HYDROGEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS REPORT

FOR

MWENDA ANDU COMMUNITY WATER PROJECT

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WITHIN LR. No. NYANDARUA/KARATI/2674 (0.04HA)

VILLAGE: MWENDA ANDU

SUB-LOCATION: MWENDA ANDU

LOCATION: MAGUMU

SUB COUNTY: NJABINI

COUNTY: NYANDARUA

CONSULTING HYDROGEOLOGIST:

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Executive summary

This report describes the results of a borehole site investigation at the Mwenda Andu area, Ndunyu Njeru, Njabini Sub County in Nyandarua County. The site is located 1.09km Southeast of Mwenda Andu market center off Ndunyu Njeru-Engineer Road as shown on the google map below.

The project is aimed at establishing water supply for community domestic use. The target community is approximately 1500 households. That translates to 7500 people assuming 5 people per house hold. The nearby source of water is a borehole and old community water supply.

The site is located in a hydrogeological zone that is charaterised by medium to high groundwater potential. Recharge is received from the Kinangop hills to the East. The fact that there is a concentration of flow line (high recharge), combined with the locally high transmissivity of volcanic suite results in relatively high rates of sustainable abstraction. The study concludes that based on the geological evidence, groundwater prospects for medium-scale abstractions are good.

The site is underlain by the so-called volcanic series mainly constituted of different types of tuffs and basal simbara basalt formation.

Based on the available hydrogeological data, it is recommended a borehole should be drilled to a maximum depth of 270m deep at a minimum 8" diameter, at the location agreed and shown to Ms. Lucy-county representative and the community. The borehole should fully penetrate the weathered tuffs. If sufficient water is obtained at a depth of approximately 250m, drilling should be stopped. This will preserve the anticipated good water quality from the shallow aquifer and save cost.

It is a legal requirement, stipulated in the Kenya water act, that the client applies for a groundwater permit to drill the proposed boreholes from the Water Resources Authority at Sub Regional office at Naivasha town.

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ABBREVIATIONS AND GLOSSARY OF TERMS

agl	above ground level
amsl	above mean sea level
bgl	below ground level
DWR	department of water resources
E	east
EC	electrical conductivity (mS/cm)
GSK	groundwater survey (k)ltd
h	head
hr	hour
l	litre
m	metre
ME&N	Ministry of Environment and Natural Resources
N	north
PWL	pumped water level
Q	discharge (m^3/hr)
s	drawdown(m)
S	south
SWL	static water level
W	west
WAB	Water apportionment board
WSL	water stuck level
mS/cm	micro-siemens per centimeter: unit for electrical conductivity
°C	degree Celsius: unit for temperature
"	inch

GLOSSARY OF TERMS

Aquifer	A geological formation or structure, which stores and transmits water and which is able to supply water to wells, boreholes or spring
Conductivity	Transmissivity per unit length (m/day)
Confined aquifer	A formation in which the groundwater is isolated from the atmosphere by impermeable geologic formation. Confined water is generally at greater pressure than the 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 damages 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 large 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.
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 water.
Infiltration	Process of water entering the soil through the ground surface.
Joint	Fractures along which no significant displacement has taken place
Percolation	Process of water seeping through the unsaturated zone, generally from a surface source to the saturated zone
Old land surface	old land surface (OLS) is the term given to an erosion surface now covered by younger surface material. in hydrogeology, OLS's frequently make good aquifers, especially where the erosion debris left behind is coarse in nature. OLS's are a frequent occurrence in the volcanic suite.

Perched aquifer	unconfined groundwater separated from an underlying main aquifer by an unsaturated zone. Downward percolation hindered by an impermeable layer.
Permeability	The capacity of a porous medium for transmitting fluid.
Piezometric level	An imaginary water table, representing the total head in a confined aquifer, and is defined by the level to which water would rise in a well.
Porosity	The portion of bulk volume in a rock or sediment that is occupied by openings, whether isolated or connected.
Pyroclastic rocks	Groups of rocks consisting of volcanic dust, ashes, lapili and course lumps of lava (volcanic bombs) explosively thrown up in molten condition, and deposited by gravity, hardened masses of dust, ashes and lapili are known as *tuff*, while course, consolidated pyroclastic debris is referred to as agglomerate.
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 to subsurface sources (e.g. river, rainfall, and lateral groundwater flow) to the aquifer zones.
Specific capacity	The rate of discharge from a well per unit drawdown.
Static water levels	The level of water in a well that is not affected by pumping (also known as rest water level).
Transmissivity	A measure of the capacity of an aquifer to conduct water through the saturated thickness (m^2/day).
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 condition).
Yield	Volume of water discharged from a well

1.Introduction

This report describes the physiography, the climate, the geology, the groundwater resources in Mwenda Andu area and the methologies used in selecting the best location for drilling one borehole. The project is located in Mwenda Andu village 1.09km south east of shopping center off Njabini-Engineer highway. The site is located within Naivasha basin- specifically in Malewa River catchment.

In topography the project area is charaterised by rift escarpment at an elevation of approximately 2694m.The soil cover is mostly food crop. Interms of climate, rainfall follows a strong bimodal pattern with the long intensive rains falling in March-May and short and less intensive rains in October-December. The rainfall is of considerable variation, with more than 1500 mm/year at the edges of the rift valley and decreasing rapidly to less than 200 mm/year in the valley bottom. The dry season occur intermittently between the two rainy seasons from January to February and from July to September.

In terms of geology and hydrogeology, the project area is characterized by volcanic rocks and quaternary lacustrine deposits from large ancient lakes, which formed during pluvial periods, becoming shallow or completely drying during inter-pluvial. Groundwater is found within three aquifer, the upper and the middle are most compost of lacustrine deposits while the lower one is of volcanic in nature.

Geoelectrical as well as hydrogeological methods were used to assess the ground water availability and potential within the farm.

It is therefore recommended that a borehole be drill at 307-15 or 307-11 to maximum depth 270m bgl. Name and details of the applicant

Name: Mwenda Andu community water supply,

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Mobile: 0711701166

Email: mwenda.andu@gmail.com

1.1 Location and Description of Proposed Activity

1.1.1 Site location

The project area is located within Naivasha basin- specifically in Malewa river catchment. It is off Nairobi-Njabini highway within Mwenda Andu area of Nyandarua county. The map (figure 1) shown below shows the location of the project area.

