HYDROGEOLOGICAL ASSESSMENT REPORT

FOR

CLIENT;

GIKINGI PRIMARY SCHOOL,

P.O. BOX 64-20302,

OLJORO OROK.

LOCATION;

GIKINGI AREA IN NYANDARUA COUNTY

REPORT NO. SOO/-/2024

REPORT COMPILED BY;

PAUL M.NJUKI 0723830680
JOHN M. MWANGI 0712860709.
(HYDROGEOLOGISTS)

Reviewed By;
S.O. OWUOR (Registered Hydrogeologist)
P.O BOX 33350 – 00600,
NGARA, NAIROBI.

JANUARY, 2024.

Summary

The present report describes the results for groundwater resources/ hydrogeological investigations at **Gikingi Primary School's** parcel of land located in Gikingi area,Gikingi sublocation, Oljoro orok Location Oljoro orok division in Nyandarua west Subcounty in Nyandarua County. The study is required for identifying a suitable site for drilling one production borehole to supply water for general purpose use in the farm. The water demand is estimated to be about **40m^3/day.**

The Project area is situated in a zone with moderate to high groundwater potential.

A borehole is recommended to be drilled at the point probe and marked at the site and referred to as **VES- 1 to a maximum <u>depth of 250 m bgl</u>.** This will ensure that the deeper aquifer will be fully penetrated as it extends to a depth of more than 100m at this site.

Water quality is expected to be good and suitable human use.

It is thus recommended that:

- An 8inch in diameter borehole be drilled at **VES 1 position to a maximum depth of 250m.**
- The borehole be installed with mild steel casings and gas-slotted screens
- The borehole hydraulical properties and aquifer characteristics should be determined during a 24-hour constant discharge test.
- Samples taken during test pumping must be submitted to a recognized laboratory for full physical, chemical and bacteriological analyses.
- A monitoring tube and master meter should be installed in the borehole to be able to monitor the water level and water consumption respectively.

With careful implementation of the project by adhering to the study's findings and recommendations and by following the Water Resources Management Authority's Guidelines (found in the Authorization letter to Drill the Borehole), the project will safely meet the client's objectives successfully without any impact to groundwater abstraction trends in the area and surrounding boreholes

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ABBREVIATIONS (All S.I Units unless indicated otherwise)

agl	above ground level
amsl	above mean sea level
bgl	below ground level
E	East
EC	electrical conductivity (μS/cm)
hr	hour
m	metre
N	North
PWL	pumped water level
Q	discharge (m^3/hr)
s	drawdown (m)
S	South
SWL	static water level
T	transmissivity (m^2/day)
VES	Vertical Electrical Sounding
W	West
WAB	Water Apportionment Board
WSL	water struck level
μS/cm	micro-Siemens per centimetre: Unit for electrical conductivity
°C	degrees Celsius: Unit for temperature
"	Inch

GLOSSARY OF TERMS

Alluvium General term for detrital material deposited by flowing water.

Aquifer A geological formation or structure, which stores and transmits water and which is able to supply water to wells, boreholes or springs.

Colluvium General term for detrital material deposited by hill slope gravitational processes, with or without water as an agent. Usually of mixed texture.

Confined aquifer A formation in which the groundwater is isolated from the atmosphere by impermeable geologic formations. Confined water is generally at greater pressure than atmospheric, and will therefore rise above the struck level in a borehole.

Development In borehole engineering, this is the general term for procedures applied to repair the damage done to the formation during drilling. Often the borehole walls are partially clogged by an impermeable "wall cake", consisting of fine debris crushed during drilling, and clays from the penetrated formations. Well development removes these clayey cakes, and increases the porosity and permeability of the materials around the intake portion of the well. As a result, a higher sustainable yield can be achieved.

Fault A larger fracture surface along which appreciable displacement has taken place.

Gradient The rate of change in total head per unit of distance, which causes flow in the direction of the lowest >head.

Grit Coarse sandstone of angular grain

Hydraulic head Energy contained in a water mass, produced by elevation, pressure or velocity.

Hydrogeological Those factors that deal with subsurface waters and related geological aspects of surface waters.

Infiltration Process of water entering the soil through the ground surface.

Joint Fractures along which no significant displacement has taken place.

Lava sheet Lava flow, in parts very thick, covering a large area.

Percolation Process of water seeping through the unsaturated zone, generally from a surface source to the saturated zone.

Permeability The capacity of a porous medium for transmitting fluid.

Phenocrysts Large, conspicuous crystals in porphyritic rocks (i.e. rocks with visible mineral crystals in a generally fine groundmass).

Phonolite Compact and fine textured volcanic rock, belonging to the trachyte-group (together with *trachyte ss.* and *latite*). Defined by a high portion of feldspar (40-90%) and feldspatoidic minerals (10-60%: analcite, nepheline, leucite, etc.), and very low to negligible quartz content (0-2%). Incorporated dark coloured minerals (0-40%) most commonly include hornblende, olivine, melanite and acmite. The structure is porphyritic with common phenocrysts of sanidine (orthoclase, or Potassium-feldspar) and nepheline.

Piezometric level An imaginary water table, representing the total head in a confined aquifer: it is defined by the level to which water would rise in a well.

