Table 2-7 BOREHOLE DATA

Province Rift Valley

District Kajiado/Narok

Sheet (20) No.7

Borehole	Scale 1:250,000	Total Depth (m)	Water Struck (m)	Rest Level (m)	Tested Yield (m^3/h)	Date of Completion
P 39	SA-37-10	113.99	104.5 44.2,92.7	55	12.6	29/6/29
P 59	"	122.53	112.2,1175	56	13.12	25/9/29
P 76	"	20.1	NIL	NIL	NIL	27/1/30
C 3481	"	110.3	32,102 103.6	21	13.6	8/3/68
C 2139	"	76.2	30.4,56.4	25.9	13.1	12/2/54
C 3538	"	65.80	-	-	Dry	27/11/68
C 3537	"	76.50	-	-	Dry	15/11/68
C 1136	"	91.8	79.3	28.4	10.9	8/6/50
C 3553	"	91.5	82.4,85.4	62.9	8.1	20/2/69
C 3649	"	292.2	253.2,255	241.7	6.48	17/12/69
C 1138	"	100.9	-	-	Dry	31/7/50
C 3552	"	68.6	-	-	Dry	3/2/69

Table 2-7 BOREHOLE DATA

Province Rift Valley

District Kajiado/Narok

Sheet ◯ No.8

Borehole	Scale 1:250,000	Total Depth (m)	Water Struck (m)	Rest Level (m)	Tested Yield (m^3/h)	Date of Completion
C 1751	SA-36-8	92	22.9	-	NIL	16/4/52
C 3882	"	143.5	49 134	45.15	8.2	25/11/72
C 4131	"	181	-	-	NIL	27/6/75
C 4143	"	197	18.3	172	Negligible	26/8/75
C 4319	"	150	86	75	1.2	1/4/77

5-2 Water level

5-2-1 Static water level

The contour of the static water l-vel is drawn in as Fig. 9 and summarized as below:

(i) Within the Rift Valley area, static water level is approximately 100 m. Further north, at the foot of volcanos, it lowers to about 200 m.

(ii) As the ground rises near Mt. Kirmanjaro, the static water level becomes lower.

(iii) In basin low lands of Amboseli, Lengesim, Stong and Athi districts in the Kajiado area, it is within 25 m.

(iv) In districts of the Narok area, close to the Rift Valley, static water level is also low.

Generally, static water levels in areas around the foot of volcanos are low due to high permeability and the difference in elevation from sea level. This is also the case for volcanos in the project area.

Deep receiving bed rock is thought to be the reason why the static water level in and around the Rift Valley is low.

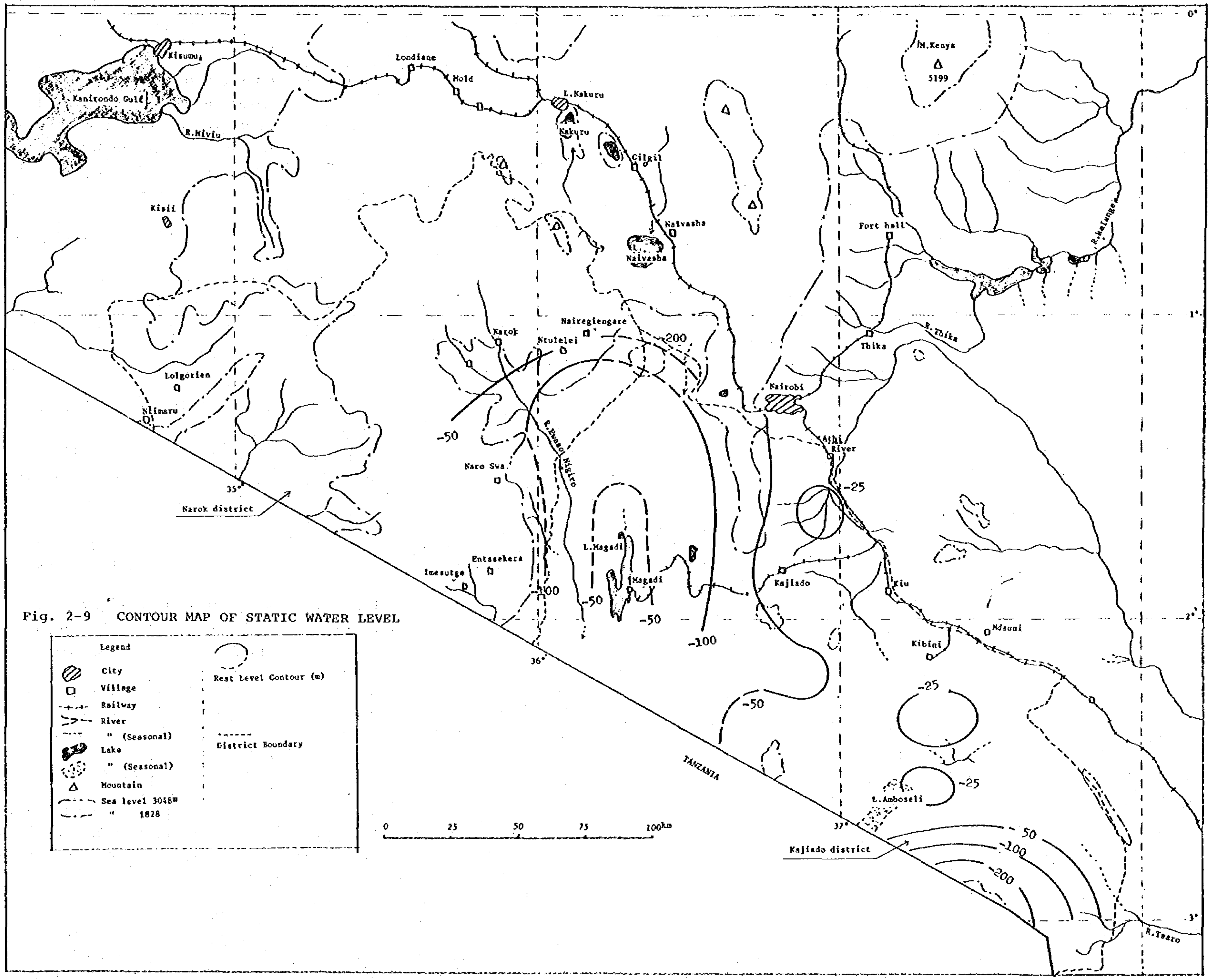


Fig. 2-9 CONTOUR MAP OF STATIC WATER LEVEL

Water resting conditons generally observed in ground water storage have also been observed in the project area; for example, water levels in the basins are near the surface. This is particularly evident in the vaste Amboseri basin at the foot of Mt. Kirimanjaro where there is plenty of water recharge and even artesian wells.

5-2-2 Dynamic Water Level

Only about 10% of the dynamic water levels are known due to sufficient aquifer test datas of water wells. Results on studies of some wells are shown in the separate table.

5-3 Water Quality

Table 8 shows water qualify of some wells in Kajiado. Generally speaking, the mineral content in the water is high. Except for fluorine, the mineral content meet WHO standards for 2nd class drinking water. Rain and surface water generally contain very small amounts of dissolved minerals. However, as water flows in the underground, the quality changes. Water quality of gournd water depends on the source of supply, flowing channels and the flowing time.

During the electric survey for this study, electro conductivity of well water was measured. The measurements are summarized in to Fig. 10. The following characteristics were found.

(1) The mineral content appearas to be high as the electrical conductivity ranged from 650 - 100$\mu\Omega$/cm. This is thought due to little rain.

(2) Minerals content increases as the water goes down stream.

(3) Mineral content sharply increases around the salt water lakes such as Lake Magadi and Lake Amboseli. This is due to salt remaining after evaporation of water.

TABLE 2-8 WATER QUALITY

(expressed in mg/litre)

	C155	C587	C1387	C1391	C1427	C2587	C3520	C3942	C4258	C811	C1390	C1713	C4002	C4004
Turbidity (J T U)	None	-	Slight	NIL	NIL	NIL	-	-	.15	-	NIL	Turbid	-	-
pH	7.1	7.1	7.5	7.1	7.1	7.3	-	7.2	8.2	7.9	7.1	8.7	9.8	8.4
Conductivity (unhos/cm)	-	-	-	-	-	-	-	840	1275	-	-	-	1850	1080
Colour (H U)	clear	-	clear	-	clear	-	-	-	5	-	NIL	Faint	-	<5
T D S 130°C	845	470	678	1240	1141	1890	-	585	-	684	810	1800	1210	730
T D S after ignition	-	-	-	-	-	-	-	375	-	-	-	-	1120	440
Carbonate hardness ($CaCO_3$)	380	371	189	422	422	394	-	330	-	-	189	-	2	152
Non-carbonate hardness	36	125	NIL	268	114	95	-	NIL	-	-	-	-	NIL	NIL
Total hardness	16	496	147	690	536	489	192	330	260	142	189	-	2	152
Total alkalinity	386	389	364	422	422	394	-	-	477	387	363	1005	427	460
Bicarbonate	386	389	364	422	422	394	296	515	-	387	363	1005	249	412
Carbonate	-	-	-	-	-	-	-	NIL	-	NIL	NIL	NIL	178	43
Chloride	202	20	85	281	324	251	17	38	173	113	139	228	175	84
Sulphate	Tr	Tr	38	20	20	25	5	35	-	32	20	192	101	43
Nitrate	Tr	Tr	Tr	-	Tr	NIL	1.0	7.5	-	present	-	Tr	NIL	3.8
Nitrite	NIL	Tr	Tr	-	NIL	NIL	-	<0.01	-	Tr	-	NIL	NIL	0.04
Fluoride	2.2	-	3.4	-	2.2	0.9	1.4	1.7	1.9	-	-	3.1	0.6	4.2
Sodium	-	-	-	-	-	-	44	72	-	-	-	-	360	195
Potassium	-	-	-	-	-	-	5	14	-	-	-	-	16	20
Calcium	102	70	50	184	139	133	49	82	-	34	102	-	0.8	32
Magnesium	39	62	5.5	56	46	38	17	30	-	14	37	-	NIL	17
Iron	1.5	-	0.2	1.8	0.3	0.6	0.2	0.2	-	0.07	0.12	0.06	-	NIL
Manganese	-	-	-	-	-	-	-	-	-	-	-	-	-	NIL
Heavy Metals (Pb, Zn, Cu)	-	-	-	-	-	-	-	1.0	-	-	-	-	NIL	NIL
SiO_2	72	-	47	26	70	60	55	70	-	24	60	13	20	-
O_2 absorbed	-	-	-	-	-	-	-	0.4	-	Tr	-	-	0.7	-
CO_2	-	Tr	-	-	-	-	-	13	-					

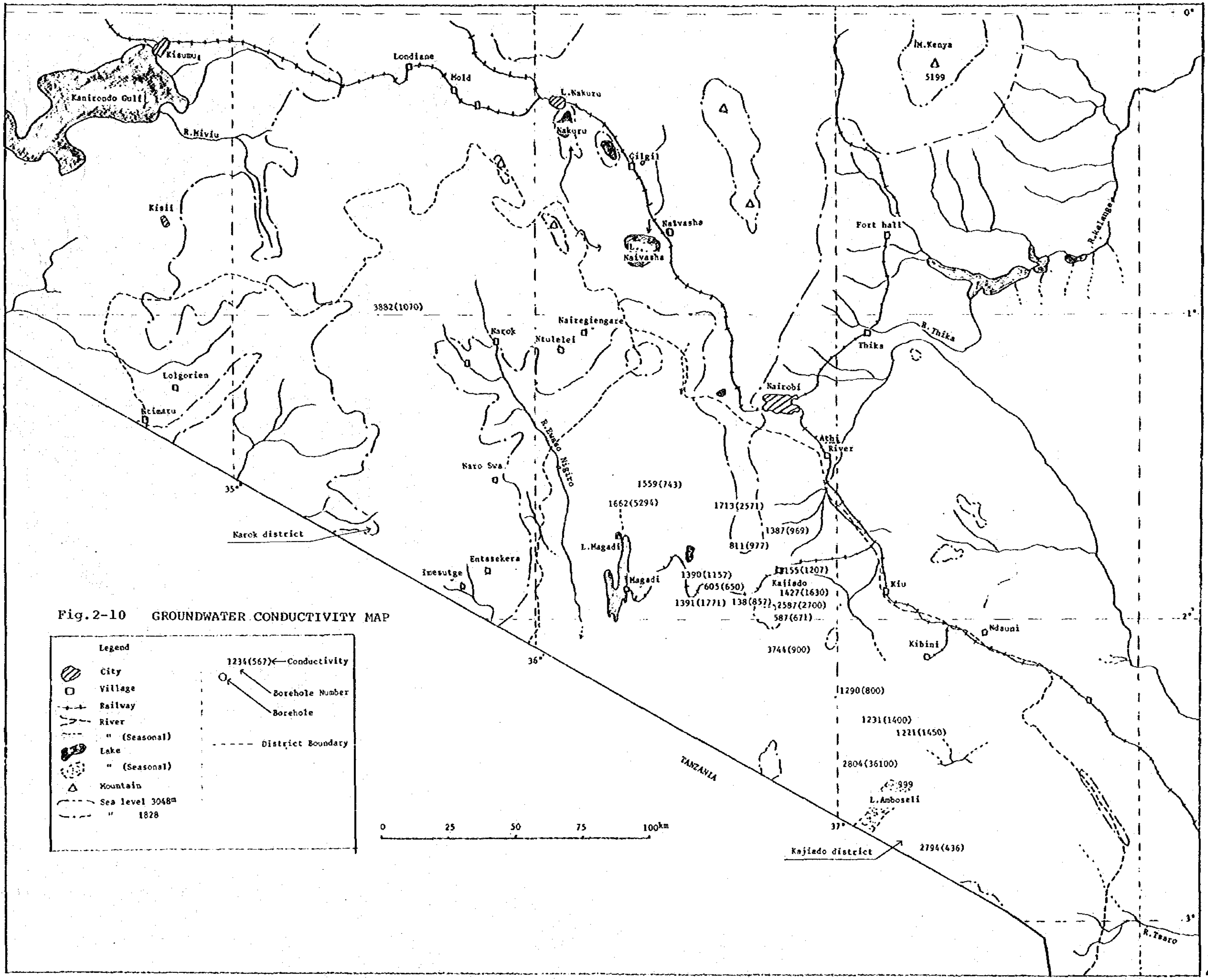
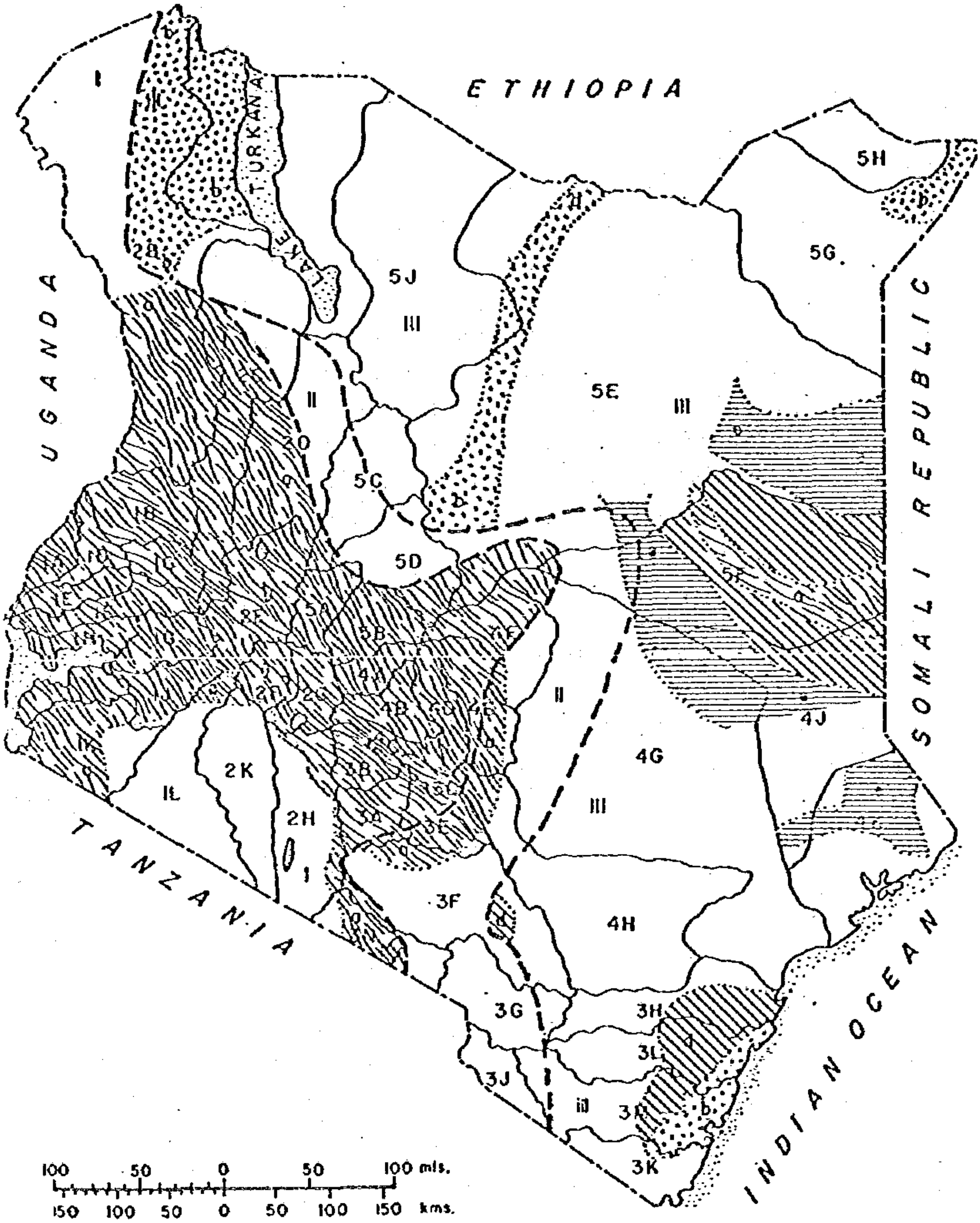


Fig.2-10 GROUNDWATER CONDUCTIVITY MAP



TOTAL DISSOLVED SOLIDS

a = 0 - 1500 mgl.
b = 1500 - 3000 "
d = 5000 - 10000 "
e = 10000 "

Fig.2-11 MAJOR PATTERNS OF GROUNDWATER CHEMISTRY

5-4 Hydrogeological Constants

Hydrogeological constants, such as the coefficent of permiability, differ greatly in aquifers according to the grain diameter, grain composition, degree of consolidation and various other factors. The coefficient of permeability represent the degree of easiness with which water can pass through under ground voids and the coefficeitn of transmissibility shows the dimension of aquifer by the multiplying the coefficient of permeability by the thickness of the aquifer. Permeability, a property of the aquifer, is determined by the coefficient of permeability.

