APPENDIX B. GEOPHYSICAL SURVEY

CONTENTS

LIST OF TABLE

Appendix-B Geophysical Survey

1. Outline of TEM Survey (purpose of geophysical survey)

A transient electromagnetic (TEM) survey was carried out in the Study Area, which covers Marigat and Mukutani Divisions, approximately 1,200 km^2 as a part of additional survey of "The Study on The Integrated Rural Development Project in The Baringo Semi Arid Land Area (Marigat and Mukutani Divisions) in The Republic of Kenya".

Primary objectives of this survey were to determine the aquifer availability of target villages and to locate the suitable borehole-drilling sites near the village centers. Secondary objectives of the study were to evaluate aquifer potential, and detect layered structure of overlying sedimentary facies, fault and fracture zones, consequently to clarify the groundwater resources potential of the Marigat and Mukutani Division.

For obtaining necessary information, two TEM systems were employed that is PROTEM 47 and 57 systems. The former is used for determination of shallower sections and the later is applied for surveying of the deeper sections. During the course of this study, a total of 42 villages of TEM soundings were completed.

2. Transient Electromagnetic Method (TEM)

The transient or time-domain, electromagnetic method, referred to as TEM, is a method to the area where the ground is energized by an artificial magnetic field and its response is measured as a function of time to determine the resistivity of the earth beneath observation point as a function of depth.

In this method, a steady current is passed through a loop of wire situated on the surface of the earth, which is inductively linked to the earth. The fact that loop sources, which have no direct contact with the earth, can be used, makes this method suitable in areas where high surface resistivities prohibit the use of conventional direct current methods.
This would include regions covered by dry sand and silt flats or extrusive volcanics.

In practice, the direct loop current is abruptly interrupted and the secondary field, which arises due to eddy currents induced in the earth, can be measured in the absence of the primary field. The eddy currents migrate from the transmitter loop into the earth and the pattern resembles the propagation of a 'smoke ring'. The rate of change of the magnetic field depends upon the underground resistivity structure. Given a poorly conductive medium, the receiver coil output voltage, which is proportional to the time rate of change of the secondary magnetic field, is initially large but decays rapidly. The response of a good conductor is initially lower but the voltage decays slowly. The time derivative of the transient magnetic field which results from these currents can be measured by a coil sensor.

The decay of the secondary field measured at surface can be analyzed to determine the resistivity of the earth at depth. The resistivities of geological materials are highly dependent upon porosity, water saturation, and pore fluid resistivity. Resistivity sounding, therefore, yields information about water content and quality, and TEM resistivity measurements are a valuable structural mapping tool for groundwater studies.

The TEM method was selected for this survey for the following reasons; (1)stability of the transmitter signal, (2)luck of static shift, (3)no near field phenomena, (4)uniqueness of the results, (5) high production rate and (6) suitability of the ungrounded source in rock desert.

3. TEM Equipment

The TEM system, which was used in this survey, was manufactured by Geonics Ltd., of Canada. The primary components of the system are a transmitter, a sensor coil and a receiver.

Two transmitters, TEM-47 and TEM-57, were used for this survey. TEM-47 is a battery-powered transmitter, which is capable of operating at high frequencies. It can be used to resolve shallow resistive units such as dry alluvium. It is a low power transmitter, however, and has a limited depth of penetration. TEM-57 operates at lower frequencies and is powered by a gasoline motor generator providing a higher output current (alternatively can be powered by 24 V battery), leading to a greater depth of penetration. By combining measurements made from both sources, both the shallow and deep sections can be adequately resolved.

A responsive high frequency receiver coil with an effective area of 31.4 square meters and an internal signal preamplifier was used for TEM-47 measurements and a more sensitive low frequency coil with an area of 100 square meters was used for TEM-57 measurements.

The receiver, a PROTEM 57D unit, samples the coil response at a series of time intervals that are delayed by a prescribed amount from each turn-off of the loop current. There are 20 geometrically spaced gates or channel positions in each time range. Decay voltages are recorded at three TEM-47 transmitter base frequencies (u-237.5, v-62.5 and h-25 Hz) and at three TEM-57 base frequencies (H-25, M-6.25 and L-2.5 Hz) during the course of this survey. A reference cable is used to establish precise timing between the transmitter and receiver.

Table-1 The Specifications of Two TEM Systems

	PROTEM 47 System	PROTEM 57 System
Receiver (Type)	Protem Digital Receiver (RX-D)	
Time Channels	20 geometrically spaced time gates for each base frequency gives range from 6 μs to 800 ms.	
Integration Time	2,4,8,15,30,60,120,240 sec.	
Calibration	Internal self calibration	
Dynamic Range	23 bits (132 dB)	
Processor	CMOS 68HC000 8MHz CPU	
Receiver Size	34 x 38 x 27 cm	
Receiver Weight	15 kg	
Operating Temperature	-40℃ ～ +50℃	
Transmitter (Type)	(TEM-47)	(TEM-57)
Current Waveform	Bipolar rectangular current with 50% duty cycle	Bipolar rectangular current with 50% duty cycle
Repetition Rate	30Hz, 75Hz or 285Hz in countries using 60Hz power line frequency. 25Hz, 62.5Hz or 237.5 Hz in countries using 50 Hz power line frequency.	3Hz, 7.5Hz or 30Hz (powerline frequency 60Hz), 2.5Hz, 6.35Hz or 25Hz (powerline frequency 50Hz). Rate below 1Hz available from PROTEM receiver through reference cable.
Turn-Off Time	Very fast linear turn-off 2.5 μs at 2 amps into 40 x 40 m loop. Faster in smaller loop.	20 to 115 μs, depending on size, current and number of turns in transmitter loop.
Output Current	3 A maximum.	25 A maximum.
Output Voltage	0 to 9 V.	18 to 60 V.
Power Source	Internal 12 volts battery.	1,000W, 110/220V, 50/60Hz single-phase motor-generator or, optionally multiple 12 V batteries.
Transmitter Size	10.5 x 24 x 32 cm	43 x 25 x 25 cm
Transmitter Weight	5.3 kg	15 kg

4. Measurement Configuration

Survey parameter tests were conducted at the beginning of the survey to aid in determination of the optimum measurement configuration for this survey. These tests were performed at a station near the Rugus area where the thickest alluvial section was expected, so that the penetration of the measurements could be assessed. The test site was also chosen to be near a power line so that the effect of electromagnetic noise upon the measurements could be considered.

