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Lithological Examination and Resistivity Trend Pattern Investigation of Groundwater Research in Philipa Idogho Campus Auchi Polytechnic, Auchi

* Tunde, Usman Nurudeen SULE, + Abdulasisi Titi UMORU & Edwin .O. OYATHELEMI
*,+,! Dept. of Mineral and Petroleum Resources Engineering Tech., School of Engineering Technology, Auchi Polytechnic, Auchi.
E-mail: ttee4all@yahoo.com, eddielemi99@yahoo.co.uk. latotuns@yahoo.com

This Research is Initiated & Co-Ordinated by DR. (Mrs) Philipa .O. Idogho, the Rector: Auchi Polytechnic, We wish to acknowledge her kind support and negotiation with the research sponsor- ETF research and development for underground water potential in Nigeria (2010).

Abstract
The ground water research venturing is very vital for creating and providing artificial surface water availability based on the scientific method of drilling. The paper examined the empirical trend analysis of VES (Vertical Electrical Sounding) of Auchi Polytechnic Ground Water Project 2011 to establish the variation and existence in the ground water, based on lithology, resistivity and the chemical components present. The pattern of the VES resistivity showed that the apparent resistivity value for the saturated layers is fairly low indicating good aquifers. In addition, a suitable drilling rig that can effectively drill to the required specifications and depth should be mobilized to the site for the project. The entire (On-the-site) drilling process should be supervised and documented by a competent and professional geologist and/or hydro-geologist who should also determine the final and terminal depth of the borehole at the site. Total drilled depth of 197m (650ft) is recommended.

Keywords: Lithology, VES, Geophysical survey, Ground water, Auchi Poly, Trend

1. Introduction
Ground water research has become a means of sustainable water for human, animal and plant survival especially in the area of low aquifer production. The ground water research venturing is very vital for creating and providing artificial surface water availability based on the scientific method of drilling (Sule, Oyathelemi and Umaru, 2013). As a result of its immediate needs to animal, plant and others, water availability and provision becomes very essential to life. Mulla, Syed, Abed and Pardha (2011) explained that water is essential for life on the earth and any other planet, identifying that it is the fundamental right of world population to gain access to pollution free water. The pollution of surface water can be treated with different techniques (Sule *et al.*, 2013). It is very difficult to get purified ground water observed (Sule, et al., 2013 and Mulla, et al., 2011). The past records of high rate of failure in the ground water drilling researches and works have resulted in the total need for pre-drilling investigations and geophysical analysis to enhance better and sustainable water presences for human and other uses (Fasunwon, Ayeni and Lawal, 2010). The basic need and sustenance of man is water (Offodile, 1983 in Anozie A.N., and Odejobi O.J, 2009). Geophysical methods have been very useful in determining the geological sequence and structure of the subsurface rocks by the measurement of their physical properties. Although there are varieties of geophysical techniques, which could be used in groundwater exploration, electrical resistivity method has proved reliable in delineating zones of relatively low resistivity signatory of saturated strata in various geologic terrains (Odejobi, 1999). The paper examined the empirical trend analysis of VES of Auchi Polytechnic Groound Water Project 2011 to establish the variation and existence in the ground water based on lithology, resistivity and the chemical component presence.

2. Brief Review of Literature

Although there are varieties of geophysical techniques, which could be used in groundwater exploration, electrical resistivity method has proved reliable in delineating zones of relatively low resistivity signatory of saturated strata in various geological terrains (Odejobi, 1999). Some chemical constituents are expected of ground water (Sule *et al.,* 2013). In the study (Majolagbe, Kasali and Ghaniyu, 2011), the following chemical observations were recorded and helped to shape the study in Lagos suburban for ground water project. The chemicals are Cd, Fe, Cu Zn Mg and Na which were determined using Flame (AAS) Atomic