Although there were many wells checked during this basic study, no hydrogeological constant is yet available. Efforts however have been made to obtain an approximate hydrogeological constant based on the dynamic water level data of some wells and using certain assumption.

TABLE 2-9 ESTIMATED HYDROGEOLOGICAL constants

Item Well No.	Depth	Stratum	Static Water Level	Dynamic Water Level	Yield m^3/d	Specific Capacity $m^3/d/m$	Coefficient of Transmi-ssibility	Coefficient of Permeabi-lity
C3747	85.9	Base	6.40	80.50	216	2.9	3.5	4.1×10^{-4}
4004	152.5	N.S.	6.95	73.76	280	4.2	5.1	5.9×10^{-4}
4022	152.0	"	8.36	27.60	190	9.9	12.1	1.4×10^{-3}
4002	132.5	"	2.51	96.47	112	1.2	1.5	1.7×10^{-4}
3190	135.0	"	39.30	61.00	280	12.9	15.7	1.8×10^{-3}
3997	214.0	"	33.50	37.80	1,092	254	310	3.6×10^{-2}
3580	108.5	Base	32.90	33.30	350	875	1,068	1.2×10^{-1}
3339	106.0	"	33.80	73.20	192	4.9	6.0	6.9×10^{-4}
3578	152.7	"	41.10	77.40	25	0.7	0.9	1.0×10^{-4}
3579	141.7	"	44.50	118.00	44	0.6	0.7	8.1×10^{-5}
3311	62.0	"	35.00	45.10	271	26.8	32.7	3.8×10^{-3}
3839	100.5	"	40.50	74.70	245	7.2	8.8	1.0×10^{-3}
3688	91.4	"	37.50	87.20	94	1.9	2.3	2.7×10^{-4}
3748	77.4	"	31.00	40.00	278	30.9	37.7	4.4×10^{-3}
2839	27.4	"	8.23	9.50	436	343	418	4.8×10^{-2}
3045	24.4	"	10.66	11.90	242	195	238	2.8×10^{-2}
3757	106.7	"	39.30	99.00	108	1.8	2.2	2.5×10^{-4}
3836	114.3	"	30.40	35.90	262	47.6	58	6.7×10^{-3}
3826	109.7	"	32.00	33.70	262	154	188	2.2×10^{-2}
3816	100.5	"	34.00	35.10	252	229	279	3.2×10^{-2}
3532	121.9	"	45.08	101.20	44	0.8	1.0	1.2×10^{-4}
3835	114.3	"	30.40	99.50	262	3.8	4.6	5.3×10^{-4}
3392	122.0	"	21.30	117.96	12	0.1	0.1	1.2×10^{-5}
3742	89.9	"	28.00	84.00	178	3.2	3.9	4.5×10^{-4}
3743	155.4	"	14.00	147.20	94	0.7	0.9	1.0×10^{-4}
3337	138.0	"	61.80	110.90	119	2.4	2.9	3.4×10^{-4}
3553	91.5	N.S.	59.10	62.90	194	51.1	62.3	7.2×10^{-3}

Note:
1. As no data on thickness of the aquifers is available, they are assumed to be 10 m.
2. Coefficient of permeability is obtained from the following empirical formula, T = 1.22 Sc. (Sc: Specific Yield).
3. Base: Basement rock, N.S.: New Sediment Rock.

These constants, though based on assumptions, serve as a useful reference. The following preliminary analysis were made:

1. There are 16 wells of the 27 tested (60%) which show a specific yield of only one-digit numbers. This indicates there are many wells yielding small amounts of water. Six good wells with specific yields of three-digits numbers and five wells with normal specific yields of two-digit numbers make up the remaining 40 percent.
2. Generally 1×10^{-4} cm/sec. is used as a standard coeficient of permeability to distinguish aquifers and aquiclude. 14 out of 27 wells (52%) are more or less at this level indicating the condition of some aquifers are unfavorable for good yields. There were 6 good aquifers with a coefficient of permeab ility of more than 1×10^{-2} cm/sec.
3. Generally, all wells are with deep dynamic water levels, some of them exceeding 75 m.

Figure lw shows the approximate distribution of yield throughout the country. The data shows a majority of the yields to range between 60 to 120 l/min. This indicates there is considerable co-relation with precipitation and yield.

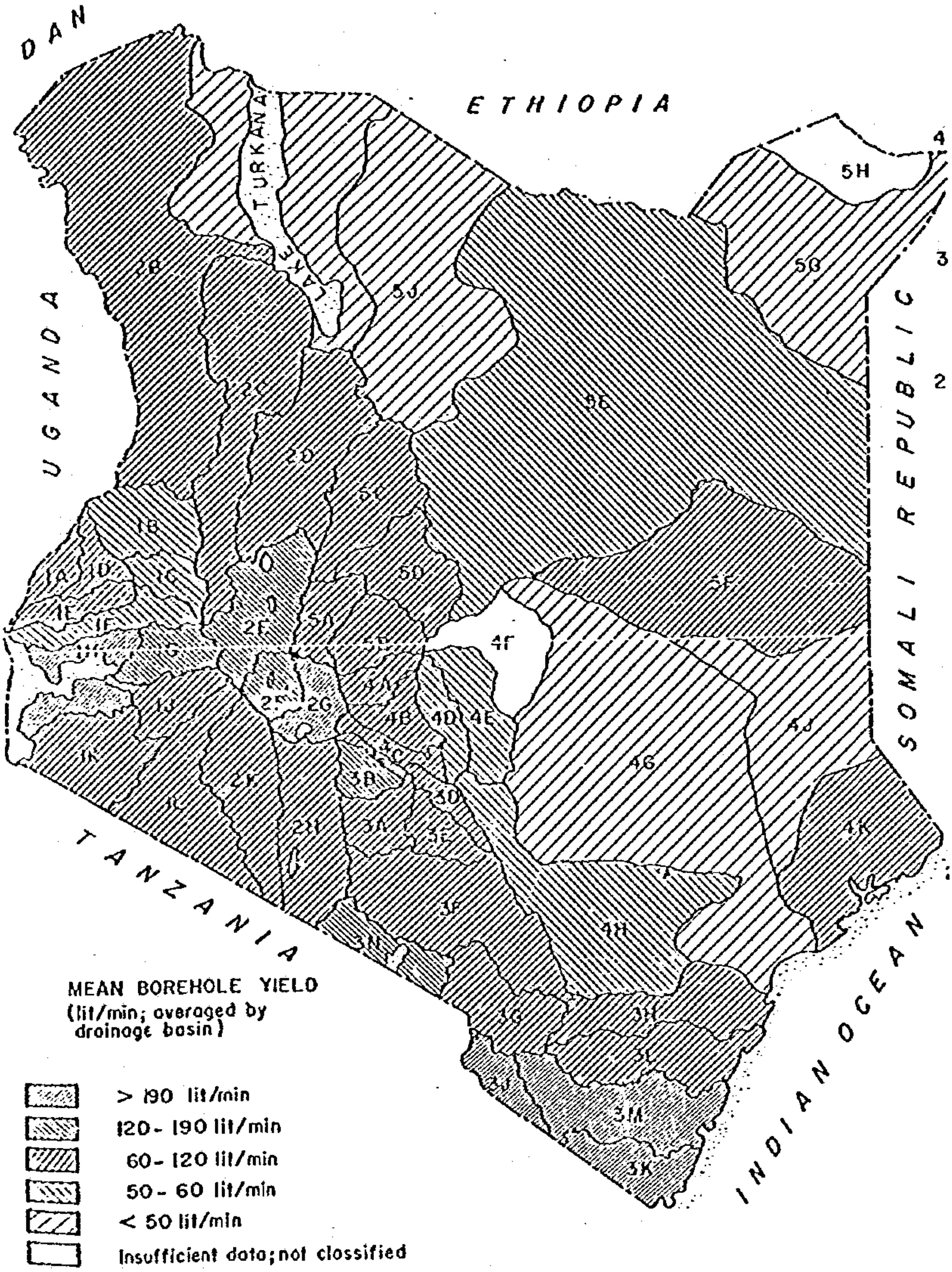


Fig.2-12 DISTRIBUTION OF YIELDS OF BOREHOLE

6. Geoelectric Resistivity Survey

6-1 Method of Survey

In locating underground water supplies which are indispensable for agriculture and industries as well as for daily life, in selecting construction sites for dams and tunnels, in prospecting for mineral deposits, and in preparing earth works for power and communication systems, it is necessary to conduct a preliminary survey of geological conditions so as to determine whether or not the ground in question is suitable for the purpose.

The most reliable method available for the geological survey is boring. The boring, however, is expensive in every respect and therefore cannot be employed as much as desired. If, by means of some other machine, the general underground conditions can be revealed prior to the boring operation, it will minimize the effort, yet maximize the effect of boring so that the survey will be improved greatly in terms of time and economy.

The structure of the earth is extremely complicated. Even if elaborate equipment is used, it would be impossible to disclose every detail of the interior of the ground from the ground surface. What can be obtained by such preliminary survey is not the interior of the ground itself but certain physical quantities which have some relation with the nature of the ground. Based on such physical quantities, the state of the underground may be interpreted. Careful interpretation is necessary to eliminate errors.

The survey of geological conditions requires measurement of physical properties and their interpretation. How the data is interpreted greatly affects the outcome of the survey. Correct judgement of geological conditions hinges solely on the interpretation. It is important to have sufficient knowledge about the physical properties of the ground.

There are many kinds of physical properties. Investigation of the ground based on such physical properties is referred to as the Geophysical Prospecting Method.

Geoelectric prospecting, one of the common geophysical prospecting tests, tests electrical properties of the ground. The resistivity method is the most widely used type of geoelectric prospecting because resistivity differs from aquifer to aquiclude and because the soil to be explored is stratified in most instances. Determining the soils' resistivity gives a clue to its geophysical nature.

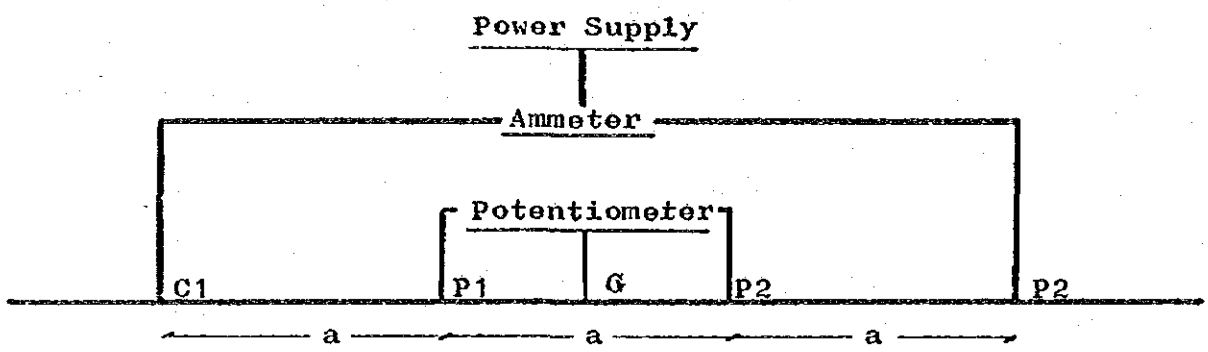
The resistivity of soil is influenced by the following factors:-

1. Mineral content
2. Compactness of soil constituents
3. Soil porosity
4. Water content

The resistivity survey will use Wenner's four-electrode method and/or the Schlunberger configuration method.

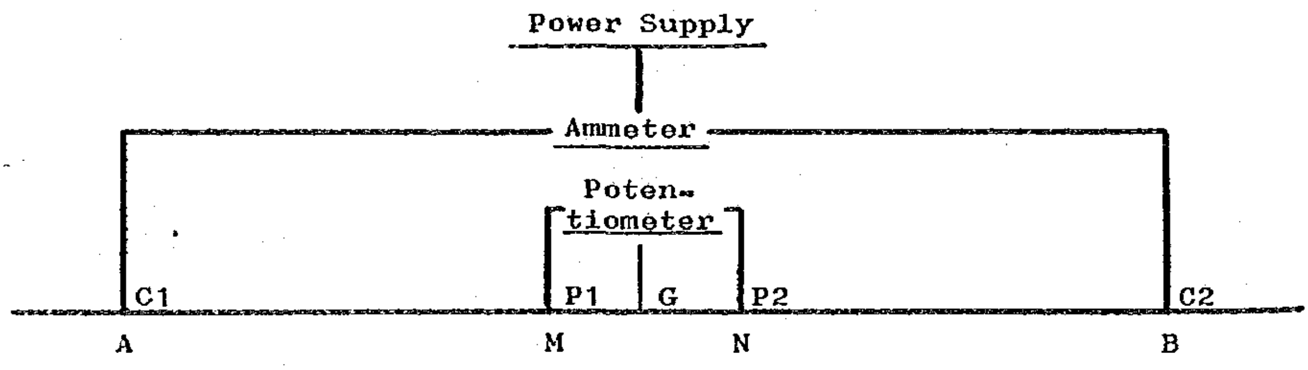
1. Wenner's Method

P1, P2 : Potential Electrode
C1, C2 : Current Electrode



$$\text{Apparent Resistivity}(\rho) = 2\pi \times \frac{\text{Potential difference}(V)}{\text{Total current}(I)} \times \text{Electrode spacing}(a)$$

2. Schlumberger's Method

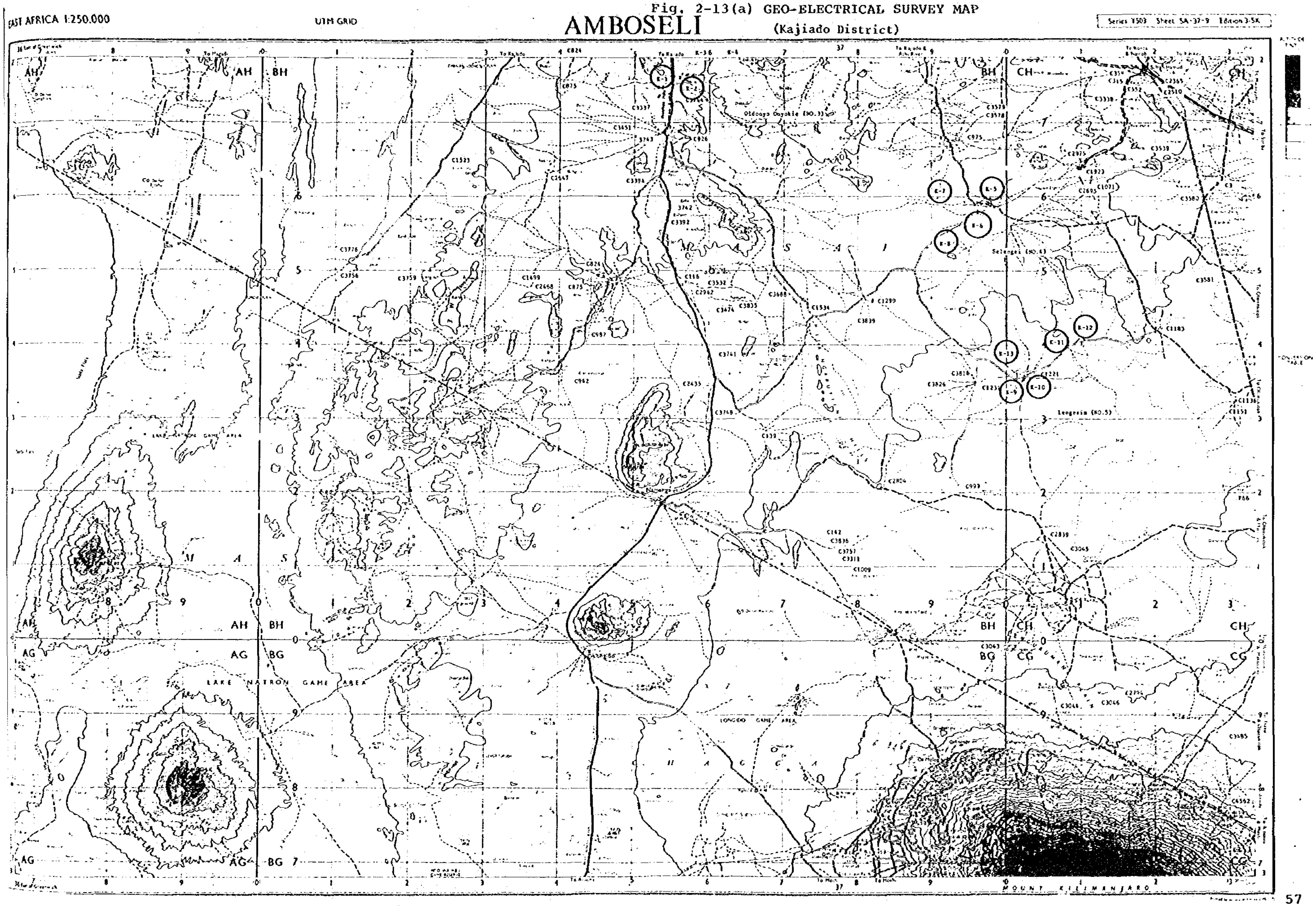


$$\text{Apparent Resistivity}(\rho) = K^{*} \times \frac{V}{I}$$

$$*: K = \frac{\pi}{4} \times \frac{\overline{AB}^2 - \overline{MN}^2}{\overline{MN}}$$

Fig. 2-13(a) GEO-ELECTRICAL SURVEY MAP

(Kajiado District)