During these tests, measurements were made at the center of square loopseveral lengths of loops varying from 50 m to 150 mmeters in width were tested. In the testing, the loop was typically energized with a current ofone(1) ampere for high frequency EM-47 measurements and a current of about 13 amperes for lower frequency EM-57 soundings. While large loop yield higher signal and have a greater depth of penetration, they can be difficult and time consuming to deploy and retrieve.

With use of 100 m x 100m insize of loop, the depth of penetrationis reaching to 150 m deep. As result, The 100 x 100 m `central loop` sounding configuration was selectedas standard configuration of the Survey.

5. Measurement Sites (villages)

TEM survey sites (villages) are selected by following the priorities that were determined by community or location base. The stations were positioned by GPS. GPS was placed at the receiver coil site and an accurate position "fix" was obtained by averaging hundreds of GPS measurements. The survey points were converted to Universal Transmercator (UTM) coordinates. This data was entered into the header of each sounding record as measurements were recorded. UTM coordinates were used during all field operations and thedatum which was used throughout this survey isARC 1960 mean V.

A total of 42 sites, 506 number of measuring point were surveyed and these 42 site locations are shown in Appendix-A, Figure 4-3. The summary of thesurveyed site are shown in below Table-2:

Table-2 Summary of TEM Survey Sites

No	Division	Location	Village (site name)	No. of Loop	No. of Point	Loop Size	TEM47/57
1	Marigat	Eldume	Eldume Pr School	1	8	100x100	47/57
2			Lororo Center	2	16	100x100	47/57
3			Kairel	1	9	100x100	47
4			Ntepes	1	9	100x100	47
5			Ilngarua Pr School	1	9	100x100	47
6		Kapkuikui	Toborweche	1	9	100x100	47
7		Kimalel	Kapkun	1	9	100x100	47
8			Kimorok Pr School	1	8	100x100	47
9			Bartulgel	2	18	100x100	47
10			Keniyach	1	8	100x100	47
11			Remut	1	9	100x100	47
12		Loboi	Kapronguno	1	9	100x100	47
13		Marigat	Barkibi	2	18	100x100	47
14			Ndambul	1	9	100x100	47
15			Sirinyo	1	9	100x100	47
16		Ngambo	Lolopiri	1	9	100x100	47
17			Masai	2	18	100x100	47
18			Sintan	1	9	100x100	47
19		Salabani	Londeyani	2	19	100x100	47
20		Sandai	Sandai Pr School	2	18	100x100	47/57
21			Chepkotoiyan	2	18	100x100	47
22	Mukutani	Mukutani	Akure	1	9	100x100	47
23			Ilmuet	1	10	100x100	47
24			Karau	1	9	100x100	47
25			Mukutani Center	1	9	100x100	47
26			Iberesati	2	18	100x100	47
27			Lakerati	1	9	100x100	47
28			Murat	1	9	100x100	47
29			Rugus	2	12	100x100	47/57
30		Arabal	Ramacha	2	18	100x100	47
31			Karma	1	11	100x100	47
32			Katilomwo	2	18	100x100	47
33			Kipkoibetu	1	9	100x100	47
34			Partalo	1	9	100x100	47
35			Losokoni	1	9	100x100	47
36			Negrecha Pr School	1	9	100x100	47
37			Arabal Pr School	2	18	100x100	47
38			Kapindasum Pr School	2	18	100x100	47/57
39		Kiserian	Loitip	2	18	100x100	47
40			Losaburbur	1	9	100x100	47
41			Sokotei	2	18	100x100	47
42			Mosuro	1	9	100x100	47
Total		42 sites (villages)		57	506	-	-

6. Measurement Noise

Electromagnetic noises are included in the receiver coil by power lines and from movement of the receiver coil by wind. Repetitive voltages measurements were made and averaged or 'stacked' to minimize these effects. The electromagnetic noise level was very low in the majority of the survey area, but noise from power lines was appreciable in the vicinity of Marigat, Eldume and Loboi.

Man made conductive object such as pipelines or metal fences can also distort data. At these sites were moved a few hundred meters and usable data was obtained.

7. Data Processing

The data, which has been recorded in the field, is first transferred from the PROTEM receiver to a personal computer, using the Geonics program "PROTEMC". This data is stored in ASCII data files, which are then read by a data inversion program.

In the first phase of data processing, the decay voltage for each gate are transformed into late-time apparent resistivity values, by normalization with respect to field data measurement parameters such as loop dimensions, receiver gain, current and sounding geometry.

The voltages, V_0 (in units of mV), which are measured by PROTEM receiver are converted to magnetic field decay rate, *dB/dt* (nV/m^2), by the following formula (Geonics,1992).

$$DB/dt = (V_0 \cdot 19200) / E \cdot 2^n$$

Where E is the receiver coil moment (m^2), and n is the amplifier gain setting. Apparent resistivities ρ_a (ohm-m) are then given as a function of time (t) by,

$$\rho_a(t) = \mu / 4p t_c \cdot \{2 \mu M / (5 t_c dB / dt)\}^{2/3}$$

in which, μ is magnetic permeability ($*4\pi*10^{-7}$ H/m), t_c is measurement time or the gate center time in seconds, and M is transmitter moment which is the product of loop area (m^2) and current (A).

An automatic one dimensional inversion technique was used to generate resistivity models composed up to 19 layers. In this process, the resistivities of the layers of a candidate model, which is chosen by the inversion program, are iteratively changed and response curves are computed to determine the model whose response best fits the observed data. The model is not restricted by the condition that the resistivities of the layers change smoothly with depth, as they are with the Occam or 'smooth' inversion method. Models derived by this technique, without artificial parameterization, can be used to produce images results were also used to estimate initial model parameters for the interactive one-dimensional inversions that followed.

8. Example of Sounding Results

All of sounding results at each sites are shown in supplement Data book. For the inversion's result, the horizontal and vertical axes are logarithmic time (ms) and apparent resistivity (Ohm-m). The symbols of box, diamond and cross are the apparent resistivity calculated by the observed coil voltage and the curve is the calculated apparent resistivity, given an earth resistivity model shown in the plot in the right side.

In the resistivity plot, the horizontal axis indicates depth (m) and the vertical axis indicates the resistivity of the earth (Ohm-m).

9. TEM Sounding Result

Automatic one-dimensional data inversion was performed to generate 19-layer resistivity models for each of the data sets. The thickness of the layers increase with depth and these models extend to a depth of 150m from the surface. These results were used to determine the aquifer availability of target villages and to locate the suitable borehole-drilling sites nearby the village center.

Though the description of the results are mentioned below for every sounding sites, finally 19 villages were represented as indicating some potential out of 42 villages surveyed. However, half of them (7 sites among 19 villages) were thought to be underlain by saline water due to its low resistivity less than 5 ohm-m. Remaining 12 were judged as possible sites to develop groundwater by borehole drilling.