The investigated site is approximately located by:

Name	Latitude	Longitude	UTMX	UTMY	ALT
OLD BH	-0.81704	36.58167	230847.4	9909612	2674.07
GICHUGU CHEGE	-0.81782	36.58134	230809.9	9909526	2678
MA-307-300/500-11	-0.81712	36.5815	230827.9	9909961	2674.67
MA-307-500/300-9	-0.81714	36.58145	230822.2	9909600	2677.87

1.1.2 Intended use

The community intends to drill a borehole for domestic use. The main sources of water include neighbouring borehole, roof harvesting and local water provider. The project is targeting approximately 7500 people. The water demand therefore, assuming design demand of 25L/H/D, totals to nearly 187m3/day for domestic use. The current sources are not assured all the time, hence the reason for this borehole.

1.1.3 Existing water supply situation

Presently water is obtained from boreholes and old gravity water supply The map below shows the location of the project site.

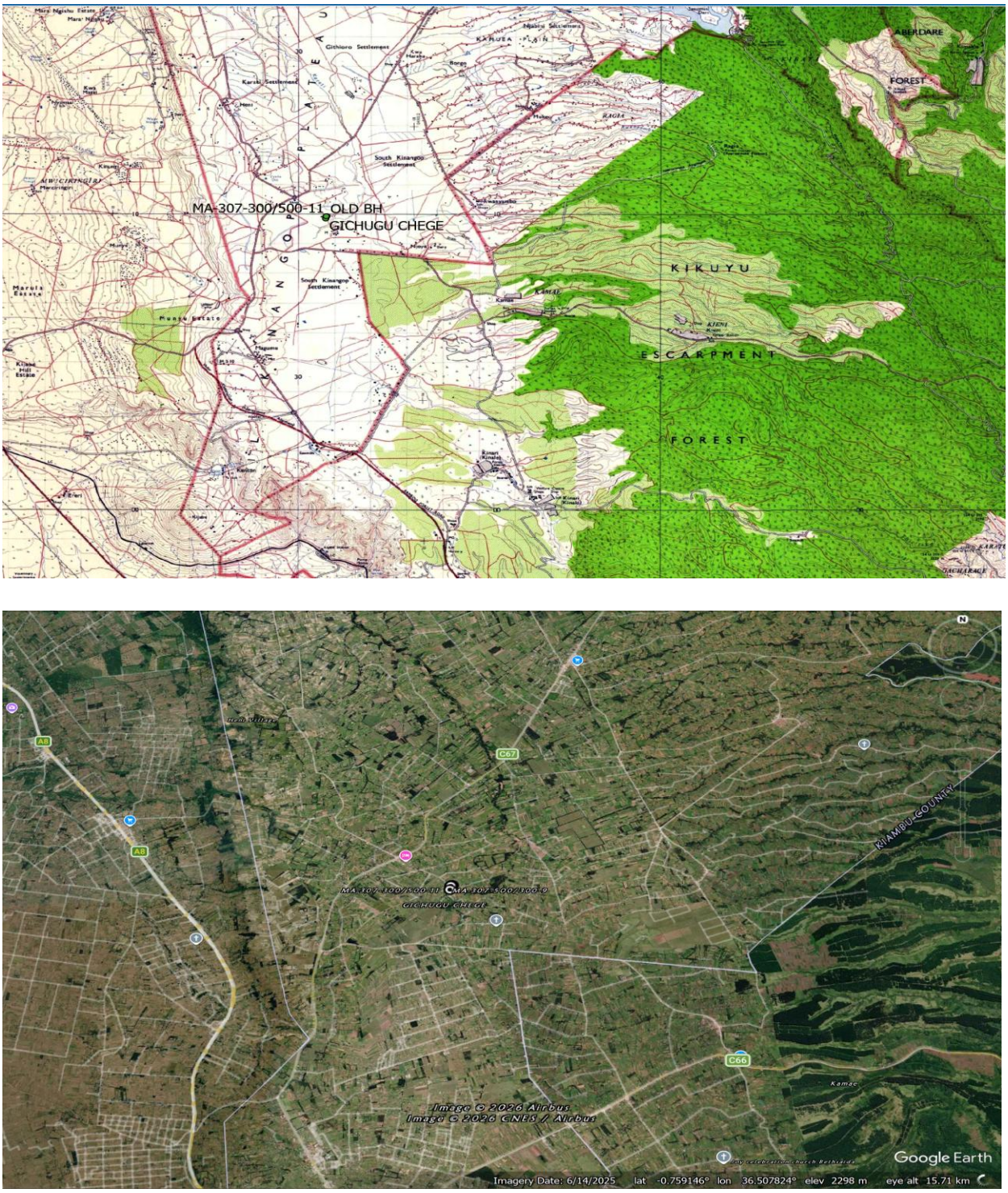


Figure 1. Map extract 134/3 and Google map showing location of the project area.

1.1.4 Soils

Soil studies in the area were carried out extensively by Boateng, (2001). The soils derived from weathering volcanic and basement rock system and occupy the slopes of the rift valley in escarpment as light grey or brown to pinkish non-calcareous soils.

Along the fault scraps, Middle Pleistocene trachytes are exposed. In the upper catchment there are non- calcareous black or grey soils overlying yellow brown compact sub soil with iron concretion. The soil in the Aberdares Mountains, Kinangop plateau and the source of the Malewa River are young soils with predominantly morillonite clays.

1.1.5 Topography

The Mwenda Andu area (along the Mwenda Andu–Njabini road) sits right on the eastern escarpment of the Great Rift Valley, and its topography is one of the clearest of rift escarpment geomorphology in Kenya.

The escarpment is a very steep slope (fault scarp) formed by tectonic stretching of the crust. Elevation drops abruptly from about 2,600–2,700 m (ndunyu Njeru highlands) to around 3,000–3600 m on the top of the Aberdares.