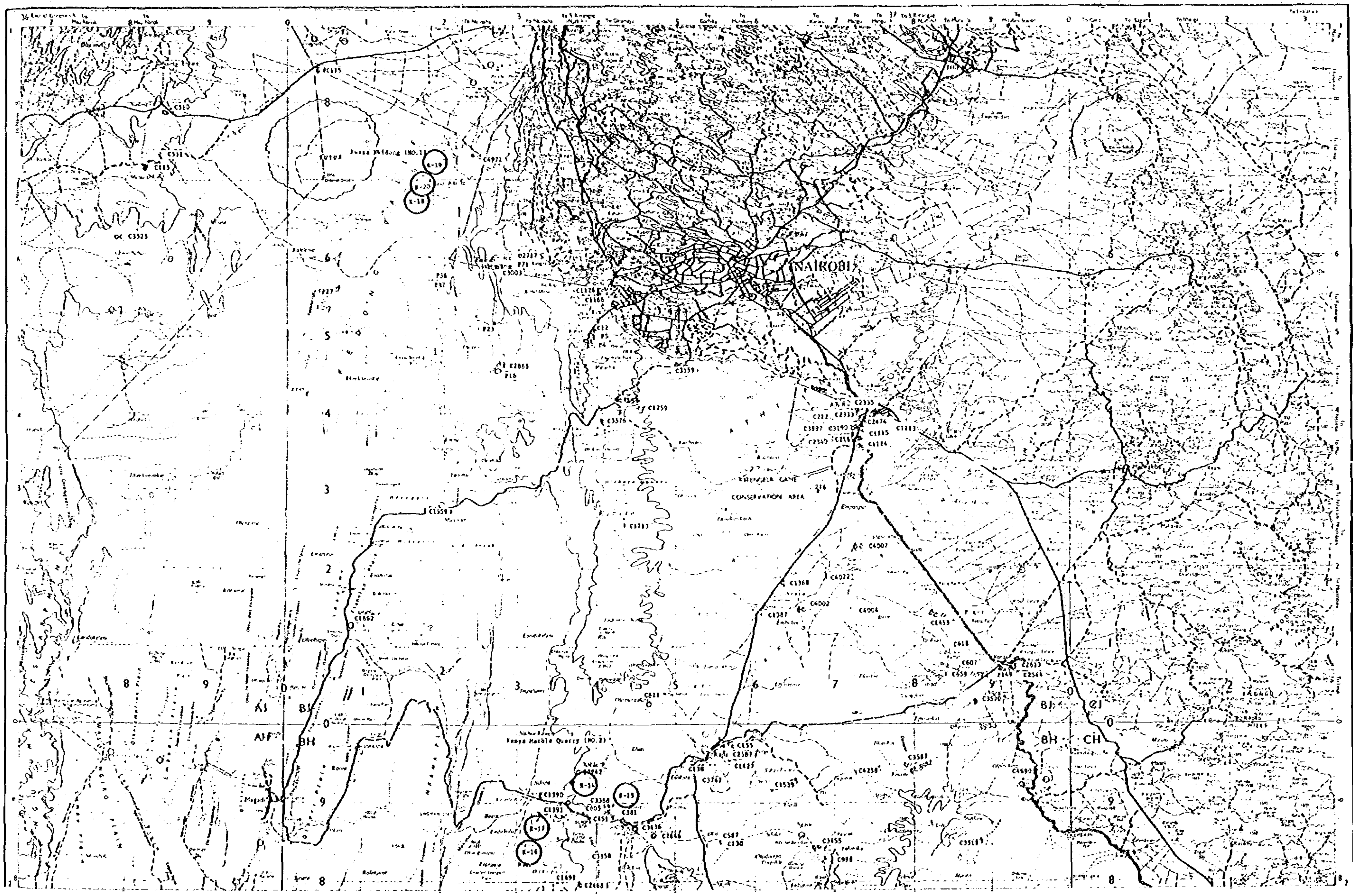


Geoelectrical Survey Site Map

EAST AFRICA 1:250,000 UTM GRID

NAIROBI Fig. 2-13 Geological Surevey Site Map (b)

Series Y503 Sheet SA-37-5 Edition 3-SK

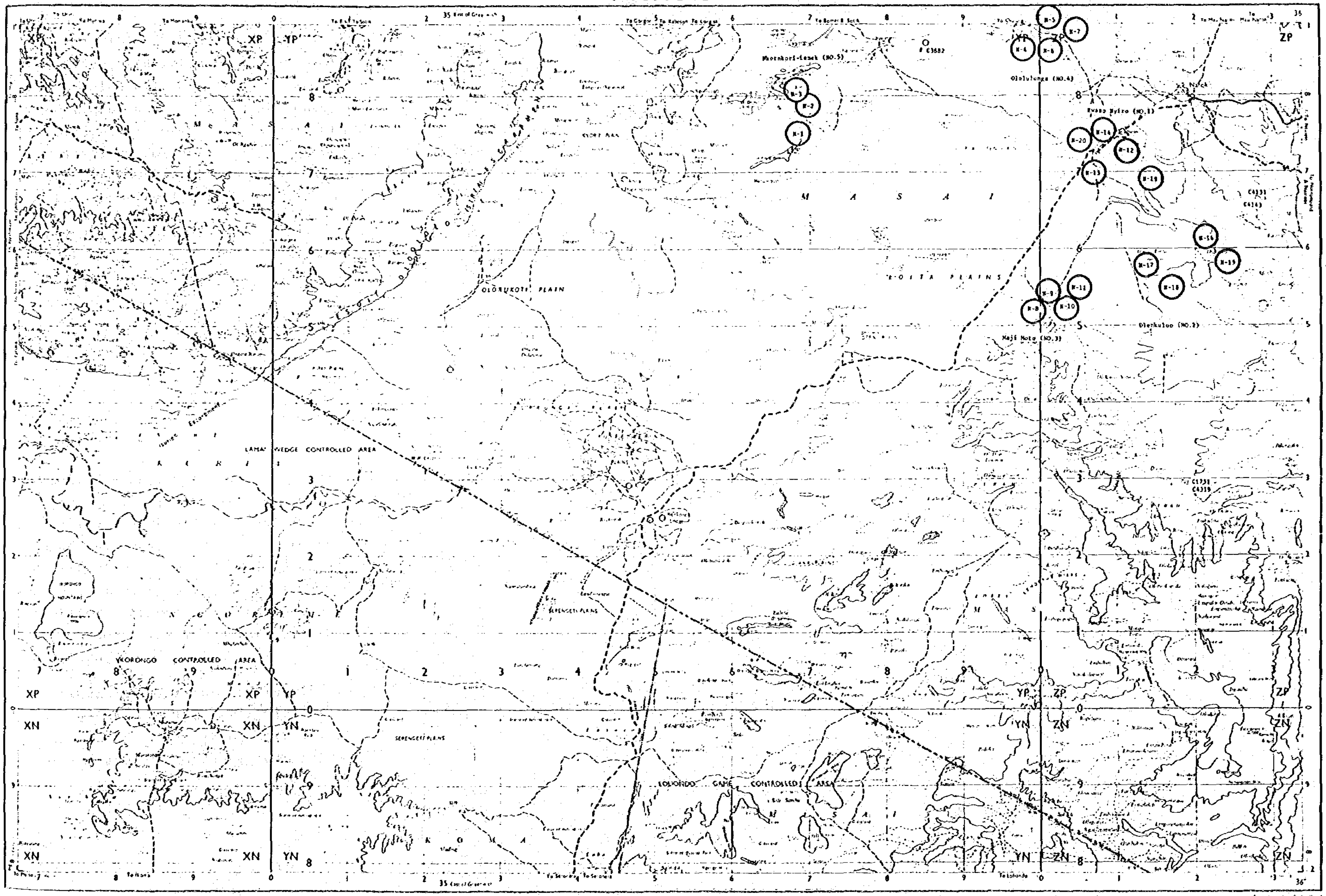


EAST AFRICA 1:250,000 UTM GRID

Fig 2-13

NAROK Geoetectrical Survey Site Map (c)

Series Y503 Sheet SA-36-8 Edition 4 SK



6-2 Analysis of Results

Specific resistivity of an unconsolidated stratum reflects hydrogeological characteristics of that stratum. Soil conditions such as weathered zones, talus sediment, and structural fissures in new sedimentary stratum of Quaternary and Tertiary formations can be found with resistivity tests. Specific resistivity of these new strata are largely dependent on the porosity (ϕ) and the water contained in the stratum.

The relation between specific resistivity and porosity in layers is shown in the empirical equation below. This equation assumes the layer with 100% staturation by groundwater. Rw is the spec specific resistivity.

$$R_o = R_w F \qquad F = \frac{a}{\phi m} \qquad (1)$$

a, m; constants

where F is the coefficient of stratum, and is a function of porosity (ϕ).

Specific resistivity of a stratum is directly proportional to water quality and inversely proportionaly to porosity. Assuming that the water quality contained in a certain calys is constant, because of large porosity of the clay and its specific resistivity is smaller. Sand and decomposed rock layers which have smaller porosity, have larger specific resistivity. Therefore, an optimum range of specific resistivity can be estimated by the conductivity of the groundwater by the above equation (1).

As ground water flows, layers with more sand and conglomerate layer, parts of the layer with larger specific resistivity form aquifer while those with lower specific resistivity, forming aquiclude, allow identifications.

Specific resistivity for consolidated rock increases with rock hardness.

In addition to the geoelectric survey, electric conductivity of well water and surface water at each site have been analyzed as part of the field work. Geological data of all nearby water wells has been collected to increasethe accuracy of the analysis. Results of the geoelectric survey analysis are below.

Kajiado District

o <u>Oldonyo Onyokie (No. 3 site)</u>

Pre-Cambrian basement rock widely distributed in this area, consists mostly of gneiss and schist. As the surface is weathered, few new rocks were observed. Occasionally, outcrops were found on riverbeds. They were generally hard rock such as gneiss or quartz. Ground water is thought to be flowing deep under the weathered zone. Judging from the conductivity of borehole C-3744, 900μΩ/cm (11Ω-m), a specific resistivity of 40 to 70Ω-meters is most likely for the aquifer of this area. The 2nd possibility is in the layer with a specific resistivity ranging from 10 to 110Ω-m.

The appraisal for each site is summarized below.

Point K-1 - This point, up to the depth of 19m, is composed of weathered zone. Then, is composed of hardrocks slightly weathered. There is no optimum aquifer. In the surface zone upto the depth of 19m, some permeability is observed, but because of the high elevation, there is probably no ground water flow except in the rainy seasons.

Point K-2 - This point was close to a river and borehole C3744 but no optimum aquifer was found. Layers with some permeability are expected at depths of 2.2 to 3.5m, 15 to 23m and 43 to 64m. The bore hole probably gets ground water from these layers.

Point K-3 - The survey was made along the upper stream of the river where underground water flows in a permeable layer laying about 2 to 13m beneath the surface. Below this were slightly weathered hard rock.

Point K-4 - The survey was conducted on the plain across the river. Generally, in this point, not much weathering was observed. Although layers with certain permeability exist between 34 to 70m under the ground, no ground water flow is expected in the dry season because of the high elevation.

From the inforamtion above, it appears there are no exceptionally good aquifers in the area. Among these points Point K-2 is the best possible source of water. Point K-3 is the next best.

Zones where ground water can be expected are limited to within a range of 500m from the river. Juding from information on the existing borehole (C3744) not much ground water can be expected from this site.

o <u>Selengei (No. 4 site)</u>

A base of Pre-Cambrian, mostly composed of schist, was found on the dry river bed of the River Selengei which runs near this site. Upstream, the river is covered by volcanic ashes of the Quarternary on the eastern side of the river while in the western side of the bank is covered by red soils.

Data of from the 96m deep borehole C1290 which is 15Km apart from this site, shows that at this point the layer is composed of a little weathered basement rock from the surface to a depth of 96m (0 to 96m), with somewhat new rocks existing in the midway. The conductivity of this borehole was 800μΩ/cm (13Ω-m). This indicates that the optimum specific resistivity of the aquifer in the site is between 50 to 80Ω-m, followed by 10 - 130Ω-m range. From these, following conclusions are obtained on each point.

Point K-5 - This point is composed of volcanic ash layer upto 0 to 15m and then considerably weathered basement rock. Specific resistivity of 8,83Ω-m suggests existence of considerably good aquifer.

Point K-6 - Although there are slightly weathered layers between 20 to 76m, generally, it is considered that judging from the large specific resistivity, there are not many aquifer.

Point K-7 - Permeable layers are supposed to exist depth of between 2.2 to 4.4m and 31 to 50m. However, due to it's depth, it is feared that during dry season ground water may dry up.

Point K-8 - Although this site has certain permeable layer in the shallow layer ranging 2.2 to 6.3m, due to fewer degree of weathering, not much is expected on existence of aquifer.

From the results of these 4 points, although no excellent aquifer is expected, K-5 point is considered to be the best in this site. If any well should be drilled in this site, such an well should be drilled at K-5 point.

From the general tendency in this site that younger layers are extending to the east of the river, there are good possibility of existence of good aquifer to the east of this river.

In the western part of the river, as is observed at Point K-7, better result will be attained at the western part too, as the center of plains lies west of this river.

o Lengism (No. 5 site)

Alluvium lowlands are covered by grey sand clay, and highlands of plateau type are mostly composed of red clays. As there are some points in highlands where quartz and schists exist, it is considered that at shallow underground, Pre-Cambrian basement can be found.

The Section of Borehole of C-1221 Borehole indicates that between 0 to 25m, alluvium layer and then basement rock composed of Geniss distributes. From the conductivity of the sample water of this borehole, 1450μΩ/cm (6.9Ω-m), appropriate specific resistivity of good aquifer is supposed to be 30 - 41Ω-m in this area. Then, it is probably that good aquifer exists in layers with specific resistivity of 7 to 70Ω-m. From these, following conclusions are obtained on each point.

Point K-9 - Survey was made around C-1221 borehole. Upto 23m, the layer is alluvial layer, with increasing specific resistivity after 23m, which corresponds to the basement rock.

Although there are aquifers, supposed to be good, in layers ranging between 17~23m, no existence of aquifer in other depth can be expected. Therefore, this ground water is considered to be river bed water flowing shallow underground layers.

Point K-10- This survey had been made at the low alluvium land. Specific resistivity is generally low and it appears that upto deeper point, weathered zone exists. As with K-9 point, it is expected that good aquifer exists between 31-42m, in addition, at the deeper point, permeability is expected because of low specific resistivity.

Point K-11- Survey was conducted at midpoint between lowlands and highlands. Not much is expected because of generally high specific resistivity. However, some permeability is expected between 26-52m where a low specific resistivity of 90Ω-m was observed.

Point K-12- Survey was conducted near the boarder between highlands and lowlands, which shows beautiful curves.

There are some aquifers which look better in the layers between 15 to 40m of which certain water supply can be expected. This water, however, is considered to be of the river bed water. In further deep point, because of the hard rocks, no water can be expected.

Point K-13- This survey point is at a mid point of a plateau. Although a thin layer, there is a layer of which existence of an aquifer is expected, between 19 and 22m. Between 22 and 83m, certain permeability is expected.

From the above results, Point K-10 is supposed to be the best point near this site. Then K-12 will be the next best point. Wells should be drilled at these two points for test of water volume and water quality.

o Kenya Marble Quartz (No. 2 site)

The surveyed point locates on the valley along the Toroka River which runs between Kajiado and Magadi. The width of the valley is about 1Km with it's surface forming smooth steps.

In this areas, which is close to the Rift Valley, the Pre-Cambrian basement rocks distribute, with many wells are drilled along the valley. It is supposed the these wells are making use of ground water which flows through these Terrace sediment and weathered basement zone. One of the borehole, C605 had shown a conductivity of 650μΩ/cm (15.4Ω-m).

Therefore, layers around this site, with a specific resistivity ranging between 62 and 92Ω-m will have good aquifers and those with 15 - 154Ω-m are supposed to follow the above layers. From these, following conclusions are obtained on each point.

Point K-14- The survey was made around Borehole C605. At this point, a sand layer composed of terrace sediment continues upto the depth of 70m. Then, basement rocks were observed. Ground water is supposed to flow in the sand layer lying at the border of these two layers.

Point K-15- This point locates 2.5Km upstream from K-14 point, and the step sediments are as thin as about 20m at this point. Furthermore, after the sediments, hard basement rocks are observed, showing less possibility of aquifers.

Point K-16- In this point which locates after the end of the valley, it appears that clays layer is sedimenting thickly. It is considered that a weathered zone existing deeper than 85m may contain aquifers.

Point K-17- This point locates at the similar point as K-16. At depth of 56m or more, basement rocks are observed. As for the conclusion, although many wells are being drilled around these points, with little success at points far from the River Toroka. As water level may be further deeper at these area, drilling with depth of more than 200 should be tried. Drilling points should be selected at points in plains closer to the Toroka river.

o Ewaso Kidong (No. 1 site)

This site is located at the foot of Susua volcano which is in the Rift Valley basi and the River Ewaso Kedong runs near this site. Topology of the surrounding areas are featured with ups and downs caused by flowing of lava. The drilling of borehole C4971 tried at a point about 5Km from this site resulted in a failure after drilling upto 300m. Since no borehole was available in the vicinity, conductivity of the Ewaso Kedong River was measured, which had shown 250μΩ/cm (40Ω-m). Consequently, it is supposed that the optimum specific resistivity of the aquifers in this area is within a range 160-240Ω-m, followed by a range of 40 - 400Ω-m. Conclusions as the results of these surveys on each point are as under.

Point K-18- Layers at this point are considered to be composed of volcanic sand and decomposed rocks upto 47m, approx. then between 47 and 50m is lava and then both layers alternate. Judging from the specific permeability, these layers are considered to be permeable. The ground water receptable is supposed to be locating deep under ground.

Point K-19- As in case of Point K-18 layers of this point is consisting of volcanic sand and decomposed rocks upto 78m, then lava between 78 to 83m and then alternative layers of tuff and lavas. They have permeability and water level in this area is considered to be low.

Point K-20- This point is supposed to show the same geological conditions as at Point K-18.

Summary of these results suggests that there are thick sedimentation of permeable volcanic eruption.

Existence of a ground water basin with larger capacity, though at a deeper water level, is expected from this site towards north of Mt. Susua. It is recommended to drill a borehole of depth of about 400m.

o Ololulunga (No. 4 site)

This site located at an area up the Ewaso Ngiro River is in a plain with thick loam layers from the Mt. Mau. Deeper layer is a Pre-Cambrian. There is a borehole C3883 about 15Km away, and the conductivity of this borehole was 1,070μΩ/cm (9.3Ω-m). (the figure obtained from a data).

Narok District

o Nkormkori-Lemek (No. 5 site)

This site located in a valley with slow slope which is located among Pre-Cambrian hills scattering around this site. Recently a borehole was drilled in this area (C4442) which a conductivity of 750μΩ/cm (13.3Ω-m). (according to borehole data). Aquifers are supposed to exist in the Alluvium layer and weathered zones with best specific resistivity of 53 to 80Ω-m, followed by a range of 12 to 130m. Results of each survey points are as under.

Point N-1 - This point locating at the foot of hills, consists of alternating layers of clay and hard rocks.