9-1 Marigat Division

Marigat Division is located in the Rift Valley floor that comprises the low elevation part of the main Rift Valley, which are dominated by Lake Bogoria and Lake Baringo. This area could be divided into 3 zones, Lake Bogoria area, Loboi Plains and Northern Lake Baringo area.

The Loboi Plains occupy the flat area (elevation 1,000 m above msl) between Lake Bogoria and Lake Baringo. The area is largely covered with fluvio-lacustrine deposits. Annual rainfall is less than 700 mm. Swamps have developed at the places where River Molo and Perkera terminate.

21 sites of TEM survey were executed at Marigat Division (8 Locations), 5 sites in Eldume, 1 site in Kapkuikui, 5 sites in Kimalel, 1 site in Loboi, 3 sites in Marigat, 3 sites Ngambo, 1 site in Salabani and 2 sites in Sandai Location.

1) Eldume Location

Eldume Location is composed by 2 Sub-Locations, which are Eldume and Ilng'arua Sub-Locations. Within 5 surveyed sites in this Location, 3 sites were in Eldume Sub-Location (Eldume Primary School, Lororo Center and Kailer village) and 2 sites in Ilng'arua Sub-Location (Ntepes and Ilngarua Primary School). These survey sites were selected by the request and prioritized by each Sub-Location's communities.

(a) Eldume Primary School

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence. All sounding points shows very low resistivities (less than 1 ohm-m), indicate the presence of brackish to saline water.

(b) Lororo Center

Lororo center locate near the diversion of the Moro Irrigation Scheme. All the soundings indicate the presence of a weathered layer of phonolite or tuffs at depth of 50-90 meter. The resistivity of this layer is 5-10 ohm-m, and may have groundwater potential in this layer.
Around 40 meters depth may have clay, above this layer small potential for shallow groundwater will be present.

(c) Kailer Village

Almost soundings show very low resistivities (< 3 ohm-m) indicating the presence of saline water at a depth below 90 meter. Above this layer, around 10 meters and 50-60 meters depth may have small potential of shallow groundwater, but the resistivities also show low (3 ohm-m) for fresh water.

(d) Ntepes Village / Ilngarua Primary School

Ntepes village and Ilngarua Primary School locate near the Perkera River. The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence at both sites. All sounding points show that the area is underlain by thick layers of very low resistivities formations (less than 2 ohm-m).

2) Kapkuikui

Kapkuikui Location is composed of 2 Sub-Locations, which are Kapkuikui and Kaptombes Sub-Location. In Kapkuikui Location, 1 site was selected for TEM survey at Toborweche village depended on Location community priority.

(a) Toborweche Village

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence.

3) Kimalel

Kimalel Location is composed of 3 Sub-Locations, Kimalel, Sabor and Koriema Sub-Locations. Within 5 surveyed sites in this Location, 4 sites locate in Kimalel and Sabor (Kapkun, Kimorok Primary School, Bartugel and Kinyach) and 1 site is in Koriema Sub-Location (Remut village). These survey sites were also selected by the request and prioritized by each sub-location's communities.

At this Location, weathered or fractured zones in volcanic rocks are expected for the groundwater occurrence.

(a) Kapkun Village / Kimorok Primary School

The resisitivity profiles do not show any feature of direct interest for groundwater occurrence at this sites.

(b) Bartugel Village

The resistivity profiles do not show any feature of direct interest for groundwater occurrence at this site. All sounding points shows that the area is underlain by thick layers of very low resistivities formations (less than 4 ohm-m), which may be volcanic ashes, agglomerate and clay.

(c) Kinyach Village

The resistivity profiles show a small groundwater potential at 50-60 meter depth. However it may be underlained by saline water due to its low resistivity (3 ohm-m).

(d) Remut Village

The resistivity profiles do not show any feature of direct interest for groundwater occurrence at this site.

4) Loboi

Loboi Location is composed of 2 Sub-Locations, which Chelaba and Maji Ndege Sub-Locations. In Loboi Location, 1 site was selected for TEM survey at Kapronguno village depended on Location community priority.

Expected groundwater occurrences in this Location are sedimentary deposit of the Loboi Alluvium, with weathered or fractured zones in the underlying volcanic rocks of Lake Bogoria trachyphonolnes.

(a) Kapronguno Village

From the soundings, 2 layers of aquifer are expected in the sedimentary deposits, one is around 20 meters deep and the other is 60-80 meters deep. Between these two aquifers, clayey sediments may occurrence.

5) Marigat

Marigat Location is composed of 3 Sub-Locations, was Endao, Perkera and Yatoi Sub-Locations. Within 3 surveyed sites in this Location, 1 site locates in Endao (Barkibi) , 1 site in Perkera (Ndambul) and 1 site is in Yatoi Sub-Location (Sirinyo). These survey sites were also selected by the request and prioritized by each sub-location's communities.

In this Location, expected groundwater occurrence is in sedimentary deposit.

(a) Barkibi / Ndambul / Sirinyo Village

The resistivity profiles do not show any feature of direct interest for groundwater occurrence. All sounding points show, that the area is underlained by thick layers of very low resistivities formations (less than 3 ohm-m) at each site especially deeper portion.

.

6) Ngambo

Ngambo Location is composed of 2 Sub-Locations, which are Ngambo and Sintan Sub-Location. Within 3 surveyed sites in this Location, 2 sites locate in Ngambo (Lolopiri and Masai) and 1 site in Sintan (Sintan village). These survey sites were also selected by the request and prioritized by each sub-location's communities.

(a) Lolopiri Village

The resistivity profiles do not show any feature of direct interest for groundwater occurrence.

All sounding points show, that this area is underlained by thick layers of very low resistivities formations (less than 2 ohm-m) below 20 meters deep. Shallow depth up to 20 meters shows 20-60 resistivities, and this layer may have occurrence of clayey or fine-grained sediments.

(b) Masai / Sintan Village

Sounding result at both villages are almost same as at Lolopiri village. The resisitivity profiles do not show any feature of direct interest for groundwater occurrence. All sounding points show, that this area is underlained by thick layers of very low resistivities formations (less than 1 ohm-m) below 40 meters depth.

7) Salabani

Sarabani Location is composed of 2 Sub-Locations, which are Salabani and Meisori Sub-Location. In Salabani Location, 1 site was selected for TEM survey at Londeyani village depended on the Location community prioritized.

Expected groundwater occurrence is in sedimentary deposits of the Loboi Alluvium.