Absorption Spectrophotometer (Buck scientific 210VGP model). The study confirmed that concentration of Pb, Fe and Cd found in Isolo study area were higher than WHO health based guideline values, indicating possible impact of landfill on the groundwater quality. This raises the question of toxicities of these elements; hence pose potential threat to man (Abdulrafiu, Adeleke and Lateef, 2011). Most of the nutritive metals analysed (Na, Zn, and Cu) in Isolo samples maintained strong positive correlation with r values ≥ 0.8 showing possible common source, unlike Ifon water samples that had all the metals analyzed found within the WHO standards for drinking water. Ifon groundwater is soft with pH within the WHO acceptable range for drinking water while Isolo water is moderately hard, acidic in nature; hence require further treatment for it to be potable. In the ground water study of the Auchi Polytechnic, presents a different view point based on the location, depth, geophysical interpretation, Lithological and laboratory test conducted before embarking on the project in the survey site (Sule *et al.,* 2013). In addition, the total field operations and data acquisition at the site lasted for two days followed by the execution of the ground water project.

3. Research project Objective

The objective of this paper is to critically investigate the trend pattern of:

- Conduction of Resistivity values at the site to obtain (VES) data for geo-electric parameters.
- Determination of the hydrogeological characteristics of the subsurface at the site based on geo-electric and available geologic information.
- Production of groundwater and quality distribution in the study area.

4. The geo-physical explanations and some evidence of the ground water project and Hydro-geochemistry

The chemistry of groundwater at any instance is dependent on a number of factors which include: Local geology, water residence time, physio-chemical environment, recharge source water chemistry and transport time. Local geology and physio-chemical settings determine the type and level of dissolution from matrix. The longer the residence time, the higher the potential for high level concentration of species; the chemistry of the source surface water holds prospects for determining the quality of groundwater but is greatly dependent on the transport time and the intervening lithology between the surface and the reservoir. Where aquifers are deep, the transport times are high and the natural filtering capacity of the earth materials may be sufficient for purifying even the dirtiest of surface water before reaching the reservoir rock. This is further enhanced where there are flow retardant matrixes, notably clays. In addition to slowing down flow and purifying influx surface water, clays are capable of chemical purification through adsorption and cationic exchange capacity.

4.1 Chemicals and Lithological Profile

Different and relevant drilling chemicals was assembled together, such as Aqua-gel, Poly-plus and Bentonite and other drilling chemicals act as a Lubricants and Cementing agent, to stabilize the WELL BORE (Borehole) wall and to prevent it from collapse, it is also use to bailout the drilling cuttings to the surface, so as to be used to generate the LITHILOGICAL PROFILE of the Borehole.

Lithological Profile Of Philipa Idogho Campus Borehole								
Depth (ft)		Lithology	Depth (ft)		Lithology	Depth (ft)		Lithology
10		Coarse gravelly, reddish brown, sand	160		Fine-medium grain, brown sand	310		Fine-medium grain, milky white, sandy clay
20		Medium gravelly, milky-red, clayey sand	170		Medium, grain, milky white, sand	320		Fine-medium, white-brown, sandy clay
30		Fine, yellowish brown, clayey-sand	180		Medium-coarse grain, white sand	330		Fine-medium, white-brown, sandy clay
40		Fine, yellowish brown, clayey-sand	190		Medium-coarse grain, white sand	340		Medium, white, clayey sand
50		Fine, yellowish brown, clayey-sand	200		Medium-coarse grain, white, sand	350		Medium-coarse grain, sandy clay
60		Fine, Milky brown, sandy clay	210		Medium-coarse grain, white, sandy clay	360		Fine-medium, grain milky white, sand
70		Fine, Milky brown, sandy clay	220		Medium grain, white, sandy clay	370		Medium grain, milky white, sand
80		Fine grain, Brownish, sand	230		Medium grain, white, sandy clay	380		Medium grain, milky white, sand
90		Fine, Milky brown, clayey sand	240		Fine-medium, milky brown, clayey sand	390		Medium grain, milky white, sand
100		Fine, Milky clayey, sand	250		Fine-medium, milky white, sandy clay	400		Medium grain, milky white, sand
110		Fine, Milky clay, sand	260		Fine-medium, milky brown, sandy clay	410		Medium grain, milky white, clayey sand
120		Fine, Milky brown clayey sand	270		Fine-medium milkish brown sandy clay	420		Fine-medium, milky white, sand
130		Fine, dark, clayey-shale	280		Fine-medium, milky white, sandy clay	430		Coarse grains, white, sand
140		Fine, Dark brown, sand	290		Fine-medium, white grain sand	440		Fine-medium, white, sand
150		Fine, Dark brown, sand	300		Fine-medium, white grain sand	450		Coarse grains, white, sand