The escarpment is not one uniform slope—it has distinct zones:

- Upper escarpment crest
  - Gently undulating highland (tea farms, settlements)
  - Cooler, wetter conditions
- Mid-slope (scarp face)
  - Very steep, dissected terrain
  - Characterized by rock outcrops, gullies, and landslide-prone slopes
  - Cut by small seasonal streams forming V-shaped valleys
- Lower foot slope
  - Slope gradually reduces toward the valley floor
  - Transitions into plains around Naivasha

The broader view from the project area shows classic Rift Valley features -Volcanic cones like Abaderes.The escarpment itself marks the boundary between uplifted highlands (Aberdare block) and down-faulted Rift Valley floor.

The rainfall is of considerable variation, with more than 1500 mm/year at the edges of the rift valley and decreasing rapidly to less than 200 mm/year in the valley bottom. The dry

season occur intermittently between the two rainy seasons from January to February and from July to September.

2. Hydrology

Though commonly referred to as a plateau, the Kinangop is really a step on the side of the Rift Valley, a plain rising from about 2499 meter in the north to 2680 meters near Kijabe. This plain is deeply dissected by the Mukungi, Kitiri, Turasha and other rivers, all tributaries of the Malewa, which ultimately discharges into Lake. Naivasha. On its southern and south-eastern fringe, the Kinangop is the catchment area for tributaries to the Athi and Tana rivers, which discharge into the Indian Ocean.

The Kinangop plain is continuous with the 0l Bolossat plain at the foot of the Sattima scarp, north of the present area near 0lKalau and 01Jara Orok. Most Of the Kinangop is farmland, though a portion particularly in the south is covered by forest. Some drainage channels in the forest have been impounded by slight earth movements.

3.0 Details of Geology and Hydrogeology

3.1 Regional Geology

The African rift valley is the most prominent morphologic and structural phenomenon in East Africa. In simple terms, it is a deep graben divided into two clearly defined branches and the study area is located centrally in the eastern branch (also called the Gregory rift). The oldest rift structures are mid tertiary and immediately predate rift volcanism, which began in the Miocene, 23 million years BP (Chorowicz et al. 1999)

The Geology of the area is characterised by volcanic rocks and quaternary lacustrine deposits from large ancient lakes, which formed during pluvial periods, becoming shallow or completely drying during inter-pluvial.

According to geological reports Numbers 12 (Shackleton 1945), 55 (Thompsons and Dodson 1958), 67 (Thompsons and Dodson 1964) and 78 (McCall 1967), the Geology of the area is mainly comprised of volcanic rocks dating back to the Miocene era. Recent

superficial deposits mainly cover the northern part of the study area. This is underlain by Pliocene tuff formations, which include citric pumice tuffs, ignimbrites and welded tuffs with lacustrine sediments, graded tuffs and diatomite. The Northeastern part consists mainly have Basalt, vesicular olivine basalt of Pliocene Miocene era and Olivine Basalt of Miocene age, Basalt and Agglomerate of Simbara series (Predominantly in Kipipiri forest area) (Rachilo 1978). The other rocks within the study area include Trachytic tuffs and alluvial deposits along river valleys. Pyroclastics and sediments of upper to middle Pleistocene periods cover the central and southern parts of the area.

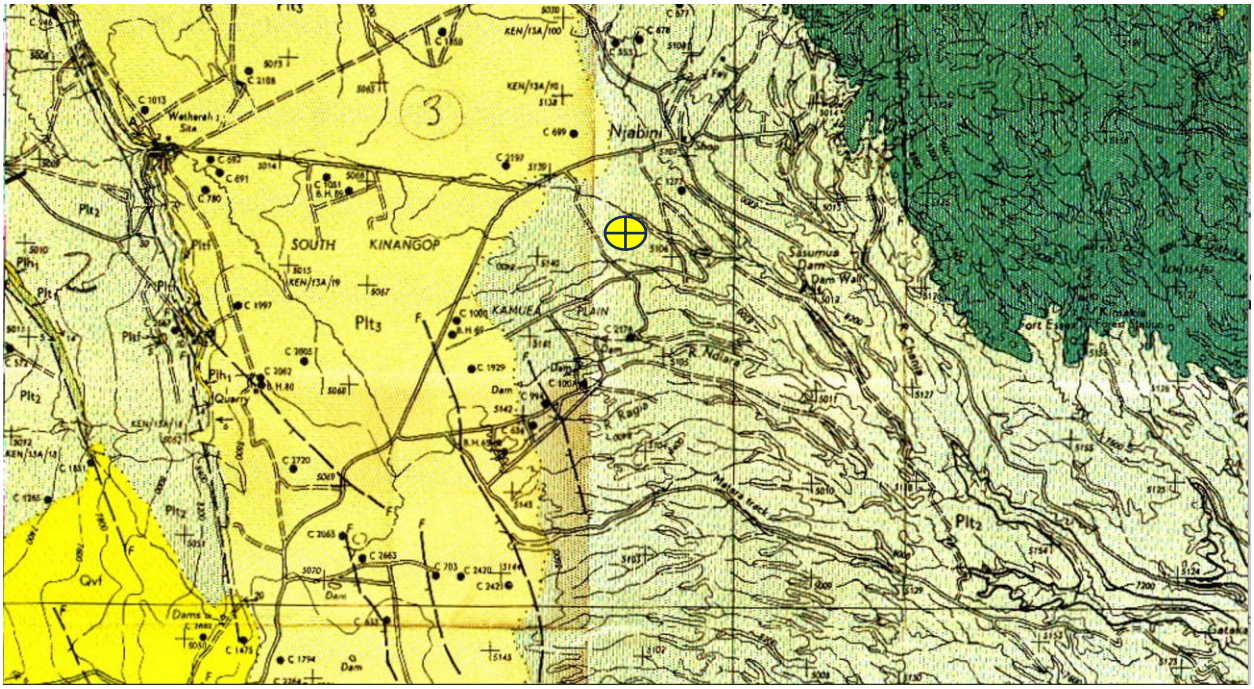


Figure 2: Geology Map

3.2 Local Geology

Pyroclastics and sediments of upper to middle Pleistocene periods cover the central and southern parts of the area.