Pyroclastic rocks Group of rocks consisting of volcanic dust, ashes, lapilli and coarse lumps of lava, explosively thrown up in molten condition, and deposited by gravity. Hardened masses of dust, ashes and lapilli are known as *tuff*, while coarse, consolidated pyroclastic debris is referred to as *agglomerate.*

Porosity The portion of bulk volume in a rock or sediment that is occupied by openings, whether isolated or connected.

Pumping test A test that is conducted to determine aquifer and/or well characteristics.

Recharge General term applied to the passage of water from surface or subsurface sources (e.g. rivers, rainfall, lateral groundwater flow) to the aquifer zones.

Static water level The level of water in a well that is not being affected by pumping (a.k.a. "rest water level")

Transmissivity A measure for the capacity of an aquifer to conduct water through its saturated thickness (m^2/day).

Tuff Here: hardened volcanic ash.

Unconfined Referring to an aquifer situation whereby the water table is exposed to the atmosphere through openings in the overlying materials (as opposed to >confined conditions).

Yield Volume of water discharged from a well.

1. INTRODUCTION

In January 2024, **Gikingi Primary School** commissioned the carrying out of hydrogeological/geophysical site investigations within their institutional parcel of land. The land is located within Gikingi area in Nyandarua County.

The address of the Client is:

Gikingi Primary School,
P.O. Box 64-20302,
Oljoro Orok.

The **client** intends to drill the borehole within their parcel of land within Gikingi area in order to have a reliable water supply.

The study was carried out as follows:

i. Detailed desk study. This included review of existing information, maps, and reports in the vicinity of the project area, borehole data etc.
ii. Geophysical/Hydrogeological study,
iii. Analysis of geophysical data and correlation with geological logs.
iv. Data analyses and reporting.

The present report describes the field investigations, recommendations and conclusions for the study.

2. BACKGROUND INFORMATION

2.1 Location

The site is situated in Gikingi area,Gikingi sublocation, Oljoro orok Location Oljoro orok division in Nyandarua west Subcounty in Nyandarua County.It also lies within the Survey of Kenya topographic sheets for Oljoro orok (No. 119/2) as shown on Fig 2.1 below. Its defining coordinates are 37M 0204132 UTM 9986763.

2.2 Physiography

The site lies at an altitude of about 2502m amsl, on a flat to very gently undulating terrain sloping south-eastwards towards the existing valley with a seasonal stream. Towards the Thompson’s Falls is a shallow asymmetrical graben: the plain occupying its floor is an extension northwards of the Kinangop Plateau. In this trough lies Lake Ol Bolossat, the highest of all the Rift Valley lakes, which stands at 2340 m amsl. Further west, the area is broken by faults forming a complex of shallow horst and graben structures. Conspicuous in the area is numerous flat swampy clay-filled pans along the depressions

2.3 Climate

The site is located in the high plateaux of Ol Bolossat and is inclined to be cold and misty and usually masked in clouds due to the effect of the Aberdares Ranges to the NE of the investigated area. It has a cool temperate, sub-humid climate (after Sombroek et al 1982). The mean annual rainfall is in the order of 1000 mm. The rainfall is fairly high on the high grounds of the Rift Valley shoulders, falling off appreciably in the lake basins.

Rainfall has a bi-modal distribution pattern with two wet seasons (March-May, and October-December).

Temperatures are highest in the months of January to March; Annual minimum and maximum temperature ranges from 6 to 18^{o}C, (TAMS, 1980). Average potential evaporation is between 1,200 and 2,000 mm per year.

2.4 Water Demand

Water from the proposed borehole will be used for domestic purpose within the insitution. Water requirement is estimated at **40m^3/day.**

3. GEOLOGY

3.1 Regional Geology

The area is underlain by Pliocene and Recent volcanic rocks which overlie Miocene and volcanic Succession. No Basement System rocks have been observed at or near the surface within the investigated area. The sections below describe the geology in a regional context, followed by a detailed assessment of the geology of the investigated area.

The area is underlain by the Lower Pleistocene volcanic rocks “Mau tuffs, Bahati tuffs and Kinangop tuffs” comprising vitric pumice tuffs, ignimbrites, welded tuffs with lacustrine sediments, graded tuffs and diatomites. These are in turn underlain by Rumuruti phonolites at depth. These volcanics are underlain by the Basement System rocks at greater depths.

3.1.1 Bahati Tuffs

A continuous series of tuffs and “ignimbrites” extends from Bahati to the plains of Ol Bolossat and the Kinangop plateau where older lava formations, the Simbara basalts and Sattima Series emerge from beneath the tuffs.

Southwards from Thomson Falls the tuff formation gradually thickens and becomes more continuous, obscuring older phonolites. The only rocks exposed in the Ol Bolossat plain belong to this formation and most of the high country is underlain by yellow tuffs of this formation. The “ignimbrite” is here very thin and discontinuous. West of Ol Joro Orok, some well stratified tuffs, apparently of lacustrine origin, are intercalated in the massive pumice tuffs. In the Oraimutia valley both the pumice tuffs and capping ignimbrite are recognized but the succession shows a complication in an overlying succession of welded tuffs of the claystone variety.

At Ol Kalou the succession becomes more complicated with pumice tuffs (some grading), overlying pumice tuff in two massive units. Northwest of Ol Kalou, pumice tuffs dipping at 9^0 to the east in bedded units have intercalated weathered zones and contain mascareignite and fossil wood. They overlie phonolites with a weathered upper surface. Elsewhere, ignimbrite overlies the pumice tuffs.