Point N-2 - Similar to N-1 point, this is consisting of alternating clay and hard rock layers. It seems that this pointlacks appropriate layer for aquifer.

Point N-3 - Although upper part is covered by a volcanic clay layer, below 50m, it is supposed that layers are mostly composed of weathered coarse grains.

Overall results suggest that good aquifer zone exists from N-3 towards the Lemek River.

From this figure, the best specific resistivity for aquifer is considered to be a range of 37 to 56Ω-m, followed by a range of 9 to 93Ω-m.

The analysis of the results is shown in attached Geoelectric-Resistivity Section, which shows similar tendency for all points. I.e. from surface a layer of loam clay spreads upto the depth of about 20m. Then upto about 60m, coarse weathered zone is observed. At depth more than 60m, at Points N-4 and N-5, both in western areas, the layers are of hard and in eastern areas, at Points N-6 and N-7, layers are supposed to be of clay. Aquifers are supposed to exist in layers upto 60m deep with good prospects for points N-5 and N-7. As further deeper layers have certain permeability, it is expected that good boreholes can be obtained by drilling upto about 150m

o Maji Moto (No. 3 site)

This site locates at the northern foot of the Loita Hills with a hot spring (55 to 50°C, approx. 1/min) flowing nearby. This hotspring, after flowing about 1Km, goes under the plain. New outcrops (mainly - quartzite) of Pre-Cambrians are seen from place to place on part of the hills.

From the conductivity of the hot spring of 550μΩ/cm (18.2Ω-m), the best specific resistivity of the aquifer of the area is judged to be 73 to 109Ω-m, followed by 18 to 182Ω-m.

Analysis of geoelectric survey points is as shown in. As is shown in this figure, a high specific resistivity is observed at the deeper layer of N-8 point with specific resistivity lowering towards the plains.

Existence of good aquifer is expected at Point N-8. Three other points where thick sedimentation of loam clays, weathered clays exist, do not seem to fit for aquifers.

o <u>Ewaso Ngiro (No. 1 site)</u>

This site locates in the center of the west Narok plain, with the Ewaso Ngiro River running near this site. (the river generally does not dry).

As no borehole water was available in the vicinity, water conductivity was assumed to be 100μΩ/cm (10Ω-m). Consideration was given for use of the conductivity of the Swaso Ngrio River, however, it is considered to be more appropriate to use 1000μΩ/cm from works so far planned).

Thus, the best specific resistivity of the aquifer around this site of 40 to 60Ω-m was reached with 10 - 100Ω-m as the next best range. Geoelectric-Resistivity Seotion shows the analysis of the results, which indicates that surface of the land is covered with loamy clays. Then Pre-Cambrian coarse sand weathered zones are supposed to exist forming aquifer, in a depth of approximately 20 to 60 meter. Layers lying further deeper - with depth of over 70m, generally layers are of hard rocks. However, on sites N-14 and N-20, of the upper stream areas, certain permeability is observed and existence of aquifer at deep layers is expected. N-19 locating at a downstream point, which is of harder layer, appears to have less possibility of aquifer.

o Olenkuluo (No. 2 site)

This site is located near the lift valley, and it shows some different topography full of ups and downs from that of the former sites. The nearby geology shows some dominant tertiary formation (layer), and the hydrated layer seems to originate in its own space, unlike the former Pre-Cambrian region.

Around the N-17 Spot, underground water is naturally flowing, and its electric conductivity was 1500μΩ/cm (6.7Ω-m). Accordingly, the nearby best suitable aquifer layer shows its specific resistivity 27 - 40Ω-m, followed by the other layer with the specific resistivity 7 - 67Ω-m as estimated.

The analytic results of geoelectric survey are as shown in Sectional View, and the specific resistivity was high in general, thus expectable aquifer layer could not found. These layers are estimated to be the hard layer of phonolite of the tertiary formation.

If water-well would be developed at the nearby site, it should be obtained by the investigation of soft layer of the tertiary formation.

7. Conclusion

The following is the summary of conclusions of the basic Hydro-geological studies on Kajiado-Narok Districts, including field survey works, studies of materials available and geoelectric resistivity survey which had been conducted during 70 days period of from November 20th, 1981 to January 28th, 1982.

(a) Rainfalls in the surveyed area were;

Kajiado district; 511mm/year and
Narok district; 939mm/year.

Our trial calculations show that out of the above precipitations following ground water may be obtained.

Kajiado area 22mm/year (or 4.3% of precipitation).
Narok area 118mm/year (or 12.6% of ").

(b) As for soils of the area, as a whole, the Pre-Cambrian basement rocks widely cover from the central to southern parts - or about 50% - of the area. The remainders are mostly consisting of the Tertiary which extends from the Rift Valley to northern parts and Quarternary which scatters on the entire area.

(c) In the Pre-Cambrian areas, ground waters exist in weathered zones. In the younger layers of the Tertiary and Quarternary, ground waters are considered to be forming ground water basins by accumulating in voids of these layers and flowing through coarse grain zones of these layers.

(d) Studies of materials which are mainly consisting of data on about 200 boreholes in the surveyed area revealed the static water level in areas along the Rift Valley was about 100 meter deep and northern parts to the Rift Valley area showed further lower static water level. On the other hand, in other areas, major parts of boreholes have shown static water level of within 50 meter. Existence of many wells was proved by the fact that over 60% of the boreholes have shown specific capacity of one-digit, while there were 22% of good boreholes which have shown 3-digit specific capacities. On coefficient of permeability, 52% of boreholes have shown about $10^{-4 cm/sec}$, similar tendency as in specific capacity. Dynamic water level is generally low with 44% of the boreholes exceeding 75m.

(e) Geoelectric survey was conducted at ten sites of which eight were in Pre-Cambrian layer, where most of the aquifers were supposed to be within 100m, suggesting that they existed in layers not too deep. Another site was in the Tertiary layer where it was supposed that the records was showing permeability up to deep layers. The last site has shown that a hard rock layer was continuing deep into the layer.

(f) Although from the start of this research, it has been our expectation that discovery of good ground water supplies might be promising in the Tertiary and Quarternary layers, one most impressive facts of this recent study is that in the northern part of the Rift Valley, no aquifer has yet been found. It is expected that geoelectric survey of deep layer and drilling of deeper layer may permit to locate aquifers.

Another impressive fact was that so far no success had been recorded in the eastern part of Narok prefecture close to the Rift Valley. It is considered that close examination of records of geoelectric survey may solve this question.

(g) It is considered that the following should be the most essential for ground water development in this area.

- o Close examination of geoelectric survey records. This will allow determination of borehole sites.
- o Conduct of electric logging have not yet been made, it is of absolute necessity to conduct this test.

Fig.2-14 Oldonyo Onyokie (Kajiado district) side
Geoelectric-Resistivity Section
(dimension: Ω-m)

S {vertical = 1 : 2000
horizontal = 1 : 40000

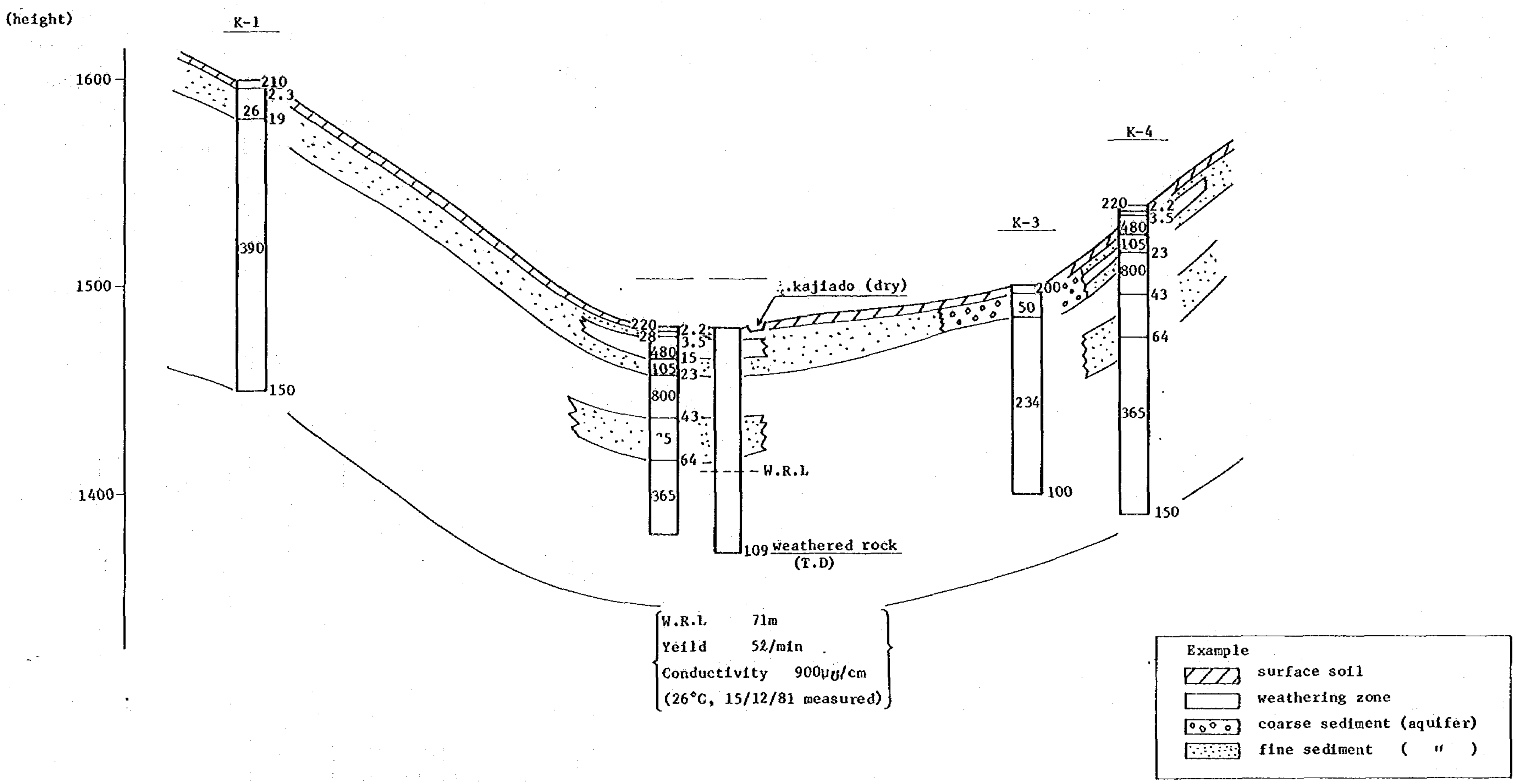


Fig.2-15 Selengei (Kajiado district) site
Geoelectric-Resistivity Section
(Dimension: Ω-m)

S {Vertical = 1 : 1000
Horizontal = 1 : 40000

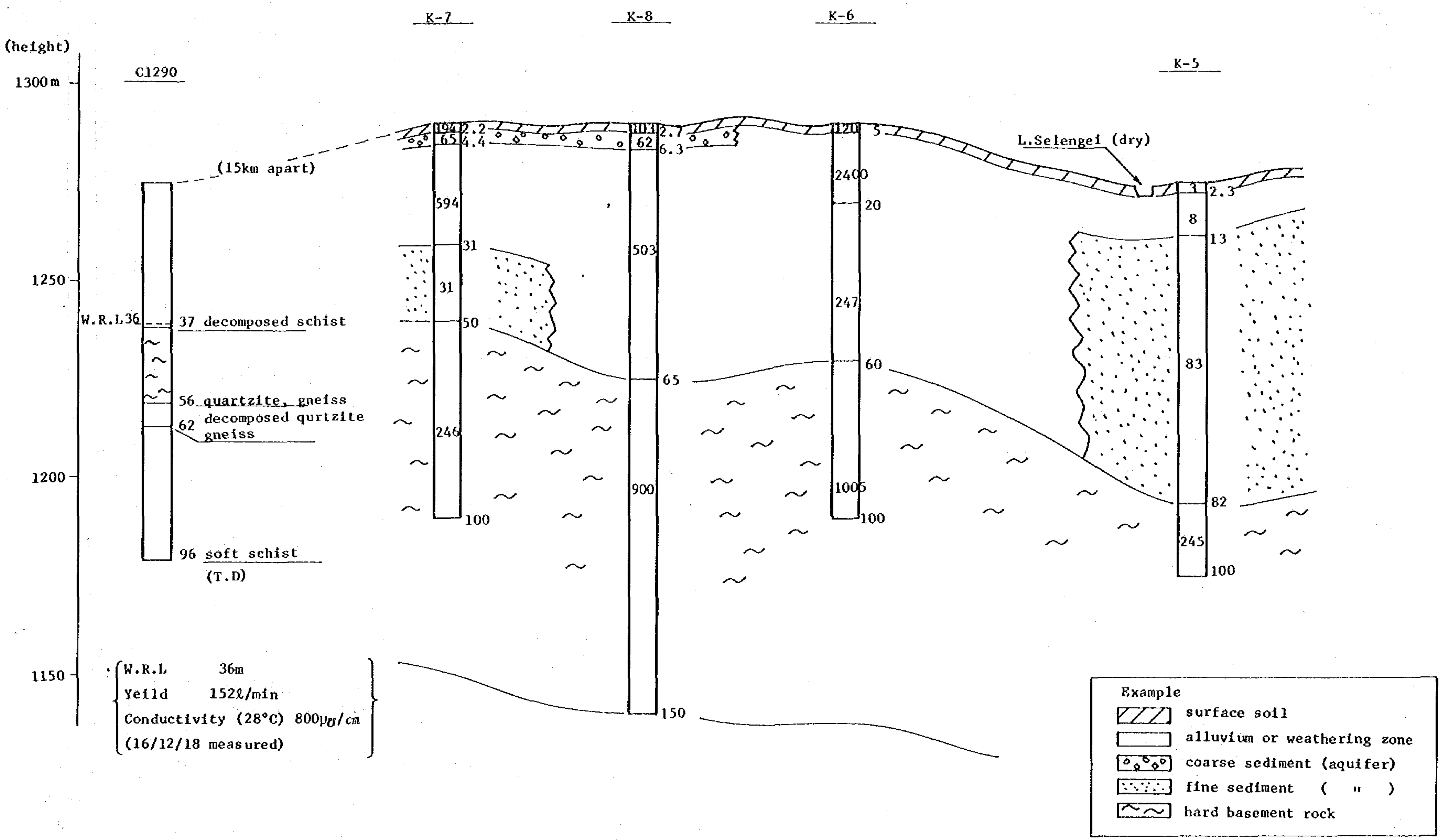


Fig.2-16 Lengesim (Kajiado district) site
Geoelectric-Resistivity Sectional Diagram
(dimension: Ω-m)