(a) Londeyani Village

The soundings were aimed to find sedimentary deposits saturated with fresh water. Prospects for groundwater at this site is good for shallow groundwater around 40 meters depth. However it may be underlained by saline water due to its low resistivity (1 ohm-m). Above the saline water layer, the deposits may be mainly a clayey composition.

8) Sandai

Sandai Location is composed of 2 Sub-Locations, which are Mbechot and Sandai Sub-Locations. In Sandai Location, 2 sites were selected for TEM survey at Sandai Primary School and Chepkotoiyan Primary School depended on the Location community priority.

In this Location, the expected groundwater occurrence is the sedimentary deposit of the Loboi Aluvium.

(a) Sandai Primary School

The soundings were aimed to find sedimentary deposits saturated with fresh water. Prospects for groundwater at this site is good for shallow groundwater around 25-65 meters depth (5-20 ohm-m), which is probably a clayey of fine grained sediments. It is likely that a good well can be drilled with an expected water strike at around 70 meters depth

(b) Chepkotoiyan

Prospects for groundwater at this site good for shallow groundwater around 30-70 meters depth. However it may be underlained by saline water due to its low resistivity (2-3 ohm-m).

9-2 Mukutani Division

Mukutani Division is located on the Mukutan plain and part of the Laikipia Escarpment, and the rivers Komol, Tangulbei, Mukutani, Ol Arabel and Waseges drain through this area to the Lake Baringo – Bogoria basin.

This area is considerably fractured with faults running north-south, and the fractures and faults form good recharge elements. Depending on the existing data, around Mukutani, there are 12 number of springs. The springs in this area are generally structurally controlled as the area is highly fractured.

Eastern part of Mukutani Division occupies the western margin of Likipia Plateau, which falls in Mukutani Division. The rock covering this area is generally phonolite, which, on the surface, has weathered into shallow loamy and gravelly rocks.

The area is covered with several elongated faults and fractures running north-south. A major escarpment runs from the area near Tangulbei south to the area near Lake Bogoria. The aquifers of this area are largely controlled by these structures.

21 sites of TEM survey were executed at this Mukutani Division (3 Location), 8 sites are locate in Mukutani, 9 site in Arabaru and 4 sites in Kiserian Location.

1) Mukutani

Mukutani Location is composed of 2 Sub-Locations, which are Mukutani and Rugus Sub-Locations. In Mukutani Location, 8 sites were selected for TEM survey by depending on the Location community prioritized.

Expected groundwater occurrence in Mukutani Location is in recent alluvial deposits weathered or fractured zones in volcanic rocks.

(a) Akure Village

Medium groundwater potential was found in the depth around 70-110 meters depth in weathered volcanics. Above this layer, fresh rock layer may lie at depth of 30-60 meters. It is likely that a good well can be drilled with an expected water strike at around 80-100 meters depth

(b) Ilmuet Village

There is low shallow groundwater potential at around 10-20 meters depth in weathered volcanic layer in this site.

(c) Karau Village

All soundings indicate the presence of at least a zone of weathered volcanic rock. The resisitivity profiles do not show any feature of direct interest for groundwater occurrence.

(d) Mukutani Center

The resistivity profiles do not show any feature of direct interest for groundwater occurrence. All sounding points show, that this area is underlained by thick layers of very low resistivities formations (less than 5 ohm-m) below 60 meters depth. Up to 60 meters may occur of clayey or fine-grained sediments.

(e) Iberesati

Soundings were executed at near Iberesati Spring. The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence at this site. All sounding points shows that the area is underlain by thick layers of very low resistivities formations (less than 3 ohm-m).

(f) Lakerati

High potential aquifer can be found at 90-115 meters depth. The resistivity of the main water bearing layer is 10 ohm-m, which may be a fractured zone with fairly deep weathering.

(g) Murat

All soundings indicate the presence of thick weathered volcanic rock. This site may have only very low shallow groundwater potential at around 10-20 meters depth in weathered volcanic layer.

(h) Rugus

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence. All sounding points show, that this area is underlained by thick layers of very low resistivities formations (less than 1 ohm-m) below 30 meters depth. Up to 30 meters shows 10-100 resistivity, and this layer may have occurrence of clayey or fine-grained sediments.

2) Arabal

Arabal Location is composed of 2 Sub-Locations, which are Arabal and Ngelecha Sub-Locations. In Arabal Location, 9 sites were selected for TEM survey by depending on Location community priority.

Expected groundwater occurrences in this Location are in sedimentary deposit of the Loboi Alluvium, and weathered or fractured of volcanic rocks.

(a) Ramacha Village

Low potential for shallow groundwater is prospected at this site, with the depth 40-60 meters in medium to coarse grained sediments. Below and above this layer may have occurrence of weathered volcanics.

(c) Karma Village

This site may have shallow groundwater aquifer at 30- 75 meters depth (resistivity: 5 ohm-m). The aquifer is expected as weathered volcanics. Borehole can be drilled at this site to a depth of 60 meters.

(d) Katilomwo Village

Medium groundwater potential was found at around 30-75 meters depth in weathered volcanics (resistivity: 10 ohm-m). It is likely that a good well can be drilled with an expected water strike at around 75 meters depth

(e) Kipkoibetu Village

Medium groundwater potential was found at the depth around 20-50 meters depth in weathered volcanics (resistivity: 15 ohm-m). It is likely that a good well can be drilled with an expected water strike at around 40-50 meters depth

(f) Partaro Village

Low groundwater potential was found at around 30-50 meters depth in weathered volcanics. Above this layer, fresh rock layer may lay at depth of 5-20 meters. It is likely that a good well can be drilled with an expected water strike at around 40-50 meters depth

(g) Losokoni Village

Between the fresh rock layer, high groundwater potential was found at the depth around 70-120 meters depth in weathered volcanics. However it may be underlained by saline water due to its low resistivity (4 ohm-m).

(h) Ngelecha Primary School

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence.

(i) Arabal Primary School

High groundwater potential was found around 35-70 meters depth in weathered volcanics. Above this layer, fresh rock layer may lie at depth of 15-30 meters. It is likely that a good well can be drilled with an expected water strike at around 60-70 meters depth

(j) Kapindasum Primary School

Low potential for shallow groundwater is prospected at this site, with the depth 10-30 meters in weathered volcanics.

3) Kiserian

Kiserian Location is composed of 2 Sub-Locations, which are Kiserian and Logumgum Sub-Locations. In Kiserian Location, 4 sites were selected for TEM survey by depending on Location community priority.