Source: Geophysical survey of Soil lithological results, 2011

Martlet Environmental Research Laboratory Limited Results Of Chemical Analysis
Name of Client: Auchi Polytechnic, Auchi

Type of Sample: Water Sample

Code	pH	EC	Sal.	Col.	Turb.	TSS	TDS	COD	HCO_3	Na	K	Ca	Mg	Cl	P	NH_4N
		µS/cm	g/l	Pt.Co	NTU	mg/l										
Water Sample	6.7	43.3	0.02	ND	ND	ND	20.5	8.2	97.6	0.78	0.09	0.88	0.06	53.1	0.07	0.01

Code	Fe	Mn	Zn	Cu	Cr	Cd	Ni	Pb	V	THC	NO_2	NO_3	SO_4
	mg/l												
Sample 1	0.25	0.02	0.01	ND	ND	0.01	ND	ND	ND	ND	0.15	0.45	1.54

ND – Not Detected, AAS MODEL-SOLAAR 969 UNICAM SERIES, FLAME USED – AIR ACETYLENE FLAME (Approved by Prof. R.O.Onyeonwu)

Code	pH	EC	Sal.	Col.	Turb.	TSS	TDS	COD	HCO3	Na	K	Ca	Mg	Cl	P	NH4N
		µS/cm	g/l	Pt.Co	NTU	mg/l										
Water Sample	6.7	43.3	0.02	ND	ND	ND	20.5	8.2	97.6	0.78	0.09	0.88	0.06	53.1	0.07	0.01

Code	Fe	Mn	Zn	Cu	Cr	Cd	Ni	Pb	V	THC	NO2	NO3	SO4
	mg/l												
Water Sample	0.3	0.02	0.01	ND	ND	0.01	ND	ND	ND	ND	0.15	0.45	1.54

ND – Not Detected, AAS MODEL-SOLAAR 969 UNICAM SERIES, FLAME USED – AIR ACETYLENE FLAME (Approved by Prof. R.O.Onyeonwu), EC- (Electric Conductivity, microseimen unit), Col-(colour, Platinium Cobalt PtCo unit), Turb- (Turbidity Nephelometry Turbidimetry Unit (NTU), TDS-(Total Dissolved Solids), TSS- (Total Suspended solid), Sal- (Salinity gram per litre g/l), COD-(Chemical Oxygen Determined)-HCO-3(Total Alkalinity), Na-(Sodium), K-(Potassium), Ca-(Calcium), Mg-(Magnessium), Cl- (Chloride), NO3-(Nitrate), NO2-(Nitrite), NH4-N- (Ammonium Nitrogen), SO4- (Sulphate), P- (Phosphorus),THC-(Total Hydrocarbon Context), Fe-(Iron), Mn- (Manganese), Zn-(Zinc), Cu- (copper), Cd-(Cadium),Cr-(Chromiun), Pb-(Lead), Ni- (Nickel) andV-(Vanadium) Unit-mg/l.

