INVESTIGATION OF GROUNDWATER POTENTIAL ZONES USING SCHLUMBERGER TECHNIQUES AT THE FEDERAL POLYTECHNIC MUBI FARM LAND, ADAMAWA STATE NORTHEASTERN NIGERIA

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Abstract

This research focuses on the investigation of groundwater potential zones using Schlumberger techniques at the Federal Polytechnic Mubi Farm Land, Adamawa State Northeastern Nigeria for the purpose of determining the depth to groundwater potential zones and to recommend the possible site for drilling boreholes in the study area. Six (6) Vertical Electrical Soundings (VES) were carried out on the field VES A, B, C, D, E, F using Schlumberger array of 100 m maximum electrode spacing, the field data obtained were interpreted using 1XD Interpex software. Qualitative and Quantitative techniques were used to interpret the data obtained on the field that indicated the result of possible six (6) VES points that can be used for groundwater exploration. Recommended depth (m) for drilling these VES points A, B, C, D, E and F were found to be at 100 ±5 m, 150 ± 5 m, 180±5 m, 180±5 m, 20 ± 5 m and 150±5 m respectively due to the presence of fracture/weathered zone and low resistivity.

Keywords: Groundwater, Schlumberger, Boreholes, Vertical Electrical Soundings (VES), Electrode and Resistivity

Acknowledgement

I appreciate the TETFUND for sponsoring this research work.

Introduction

Groundwater is one of the main source of water that can be found beneath the earth surface. Human daily activities requires the uses of water for difference purposes such as: industrial, Agricultural, and Domestic purposes. Naturally groundwater is being recharge by rain which infiltrate through the soil or the secondary pores of the subsurface (Nampak *et al.,* 2014).

Searching for potential zones for groundwater exploration cannot be over emphasized due to the fact that increase in population in Federal Polytechnic Mubi community has led to shortage of water within the community the water available could not meet the demand of the people living in the area. In order to drill bole hole for the community development and groundwater exploration there is need for geophysical survey to obtain the detail information about the potential zone for groundwater exploration.

Electrical resistivity methods have been used in different parts of the world to solve challenges in the field of geophysics and geology for groundwater exploration and engineering studies. The Vertical Electrical Sounding methods (VES) are depth sounding methods. From previous studies Vertical Electrical Soundings has been found effective in obtaining the geo-electric parameter and Dar-zarrouk parameters (Oladunjoye *et al.,* 2018; Nwobi *et al.,* 2022; Okolie *et al.,* 2010; Shishaye and Abdi (2016); Sikah *et al.,* 2016; Hassan *et al.,* 2017; Metwaly *et al.,* 2012; Sikami *et al.,* 2017; Ndatuwong and Mathew (2022); Mbah and Nur (2021); Sunday and Usman, (2021); Lazarus *et al.,* 2020; Tantasso, 2025).

This research focuses on the use of Schlumberger technique to investigate the groundwater potential zones for groundwater exploration in order to determine the best site for drilling boreholes in the study area.

Location of the Study Area

This region is located between latitudes 10^0 015'N and 10^0 025'N and longitudes 13^0 015'E and 13^0 025'E. The area, which is roughly 10 km^2, is easily accessible. There are usually gentle escarpments, undulating slopes, and steep hills in the area. Geological and geomorphological processes have produced the landform. The region's high relief, which ranges from 2000 meters above sea level in the west to 3900 meters above sea level in the south, is what defines it. There are hard rock formations in the research area, and there is a severe water shortage that affects both drinking and agriculture. Only worn and fractured strata and upper unconsolidated layers can contain groundwater in this kind of terrain.

Geology of the Study Area

The study region is situated in the Northern Part of Adamawa State, inside the Precambrian Basement Complex. These are composed of sandstones that are interbedded in conglomerates. However, lateritic soils can cover the basement complex rocks in some locations. The Yadsaram River and its tributaries' flood basins are the only places where alluvium from recent rivers may be found. It is distinguished by the presence of clay pebbles from the nearby basement rocks and fine- to medium-grained sandy elements. Underlying the research region are the undifferentiated basement rocks, which are basement complex rocks. Among them are gneiss, magmatites, and older

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granites. The Pan African Orogenic cycle is responsible for the intrusion of rocks into the Older Granite series. These rocks fall into three (3) major groups: syntectonic to late tectonic granite, migmatite, and basic and intermediate intrusive (McCurry, 1976).