3.1.2 Pumice Tuffs

The yellow to creamish buff pumice tuffs are dominantly composed of coarse vitric tuff, grading into lapilli tuff. These tuffs consist of glass fragments and felspar crystals. The tuffs weather readily to clayey material and also show a deep red clayey soil capping where they form the land surface. The medium grained pumice to finer grained clays and sandy soils produced by weathering of finer ash occur within this formation.

3.1.3 Graded Tuffs

As already noted, there are many occurrences of finely stratified lake beds within the yellow pumice tuffs. The finer and better stratified members are of waterlain origin, and are composed of particles derived from disintegrated pumice. In the silt grades, the vitroclastic textures cannot be seen, but it is visible in the coarser sand grades. In some of the coarser grades, the particles are so angular and so well compacted due to their fragility that the outlines of individual grains are not readily distinguishable.

3.1.4 Ignimbrites

These include the coarse fragmental rocks, characterised by crystallization of the matrix in fibrous fringes and spherulites or a complete absence of crystallization, and also finer welded tuffs (clay stones). The single flows of ignimbrite are up to 30 meters thick and frequently show columnar jointing. They locally have a friable texture and show a super abundance of enclaves giving an appearance of a true tuff of pyroclastics origin, but flattened magmatic enclaves of considerable dimensions locally indicate that they cannot be deposits derived from volcanic showers. Many of the ignimbrites show localized weathering and alteration to yellow and brown rocks easily mistaken for pumice tuffs-incandescent avalanche deposits or true pyroclastics. The ignimbrites are essentially all trachytic in composition.

3.1.5 Oramutia and Ol Bolossat Volcanics

There are numerous occurrences of shallow fillings of yellow-brown pumice tuffs and welded tuffs in the valleys in these two areas. In Oramutia, thin clay stones rest unconformably on the older pumice tuff and coarse ignimbrite of the Bahati tuff succession. These later ignimbrites and tuffs are of later age than the Oramutia fault which disrupts the earlier tuffs and the underlying phonolites. They pass over the line of this fault into the eastern part of the Oramutia valley undisturbed by any movements except minor renewals on the fault line, which displace the welded tuffs a few meters down to the west and show nearly vertical fracture planes.

3.1.6 Rumuruti Phonolites

The phonolites of the Rumuruti group are seen in deep sections in many localities. They form a succession of numerous lava flows, individual flows having thicknesses of 15 to 30 meters. The flows are separated by weathered zones but there is little or no tuffaceous material associated with this group. The Rumuruti phonolites show a remarkable change in thickness from east to west. They thin out rapidly into the Rift Valley. There is no consistent succession throughout the area but a distinct separation into sets of flows can be made. These lavas are fine textured. At the investigated site, the lavas are not exposed, being obscured by the overlying tuffs, pumice and volcanic soils.

3.1.7 Thompson Falls Phonolites

These phonolites are well seen between the Thompson falls and Oljoro Orok. They are blackish grey in colour, resembling basalt rather than phonolites. They weather into large boulders several feet across with a ferruginous coating.

3.1.8 Recent Deposits (Volcanic Soils)

Superficial deposits underlying the site comprise volcanic soils developed on the pyroclastics rocks. The soils are well drained, deep, dark reddish brown, friable and smeary, silty clay, with humic top soil (Mollic Andosols).

3.2 Geological structures

The structural pattern of the area shows a completely probably quite unparalled in the Rift valley system, owing to the number and variety of orientation of the faults. The major faulting episode took place after the eruption of the Rumuruti plateau phonolites and associated lavas. It almost certainly also succeeded the eruption of the Thompson’s falls phonolites which appear to be part of the plateau succession. The main faulting direction is SW-NE. This also forms the general direction of faulting in the area. On the south eastern part of the investigated site a lineament interpreted to be a minor fault was identified. A study of topographical and geological maps shows the drainage in the area is structurally controlled. In addition, a major geological structure (fault) about 5 km NE of the site is mapped in the geological map, referred to as Satima fault. The structure is orientated in a north-south direction. This geological structure controls the groundwater flow in this region.

3.3 Geology of the Investigated Site

The site is underlain at the surface by dark to reddish brown superficial deposits and volcanic soils. Beneath the volcanic soils is the Lower Pleistocene volcanic rocks, Kinangop tuffs and the Thompson falls phonolites. These are underlain by Rumuruti phonolites. There are two layers of Rumuruti phonolites separated by an old land surface (OLS).

The thickness of these formations at the investigated site cannot be estimated accurately as there are no boreholes drilled within a radius of one kilometre whose geological logs could be analysed. Besides geological logs of other boreholes drilled in the general area do not give proper description of the geological formations encountered during the drilling. Furthermore, the composition of the underlying geological formations has marked similarities and therefore, boundaries between the formations are hard to distinguish.

4. HYDROGEOLOGY

4.1 Introduction

The hydrogeology of an area is normally intimately dependent upon the nature of the parent rock, structural features, weathering processes and the form and frequency of precipitation.

Regional Hydrogeology

The only major permanent rivers that drain the volcanic rocks and the sedimentary formations in the area are the Ewaso Ngiro River, Equator and Chamuka rivers. The two rivers forming the major drainage system maintain constant flow throughout the year. All other rivers and streams flow for only a short period of the year following the rains. Along the existing valleys, numerous ponds are found which hold some volume of water after the wet season.

4.2 Existing boreholes

There are several boreholes which have been drilled within this area and their details is as indicated below.