S {vertical = 1 : 1000
horizontal = 1 : 40000

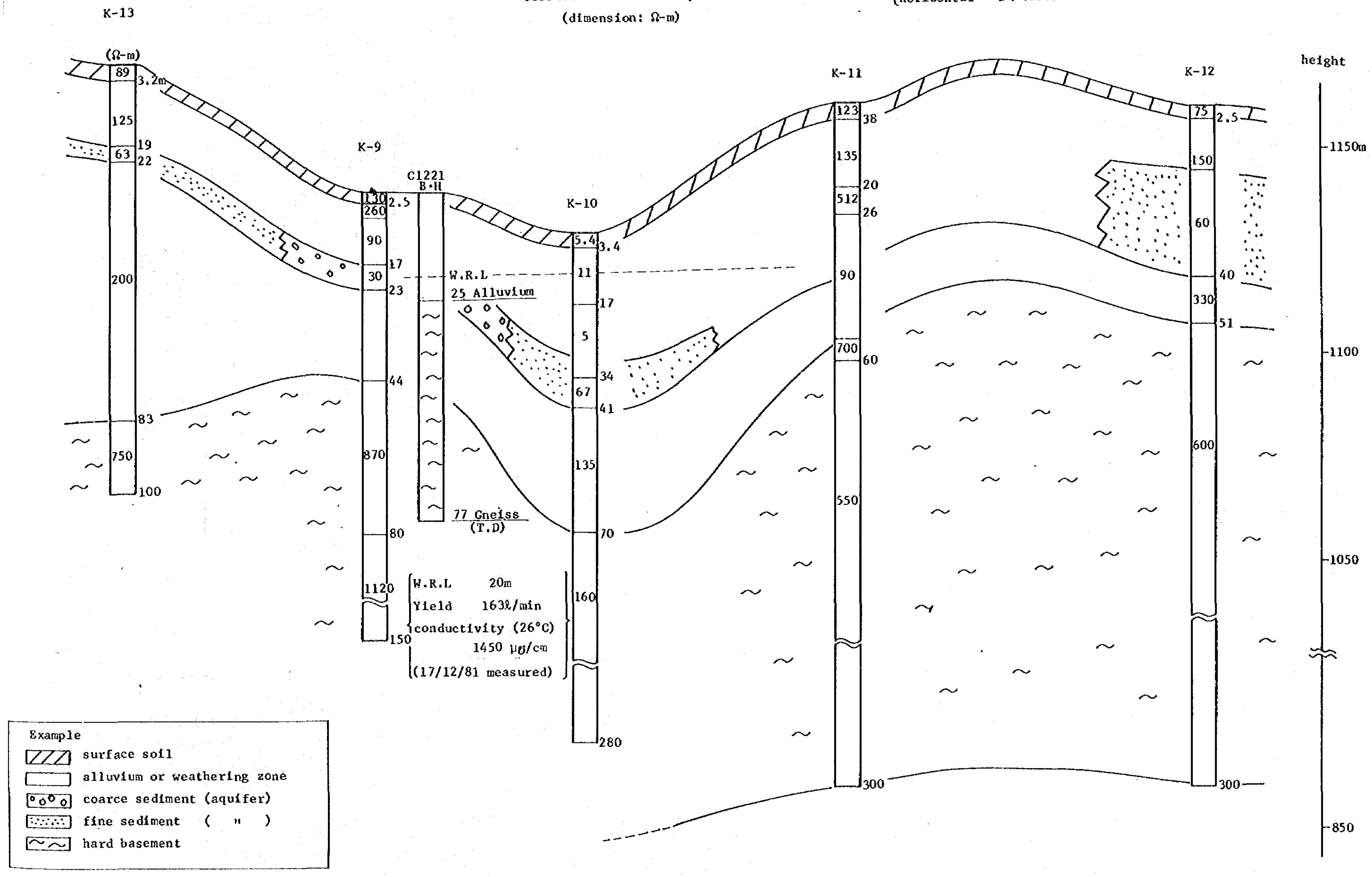


Fig.2-17 GEOELECTRIC - RESISTIVITY SECTION OF KENYA MARBLE QUARRY SITE

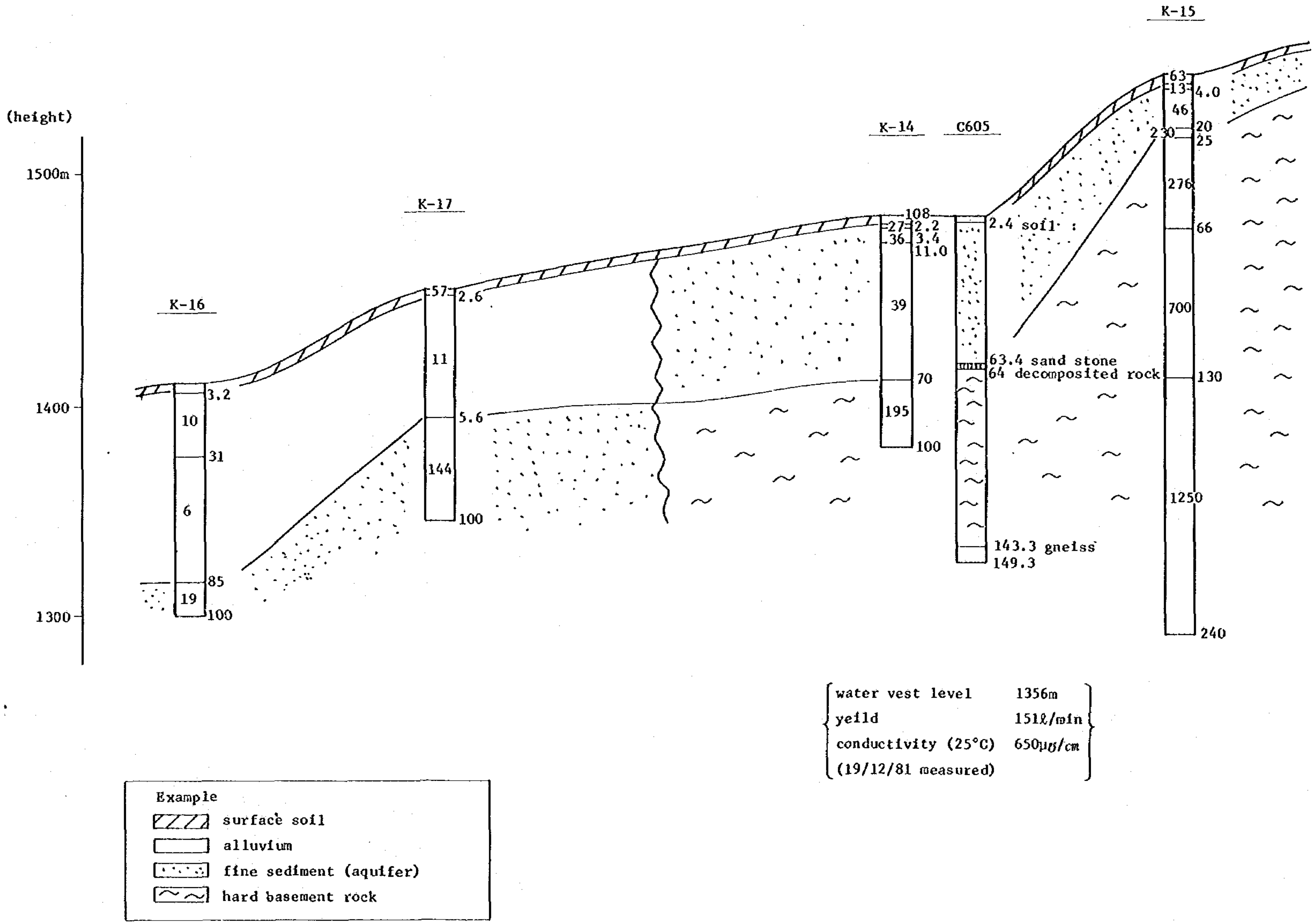


Fig.2-18 GEOELECTRIC - RESISTIVITY SECTION OF EWASO KIDONG SITE

(dimension: Ω-m)

S { vertical = 1 : 2000 / horizontal = 1 : 4000

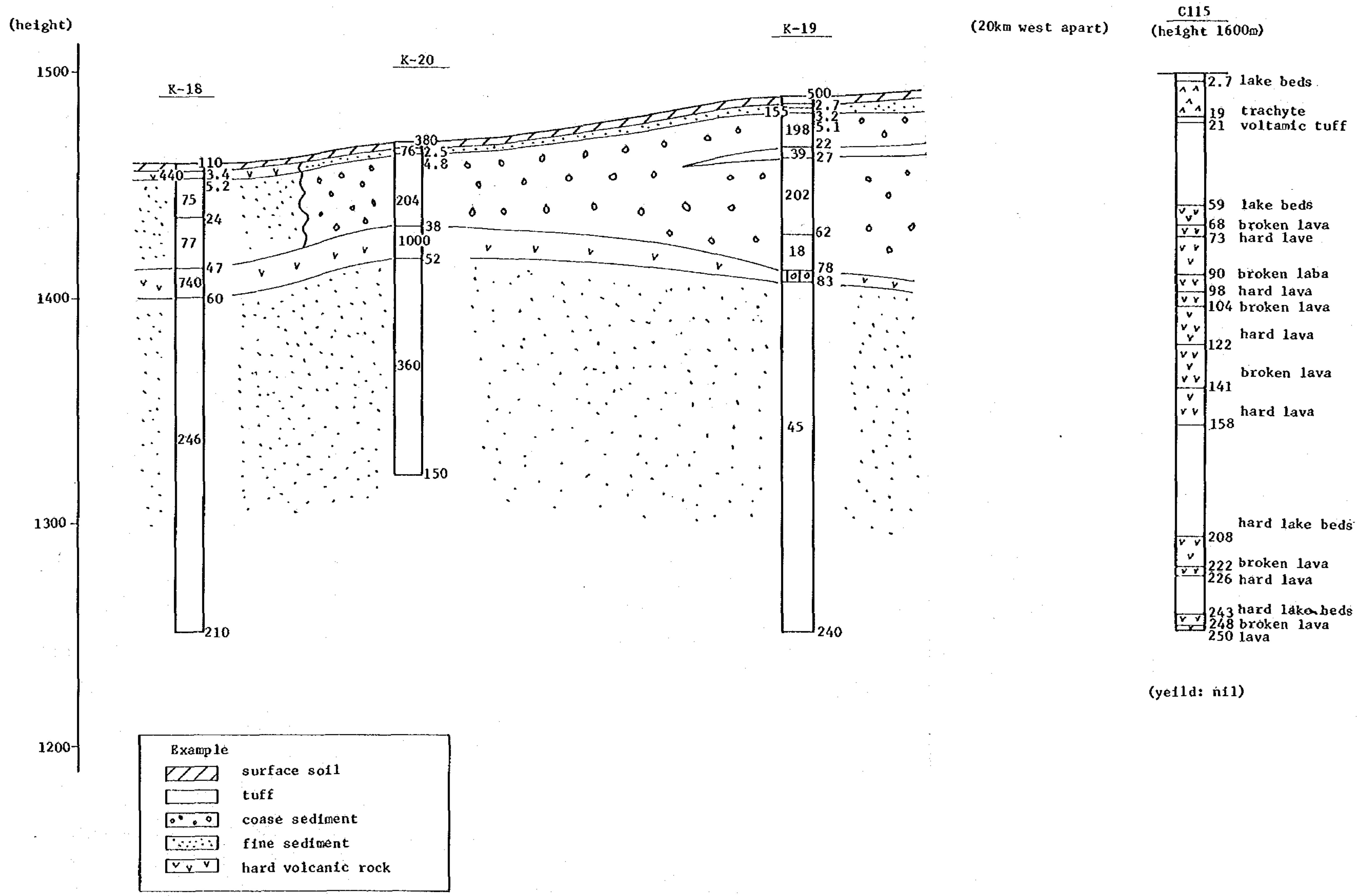


Fig.2-19 GEOELECTRIC - RESISTIVITY SECTION OF NKORNKORI LEMEK SITE

S {vertical = 1 : 1000; horizontal = 1 : 10000}

(dimension: Ω-m)

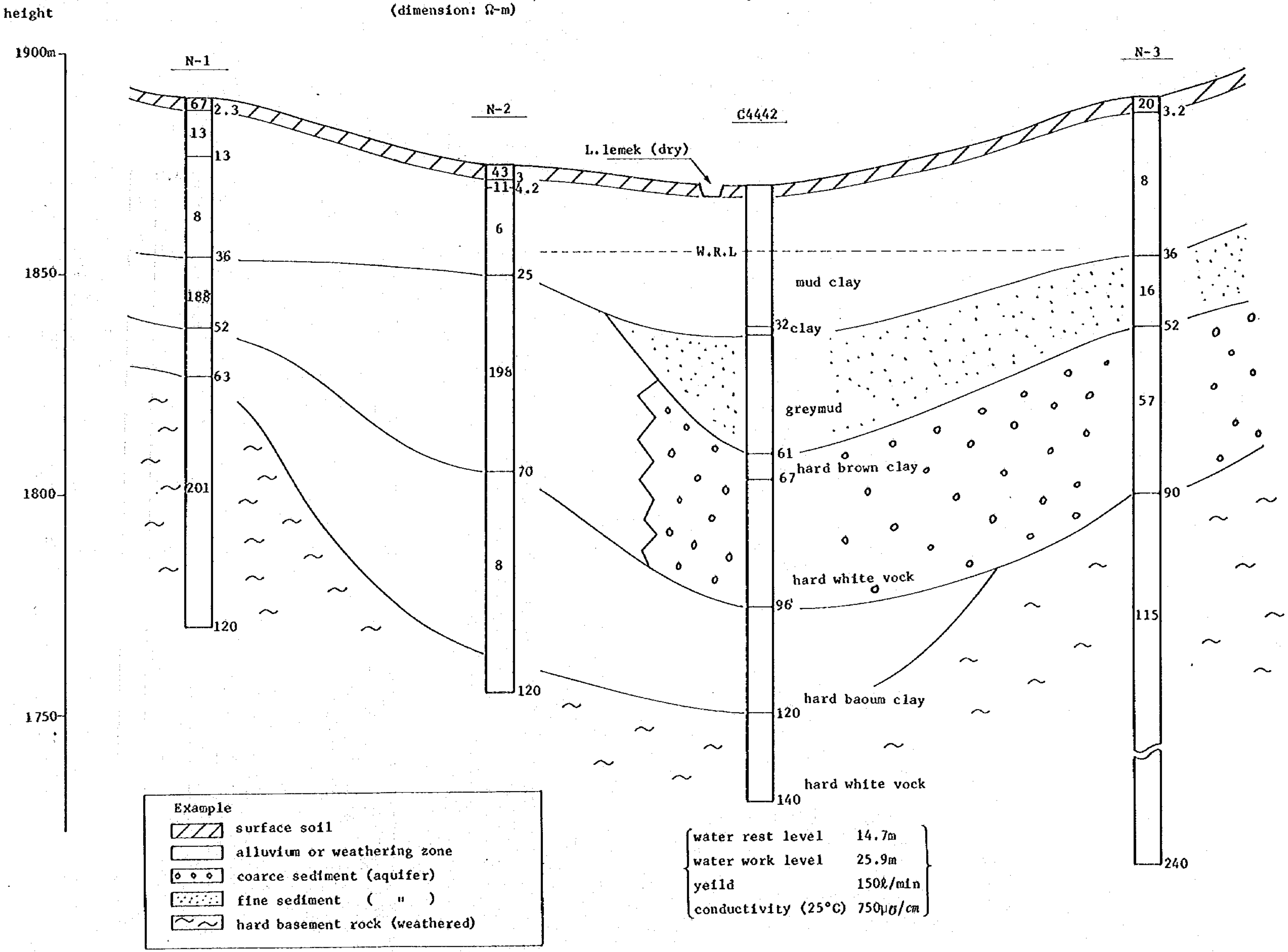


Fig.2-20 GEOELECTRIC - RESISTIVITY SECTION OF OLOLULUNGA SITE

(dimension: Ω-m)

S { vertical = 1 : 2000; horizontal = 1 : 15000 }

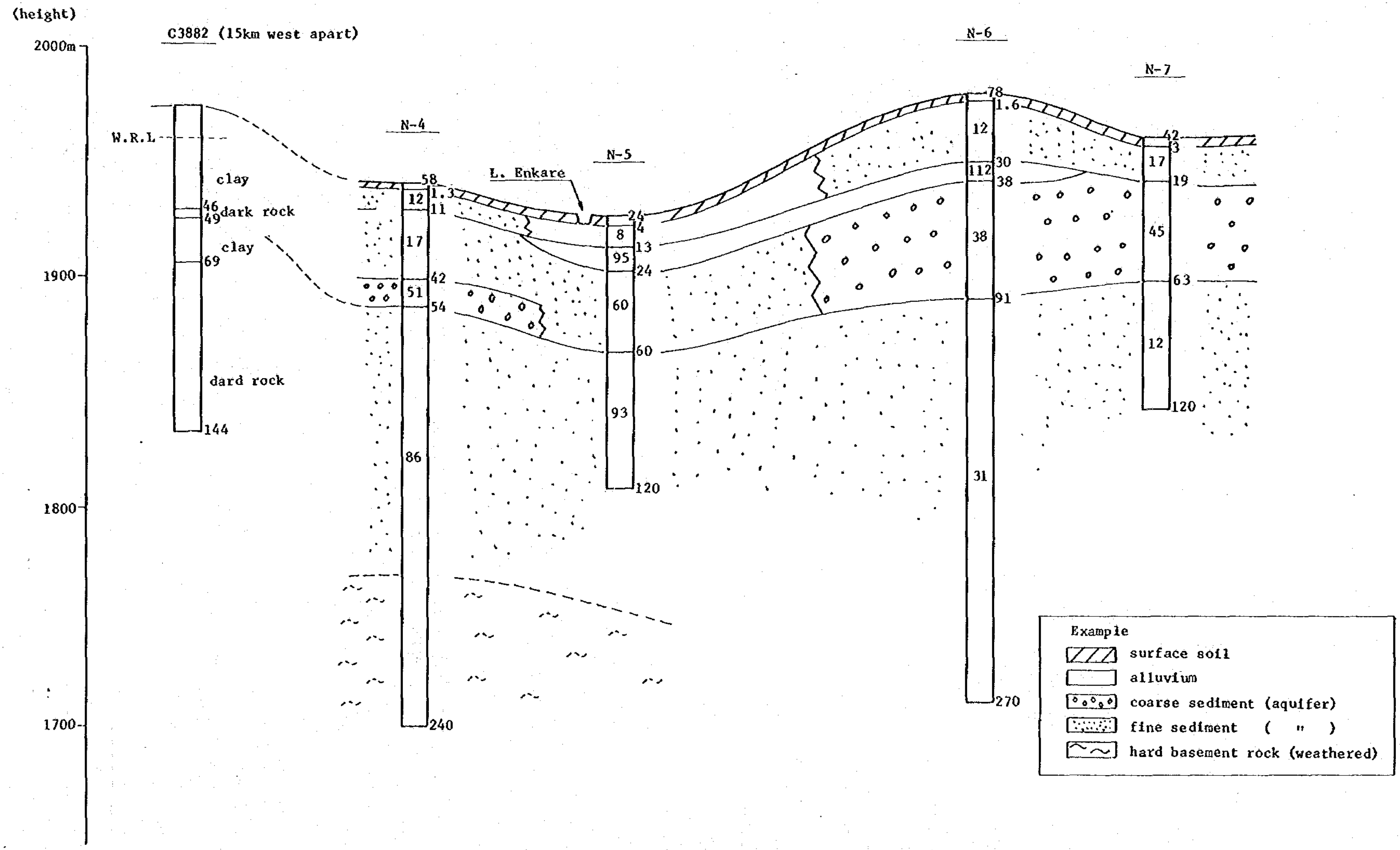


Fig. 2-21 GEOELECTRIC - RESISTIVITY SECTION OF MAJI MOTO SITE

vertical = 1 : 2000
horizontal = 1 : 15000

(dimension: Ω-m)

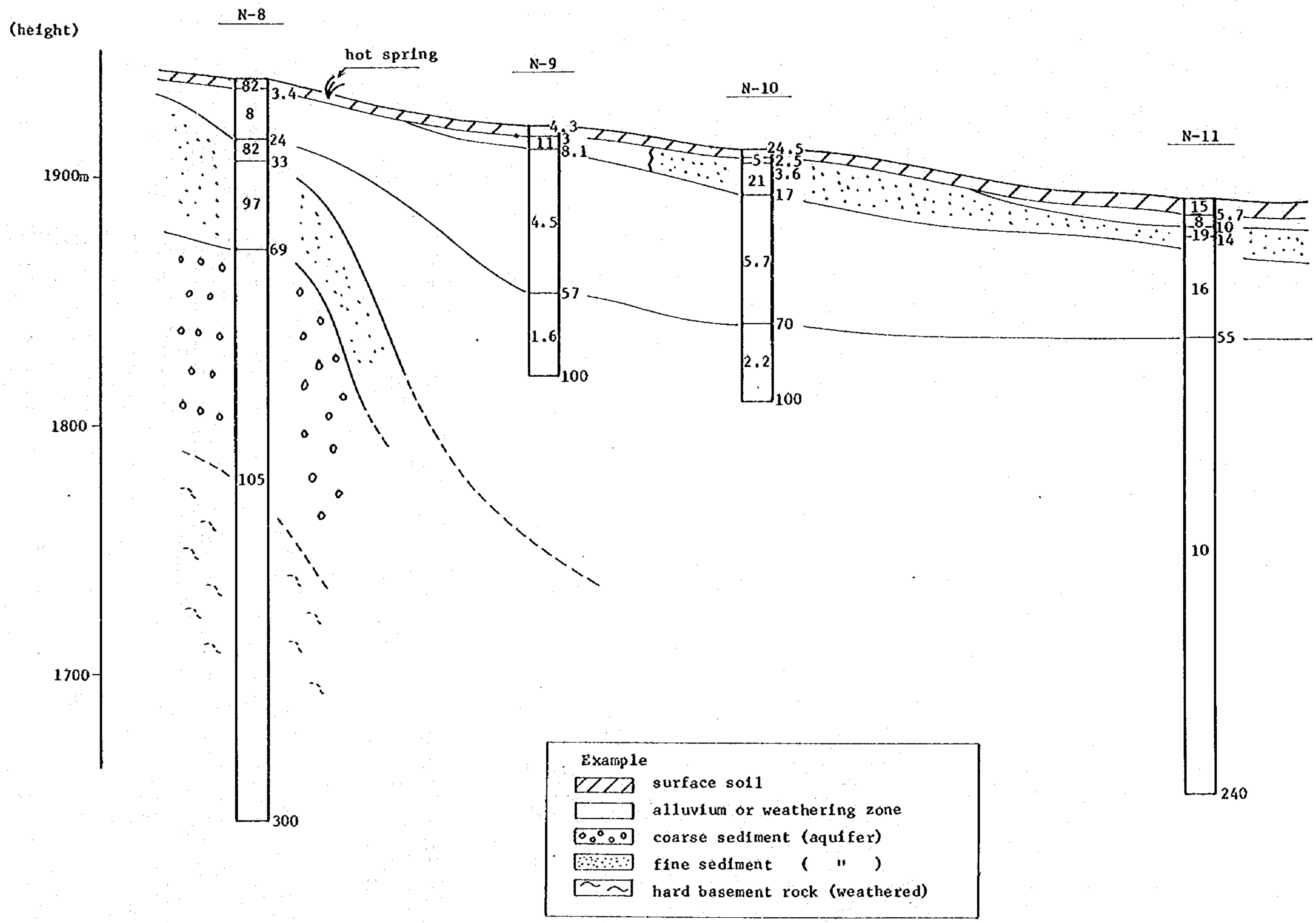


Fig. 2-22 GEOELECTRIC - RESISTIVITY SECTION OF OLENKULUO SITE

(dimension: Ω-m)