5. Environmental Evaluation

The environmental sensitivity of the subsurface geological environment is generally evaluated in terms of the ease with which harmful by-products of surface activities infiltrate/diffuse downward to the groundwater system. Sensitivity also relates to the potential for accumulation of harmful levels of species in agricultural soils. This study is focused basically on the first aspect. Quantitatively, the ease of flow of fluids in elastic materials is characterized by two petro-physical variables, namely, hydraulic conductivity (intrinsic permeability) and porosity. While porosity defines the available rock volume for fluid residence, hydraulic conductivity quantifies the interconnectivity of the pore throats. Hydraulic conductivity, therefore, determines the ease of travel of contaminants from the surface environment to the subsurface hydrogeological environment.

5.1 Geophysical report

Geophysical survey was conducted as a pre-requisite for a successful groundwater exploration, it also gives an in-depth/insight into different Formation to be encounter while drilling, this enable us to prepare different drilling bit that could easily penetrate different layers of strata specified in the survey report, this is because using appropriate drilling bit for each Formations encountered reduce cost and it goes a long way in saving our precious time on the execution of the borehole.

6. Material and Method of Study

6.1 Site location and description

The geophysical exploration was carried out within Auchi Polytechnic, Auchi, Edo State, Nigeria. VES 1 is approximately defined by the geographical coordinates of latitude N070 02'44.4" and Longitude E0060 16'11.8". The observed elevation above the mean sea level is 213 m.

6.2 Geology and Hydrogeology

Desktop study and field observations show that the geological materials underlying the site belong to the Ajali Formation. The Formation hitherto known as upper coal measure is made up of false-bedded sandstone, thin lenticular shales, coal and pebbly gravel. The texture is variable but generally speaking, it is coarse. Hydrogeologically, the formation is a good prospect and it is often associated with fairly deep water table conditions.

6.2.1 Field procedure

The groundwater exploration carried out at the site was done using electrical resistivity sounding techniques (VES). This was achieved with the aid of ABEM AC Terrameter and other field accessories. Geographical coordinates and elevations were obtained from the GARMIN GPS map 76CSx' set. Three Vertical electrical sounding (VES) were done at the site using Schlumberger array. The total spread length (i.e. AB/2) attained for the three VES points within the limit of the available space were 500m, 350m, and 150m. However, the artificially generated electrical signal can hardly go beyond AB>2Km. This is why resistivity sounding is best suited for groundwater and not petroleum exploration. (Kearey and Brooks, 1988).

Site clearing

Site clearing was embark upon to make easy access for the mobilization of the equipment and personnel to site, for smooth operation

Mud pit and channel construction
A mud pit was immediately dug in readiness for Rig-Up, a sizeable one was constructed, and it's of 3x3x4ft dimension, this serves as a drilling fluid reservoir and chemical chamber as well as cutting gathering units.

Equipment
A rotary Rig was mobilized to site, a mechanical type in operation, since the geophysical report specify the area to be a sedimentary terrain hence the rotary rig is the most appropriate for it.

Drilling and sampling
While drilling was going on, samples was being collected at 3m/10ft interval, this was monitored throughout the period of the drilling. However, the total drilled depth was 450ft and we cased exactly at the depth of termination.

Well casing and screen
This is done to keep loose sand and gravel from eclipsing into the borehole, it is also necessary to use well-casing and screen. The screen supports the borehole wall, while allowing water to enter the well. Unspotted casing is placed above the screen to keep the rest of the borehole open and serve as housing for pumping equipment. Since the screen is the most important and the HEART of the well, we did the slotting of the PVC pipes to a total length of 30ft and installed same.

Pump testing
This is the test carried out before the water will be confirmed fit for consumption and for other domestic

purposes. The first stage of the pump testing lasted for about eight (8hrs) hours to ascertain the drawdown, so as to confirm the Riser position. Thereafter we continue with the pump testing for about thirty-two hours (32hrs), to determine how prolific the aquifers are. In addition to the pump testing a 5.5HP submersible pump was installed and furthermore water samples was sent to the Lab for physio-geochemical and Biological analysis, in order to ascertain the hydro-geochemical impurity of the groundwater so as to pin-point the exalt type of water treatment plant-unit to be installed.