(a) Loitip Village

All soundings indicate the presence of thick clayey or fine grained sediments. This site may have only very low shallow groundwater potential at around 5-10 and 40-80 meters depth.

(b) Losaburbur Village

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence. Thick layers of very low resistivities formations (less than 1 ohm-m) below 15 meters depth up to 90 meters, show the presence of brackish to saline water.

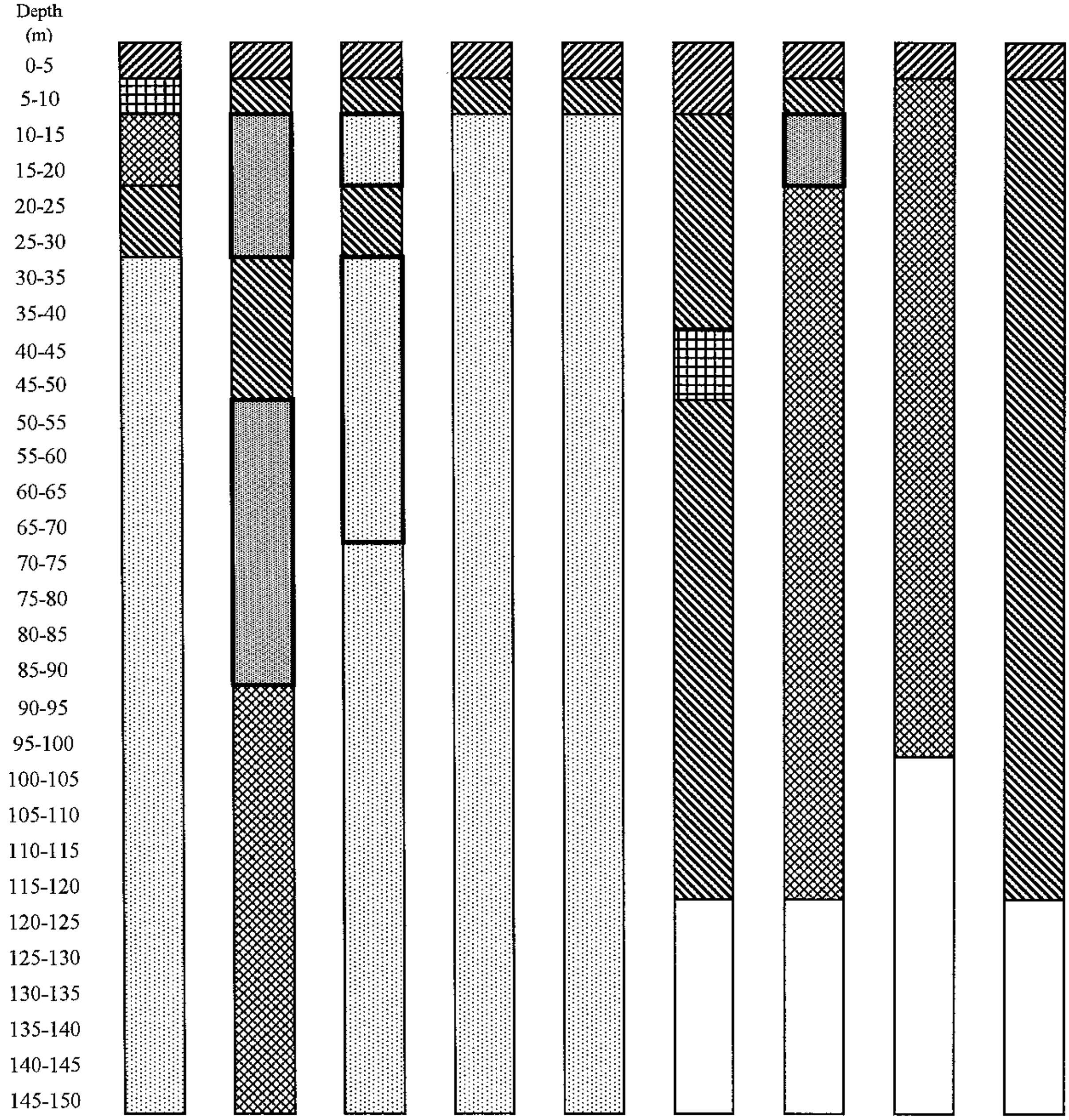
(c) Sokotei Village

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence. All sounding points shows very low resistivities (less than 2 ohm-m), indicate the presence of brackish to saline water.

(d) Mosuro Village

The resistivity profiles do not show any feature of direct interest for fresh groundwater occurrence.

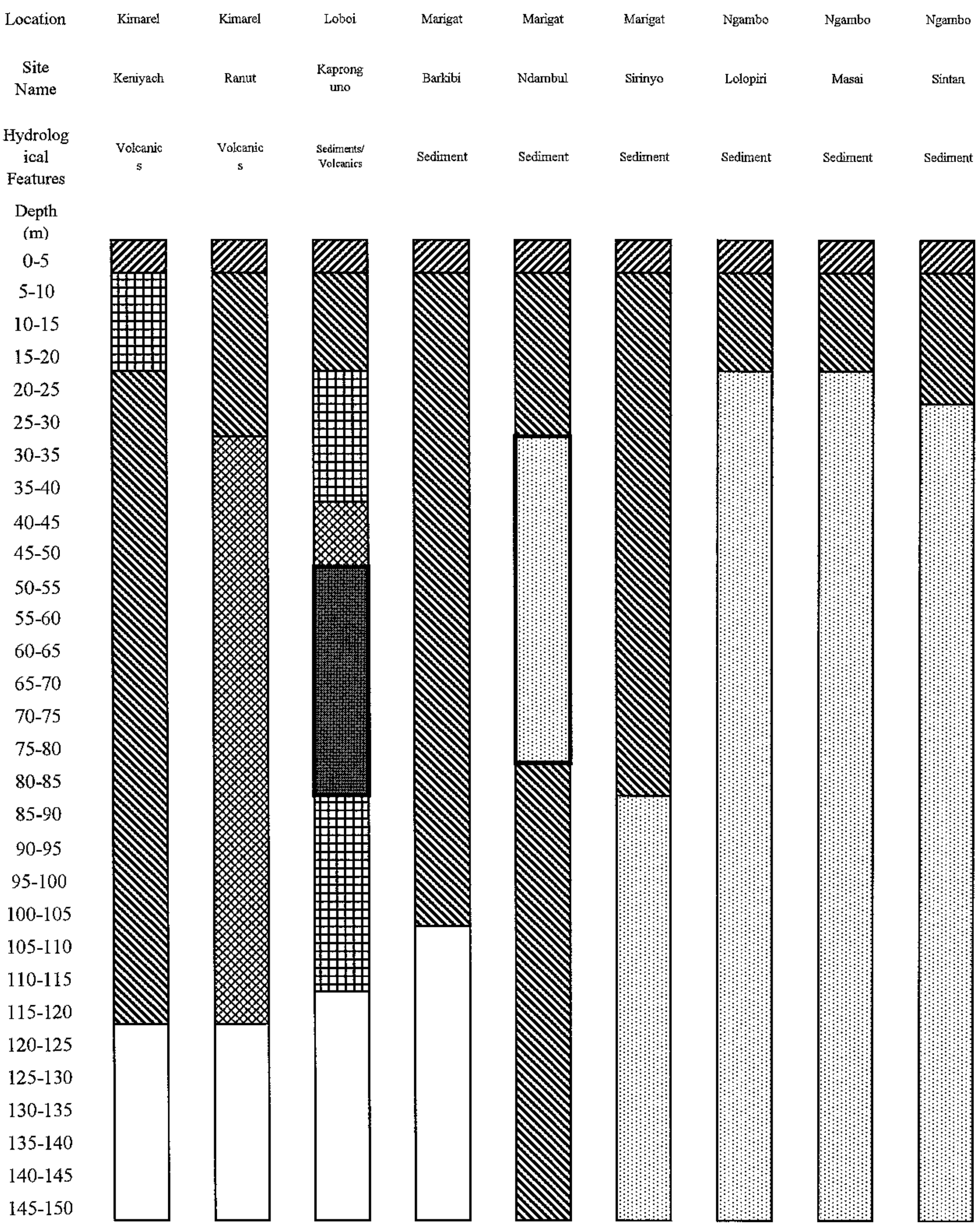
Location	Eldume	Eldume	Eldume	Eldume	Eldume	Kapkuikui	Kimarel	Kimarel	Kimarel
Site Name	Eldume Pr School	Lororo Center	Kairel	Ntepes	Ilngarua	Toborwe che	Kapkun	Kimorok Pr School	Bartugel
Hydrological Features	Sediment	Sediment	Sediment	Sediment	Sediment	Volcanic s	Volcanic s	Volcanic s	Volcanic