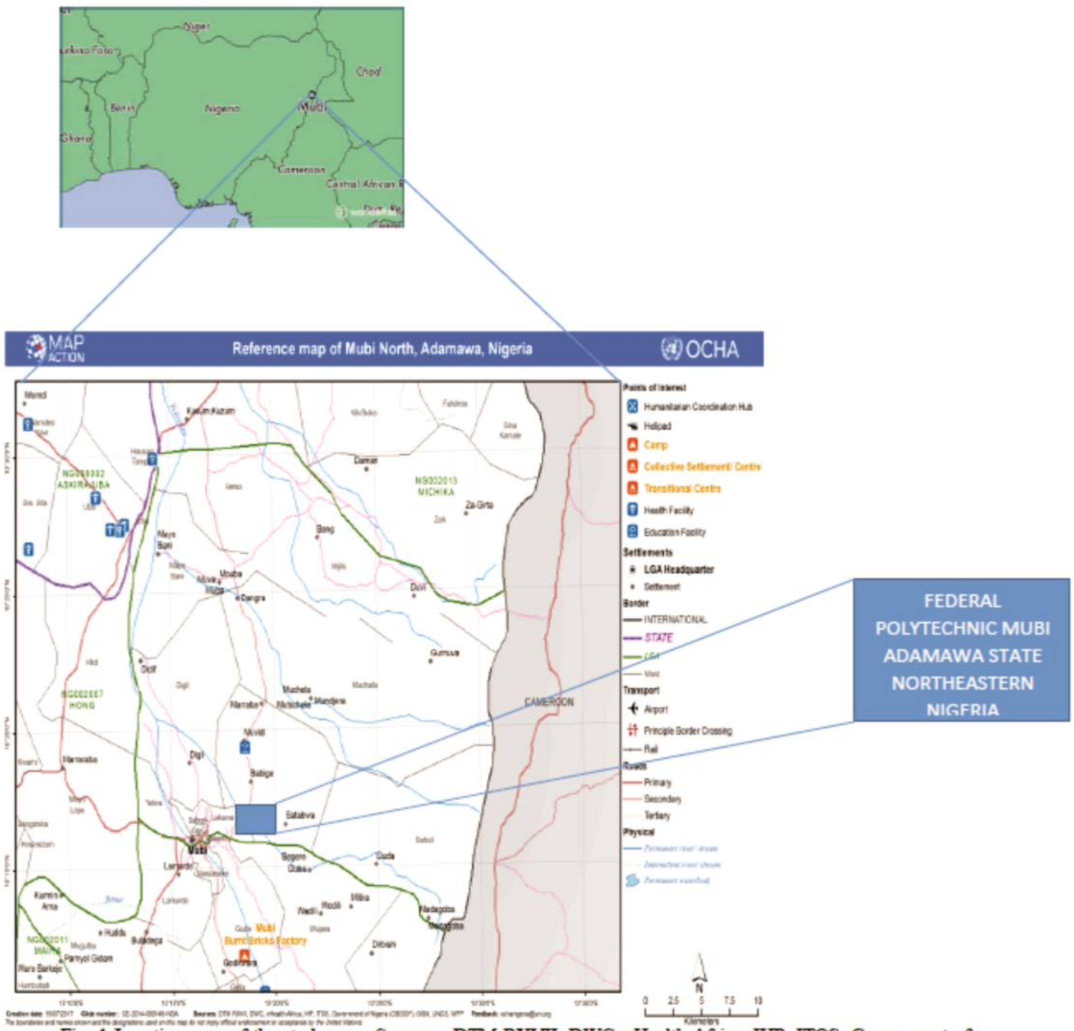

Fig: 1 Location map of the study area, Sources: DTM RXVII, DWC, eHealth Africa, IHP, ITOS, Government of Nigeria (OSGOF), OSM, UNCS, and WFP. Mubi North Local Government Map.

Materials and Methods
Materials

(i) Terameter
(ii) Electrodes
(iii) Car Battery
(iv) Connections wires
(v) GPS
(vi) Hammer
(vii) Laptop

(viii) Geo-software

Method

The Schlumberger array was set up in the study area to carry out a geophysical survey. Vertical Electrical Soundings techniques were employed by using a central electrode, two potential electrodes, two current electrodes and direct current (dc) from a car battery. The data collected from this geophysical survey can be used for the analysis of subsurface resistivity variations, which can indicate the presence of different geological formations and groundwater resources. This method is particularly useful in hydrogeological studies and environmental assessments. The arrangement was set up as shown in Fig. 2. The distance between the central electrode and potential electrode was 0.2 m (MN/2), and the distance of current electrodes was at 1 m (AB/2). The first vertical electrical sounding was carried out by sending direct current into the ground through the subsurface to determine the resistivity of the sounding point. Increasing depths are realized by enlargement of the current electrodes from 1 m to 1.5 m, 2.00 m, 2.50 m .....10.00 m and the value of MN/2 was at 0.2 m. The value of (MN/2) was increased to 1.5 m when the value of (AB/2) was increased to 13.00 m and the maximum value of (AB/2) measured was 100 m. Geographical Positioning System (GPS) was used to record the co-ordinate of each VES points, Six (6) Vertical Electrical Soundings (VES) was carried out on the study area. For each sounding, the Terameter computes and displays a mean digital value of the apparent resistivity of the subsurface under investigation.