3.3 Groundwater Occurrence and Recharge

3.3.1 Recharge by Rainfall Percolation

The existing storage media potential will be affected by the mechanism of percolation of rainfall or river water down to the aquifer. If the infiltration capacity is low due to the

precence of aquiclude like clay, the recharge to the aquifer will be low. Percolation depends on the soils structure, vegetation cover and permeability of the rocks. Clayey formations naturely inhibits percolation. Aquifers may also be recharged lateraly if the rock is permeable over a wide area. Recharge in the present study are is probably derived lateraly as far as hills to the East.

3.3.2 Groundwater Potential

The site and the surrounding areas have many boreholes. Two boreholes drilled in the project area have reported high yields. The boreholes within the same geology have over 70m3/hr. The table below shows details of boreholes drilled in the area. It is therefore important to fully penetrate the lake sediments. Table 1.list of boreholes near the project area.

ID	OWNER	DLONG	DLAT	GRIDX	GRIDY	TDEPTH	M_WSL	WRL	YIELD	POT	BASIN
633	MITCHEL M.G.	36.5833	-0.8333	231027	9907819	183	180,222,264	109	3.96	G	4CA
703	TOM BROWN	36.6	-0.8167	232886	9909656	94	75	85	13.62	G	4CA
1007	MUKOE FARM	36.6167	-0.7833	234743	9913352	61	45	23	11.25	G	4CA
1475	MUNYU ESTATE	36.55	-0.8333	227318	9907816	107	100	61	2.04	G	2GD
1794	KENTON FARM	36.5667	-0.8333	229178	9907817	236	226	199	0.9		2GD
2063	J.V.LANSBERG	36.5833	-0.8167	231026	9909655	129	119	99	5.4	G	2GD
2138	KENYA RAILWAYS	36.5833	-0.9167	231033	898593	124	46	35	13.56	G	2H
2172	KENYA RAILWAYS	36.5833	-0.9167	231033	898593	143	87	42	2.46	G	2H
2176	NDIARA	36.6333	-0.7667	236591	9915189	77	28,40,73	17	9.78	G	4CA
2263	BAMBOO FOREST FARM	36.5667	-0.85	229179	9905970	274					3BC
2662	JOHNSON MRS	36.5667	-0.8333	229178	9907817	256	167,143,219	201	5.46	G	2GD
2663	CATHOLIC MISSION	36.5833	-0.8167	231026	9909655	137	110	98	11.4	G	2GD
2720	ALSE LTD	36.5667	-0.8	229176	9911501	282	276	219	2.28	G	2GD
10706	KINUNGI COMMUNITY	36.5358	-0.8			200	175,201	96.2	6	G	

STATISTICS

	TDEPTH	MWSL	WSL1	WSL2	WRL	YIELD
AVERAGE	164.5	135.1	158.5	135	98.78	6.77
MIN	61	45	28	40	17	0.9
MAX	282	276	264	222	219	13.62