Estimated Groundwater Potenstial

Aquifer Yield *1	▲	▲	×				×		
Water Quality	saline								
Depth (m)	90-100	60-90							

*1 : ○ fair. △ medium. ▲ low. × very low

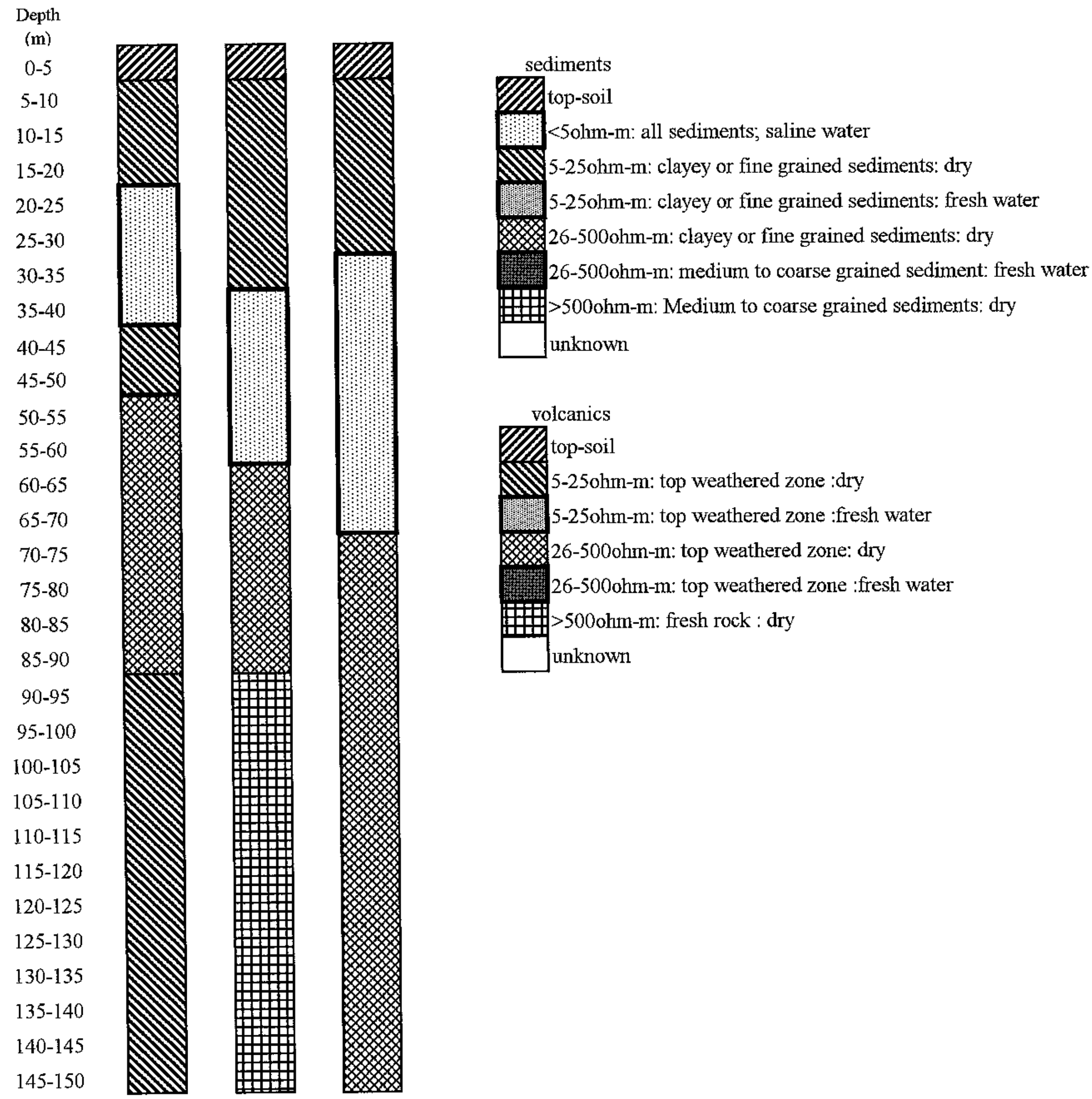


Estimated Gr

	Keniyach	Ranut	Kaprong uno	Barkibi	Ndambul	Sirinyo	Lolopiri	Masai	Sintan
Aquifer Yield *1			▲		▲				
Water Quality					saline				
Depth (m)			60-80		40-80				