S {vertical = 1 : 2000; horizontal = 1 : 15000}

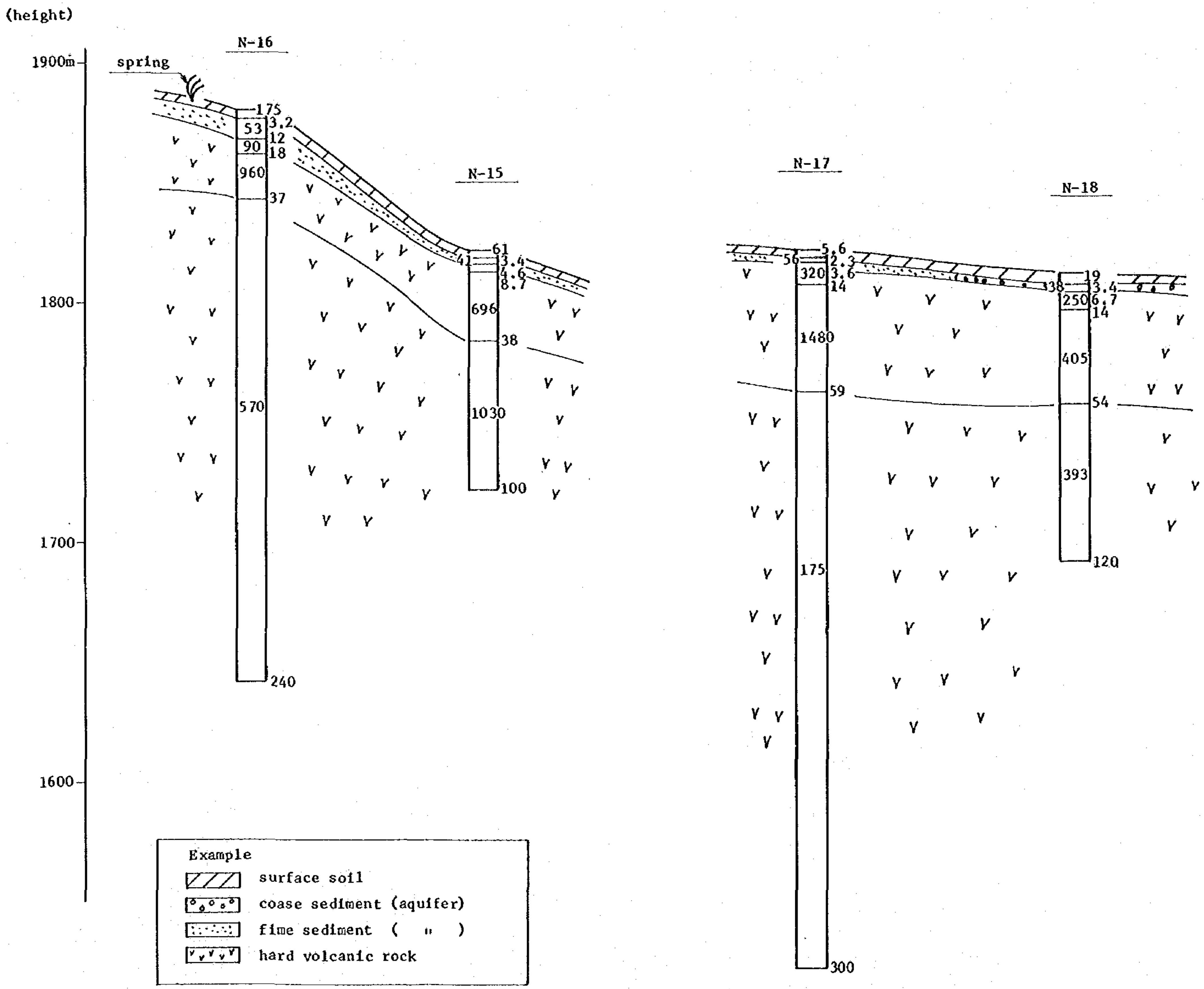
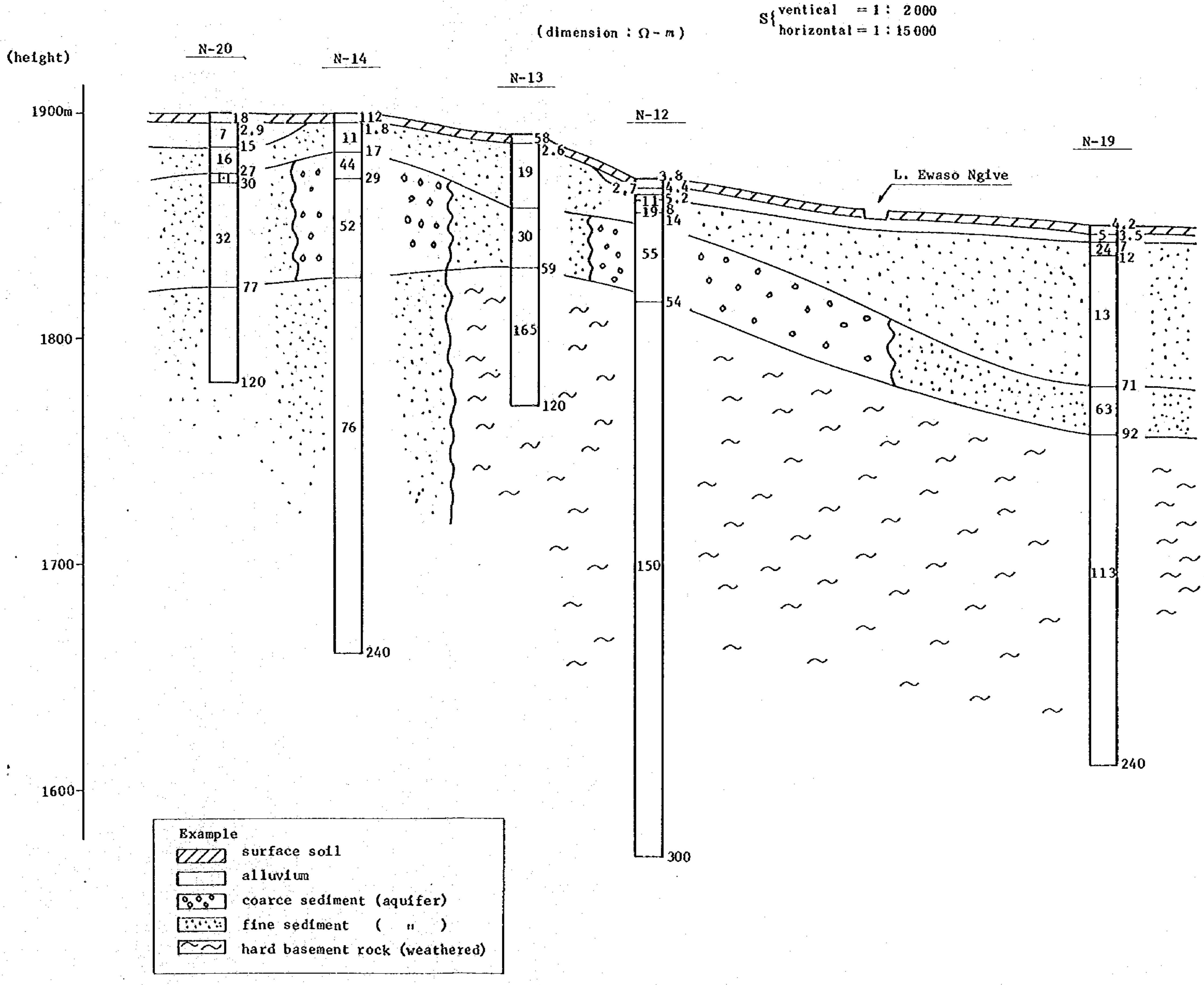


Fig. 2-23 GEOELECTRIC - RESISTIVITY SECTION OF EWASO NGIRO SITE



APPENDIX 3

MINUTES OF DISCUSSSION

JAPAN/KENYA CO-OPERATION
AGREED MINUTES OF DISCUSSION

In response to a request by the Republic of Kenya for the Kajiado/Narok ground water development project the Government of Japan sent through the Japan International cooperation Agency (JICA) a team headed by Mr. Kiyoshi Kato, Director, Grant-aid Department, JICA to Kenya to conduct a basic design study for 9 days from December, 7 to 15, 1981.

The team had a series of discussions and exchanged views with leading officials from the Ministries of Water Development and Livestock Development.

As a result of the study and discussions, both parties agreed that the principal concepts that have been agreed upon, shall form the basis of the report made to the Governments of Kenya and Japan. The major items are prescribed herein and in the annex.

NAIROBI, 15th December, 1981

Mr. Kiyoshi Kato,	Mr. A.N. Ndiho,
Leader,	for PERMANENT SECRETARY
Japanese Basic Design Study Team	Ministry of Water Development KENYA

ANNEXE

I. Project sites identified by the Government of Kenya for future development. Geophysical investigations are to be undertaken on the first five sites of the Group Ranch category in both Districts.

II. Inception Report as finally agreed by the Ministry and the Basic Design Study Team.

III. Equipment list in their order of priority as agreed by the Basic Design Study Team and the Ministry.

IV. Kenya Government obligations.

V. List of Participants in the Meetings.

VI Other Kenyan request.

ANNEXE I

The following project sites have been selected by the District Development Committee and submitted to the Ministry for the RWS Programme Phase V.

Narok District

1. Nairage Nkare
2. Ololounga
3. Ewaso Ngiro
4. Narosura
5. Olmasutie
6. Emarti
7. Enabelbel
8. Enengetia
9. Mosiro
10. Olopironit

Kajiado District

1. Kajiado Town
2. Nol Turesh
3. Kibiko
4. Kisamis
5. Elangat Nkorai
6. Oloorera
7. Eukorika
8. Kiseria Nkorai
9. Mparasha Pipeline

Apart from the sites for RWS Programme Phase V, there are 47 schemes listed under the Group Ranch Water Supply Programme for future implementation. These are as follows:-

Kajiado

1. Ewaso Onkidongi
2. Loodoariak
3. Kilonito
4. Oldonyio-Onyokie
5. Shombole
6. Endoinyio Narok
7. Olkeri
8. Torosei

9. Meto
10. Lorngosua
11. Ilpartimar
12. Oldonyio-Orok
13. Mailua
14. Enkaroni
15. Nkoile
16. Esokota
17. Sajiloni
18. Enkorika
19. Lolgirra
20. Olkulului
21. Osilalei
22. Emotoroki
23. Lolarash-West
24. Lolarash-North
25. Lolarash-South
26. Mbirikani
27. Kuku
28. Individual Ranches - Ilbissil Area 2B/H
29. Individual Ranches Kaputiel Plains 3B/H
30. Individual Ranches Kajiado Area 2B/H

Narok

1. Ewaso Nyiro
2. Oldonyo Rasha
3. Olenkuluo
4. Maji Moto
5. Narosura
6. Ololulunga
7. Nkorkorri - Lemek
8. Moyoi Transmara
9. Oloirien-Transmara
10. Entasekera
11. Olmetic
12. Morijo Loita
13. Naikarra
14. Leshota
15. Noorpopong-Suswa
16. Olkinyei
17. Koiyaki

ANNEX II

The Ministry of Water Development
Republic of Kenya

INCEPTION REPORT

FOR

BASIC DESIGN STUDY

ON

KAJIADO-NAROK GROUNDWATER DEVELOPMENT

November, 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

<u>TABLE OF CONTENTS</u>

1. INTRODUCTION

A request was made by the Government of the Republic of Kenya to the Government of Japan for international cooperation of the captioned project on the grant basis. Upon the receipt of the request a contact mission was sent to the Government of Kenya in September, 1981.

Objectives of the contact mission were to study the background of the project and to identify the concept of the project for further justification of the execution of the requested international cooperation. For this purpose, a preliminary study and discussions were made by the mission and the Government officials concerned.

As a result, it was found that about 20 sites were applied to the Ministry for implementation of the rural water supply scheme by the District Development Committee in the project area under the Rural Water Supplies Programme Phase V and also about 30 schemes are under planning in the Ranch Development Programme.

Based on the conclusions derived by the contact mission, the Government of Japan determined to undertake the basic design study. For this purpose a basic design study team is dispatched to the Kenyan Government by the Japan International Cooperation Agency.

The objectives of the basic design study are to draw a clear picture of the project in the context of its justification and to identify the contents of necessary international cooperation. It is also an important subject of the basic design study to make necessary arrangements for the operation and maintenance of the equipment to be provided through international cooperation for their maximum contribution to the project. Finally the assessment of the effectiveness of the international cooperation to the project is an important aspect of the basic design study.

Purpose of this inception report is to summarize objectives and scope of the basic design study and necessary cooperation to be extended to the study team for the successful result of the study.

2. BACKGROUND OF THE PROJECT

A greater part of Kenya is occupied by dry areas which are receiving an annual precipitation of less than 600 mm/year. Accordingly, the water development aiming at an efficient water use and its equitable distribution is one of the most important policies in her development programme. For this purpose a total sum of 6,400 million shillings is appropriated for various kinds of water developments in the five year development plan during 1979 and 1983.

Previously, in the development plan 1974-1978 the basic development goal of the water sector was described as "Bringing to the entire population the benefits of a safe water supply to the requirements for domestic and livestock consumption." It has been the stated intention of the Government to achieve this by the year 2000.

However, at present the population which is receiving clean and safe water supply is 2,700,000 in urban areas and 1,480,000 in rural areas which is equivalent to only 28% of the total population, 14,900,000.

Development activities in the water sector can be classified according to whether they are primarily concerned with the water supply needs of rural dwellers or primarily aimed at expanding water supplies in urban places. Within these broad classes, and taking account into the resources constraint, programme targets have been set for the 1979-1983 plan period. These are :-

i) To expand the coverage of improved water supplies to include more people residing in the rural areas thereby increasing the total rural population served to over 4 million people by 1983.

ii) To increase the number of people served by an improved water supply in urban places by 1,360,000 so that the total urban population served will be approximately 3,945,000 people by 1983.

iii) To achieve a better balance between the sewerage systems and water supplies in some of the larger urban places.

iv) To complete Stage I of the National Master Water Plan concerned with data collection, and then to move into Stage II concerned with the master plan for national use of water resources over the next years or so.

v) To increase substantially the effort applied to water conservation over the plan period in recognition of the increasing importance of conserving as much as possible of the nation's water resources and related it to the soil conservation programme.

vi) To expand activities in the areas of flood protection and drainage of swamps and valley floors as part of the effort to increase the quantity of agriculturally productive land in the country.

vii) To expand the use of water for minor irrigation activity throughout the country.

viii) To upgrade substantially the role of the private sector water development activity and to integrated this effort completely with planned public sector activities and self-help activities.

In order to achieve above targets, much efforts have been made through the phased Rural Water Supplies Programme since 1970. At present a part of the rural water supply schemes under Phase III and Phase IV are under construction and preparatory work has been commenced for Phase V.

At the same time, development of arid and semi-arid regions in the country is also another emphasis in the national development programme. For this purpose various measures have been applied to upgrade economy and living standard in such dry areas.

For this purpose, another water supply schemes are provided in the semi-arid and arid areas under the Ranch Development Programme. This is a special water supply programme for livestock development in the North Eastern Province, Narok-Kajiado Province and Taita Province partly sponsored by the World Bank since 1976.

3. THE BASIC DESIGN STUDY

3.1 The Project Area

Under the circumstances, the Kajiado-Narok are is selected for the project area. The Kajiado-Narok area lies approximately between latitudes 0°35'S and 3°15°S and longitudes 34°30'E and 37°55E' covers some 28,000 km^2.

To the West, Narok District is bordered by South Nyanza and Kisii Districts; to the North-West by Kericho District; to the North by Nakuru District. To the East of Narok District is Kajiado District which is bordered to the North by Nakuru, Kiambu and Nairobi District; to the East by Machakos District and to the South by Tanzania Republic.

Although the area has seven permanent and seasonal rivers flowing westwards and southwards, groundwater is the major source of water due to the vast aridness and the diverse topography. The area has littlerainfall of between 400-500 mm/year which contribute to the aridness and prolonged droughts.

The Mau Narok, Loita and Chyulu Hills form recharge and catchments to a small portion of the whole area.

Geologically, the area is underlaid by both metamorphic and volcanic rock formations. Generally, the metamorphic rocks give very little yields and poor quality of water while the volcanics have high and good quality waters.

The project area has a population of about 350,000, some settled here and there near the hills along the riverbeds. Others lead a nomadic life dictated by availability of water and seasonal grazing. population of 750,000 is projected for the year 2000. There are over 200,000 heads of cattle, goats and sheep. Only lesr than 10% of the total population has access to clean water.

The economic activities in the area include traditional livestock keeping, as the major pre-occupation,subistence framing and tourism. The latter thrives on wild game viewing by tuursits.