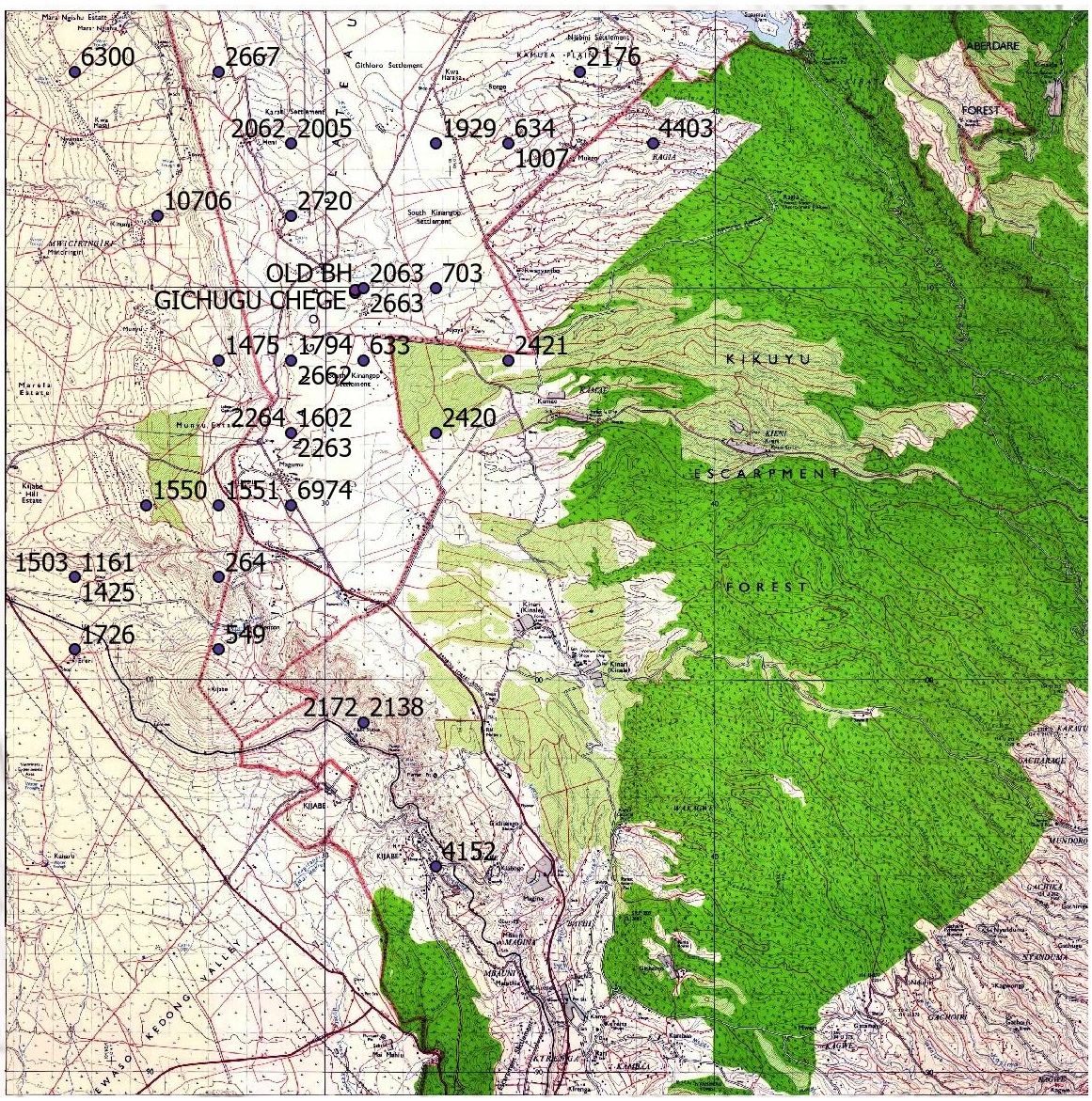


Figure 3: Hydrogeology Map

3.3.3 Porosity and Permeability of the underlying Formations

The porosity of unfractured volcanic rock varies from less than 1% in dense basal to more than 85% in pumice. Dense massive flow rock will have from 1 to 10% porosity, while vesicular volcanics will have from 10 to 50%. Porosity may be high, but permeability is largely a function of other primary and secondary structures within the rock. In addition to the features causing permeability the porosity may be increased locally in the rock by weathering. Buried soils are a common feature of thick sequence of volcanic rock. Soils in

most areas are less permeable than the volcanic rock and important horizons for forming perched aquifers.

Typical zones of high porosity and permeability include: buried (erosional surfaces), vesicles, smalls pockets of pyroclastic blocks and cooling joints. Unaltered pyroclastics will have porosities and permeabilities directly related to fragment size, sorting and degree of cementation. Poor sorting and abundance of fine material will cause most pyroclastics deposits to have low permeability but moderate to high porosities. welded tuffs have medium to low porosities and very low permeabilities. based on the a bove

Geological formation	Expected depth(m bgl)	Porosity(%)	Density(g/cm^3)	Permeability(m/day)
Volcanic soils	1.7	50	1.5	$4x10^{-4}$
Ashes	>100	35	2	$4x10^{-5}$

the table below gives an indication of the expected porosites and permeabilities for the formation underlying the site. Table 2: Estimated porosity and permeability values

3.3.4 Hydrochemistry

The existing boreholes in Mwenda Andu area have encountered groundwater of varying qualities. Boreholes in the area are reported to be good for human consumption.

4.0 Geophysical Investigation Method

Agreat variety of geophysical methods are available to assist in the assessment of geological subsurface conditions. In the present survey resistivity also known as the geoelectrical method was used.PWQT was used to visualise the different geological profile both hoarizontally and vertical.It is this fracture that are crucial groundwater targets in this dry area.

4.1 Basic Principles of the Natural Electric Field Method - Frequency Selection System (PQWT) Method

4.1.1 PQWT – GT 500A

PQWT-GT Auto-analysis Geophysical Detector is the eighth-generation of multi-channel prospecting instrument newly developed by Hunan Puqi Geologic Exploration Equipment

Institute and Hunan Puqi Water Environment Institute Co. Ltd.; it is based on the principle of natural electric field frequency selection method. It is widely used in underground water sources, geological structures, mine veins, mine tunnels, cavities, karst caves, ant holes, mined-out areas, dam pipe surge, landslides and other fields. This series of instruments integrates 5 independent invention patents of PQWT, including data acquisition system, data processing system, automatic mapping system, automatic analysis system and circuit system. It realizes the simultaneous data acquisition of multi-channel and multi-frequency, completely solves the influence of unstable factors caused by the time difference of the natural electric field source, and greatly improves the accuracy and work efficiency. The instrument can process the collected data, automatically draw curve map, profile map, and 3D renderings in real time, and automatically analyze abnormal areas, so as to provide scientific basis for analyzing geological structures quickly and effectively.

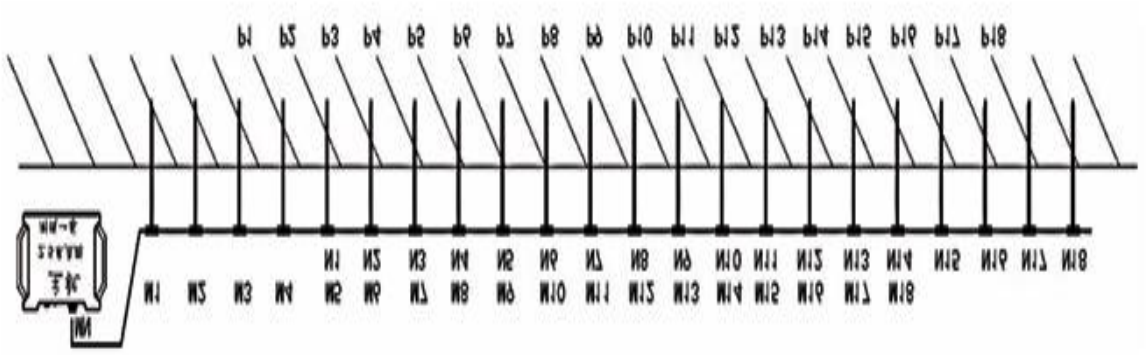


Figure 2.1: Procedure for Exploration using PQWT instrument.

How to calculate the meters on the ground, according to point in the profile map?

Carry out linear wiring in the area to be measured, place cable and electrode rod according to the number of selected measurement points, keep electrode rod and cable in good contact, and the electrode is properly grounded. Number of measuring points = electrode rod -4. When 10 measuring points need to be measured, 14 electrode rods need to be placed. As shown in the figure: The data collected by the host machine is the central points of M pole and N pole, and the central point of M1 and N1 is the first measuring point P1, which is the position of the third electrode rod. The center point of M2 and N2 is the second measuring point P2, which is the position of the fourth electrode rod, and so on



Figure 2.2: Electromagnetic induction equipment set.

Automatic mapping water detector is based on the earth's electromagnetic field as the field source, based on the difference in the conductivity of different underground geological structures, and by studying the variation law of the electric field components at different frequencies to study the geological structure and changes, to find groundwater resources by scientific method. Changes in geological structures are displayed in real-time through multiple curves. Automatic form mapping geological profile by one key operate easily, get rid of complicated computer graphics. The investigator can quickly understand the geological structures through the automatic mapping curve and profile and analyze specific information such as aquifers, fractures, faults, and karst caves. The instrument is widely used in the rapid analysis of geological structure changes in different terrains such as plains, hills, mountains, plateaus and basins to determine well locations, aquifers and aquifer depth.