*1 : ○ fair. △ medium. ▲ low. × very low

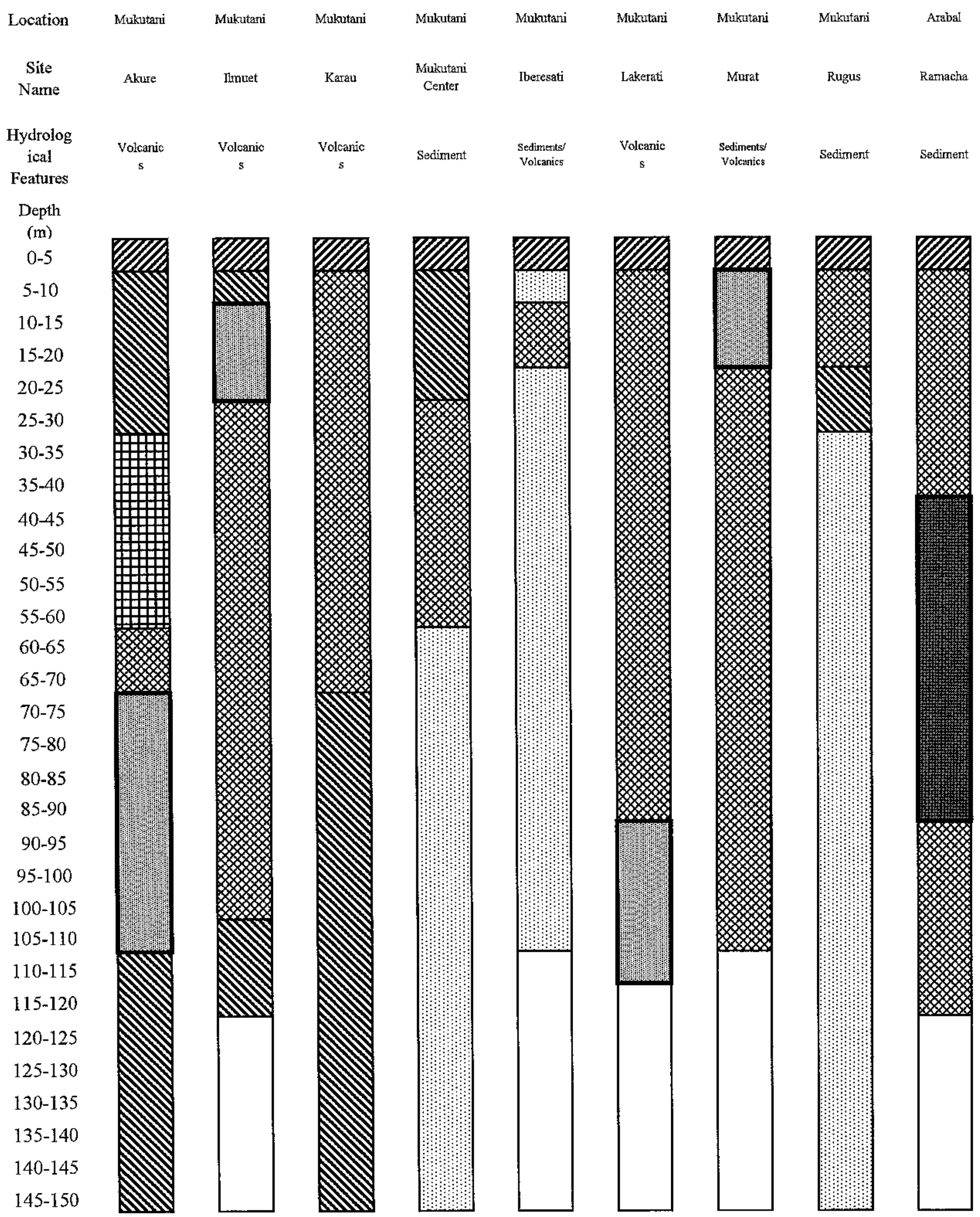
Location	Sandai	Sandai	Sandai
Site Name	Londeyani	Sandai Pr School	Chepkotoiyan
Hydrological Features	Sediment	Sediment	Sediment



Estimated Grc

Aquifer Yield *1	○	○	○
Water Quality	saline	saline	saline
Depth (m)	20-40	30-50	40-60