On the whole, the project area has big potential for livestock and agricultural development provided that good water is made available. similarly, the living conditions of local people will be improved and more social facilities provied. There is therefore very big demand for a lot of good clean water to be made avilable.

3,2 THE PROJECT.

In order to provide clean and adequate water for both of people and livestock in the area. The project implementation is organized in the following stages.

(1) Water Resources Assessment.

The initial stage of the project is to assess the type and magnitude of water resources available in the project area.

The responsibility for water exploration and assessment rests directly with the Water Resources Department.

Since the project area is occupied by semi-arid areas to a great extent the ground water could be the only avaialble water source in many places. However, the surfaces water is also available in certain areas around isolated hills. Considering the price of water the first priority is placed on the surface water development where ver sufficient and reliable water sources are available.

(2) Water Source Planning

Based on the results derived from water resources a assessment, The most rational type of water source has to be planned in each locality of the scheme. Economy of the water is one of the most important aspect in the selection on the water source.

In a semi-arid area a deep well could be the only water source. However, considerational are given to shallow wells with hand pumps where a shallow aquifer is available which has advantages in both of capital investment and operation/maintenance cosy.

The other type is small to medium scale earth dams for conservation of surface water. For this purpose the existiong Dam Construction Unit have been achieving considerable performance on the other provinces with the similar geographical conditions. DUC is consisted of earth moving heavy machinery and supporting equipment. At present, 5 Dcus are under operation in various areas in dry regions of the country.

(3) Project Implementation

At this stage of the project, necessary project, necessary procedure are undertaken for the implementation of the each identified scheme which requires ample volume of work for designing and material for construction.

There are two major national programmes in relation to the project, the one is Rural Water Supplies Programme and the other is Ranch Water Development. The Rural Water Supplies Programme is the most important national water supply programme and commenced in 1970. The phase I of the programme completed 72 rural water supply schemes. The pase II has completed 29 schemes with sh.56.7 million in 1972. In the phase III and phase IV. 70 schemes and 65 schemes were plannes respectively and are undergoing at present. Recently preparatory work for phase V has been commenced. Many numbers of water supply schemes are planned for the project areas u nder this progamme. The Ranch Water Supply is a rural water supply progamme aiming at the up-grading the living standard of the local people and watering livestock especially in arid and semi-arid regions in the nation. This programme has been operated since 1976 and at present various kinds of schemes are under construction in the other dry erea Kajiado/Narok is also a part of project area of this programme.

Under the circumstances the importarnce of the project can not be over emphasized. Each department in the Ministry of Water Department has been making a great effort to achieve the set targets of the national water developmebt programme. However, However, the lack of manpower and equipment and also insufficient fund for the project implementation are the setback to the project to be solved.

3.5 Objectives of The Basic Design Study

Objectives of the Basic Design Study are summarized as shown below :-

(1) To study the present state and the future projection of Rural Water Supply;

(2) To identify the relative situation of the existing and the future projection of the present state of rural water supplies in the project area in comparison with the national condition;

(3) To determine the implementation schedule of Rural Water Supply in the project area;

(4) To identify the necessary items and types of machinery, equipment and material to be provided by this international cooperation;

(5) To estimate the cost of the above necessary items;

(6) To study the most efficient method of operation and maintenance of the machinery and equipment to be provided by this international cooperation;

(7) To determine the most effective method of the required training of the local staff;

(8) To train the local staff on hydrogeological investigation including resistivity survey and

(9) To assess the extent of the effectiveness of the international cooperation to the project.

4. SCOPE OF STUDY

4.1 General Background of Rural Water Supply in Kenya

The contents of the study is summarized as shown below.

(1) Study on the basic policy and its background of the Rural Water Supply in Kenya.

(2) Present state and future projection of Rural Water Supply.

a) Present state of supply and demand
b) Future projection of supply and demand

(3) Type of Rural Water Supply

a) Type of water source
b) Type of water supply facilities

(4) Design criteria and standard design

(5) Cost of Rural Water Supply

a) Material cost and transportation
b) Plant and hire cost
c) Wages

(6) Standardized cost of Rural Water Supply per capita

(7) Financial aspect of Rural Water Supply

(8) Method and system of operation/maintenance including revenue

4.2 Project Preparation

(1) Present state of Rural Water Supply in the project area

a) Present state of supply and demand
b) Future projection of Rural Water Supply
c) Type of available water sources

(2) Determination of project priority and its implementation schedule

(3) Project Site

a) Description of the project sites
b) Hydrogeological condition
c) Supply and demand
d) Basic Design
e) Cost Estimate
f) Cost estimate of the future implementation of the project

4.3 Method and system of the project implementation

a) Institutions and organizations related to the project implementation
b) Financial background of the project
c) Method of operation and maintenance of the items to be provided by this international cooperation
d) Scope of the international cooperation and responsibility of the Kenyan Government for the project

1.4. Identification of necessary international cooperation for the project

a) Determination of the specification for the required machinery equipment and material
b) Determination of the quantity for the required machinery, equipment and material
c) Cost estimate of the necessary machinery, equipment and material
d) Determination of the method and cost estimate of the necessary training of the local staff

1.5 Assessment of the effect of this international cooperation on the project

1.6 Training of the local staff for hydrogeological fiedl investigation and its analysis including resistivity survey

1.7 Recommendations

The flow chart of the scope of study is summarized as shown in Fig. 1.

Fig 1a Flowchart

General Background of Rural Water Supply

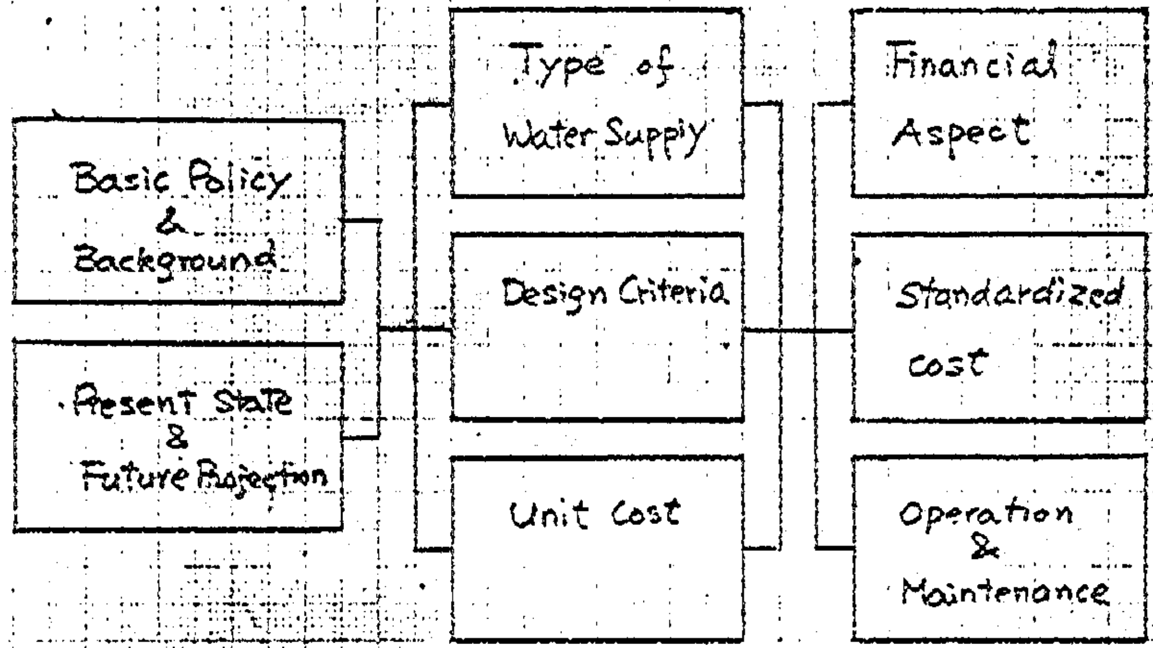
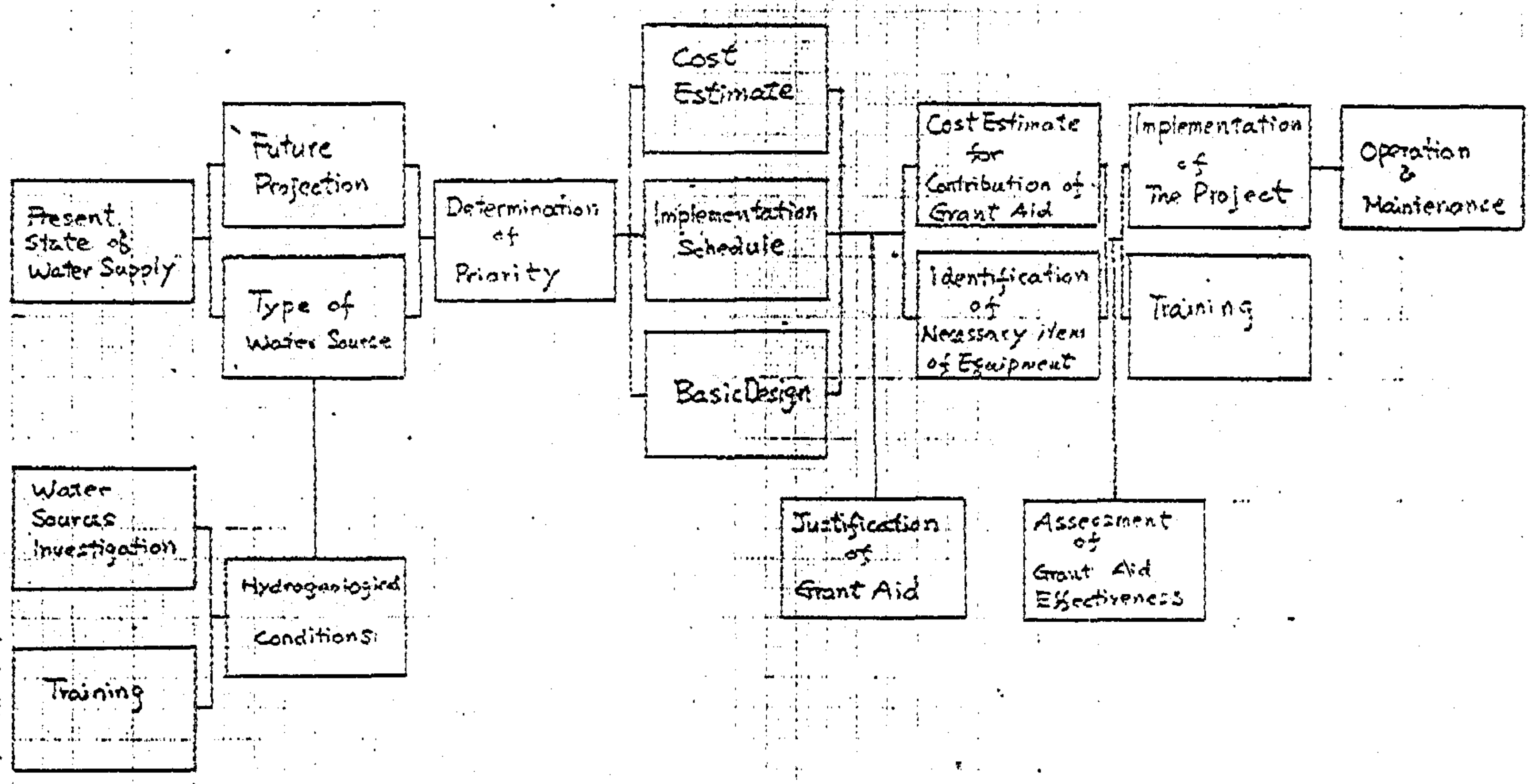


Fig 1b Flowchart

Project Preparation



5. SCHEDULE OF THE BASIC DESIGN STUDY TEAM

The team is consisted of the following four members :.

Team Leader :	Mr. Kiyoshi KATO
Deputy Team Leader: (Planning Engineer)	Mr. Akihiko TOGO
Team Member : (Geophysicist)	Mr. Yukio HOSHINO
Team Member : (Hydrogeologist)	Mr. Yoshimi KISHIKAWA

The time schedule of the study team is shown in the attached sheet.

6. REPORT

Reporting schedule is summarized as below :-

Final Report (10 copies in English) : 20th March 1982

The Final Report (10 copies in English) will be submitted to the Ministry of Water Development by the end of March 1982.

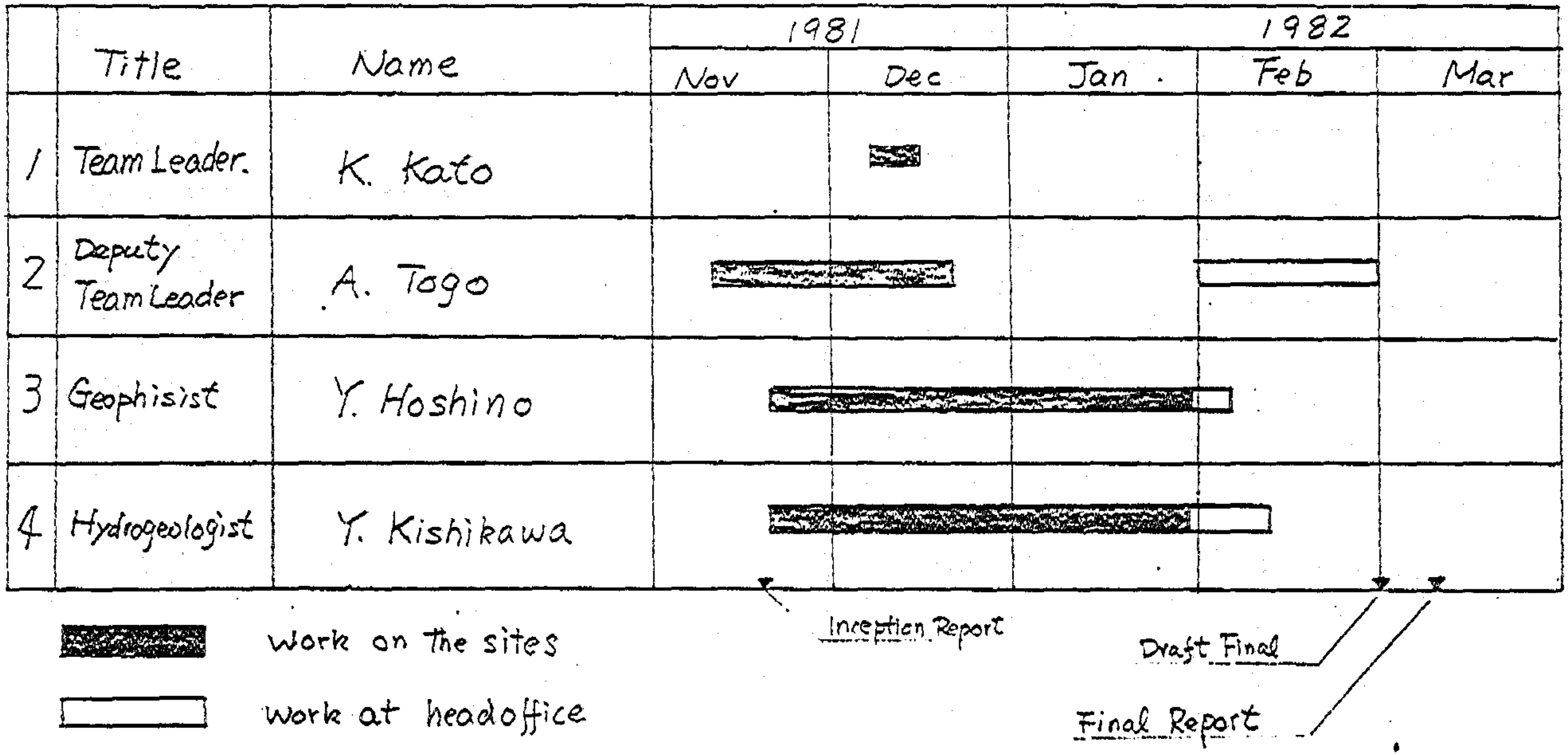
7. CONTRIBUTION OF THE GOVERNMENT OF KENYA TO THE PROJECT

In order to complete this basic design study the Ministry of Water Development is kindly requested to provide the study team with the following data, information and necessary services.

(1) Requested data

a) Available data of hydrology and meteorology
b) Available data of hydrogeology and geology
c) Population census and its future projection
d) Topographical maps scale of 1:50,000 and 1:250,000
e) Price list of the necessary items of rural water supply and drilling
f) Statistics of rural water supply
g) Design criteria and standard design
h) Drinking water standards

Time Schedule of Basic Design Study



(2) Details of present state of rural water supply in the project area

(3) Priority list of water supply schemes and its implementation schedule in the project area

(4) Detailed information of other international cooperation in relation to the rural water supply in the project area

(5) Required counterpart staff

a) 4-hydrogeologists or geophysicists for the training of hydrogeological investigation

b) At least one senior officer from each related division to the project for study on items described in Chapter 4 of this plan of operation

(6) Transportation for hydrogeological field survey. At least one four wheel drive vehicle.

(7) Field accommodation during field surveys for the hydrogeological survey team.

APPENDIX I

PLANT AND EQUIPMENT FOR A NEW CONSTRUCTION UNIT

No.		No.
1.	Bulldozers 300 HP	2
2.	Bulldozers 200 HP	1
3.	Motorised scraper, $15m^3$	3
4.	Towed scraper, $13m^3$	1
5.	Motor grader, 140 HP	1
6.	Selfpropelled compactor	1
7.	Front loader Excavator (Backhoe)	1
8.	Lorry 7-8 tons, tipper	2
9.	Lorry 7-9 tons, flat back	1
10.	Fuel tankers	2
11.	Low-loader, 60 tons pay load	1
12.	$5m^3$ drinking water tanker	2
13.	1500 gallon water trailer	2
14.	Workshop trailer equipped	1
15.	Storage trailer	1
16.	Office caravan equipped	1
17.	Living caravan equipped + 2	2
18.	Diesel generator 250V, 2.5KVA (lighting power)	1
19.	Tents (military type) + equipment	40
20.	Pick-up. 4WD	2
21.	Station Wagon 4WD	2
22.	Various tools and equipment (pumps, mixers, compressors) soil lab.	
23.	Communication equipment	1

Item No. 18-power generator to be supplied chassis mounted. Item No.6 to be a sheep foot roller Item No. 26 will be used along with item No. 11 Item No.24 will be used for pulling the caravans, compressors power generator, welding generator.