Interpretation is based on imaging using pseudo-seismic responses as well as 2D and 3D inversion.

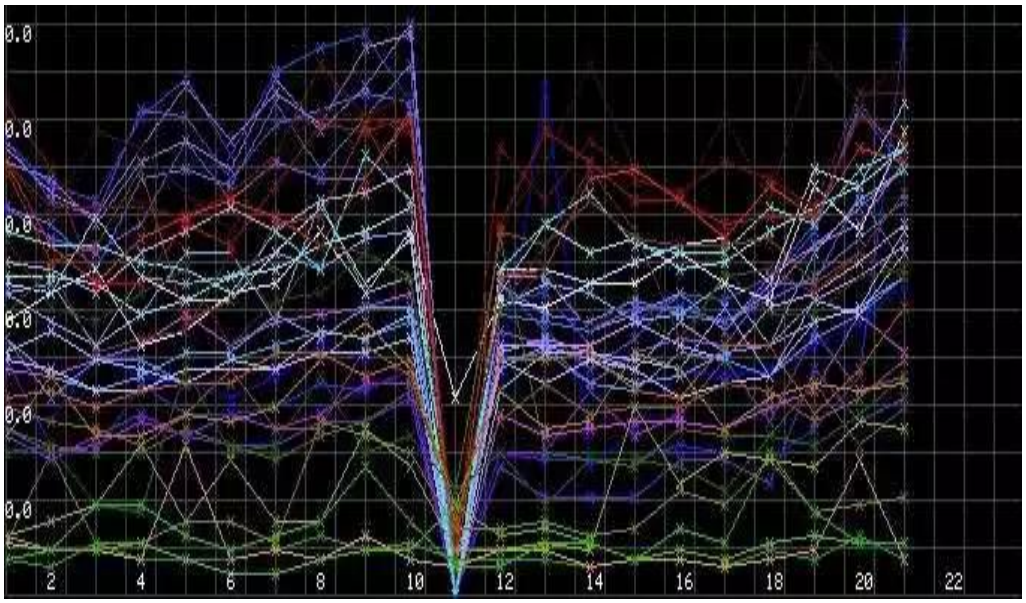


Figure 2.3: PQWT frequency curves

Above the profile, the horizontal direction indicates the point, and the vertical direction indicates the depth. Blue light blue is generally aquifers (may also be soft mud or low-resistance ore), yellow is rock formations, and red is generally harder rocks or some areas are Hollow, because groundwater is easy to form in fissures or faults, so we look at the aquifer (blue) in the rock layer (yellow).

Above the curve, the horizontal direction indicates the point position, and the vertical direction is the measured potential difference (resistance). The resistance of water is low, so look at the V-type, the lowest point.