Table of existing boreholes in the project area

A	B	C	D	E	F	G	H
BH No. C-	**Owner**	**Location (X km dir)**	**Depth (m bgl)**	**WSL (m bgl)**	**WRL (m bgl)**	**Q (m3/hr)**	**PWL (m)**
Ref.	**Gikingi primary school's Site**						
11643	Muriithi Wamithi Joshua	4.3NNW	180	26,80,126,138	139	11.64	-

Description of columns

A	Ministry of Water Resources Identification Number (lowest numbers represent oldest holes)
B	Owner
C	Distance in km and bearing from selected BH site
D	Total drilled depth in meters below ground level (m bgl)
E	Water Struck Level 1, 2 and 3, depth at which the aquifer was encountered, in meters below ground level (m bgl)
F	Water Rest Level, depth of piezometric surface, or water table, in meters below ground level (m bgl)
G	Tested yield in m^3/hr
H	Pumped Water Level

4.2.1 *Borehole Data Analyses and Aquifer Outline of the Area.*

The available data indicates that various water struck levels occur within drilled depth of 80-140m bgl.

i. The first intercalated aquifer is found between 80-140m bgl within the contact of different lava flows.

ii. The second main aquifer is between **140 and 250.**

4.4.1 Impacts to Abstraction Trends and Analyses of Boreholes within 800-m from the Proposed Site

From the records NO boreholes are located within 800m radius and hence there is no envisaged interference in abstraction trends if the borehole under study is drilled.

The existing borehole has a good yield which is an indication of underlying productive aquifers.

4.3 Recharge

The recharge mechanisms (and the rate of replenishment) of the local aquifers has not been fully established. The two major processes are probably direct recharge at surface (not necessarily local) and indirect recharge via faults and/or other aquifers.

Direct recharge is obtained through downward percolation of rainfall or river water into aquifer. If the infiltration rate is low due to the presence of an aquiclude (such as clay), the recharge to the aquifer is low. Percolation will depend on the soil structure, vegetation cover and the state of erosion of the parent rock. Rocks weathering to clayey soils naturally inhibit infiltration and downward percolation. Aquifers may also be recharged laterally if the rock is permeable over a wide area.

In the present study area, the principal recharge zones are the eastern flanks of the rift Valley. These areas probably receive higher rainfall than the investigated site. As a result, the aquifers identified are indirectly recharged by underground drainage of water falling some distance from their present locations.

4.3.1 *Mean Annual Recharge*

Although rainfall within the study area is low, regional recharge is of great essence in this area. Much of regional recharge occurs within the eastern flanks of the rift valley followed by base flow within the thick volcanic sheets and faults which characterise the region. **However, this recharge mechanism is mainly important for the replenishment of (regional) volcanic aquifers and is what has been used to estimate the Mean Annul Recharge.**

At the present location, water also percolates directly into the faults, fractures, local rivers and streams (via fractures) thus deeper and adjacent units are recharged over time.

Mean Annual Recharge has therefore been estimated as follows:

The Recharge is estimated as 5% of the Mean Annual Rainfall of the recharge area

1400mm x 5%

Mean Annual Recharge = 70mm

However, this recharge amount is probably estimation due to the possibility of influent local recharge through local rivers and rainwater percolation through faults into the weathered/fractured basement rock system and overlaying OLS.

4.4 Discharge

Discharge from aquifers is either through natural processes as base-flow to streams and springs, or artificial discharge through human activities. However considering the few number of boreholes in the area this form of discharge is not much pronounced.

The total effective discharge from the aquifers via either of the above means is not known. The main form of discharge is through flow along formations and faults/ interconnected fractures.

4.5 Aquifer Properties.

4.5.1 *Calculation of Aquifer Properties.*

To calculate the area Aquifer Properties, testing pumping data of an existing productive borehole is paramount which in our case does not exist.

4.5.2 *Estimation Aquifer Transmissivity*

The raw test Pumping Data of any borehole in the area was not available to assist in calculation of Aquifer Transmissivity using **Jacob's formula (Driscoll 1986):**

Thus, in absence of proper pump test data, the **Logan method of approximation** could have been employed (Logan, 1965). This method however has errors of 50% or more and is thus used for estimation purpose only.

Aquifer Transmissivity (T) is thus estimated as follows:

$$T=1.22Q/\Delta S$$

Where: Q = Yield per day
ΔS = Draw down

4.5.3 *Hydraulic Conductivity*

The Hydraulic Conductivity (K) is estimated as follows:

$$K = T/\text{Aquifer Thickness}$$

4.5.4 *Specific Capacity*

The aquifer Specific Capacity (S) = $Q/\Delta s$.

4.5.5 *Groundwater Flux*

The Groundwater Flux (F) is estimated based on a borehole which more or less share the same aquifers.

$F = K.i.h.w$ Where K- Hydraulic Conductivity = m/day

i – Slope

h- Aquifer Thickness

w- Arbitrary distance,

4.6 Water Quality

In the general Gikingi area, the quality of groundwater is generally good, except for the fluoride content, which surpasses the W.H.O. upper limit of 1.5 ppm. Available records show high fluoride concentrations in the project area that also surpasses W.H.O upper limits. High fluoride intake, especially in growing infants, may cause dental or skeletal fluorosis. Should the fluoride concentration of the proposed borehole exceed 1.5 ppm, it is advisable to provide an alternative source of drinking water for infants (bottled water would be the best option). Over a short time span, the consumption of water with excess fluoride is not harmful to adults. Other option of minimizing fluoride levels include mixing borehole water with low fluoride water. W.H.O. and EC guideline concentrations are included for reference in appendix section.