Item No.25 mainly for casual labourers and subordinates

NO.		QTY
24.	Excavator (Wheeled)	1
25.	Farm Tractor with open trailer	1
26.	Concrete mixer	1
27.	Block making machine	1
28.	Compressor Drilling	1
29.	Service Truck (Lorry)	1
30.	Mobile workshop (Mechanical Engineer's	1
31.	Block Making machine	1
32.	Water Pump (6 HP)	1
33.	Unit-Huts (Living)	20

BREAKDOWN OF ITEM NO. 22 (TOOL AND EQUIPMENT)

Portable compressor	1
Tool kits (Mechanical)	10
Tool kits (Electricians)	5
Tool Kits (Panel Beater)	2
Tool Kits Welder	2
Hydraulic Press for track type tractors	1
Petrol driven Arc Welding set	1
Gas Welding equipment	2
7 ton workshop gantry	1
Trolley jacks 15 tons	2
Trolley jacks 7 tons	2
Steam Cleaner	1
Paraffin Cleaner (Bath)	1
Fuel Injector's Tester	1
Lifting Tool (Manual Fork Lift)	1
200 PSi Workshop Air Compressor	1
100 Tons workshop press	1

APPENDIX II

EQUIPMENT LIST

1-1	Top Drive Rotary Water Well Rig	2 units
2.	Tricone Bits (for 10,000M)	1 lot
3.	Test pumping Equipment Submersible Type	2 units
4.	Testing Equipment	2 units
5.	Well Casings and Screens	1 lot
6.	Pumping Unit (permanent)	60 units
7.	Transportation Equipment	

- a. Station Wagon 4x4 — 3 Nos.
- b. Pick-up — delete
- c. Trailer Mounted Water Tank 6M3 — 2 Nos.
- d. Fuel Tank Lorry, 6M3 — 2 Nos.
- e. Full/semi trailer 10-ton loading capacity with trailer tractor — 2 Nos.
- f. Cargo Type Truck loading capacity 8-ton with 3-ton hydraulic crane — 2 Nos.
- g. Crane Truck, 10-ton capacity — 2 Nos.

8. Camping Equipment

- a. Caravan for drilling engineers & counterpart — 4 Nos.
- b. Trailer mounted dining & shower facilities — 2 Nos.
- c. Prefabricated toilet — 2 Nos.
- d. Camping tents for labourers, drivers & spare stock — 20 Nos.
- e. Stationery water tank and fuel tank 3M3 — 4 units

9.	Mobile workshop including welder, lathe, boring machine, generator etc.	1 unit
10.	Fed and Foam materials	1 lot
11.	Miscellaneous materials including steel bar, steel plate, holt and nuts, wire ropes, angles etc.	1 lot
12.	Communication Equipment	1 unit
13.	Spare Parts for years	1 lot
14.	Japanese drilling engineers 4-persons for one year.	

ANNEX III

See APPENDIX 1 of this report.

ANNEX IV

ARRANGEMENTS TO BE TAKEN BY THE GOVERNMENT OF KENYA

1. To ensure prompt unloading and customs clearance at ports of disembarkation in Kenya and prompt internal transportation therein of the products purchased under the Grant.

2. To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in Kenya with respect to the supply of the products and the services under the verified contracts.

3. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into Kenya and stay therein for the performance of their work.

4. To maintain and use properly and effectively the equipment purchased under the Grant.

5. To bear all expenses, other than those to be borne by the grant, necessary for the local transportation of the machineries, equipment and services under the Grant.

ANNEXE V

List of Participants

a) Japanese Participants

Basic Design Study Team

K. Kato	Director, Grant Aid Department J.I.C.A.
S. Sasaki	Grant Aid Department, J.I.C.A.
A. Togo	Pacific-Consultants International

Embassy of Japan and JICA Nairobi Office

M. Hayama	First Secretary, Embassy of Japan
K. Okabe	Resident Representative, J.I.C.A. Nairobi office
H. Takenaka	J.I.C.A. Nairobi office

b) Kenya Government Participants

Mr. A. N. Ndiho	Under Secretary, Ministry of Water Development.
Mr. M. Mbutha	Assistant Secretary, M.o.W.D.
Mr. D. M. Kirori	Director, Water Resources Dept. Ministry of Water Development
Mr. F. M. Mureithi	Deputy Director, Water Engineering, Ministry of Water Development.
Mr. W. J. Odhiambo	Deputy Director, Engineering Department, Ministry of Water Development.
Mr. S. Makondiege	Deputy Director, Engineering Department, Ministry of Water Development.
Mr. Kadelback	Engineering Department, Ministry of Water Development.
Mr. E. M. Mwai	Chief Geologist, Ministry of Water Development.
Mr. Njui	Head, Ranch Section, Ministry of Water Development.
Mr. S. Ochieng	Head, Drilling Section, Ministry of Water Development.
Mr. A. Abdalla	Drilling Section, Ministry of Water Development.

Mr. W. Hagstron	Drilling Section, Ministry of Water Development.
Mr. R. Langat	Assistant District, Ministry of Livestock Development

ANNEXE VI

Other Kenyan requests:

1. Two Japanese drilling engineers and one mechanic for a period of at least 6 months.

2. Consultant for tender preparation and evaluation.

3. Training in Japan

APPENDIX 4

ITINERARY OF THE STUDY TEAM

Itinerary of Basic Design Study Team

Nov 9	Mon	Departure of Mr. A. TOGO
10	Tue	
11	Wed	Arrival at Nairobi, Meeting at JICA and Embassy of Japan
12	Thi	Meeting at Ministry of Water Development(MWD)
13	Fri	Meeting with Under Secretary Mr. A.N-Ndiho
14	Sat	Data Collection
15	Sun	Data Arrangement
16	Mon	Data Collection
17	Tue	Data Collection
18	Wed	Meeting with Water Resources and Engineering Departments
19	Thi	Data Collection
20	Fri	Submition of Draft Inception Report
21	Sat	Data Collection
22	Sun	Data Arrangement, Arrival of Messrs. Hoshino & Kishikawa at Nairobi
23	Mon	Meeting with Director of Engineering Department
24	Tue	Meeting with Permanent Secretary of M.W.D.
25	Wed	Meeting with Mr. A.N. Ndiho, Water Resources Department & Engineering Department
26	Thi	Data Collection
27	Fri	Meeing for coordination of Water Resources and Engineering Department
28	Sat	Data Collection
29	Sun	Data Arrangement
30	Mon	Visit to Ministry of Livestock Development
Dec 1	Tue	Meeting with Mr. A.N. Ndiho and received comments on Inception Report
2	Wed	Meeting with Messrs. Mureithi and Kirori

Dec 3	Thi	Data Collection	
4	Fri	Data Collection, Handover of Equipment	
5	Sat	Data Arrangement	
6	Sun	Data Arrangement	
7	Mon	Team Leader arrived at Nairobe Start of Training of hydro.geo Survey	
8	Tue	Data Collection, Field Survey of Kajiado	
9	Wed	Field Survey, Field survey of Kajiado	
10	Thi	Data Collection & Discussion, Field Sruvey of Hydrogeology	
11	Fri	Data Collection & Discussion	
12	Sat	Data Collection & Discussion	
13	Sun	Data Arrangemnt	
14	Mon	Meeting on contents of grant Aid.	
15	Tue	Submition of Inception Reprot	
16	Wed		
17	Thi		
18	Fri		
19	Sat		
20	Sun		
21	Mon		
22	Tue		
23	Wed		
24	Thi		
25	Fri		
26	Sat		
27	Sun		
28	Mon		
29	Tue		

Dec 30	Wed	Field Sruvey Completed at Kajiado
31	Thi	Data Analysis
Jan 1	Fri	Data Analysis
2	Sat	Data Analysis
3	Sun	Data Analysis
4	Mon	Field Survey Started at Narok
5	Tue	
6	Wed	
7	Thi	
8	Fri	
9	Sat	
10	Sun	Field Survey at Narok
11	Mon	
12	Tue	
13	Wed	
14	Thi	
15	Fri	
16	Sat	
17	Sun	
18	Mon	
19	Tue	Field Survey Completed at Narok
20	Wed	Data Analysis & Training
21	Thi	Data Analysis & Training
22	Fri	Data Analysis & Training
23	Sat	
24	Sun	Data Arrangement

Jan 25	Mon	Reported Progress in Field Survey
26	Tue	Departure of Messrs Hoshino and Kishikawa
27	Wed	
28	Thi	Arrival of Hydrological Study Team of Tokyo

APPENDIX 5

LIST OF MACHINERY
FOR DAM CONSTRUCTION UNIT

APPENDIX I

PLANT AND EQUIPMENT FOR A NEW CONSTRUCTION UNIT

No.		No.
1.	Bulldozers 300 HP	2
2.	Bulldozers 200 HP	1
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5.	Motor grader, 140 HP	1
6.	Selfpropelled compactor	1
7.	Front loader Excavator (Backhoe)	1
8.	Lorry 7-8 tons, tipper	2
9.	Lorry 7-9 tons, flat back	1
10.	Fuel tankers	2
11.	Low-loader, 60 tons pay load	1
12.	5m^3 drinking water tanker	2
13.	1500 gallon water trailer	2
14.	Workshop trailer equipped	1
15.	Storage trailer	1
16.	Office caravan equipped	1
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18.	Diesel generator 250V, 2.5KVA (lighting power)	1
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25.	Farm Tractor with open trailer	1
26.	Concrete mixer	1
27.	Block making machine	1
28.	Compressor Drilling	1
29.	Service Truck (Lorry)	1
30.	Mobile workshop (Mechanical Engineer's	1
31.	Block Making machine	1
32.	Water Pump (6 HP)	1
33.	Unit-Huts (Living)	20

<u>BREAKDOWN OF ITEM NO. 22 (TOOL AND EQUIPMENT)</u>

	QTY
Portable compressor	1
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Tool kits (Electricians)	5
Tool Kits (Panel Beater)	2
Tool Kits Welder	2
Hydraulic Press for track type tractors	1
Petrol driven Arc Welding set	1
Gas Welding equipment	2
7 ton workshop gantry	1
Trolley jacks 15 tons	2
Trolley jacks 7 tons	2
Steam Cleaner	1
Paraffin Cleaner (Bath)	1
Fuel Injector's Tester	1
Lifting Tool (Manual Fork Lift)	1
200 PSi Workshop Air Compressor	1
100 Tons workshop press	1

APPENDIX 6

RECEIPT DOCUMENT OF EQUIPMENT

G.P. 246

INTERNAL MEMO

From Storekeeper	To Mr. Yoshimi Kishikawa
My Ref. WD/4/2/38/30	Your Ref.
Date 23rd January, 1982	Date

SUBJECT

List of Equipment Received into the Geology Store from JICA (on behalf of Japanese Government) on 5/12/81:

GEOELECTRIC INSTRUMENTS:

1. ES-G2, RESISTIVITY EQUIPMENT

TRANSMITTER (2112)-AND RECEIVER (2113) MODEL 2220	1 UNIT
-CURRENT ELECTRODE, AB-1 (2510)	8 pcs
-DRY CELL, BM-1 (2906)	5 pcs
-BACK CARRDER (1651)	4pcs

2. CABLE(BLACK) W/CABLE REEL (1618) 400m — 2 ROLLS

-CABLE(RED) W/CABLE REEL (1618) 400 m	2 ROLLS
-DRY CELL, UN-1 AND ACCESSORY CORD	1 SET

3. CABLE (BLUE) W/CABLE REEL (1618) 400m — 1 ROLL

-CABLE (GREEN) W/CABLE REEL (1618) 400m	1 ROLL
-DRY CELL, BM-1 (2906)	13pcs
-WOODEN BOX FOR DRY CELLS (BM-1)	2pcs
-BATTERY 12V 32 AH W/CARRYING BAND (1925)	1 pc
- BATTERY HCHARGER, 220V (1927)	1 UNIT
-TESTER	I UNIT
-TOOLS	1 UNIT

4. ELECTRIC CONDUCTIVITY TESTER — 1 SET

- SPECIFIC EARTH RESISTANCE TESTER* 5 ELECTRODE	1 SET
- ELECTRIC CALCULATER (L1214) + ADAPTOR ADI - 234V	1 SET
-ELECTRIC CALCUALTER (L 3) + ADAPTOR ADI-234V	2 SET
-DRY BATTERY (UM-1)	40 pcs
-BATTERY BAG	4 pcs
-SAMBLE BOTTLE	30 pcs

I have received the above listed items in Geology Store.

Storeman : Mr. Wildfred K. Ng'ang'a ....Ng'ang'a....

Writters: Mr. Justus T. Ituli(geologist) ....

145+
1828=81037
NC

5/12/81

CAMP ON

18 1830=81037
22145 JICANOB

OUT

THIS IS JAPAN INTERNATIONAL COOPERATION AGENCY

発信分 号
56.11.18

TOKYO JICA 18 1530

JICANOB NAIROBI

TLX

(KENYAKOKU CHIKASUI KAIHATSU KEIKAKU) GR204

1. HYOOKI CHOOSANI HITSUYOONA KAKINO DENKITANSAYOO SHIKIZAIWO 4 CASES NIWAKE (YAKU 500KG) 22HI BA-055 NITE HOSHINO KISHIKAWA RYOO DANYINNI KEIKOO SASETAITO JUNBISHITE IRUTOKORO SHORT NOTCE NARUMO TSUUKAN TETSUZUKINI BENGIWO HAKARARERUYOO MIZUSHIGENSHOONI TSUUCHIARITAI.
2. SHIKIZAI LIST

C/NOS.	DESCRPTION OF GOODS		QUANTITY	AMOUNT
	GEOELECTRIC INSTRUMENTS:			
1.	BS-G2, TRANSMITTER (2112) AND RECEIVER(2113)			
		MODEL 2220	1 UNIT	920,000YEN
	CURRENT ELECTRODE, AB-1	2510	8 PCS.	44,000
	DRYCELL, BM-1	2906	5 PCS.	14,250
	BACK CARRDER	1651	4 PCS.	48,000
2.	CABLE(BLACK) W/CABLE REEL(1618) 400M		2 ROLLS	70,000
	CABL(RED) W/CABLE REEL (1618), 400M		2 ROLLS	70,000
	DRYCELL, UM-1 AND ACCESSORY CORD		1 SET	57,000
3.	CABLE(BLUE) W/CABLE REEL(1618), 400M		1 ROLLS	35,000
	CABL(GREEN) W/CABLE REEL(1618), 400M		1 ROLLS	35,000
	DRYCELL, BM-1	2906	15 PCS.	42,750
	WOODEN BOX FOR DRYCELL(BM-1)		2 PCS.	24,000
	BATTERY 12V 32AH W/CARRYING BAND	1925	1 PC.	13,000
	BATTERY CHARGER, 220V	1927	1 UNIT	25,000
	TESTER		1 UNIT	5,000
	TOOLS		1 SET	10,000
4.	ELECTRIC CONDUCTIVITY TESTER		1 SET	245,000
	SPECIFIC EARTH RESISTANCE TESTER + 5 [illegible]		1 SET	140,000
	ELECTRIC CALCULATER (L 1214) + [illegible]		1	19,000
	ELECTRIC CALCULATER (L 3) + [illegible]		2	24,000
	DRY BATTERY	(UM-1)	40	3,600
	BATTERY BAG		4	24,000
	SAMPLE BOTTLE		30	27,000
	TOTAL			1,895,600.- YEN

JICAHDQ

Date 5/12/81

COL CFMD

I have received all the listed items — in Geology Store

56.11.18

NNNN
V

Wilfred Nganga — [signature]
Witness — Mr. Ituli — [signature]

APPENDIX 7

AGREEMENT ON THE SITE SELECTION FOR HYDROGEOLOGICAL SURVEY

OFFICE OF THE PRESIDENT
PROVINCIAL ADMINISTRATION

Telegrams: "DISTRICTER", Narok
Telephone: Narok 4
When replying please quote
Ref. No. ADM. 15/18/Vol. [illegible]/222
and date

OFFICE OF THE
DISTRICT COMMISSIONER
P.O. Box 4
NAROK, KENYA

6th January, 1982

(120)

7 JAN 1982

JAPAN INTERNATIONAL CO-OPERATION AGENCY
KAJIADO/NAROK GROUND WATER
DEVELOPMENT PROJECT
GROUND WATER ASSESSMENT PROGRAMME

Following findings gathered from Narok District by JAICA Team and in addition to discussions between Mhalule/ JAICA Team on Wednesday 6th January, 1982 in D.C's Office, Narok it was recommended that the priority for implementing water projects in Narok District should be as follows:-

1. Ewaso Nyiro
2. [illegible]
3. Maji Moto
4. Ololunga
5. [illegible] - Lemek

All these proposed projects which are in Group Ranches are in accordance with previous District Development Committee meeting recommendations.

Mhalule

([illegible])
Copy: DISTRICT COMMISSIONER
NAROK

c.c. The District Water Officer,
NAROK.

D.D.O.,
NAROK, (to see file copy.)

OFFICE OF THE PRESIDENT

Telegrams: "DISTRICTER", Kajiado
Telephone: Kajiado 4
When replying please quote
Ref. No. ..ADM..15/18/16 and date

OFFICE OF THE
DISTRICT COMMISSIONER
P.O. Box 1, KAJIADO

15th December, 19..81

Japan International Co-operation Agency,
Kajiado/Narok Ground Water Development, Project.

(Att. Mr. Kishikawa)

Dear Sir,

RE: GROUND WATER ASSESSMENT PROGRAMME

Following our discussion (Mule/JAICA Team) held in my office on 10th and 15th December, it was agreed that borehole sitting and drilling by JAICA team should be carried out vide the following sites ranked according to priority:-

1. Ewaso - Kidong
2. Kenya Marble Quarry (K.M.Q)
3. Oldonyo - Onyokie
4. Selengei
5. Lengism.

All the agreed sites were in accordance with District Development Committee recommendations of previous meetings.

Thanking you for your interest in this worthy cause.

Yours faithfully,

(D.M. MULE)
DISTRICT DEVELOPMENT OFFICER KAJIADO,
FOR: DISTRICT COMMISSIONER,
KAJIADO.

c.c.

District Water Officer,
KAJIADO.

APPENDIX 8

MEMBER OF BASIC DESIGN STUDY TEAM

MEMBER OF BASIC DESIGN STUDY TEAM

Team Leader :	Mr. Kiyohsi Kato
Planning Engineer :	Mr. Akihiko Togo
Geophysist :	Mr. Yukio Hoshino
Hydrogeologist :	Mr. Yoshimi Kishikawa
Coordinator :	Mr. Saburo Sasaki

JICA