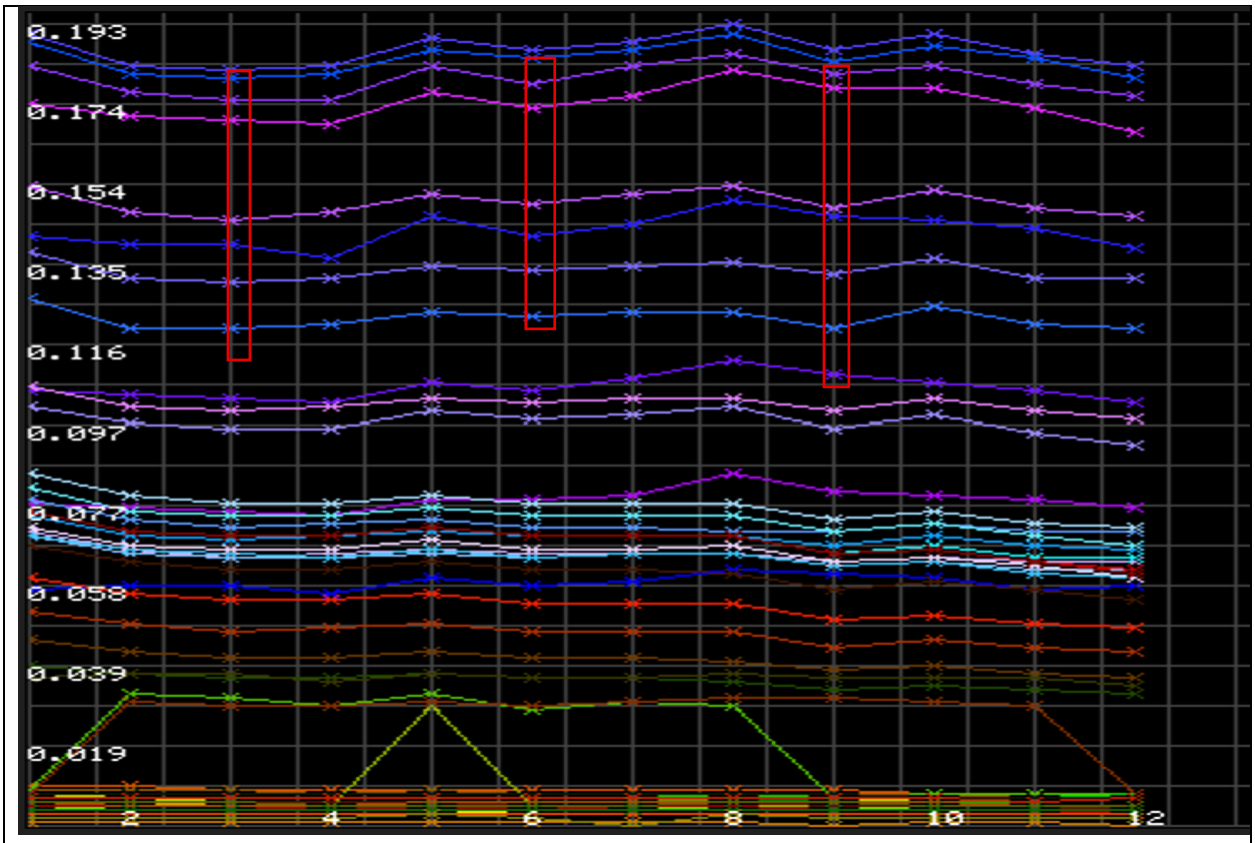
4.2 Fieldwork and Results

4.2.1 Fieldwork

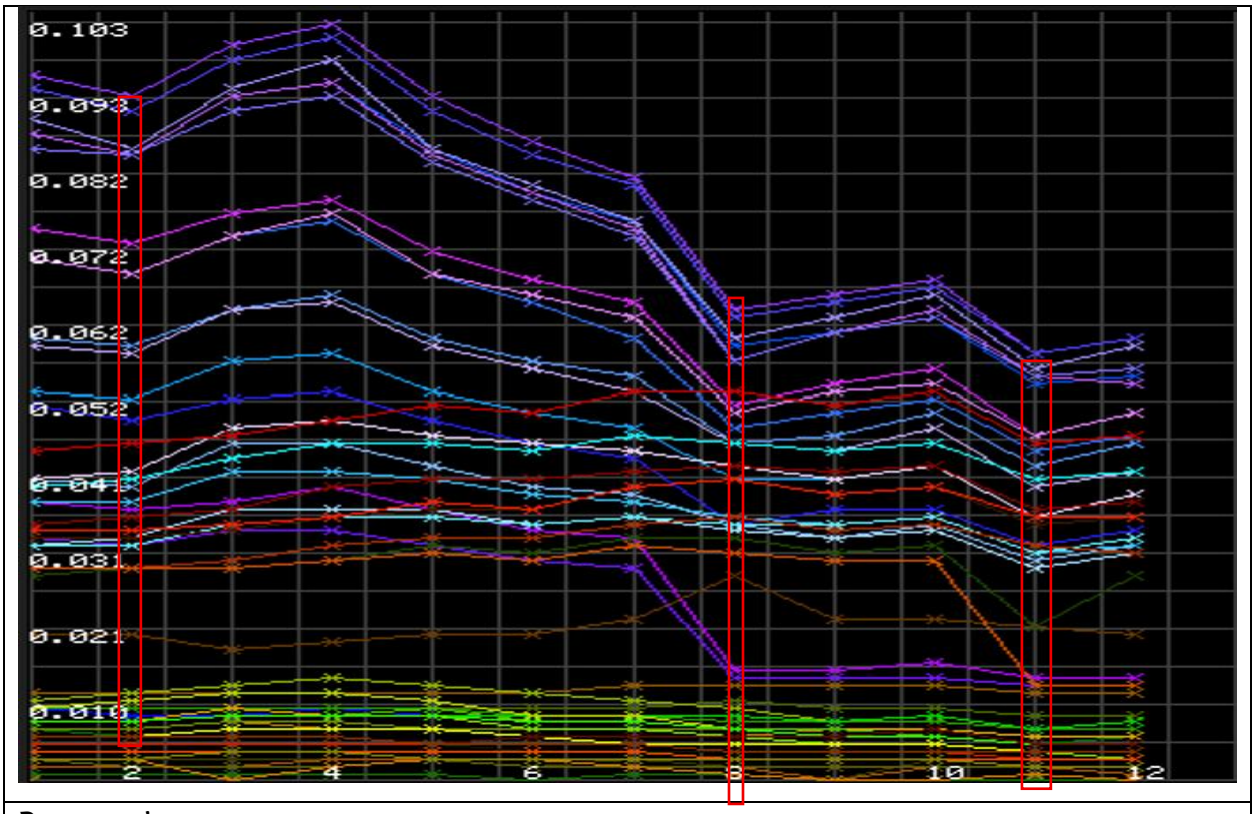
Fieldwork was carried out in the 28th A, 27th August 2026. Two PQWT lines were carried out within block. The locations of the measurements are shown on the figure 1 location map.


OLD BH
MA-307-300/500-11
MA-307-500/300-9
Image © 2026 Airbus
Google Earth
1985
Imagery Date: 4/2/2025 lat -0.817184° lon 36.581523° elev 2677 m eye alt 2.76 km