4.7 Impacts of the Proposed Activity to Water Quality, Wetlands or Protected Areas.

The Proposed drill site and related works are expected to pose no impact on water quality, either Surface or groundwater resources. There is no any surface water body near the drill site that can be contaminated by waste waters generated during drilling. The entire drilling, borehole construction, pump tests, and completion works will be done under supervision to professional standards. Entry of any foreign material until completion will be avoided to avoid any entry of foreign material into the borehole and only inert materials will be used in construction. The borehole will be properly developed to open up the aquifers and clean the borehole water. Monitoring of ec during drilling will be done to detect and seal any aquifer with elevated mineralization.

The site is not located within a wetland or protected land and has no negative impacts on biodiversity.

5. GEOPHYSICAL INVESTIGATION METHODS

A great variety of geophysical methods are available to assist in the assessment of geological subsurface conditions. The most commonly used in groundwater survey is resistivity method (also known as the geo-electrical method).

5.1 Resistivity Method

It is sometimes referred to as DC resistivity technique. This method measures the earth's resistivity by driving a direct current (DC) signal into the ground and measuring the resulting potentials (voltages) created in the earth. From that data the electrical properties of the earth (the geoelectric section) can be derived and thereby the geologic properties inferred. The diagram below illustrates the basic electrical array for that measurement.

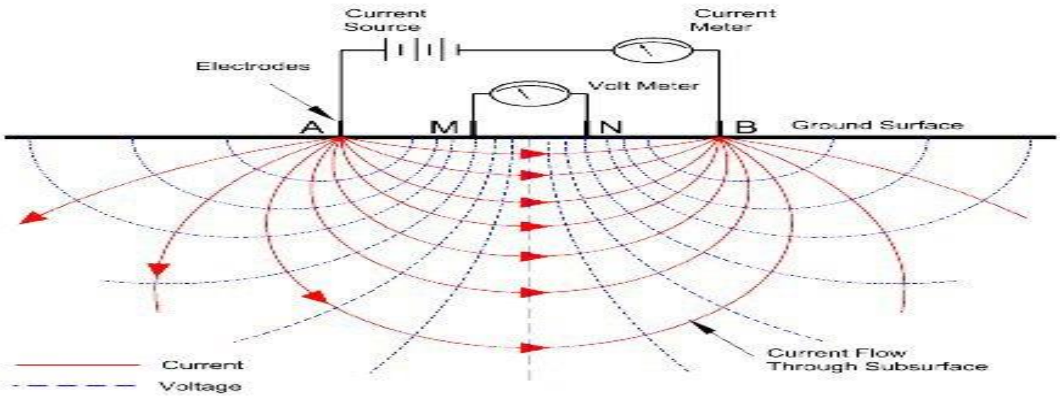


Fig 5.1:Schematic Diagram of DC Resistivity Method

The figure above is a schematic diagram showing the basic principle of DC resistivity measurements. Two short metallic stakes/current electrodes (AB) are driven about 1 foot into the earth to apply the current to the ground. Two additional potential electrodes (MN) are used to measure the earth voltage (or electrical potential) generated by the current. Depth of investigation is a function of the distance of current electrodes

In this method an electric current is passed into the ground and the potential difference measured to get the Resistivity of the underlying layers

There are many Resistivity arrays used in the field. The ones most commonly used in groundwater survey are the horizontal resistivity profile and vertical electrical sounding (VES).

5.2 Basic Principles

The electrical properties of rocks in the upper part of the earth's crust are dependent upon the lithology, porosity, the degree of pore space saturation and the salinity of the water. It is imperative to note that:

1 Saturated rocks have lower resistivities than unsaturated and dry rocks.

2 The higher the porosity of the saturated rock, the lower its resistivity.

3 The higher the salinity of the saturating fluids, the lower resistivity of the host media.

4 Clays and conductive minerals also reduce the resistivity of the rock.

The resistivity of earth materials can be studied by measuring the electrical potential distribution produced at the earth's surface by an electric current that is passed through the earth.

The resistance R of a certain material is directly proportional to its length L and cross-sectional area A, expressed as:

$$R = Rs * L/A \qquad \text{(Ohm)} \qquad (1)$$

Where Rs is known as the specific resistivity, characteristic of the material and independent of its shape or size. With Ohm's Law,

$$R = dV/I \qquad \text{(Ohm)} \qquad (2)$$

Where dV is the potential difference across the resistor and I is the electric current through the resistor, the specific resistivity may be determined by:

$$Rs = (A/L) * (dV/I) \qquad \text{(Ohm.m)} \qquad (3)$$

5.3 Horizontal Electrical Profile (HEP)

In horizontal Electrical Profile, lateral changes in resistivity are measured at a given depth depending on the values of AB and MN where AB is the distance between the current electrodes and MN is the distance between the potential electrodes. The variation in resistivity reflects the variation in the Lithology of the area. The direction in which a profile is taken is always across the fault line. The profile would therefore detect this regions and a VES would be done at the appropriate areas to confirm the presence of water. Apparent resistivities are different from the actual resistivities of the profile because of changes in the electric current that result from its pathway through various earth materials. Therefore, the apparent resistivities often require inversion modeling to convert the raw data to actual resistivities.

