's personnel who is judged to be "unqualified" by the Client for the execution of the work.

3. Specification

3.1 Purpose

Level survey in this specification means to determine the altitude of the casing-top of the 65 boreholes concerned and to install the bench marks close to the individual borehole by connecting to the existing national bench marks.

3.2 Leveling Route

The Contractor shall select the most appropriate survey route between existing bench marks and target points, and submit the route map for acceptance of the Client.

3.3 Reconnaissance

The target points to be surveyed will be shown by the Client on individual site to the Contractor prior to the preparation of the leveling route plan.

3.4 Accuracy

Difference of double running or permissible error when closured to other existing bench mark shall be less than $100\sqrt{S}$ millimeter (mm) (where S is distance of single running in kilometer (km)).

3.5 Check and Re-survey

The survey result will be checked by the Client irregulary during the survey work. If the result is found to be unsatisfactory, the Contractor is responsible to have re-survey, by his own expenses, for the section requested by the Client.

3.6 Instrument

The four (4) sets of level will be provided by the Client for use of the survey work. The Contractor shall take good custody of the instruments and are to be binded to return them to the Client in good condition after completion of the field work.
Other instruments and materials necessary for the work shall be prepared by the Contractor.

3.7 Mode of Operation

(1) The survey shall comprise fore and back leveling (double running).
(2) Minimum reading unit shall be one (1) millimeter.
(3) The distance of fore and back sights shall be not more than 100m.

3.8 Calculation

Altitude of the borehole casing tops and the bench marks shall be obtained from observation values.

3.9 Documents and Data to be submitted

The Contractor shall submit following documents and data

(1) Field data of the level reading

(2) Results of altitude calculation