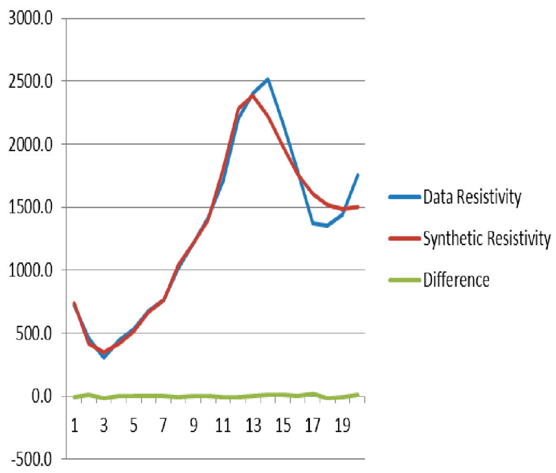
7. Data Interpretation

The quantitative interpretations of the resistivity sounding curves were done to obtain the geo-electric parameters (i.e. resistivity) with the aid of computer assisted iteration techniques.

VES-1 AUCHI POLY
Schlumberger Array
Northing: 0.0 Easting: 0.0 Elevation: 0.0
Layered Model: Smooth Model:
Spacing (meters)

No	ABS/2	MN	Data Resistivity	Synthetic Resistivity	Difference
1	2.00	0.80	719.0	741.1	-3.08
2	3.00	0.80	460.0	416.6	9.43
3	4.00	0.80	304.0	350.9	-15.43
4	6.00	2.00	440.0	417.9	5.02
5	8.00	2.00	530.0	510.4	3.69
6	12.00	2.00	680.0	667.9	1.76
7	15.00	6.00	761.0	767.5	-0.856
8	25.00	6.00	1014.0	1043.5	-2.91
9	32.00	6.00	1211.0	1214.9	-0.325
10	40.00	10.00	1414.0	1399.8	1.00
11	60.00	10.00	1708.0	1802.8	-5.55
12	100.00	20.00	2206.0	2279.1	-3.31
13	150.00	20.00	2403.0	2382.4	0.853
14	200.00	20.00	2513.0	2217.1	11.77
15	250.00	20.00	2160.0	1978.9	8.38
16	300.00	20.00	1791.0	1764.3	1.49
17	350.00	20.00	1373.0	1609.4	17.22
18	400.00	30.00	1357.0	1519.8	-12
19	450.00	30.00	1442.0	1487.9	-3.18
20	500.00	30.00	1754.0	1501.9	14.37

Source: Geophysical survey resistivity results, 2011.



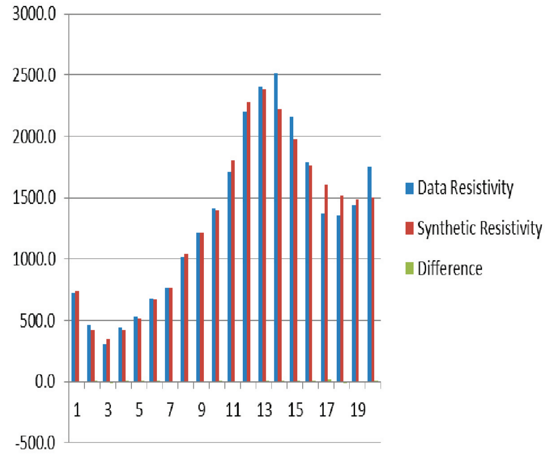
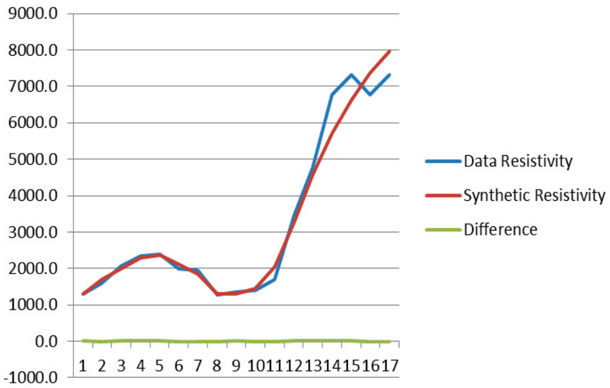