5.4 Vertical Electrical Soundings (VES)

When carrying out a resistivity sounding, current is led into the ground by means of two electrodes. With two other electrodes, situated near the centre of the array, the potential field generated by the current is measured. From the observations of the current strength and the potential difference, and taking into account the electrode separations, the ground resistivity can be determined.

While carrying out the resistivity sounding the separation between the electrodes is step-wise increased (in what is known as a Schlumberger Array), thus causing the flow of current to penetrate greater depths. When plotting the observed resistivity values against depth on double logarithmic paper, a resistivity graph is formed, which depicts the variation of resistivity with depth.

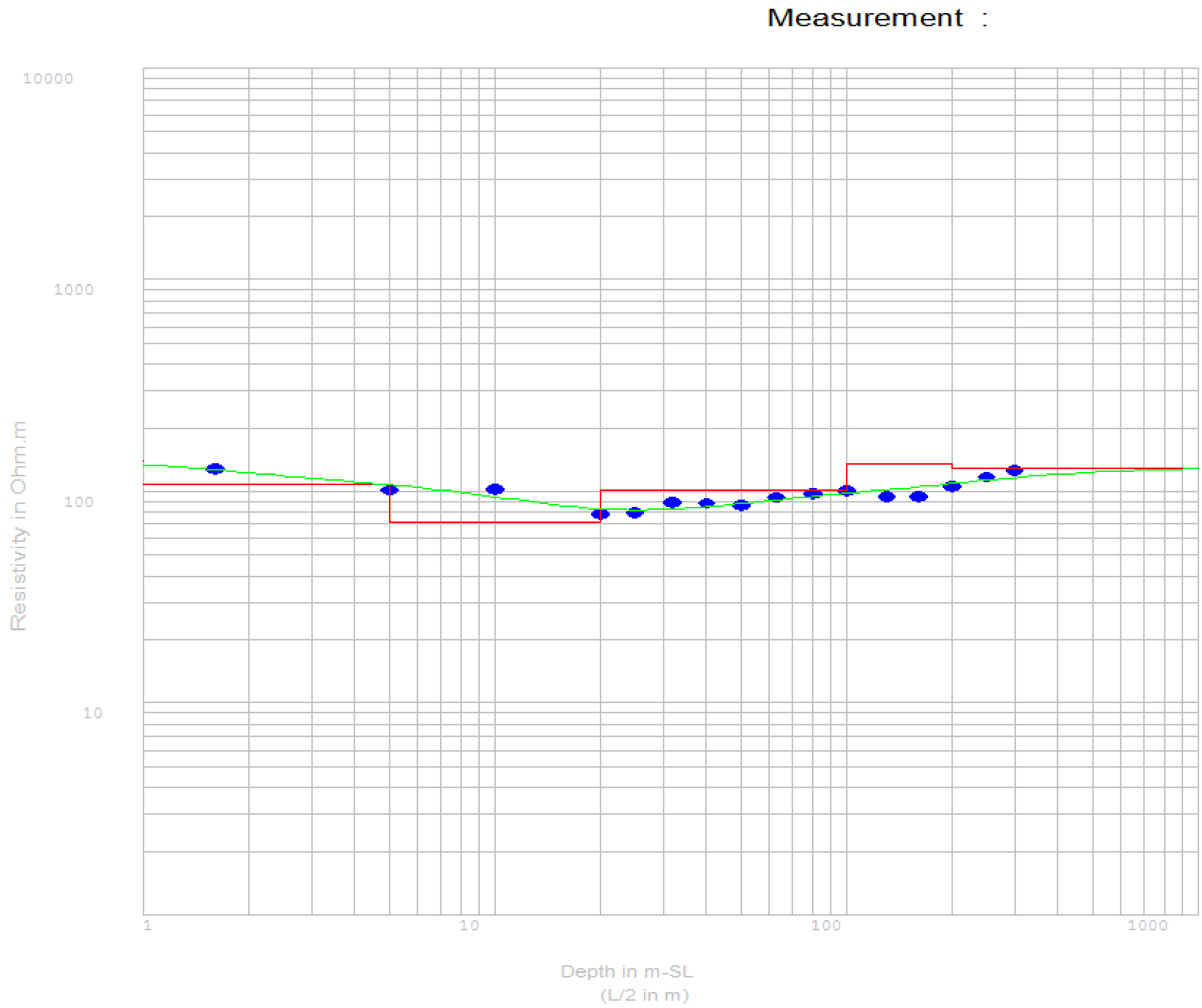
This graph can be interpreted with the aid of a computer, and the actual resistivity layering of the subsoil is obtained. The depths and resistivity values provide the hydrogeologist with information on the geological layering and thus the occurrence of groundwater.

6. FIELDWORK AND RESULTS

Field work comprising of One Vertical Electrical Sounding (VES) was carried out on January, 2024.The aim of the soundings was to determine the prevailing hydrostratigraphy at the site.