*1 : ○ fair. △ medium. ▲ low. × very low

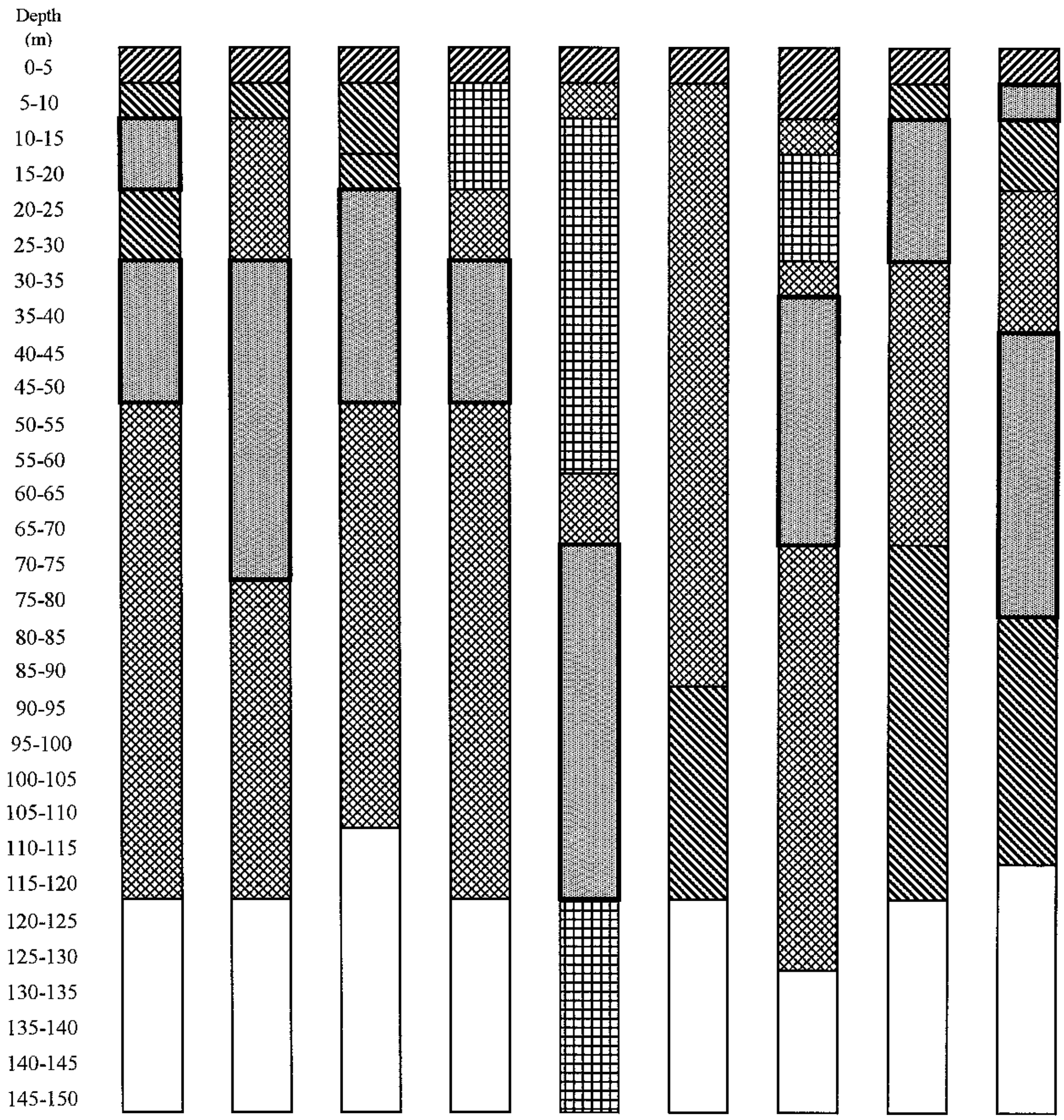


Estimated Groundwater Potenstial

	Akure	Ilmuet	Karau	Mukutani Center	Iberesati	Lakerati	Murat	Rugus	Ramacha
Aquifer Yield *1	△	▲				○	×		▲
Water Quality									
Depth (m)	80-100	10-20				90~100			40-60

*1 : ○ fair. △ medium. ▲ low. × very low

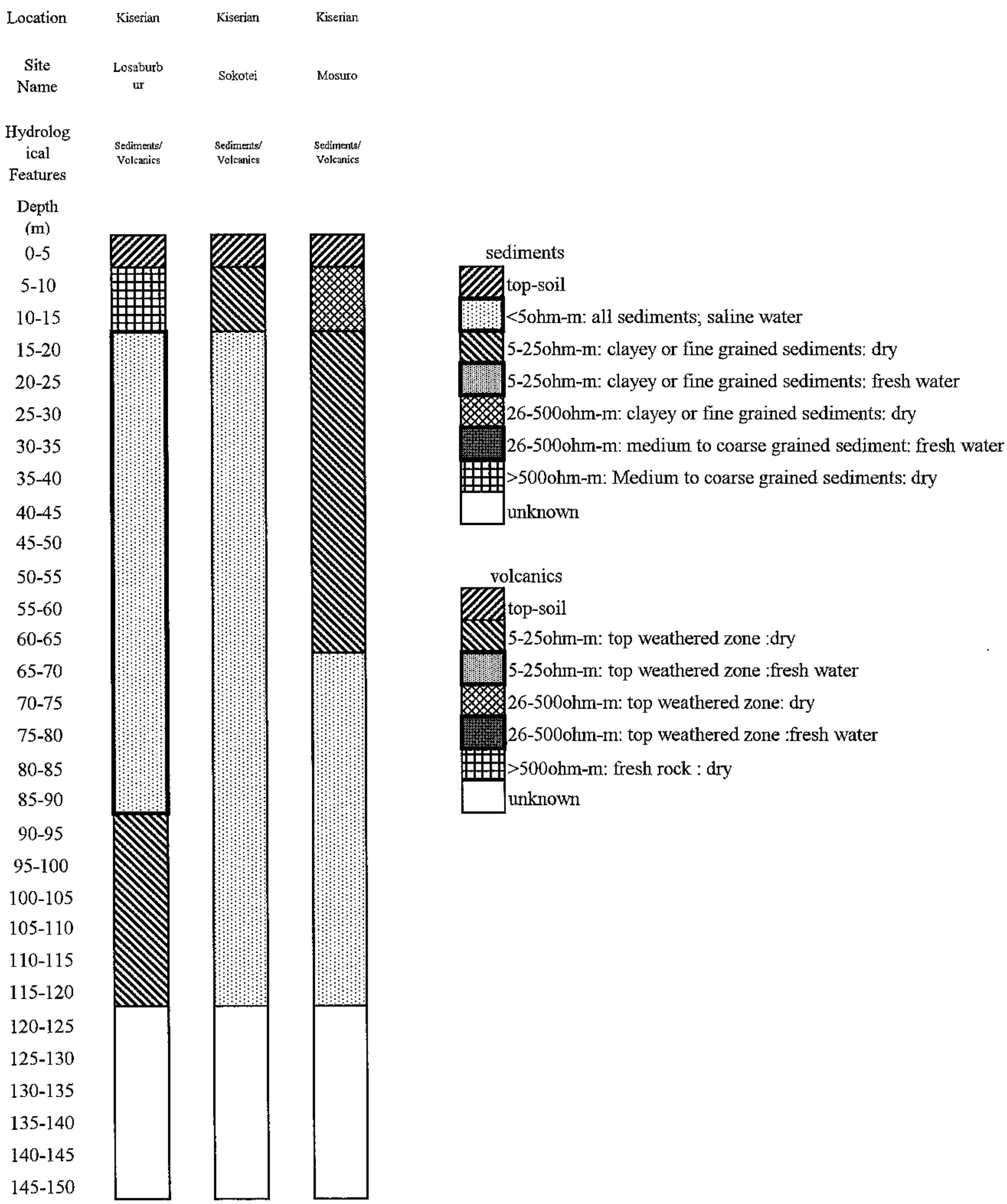
Location	Arabal	Arabal	Arabal	Arabal	Arabal	Arabal	Arabal	Arabal	Kiserian
Site Name	Karuma	Katilomo	Kipkoibetu	Parotsro	Losokoni	Neglecha Pr School	Arabal Pr School	Kapindas Pr School	Loitip
Hydrological Features	Volcanics	Volcanics	Volcanics	Volcanics	Volcanics	Volcanics	Volcanics	Volcanics	Sediments/ Volcanics



Estimated Grc

Aquifer Yield *1	△	△	▲	▲	○		○	▲	×
Water Quality					saline				
Depth (m)	30-50	30-60	30-40	40-50	80-120		40-70	10-20	

*1 : ○ fair. △ medium. ▲ low. × very low



Estimated Gr(

Aquifer Yield *1	▲		
Water Quality	saline		
Depth (m)	30-60		

*1 : ○ fair. △ medium. ▲ low. × very low