4.2.2 Results

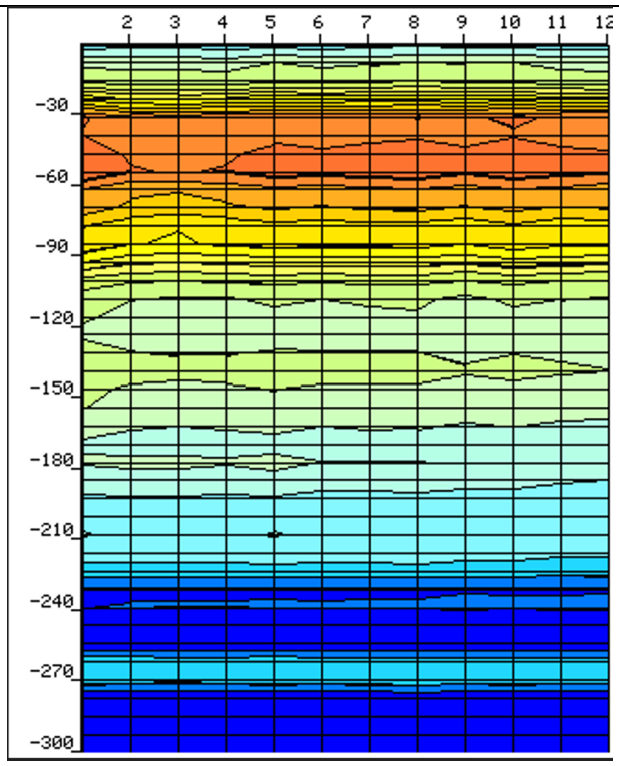


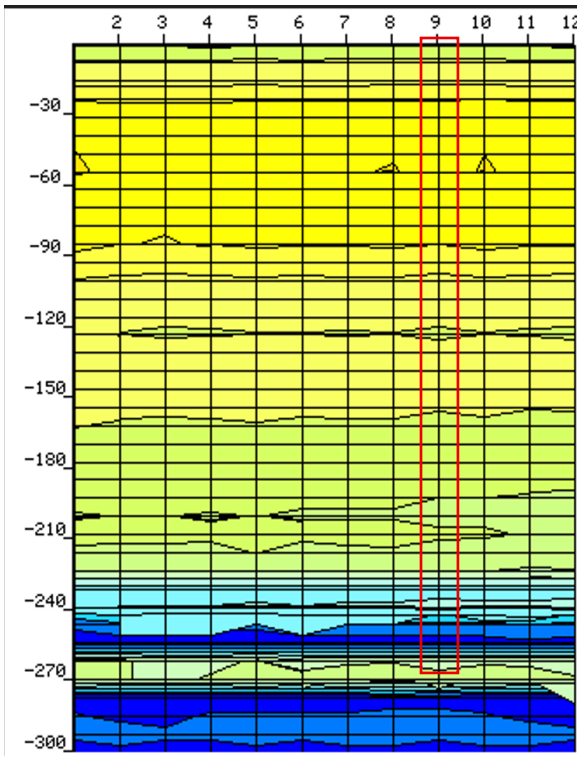
Line 308-300-station_3,6 &9



Processed

307-300-station_2,8 &11. This is line ranks 1

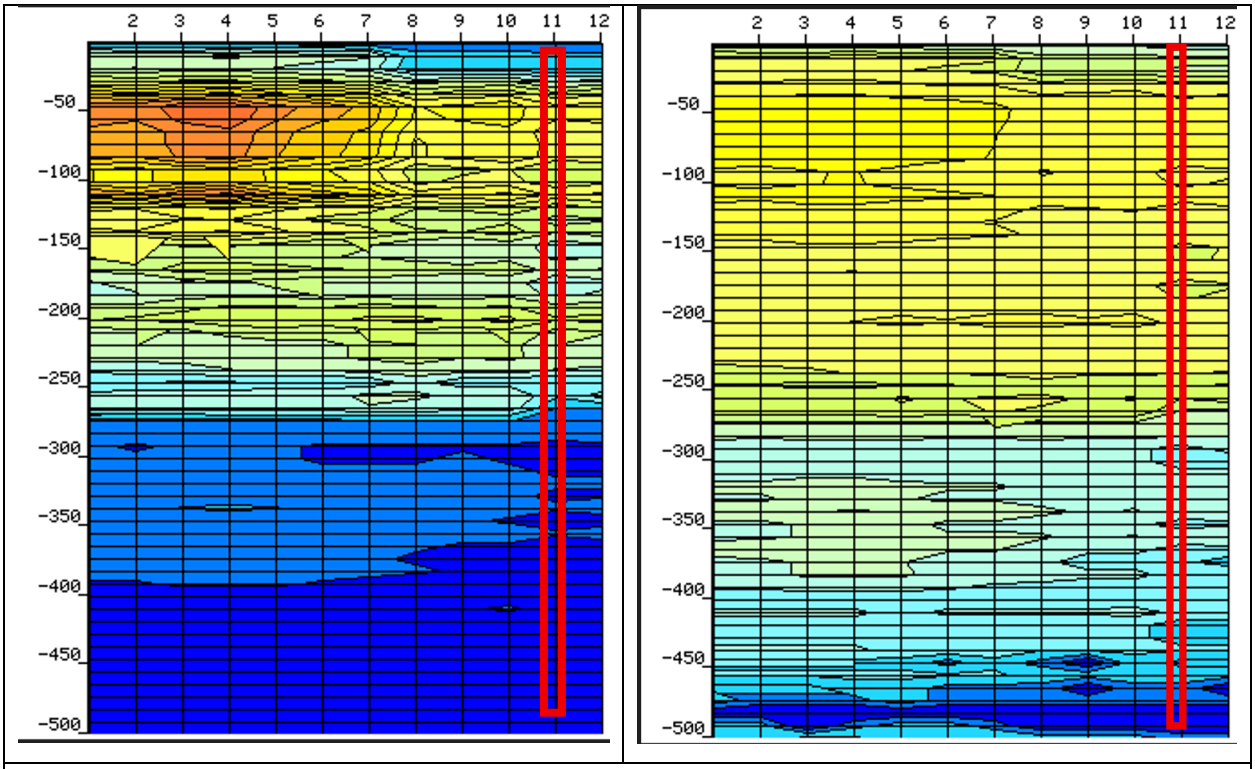




Line 308-300-station_

Unprocessed Processed Line

308-300-station_11. This is line ranks 4



Unprocessed Processed Line

307-300-station_11. This is line ranks 1. These shows a distinct fracture with high groundwater potential

5.Conclusions and Recommendations

5.1 Conclusions

From the geological, hydrogeological and geophysical evidence gathered, it is concluded that the drill site selection is the best and also the investigated area is located in a hydrogeological zone charaterised by a medium to high groundwater potential. The deeper aquifers are often confined and will have relatively high specific yields. A borehole drilled in this area with an adequate sustainable water supply for the client.

should target deep water bearing units within the highly weathered and fracture and faulted volcanic rocks. Although water strikes are expected in the shallow depths as indicated in table 4 from the interpreted results, penetration of the deeper aquifers is

advised. Water levels are expected to rise with increased depth. The hills and the local percolation are expected to recharge the aquifer.

5.2 Recommendations

In view of the above it is recommended that:

1. An 8" borehole be drilled to a maximum depth of 270m at PQWT station 307-300/500-11.

2. The borehole be installed with 6" diameter steel casing and screens with slots of 0.5 mm and high % open area. The safe yield of the borehole is expected to be in the range of 10-18m3/hr.

3. The borehole be installed with a master meter and an airline /piezometer to monitor groundwater abstraction and to facilitate regular measurements of the static water level in the borehole.

4. Upon drilling completion, a 2-liter water sample from the borehole should be collected for reference to WRA testing laboratory, or any other competent water testing authority for a full physical, chemical and bacteriological analysis before the water is put to use. A copy of the analysis should be sent WRA Regional office for record.

5. The recommended drilling site is known to the Nyandarua County representative, Chairman, community members and the hydrogeologists.

6. On the basis of this report, authorization to drill the borehole can be applied from Naivasha sub region within RVCA.