Fig 1: Graph of Geophysical Trend Analysis of VES 1

VES-2 AUCHI POLY
Schlumberger Array
Northing: 0.0 Easting: 0.0 Elevation: 0.0
Layered Model: Smooth Model:
No Spacing (meters)

No	ABS/2	MN	Data Resistivity	Synthetic Resistivity	Difference
1	2.00	0.80	1298.0	1293.8	0.31
2	3.00	0.80	1604.0	1690.2	-5.37
3	4.00	0.80	2080.0	1983.9	4.61
4	6.00	2.00	2336.0	2301.4	1.47
5	8.00	2.00	2393.0	2362	1.29
6	12.00	2.00	1991.0	2113.3	-6.14
7	15.00	6.00	1945.0	1843.1	-5.23
8	25.00	6.00	1265.0	1310.04	-3.56
9	32.00	6.00	1340.0	1292.5	3.59
10	40.00	10.00	1407.0	1443.8	-2.63
11	60.00	10.00	1696.0	2036.9	-20.1
12	100.00	20.00	3456.0	3246.2	6.06
13	150.00	20.00	4771.0	4580.1	4
14	200.00	20.00	6786.0	5703.7	15.94
15	250.00	20.00	7324.0	6628.2	8.37
16	300.00	20.00	6786.0	7372.5	-8.64
17	350.00	20.00	7312.0	7958.5	-8.84

Source: Geophysical survey resistivity results, 2011.



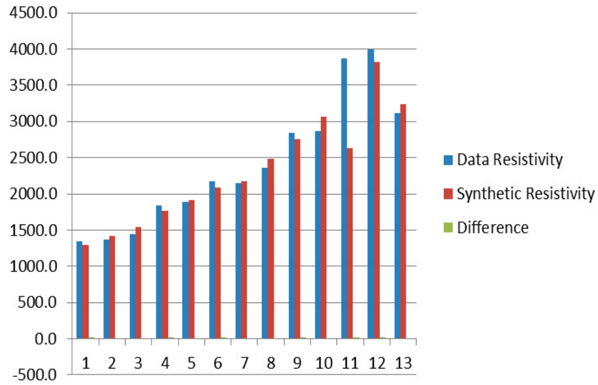


Fig 2: Graph of Geophysical Trend Analysis of VES

2

VES-3 AUCHI POLY

Schlumberger Array

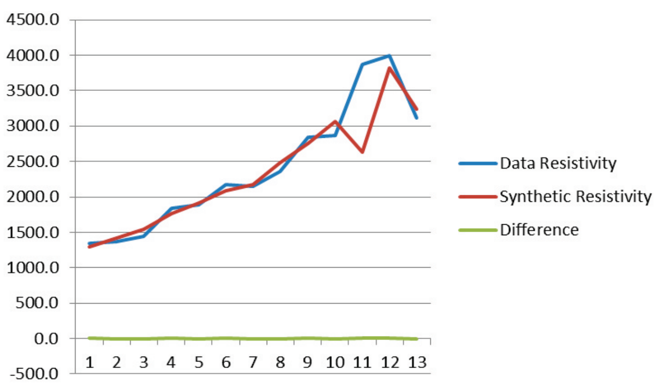
Northing: 0.0 Easting: 0.0Elevation: 0.0

Layered Model: Smooth Model:

No Spacing (meters) Data Resistivity Synthetic Resistivity DIFFERENCE

No	ABS/2	MN	Data Resistivity	Synthetic Resistivity	Difference
1	2.00	0.80	1338.0	1293.0	3.29
2	3.00	0.80	1371.0	1414.5	-3.17
3	4.00	0.80	1438.0	1545.8	-4.4
4	6.00	2.00	1838.0	1763.3	4.06
5	8.00	2.00	1891.0	1910.9	-1.05
6	12.00	2.00	2172.0	2081.9	4.14
7	15.00	6.00	2144.0	2167.9	-1.11
8	25.00	6.00	2356.0	2483.1	-5.39
9	32.00	6.00	2841.0	2756.9	2.95
10	40.00	10.00	2865.0	3066.8	-7.04
11	60.00	10.00	3873.0	2628.3	6.38
12	100.00	20.00	3998.0	3823.8	4.35
13	150.00	20.00	3110.0	3232.5	-3.93

Source: Geophysical survey resistivity results, 2011.



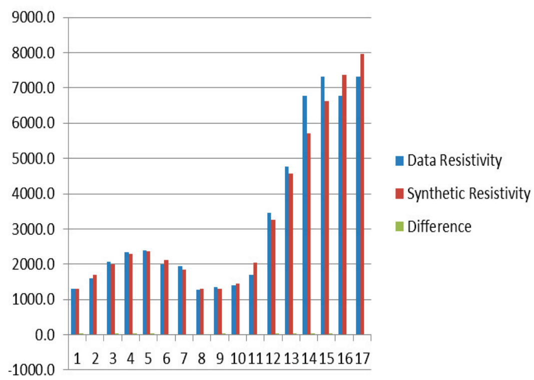


Fig 3: Graph of Geophysical Trend Analysis of

VES 3

8. Results and discussion

The interpreted result is presented as sounding curves and descriptive geo-electric logs/Section. Seven geo-electric layers were resolved for VES-1. Layer 1 and 2 stand for lateritic topsoil and subsoil with thicknesses of 0.875m and 1.13m and Layers 3 is the sandy horizon. Layer 4 is designated as the resistive sandy/sandstone/clayey layer. The fifth layer is the saturated sandy/ partly clayey horizon. Layer 6 is also saturated sandy/sandstone/partly clayey unit. The seventh layer of unknown thickness is designated as the dry/resistive sandstone horizon. VES 2 and 3 are of the same trend. Two distinct saturated layers (i.e. Aquifers) were identified from the interpreted VES results. The first is layer 5 while the second is layer 6. The calculated thicknesses of layers 5 and 6 are 65.71m and 52.88m respectively. Furthermore the depth to the base of layer 6 is 170m (561ft). The apparent resistivity values for the saturated layers are fairly low, indicating good aquifers. In view of the above hydrogeological and hydro-geophysical analysis can be deduced that groundwater resource development through borehole drilling at the site is feasible. Therefore the borehole at the site, a maximum drilled depth of 197m (650ft) is recommended and VES 1 is the recommended drilling point. It is advised that the terminal drilled depth of the borehole at the site should be left at the discretion of the site geologist and hydro-geologist, who should document and supervise the borehole construction work in it's entirely.

9. Conclusion and recommendation

To establish water quality and portability of water source, a full analysis of the water sample from the developed borehole should be done at a reputable laboratory for physio-geo-chemical and biological analysis, in order to ascertain the hydro-geochemical impurity determination of the groundwater, so as to pin-point the exalt type of water treatment plant-unit to be installed. In addition to the pump testing, a 5.5HP submersible pump should be installed. For future proposed borehole around the site project location, a maximum drilled depth of 197m (650ft) and VES 1 is the recommended drilling point. It is advised that the terminal drilled depth of the borehole at the site should be left at the discretion of the site geologist and hydrogeologist.

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