6.1 Results

VES 1 Geo-electric Layers, Sounding curve and Interpretations



Meas. #	L/2 in m	R in Ohm.m	don't use
1	1.60	128.55	☐
2	5.00	101.65	☐
3	10.00	102.74	☐
4	20.00	78.40	☐
5	25.00	79.19	☐
6	32.00	88.35	☐
7	40.00	87.99	☐
8	50.00	86.35	☐
9	63.00	93.78	☐
10	80.00	98.26	☐
11	100.00	100.94	☐
12	130.00	94.29	☐
13	160.00	94.90	☐
14	200.00	105.93	☐
15	250.00	117.29	☐
16	300.00	126.16	☐
	.00	.00	☑

Interpretation of Ves Sounding

Depth (m bgl)	Resistivity (Ohm-m)	Geological Interpretation
0-2.5	128	Superficial deposits
2.5- 10	101	Unconsolidated Kinangop Tuffs
10- 80	100	Analcitic phonolites
80-200	105	Fractured/weathered Phonolites
>200	125	Weathered lava

The VES 1 measurements results indicate a shallow superficial layer to a depth of about 2.5 m bgl interpreted to be dry superficial deposits comprising volcanic soils and alluvium. This is underlain by a layer to a depth of 10m bgl interpreted to be weathered pumice tuffs of the Kinangop Tuff series. This layer is moist and shallow water strikes are expected. Below this is a high resistivity layer to a depth of 80 m bgl, interpreted to be the Thompson's Falls phonolites. This is underlain by a weathered and fractured porphyritic phonolites of the Rumuruti series and Old Land Surfaces. Water strikes are expected in this layer. Below this is a low resistivity layer at depths greater than 200mbgl. This is interpreted to be weathered lava.

Groundwater Potential at **VES 1** is good and hence **IT IS RECOMMENDED THAT AN 8 INCH IN DIAMETER BOREHOLE BE DRILLED AT VES 1 TO A DEPTH OF 250M.**

6.2 Site Identification

The proposed Drilling site is at **VES 1** and it is clearly marked and known to the client.

7. CONCLUSIONS AND RECOMMENDATIONS

On the basis of all the information gathered in the field, geological, geophysical and hydrogeological evidence, there are good chances of striking water at the site.

A borehole is recommended to be drilled in the site at **VES- 1 to a maximum depth of 250 m bgl.** This will ensure that the deeper aquifer will be fully penetrated as it extends to a depth of more than 100m at this site.

Water quality is expected to be good and suitable for domestic use.

It is thus recommended that:

- An 8inch in diameter borehole be drilled at **VES 1 position to a maximum depth of 250m.**
- The borehole be installed with mild steel casings and gas-slotted screens
- The borehole hydraulical properties and aquifer characteristics should be determined during a 24-hour constant discharge test.
- Samples taken during test pumping must be submitted to a recognized laboratory for full physical, chemical and bacteriological analyses.
- A monitoring tube and master meter should be installed in the borehole to be able to monitor the water level and water consumption respectively.

8. REFERENCES

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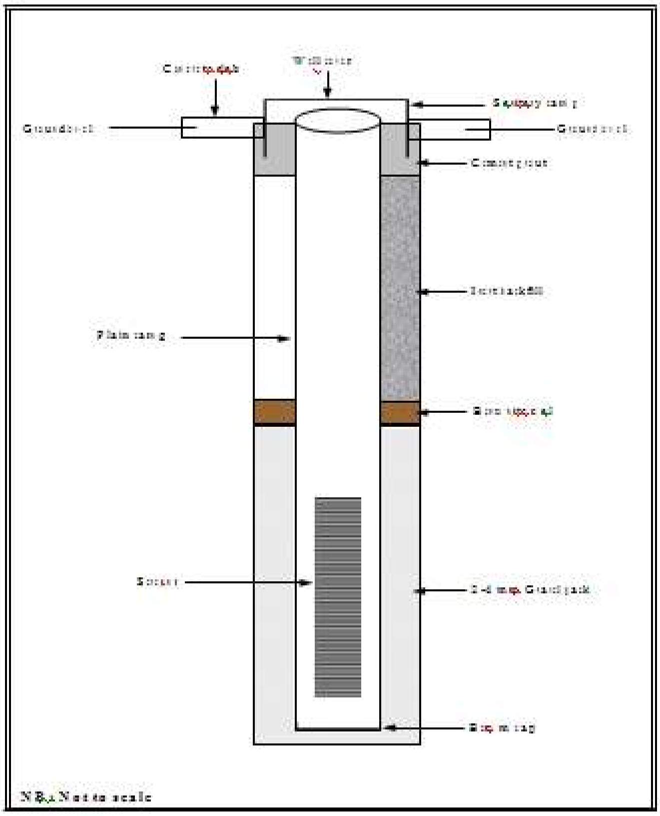
APPENDICES