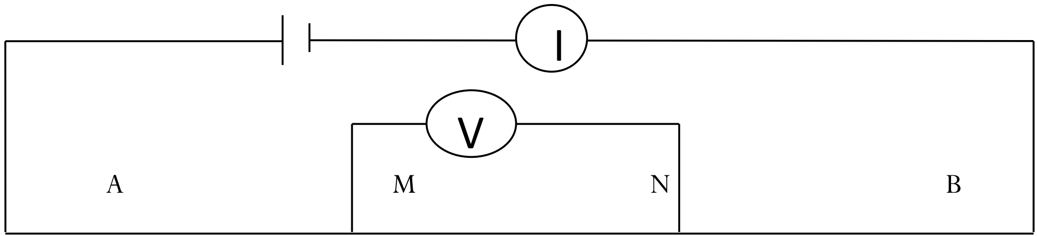

Figure 2: Schlumberger Configuration

Result Interpretation

To represent the vertical variations of subsurface resistivity at various depths, the Interpex IX1D resistivity program was used, which was one- dimensional (1D) inversion to process the apparent resistivity data. Data on apparent resistivity was entered using this software in a common geo-soft format. By using a filtering technique that includes vertical curve segment shift and single point correction, it also smoothens the field curve. This package changed the apparent resistivity values, which were collected in the field based on electrode spacing, into true resistivity values that depend on layer depth, allowing for a better understanding of the actual condition of the ground. The interpreted data's outcome is displayed.

Table 1: Field Data of Schlumberger Array for VES A

VES A
Schlumberger Array
Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	DIFFERENCE	Smooth Model: Synthetic Resistivity	DIFFERENCE
1	1.00	0.200	2460.0	2323.3	5.55		
2	1.50	0.200	864.0	910.6	-5.39		
3	2.00	0.200	356.0	371.2	-4.27		
4	2.50	0.200	198.0	198.5	-0.266		
5	3.00	0.200	165.0	146.5	11.15		
6	4.00	0.200	140.7	125.0	11.13		
7	5.00	0.200	130.3	121.1	7.07		
8	6.50	0.200	116.8	118.3	-1.23		
9	8.00	0.200	108.0	115.9	-7.32		
10	10.00	0.200	102.0	112.2	-10.07		
11	13.00	1.50	98.00	105.4	-7.63		
12	16.00	1.50	96.00	97.35	-1.40		
13	20.00	1.50	82.72	85.49	-3.35		
14	25.00	1.50	72.97	71.09	2.57		
15	30.00	1.50	52.85	58.68	-11.04		
16	40.00	1.50	43.42	41.43	4.56		
17	50.00	1.50	35.79	32.10	10.28		
18	65.00	1.50	26.72	25.92	2.97		
19	80.00	1.50	21.42	23.61	-10.26		

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
1	5580.8	0.478	-0.478	8.569E-05	2668.7
2	118.5	12.93	-13.40	0.109	1532.3
3	21.16		-13.40		

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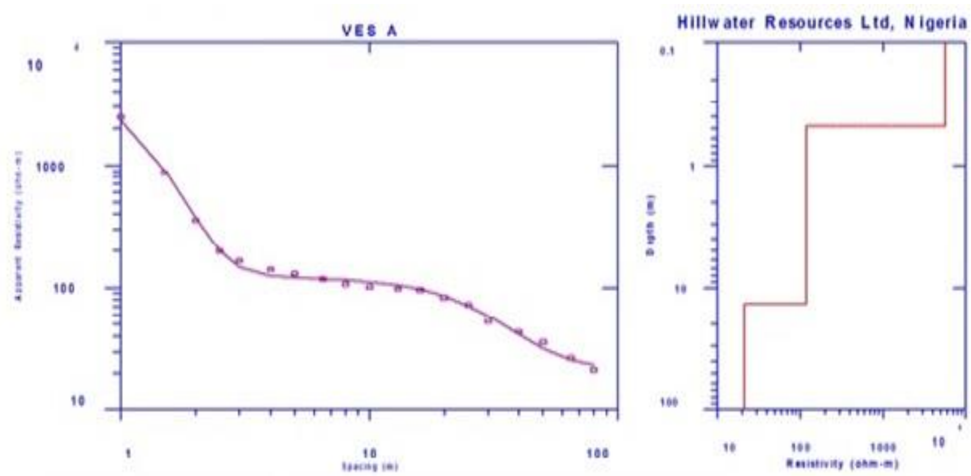