APPENDIX I - Acceptable Ionic Concentration - Various Authorities

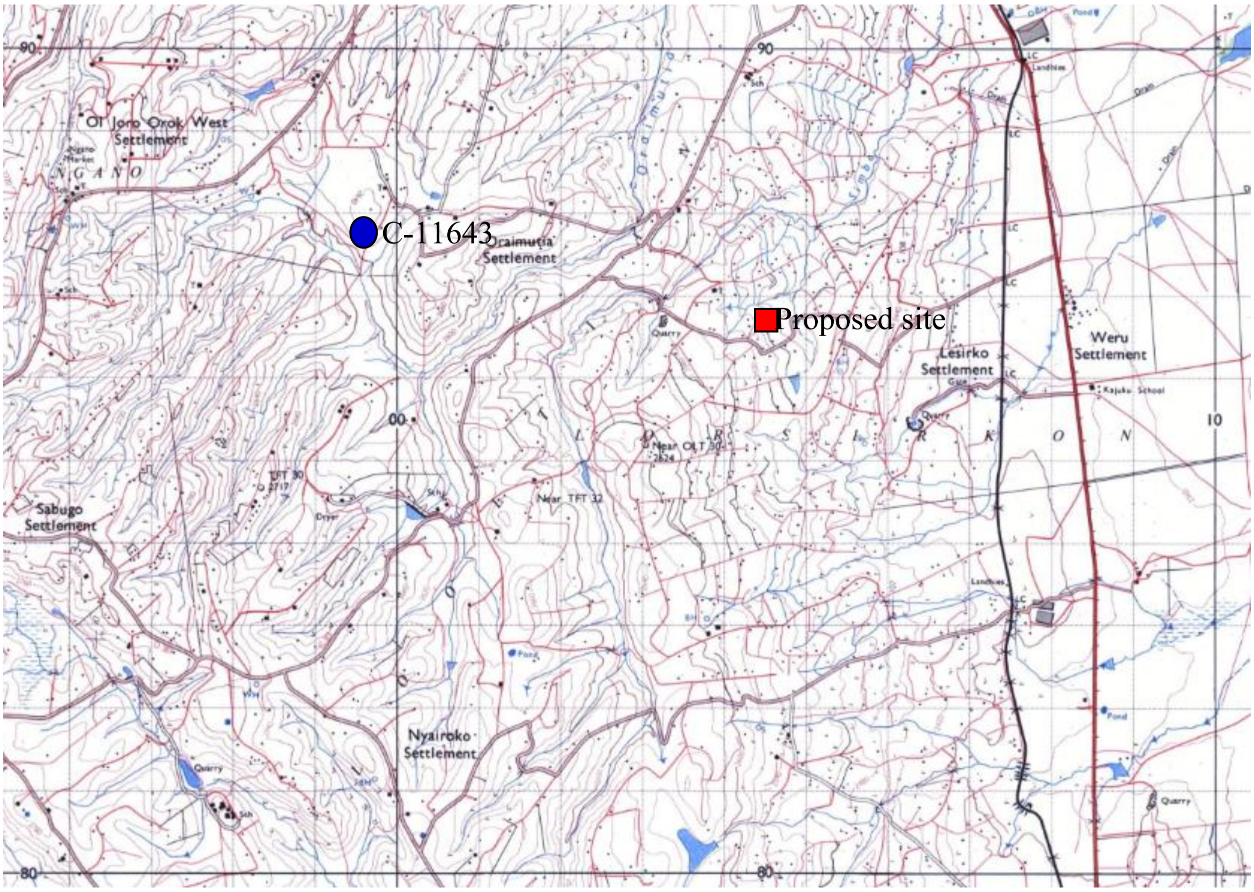
Substance or Characteristic		World Health Organization: 1983 Guidelines; Guideline Value (GV)	1971 Int. Standards; Upper limit (HL), (tentative)	European Community: EC Directive 1980 relating to the quality of water intended for human consumption: GuideLevel (GL)	Max. Admissible Concentration (MAC)
Inorganic Constituents of health significance;					
Antimony	Sb				0.01
Arsenic	As	0.05	0.05		0.05
Cadmium	Cd	0.005	0.01		0.005
Chromium	Cr	0.05	0.05		
Cyanide	CN	0.10	0.05		0.05
Fluoride	F	1.5	1.7		1.5
Lead	Pb	0.05	0.10		0.05
Mercury	Hg	0.001	0.001		0.001
Nickel	Ni				0.05
Nitrates		10 (as N)	45 (as N03)	25 (as NO3)	50 (as NO3)
Selenium	Se		0.01		0.01

Other Substances			GV: Desirable Level:		Highest Permissible Level:	Maximum		GV:		MAC:
Aluminium	Al		0.20					0.05		0.20
Ammonium	NH4							0.05		0.50
Barium	Ba							0.10		
Boron	B							1.0		
Calcium	Ca				75		50	100		
Chloride	Cl		250		200		600	25		
Copper	Cu				0.05			0.10		
Hydrogen Sulphide	H2S	ND							ND	
Iron	Fe		0.30		0.10		1.0	0.05		0.20
Magnesium	Mg		0.10		30		150	30		50
Manganese	Mn		0.10		0.05		0.50	0.02		0.05
Nitrite	NO2									0.10
Potassium	K							10		12
Silver	Ag									0.01
Sodium	Na		200					20		175
Sulphate	SO4		400		200		400	25		250
Zinc	Zn				5.0		15	0.10		
Total Dissolved Solids			1000		500		1500			1500
Total Hardness as CaCO3			500		100		500			
Colour	^{o}Hazen		15		5		50	1		20
Odour			Inoffensive		Unobjectionable				2 or 3 TON	
Taste			Inoffensive		Unobjectionable				2 or 3 TON	
Turbidity	(JTU)		5		5		25	0.4		4
pH			6.5 - 8.5	7.0 - 8.5	6.5 - 9.2	6.5 - 8.5	9.5 (max.)			
Temperature	^{o}C							12		25
EC	uS/cm							400		
Notes	ND - Not Detectable				IO - Inoffensive					
	GL - Guide Level				UO - Unobjectionable					

(Based on Table 6.1, in Twort, Law & Crowley, 1985 - Water Supply, Edward Anorld, London).



Schematic Design for Borehole completion



TOPO MAP EXTRACT OF THE STUDY AREA.