Fig 3. Showing interpreted data of VES A

Table 2: Field Data of Schlumberger Array for VES B

VES B
Schlumberger Array
Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	DIFFERENCE	Smooth Model: Synthetic Resistivity	DIFFERENCE
1	1.00	0.200	1540.0	1427.3	7.31		
2	1.50	0.200	620.0	673.8	-8.67		
3	2.00	0.200	316.0	336.0	-6.34		
4	2.50	0.200	223.0	208.7	6.38		
5	3.00	0.200	173.0	163.4	5.54		
6	4.00	0.200	163.0	140.3	13.92		
7	5.00	0.200	156.0	135.4	13.18		
8	6.50	0.200	135.1	132.5	1.85		
9	8.00	0.200	124.1	130.7	-5.33		
10	10.00	0.200	120.7	128.4	-6.42		
11	13.00	1.50	115.0	124.4	-8.18		
12	16.00	1.50	108.0	119.3	-10.52		
13	20.00	1.50	100.0	111.3	-11.36		
14	25.00	1.50	95.00	100.3	-5.59		
15	30.00	1.50	92.42	89.33	3.34		
16	40.00	1.50	74.20	70.74	4.66		
17	50.00	1.50	60.79	57.89	4.76		
18	65.00	1.50	47.48	46.95	1.10		
19	80.00	1.50	40.22	41.71	-3.70		
20	100.0	1.50	38.18	38.57	-1.04		

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
1	2858.8	0.520	-0.520	1.822E-04	1489.1
2	130.9	16.22	-16.74	0.123	2124.5
3	34.96		-16.74		

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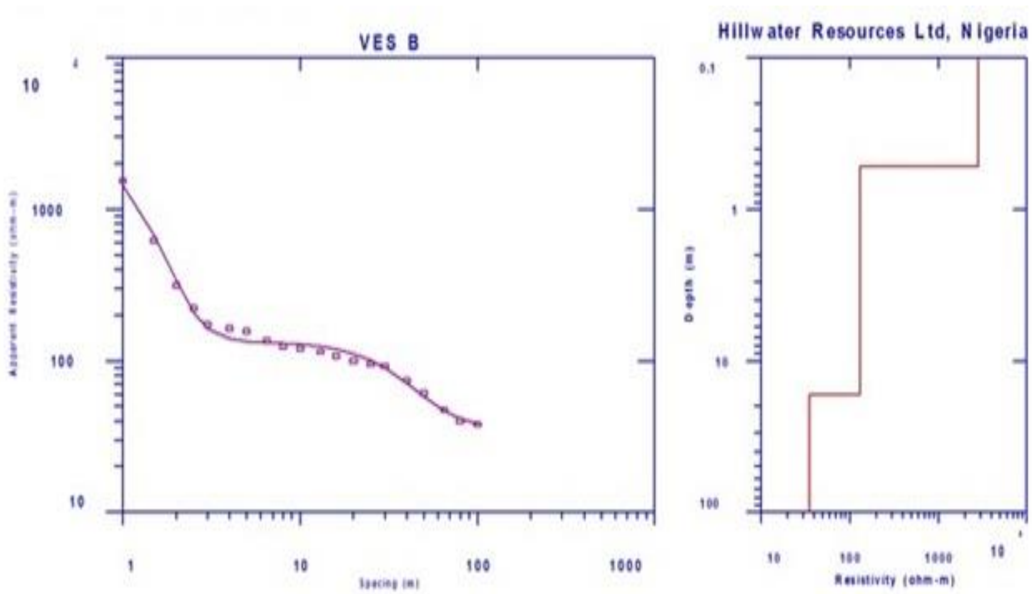

Fig 4. Showing interpreted data of VES B

Table 3: Field Data of Schlumberger Array for VES C

VES C

Schlumberger Array

Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	Layered Model: DIFFERENCE	Smooth Model: Synthetic Resistivity	Smooth Model: DIFFERENCE
1	1.00	0.200	848.0	736.5	13.14		
2	1.50	0.200	686.0	681.2	0.685		
3	2.00	0.200	584.0	605.2	-3.64		
4	2.50	0.200	478.0	522.1	-9.23		
5	3.00	0.200	398.0	443.1	-11.33		
6	4.00	0.200	307.0	317.9	-3.56		
7	5.00	0.200	271.0	238.9	11.81		
8	6.50	0.200	193.0	178.5	7.49		
9	8.00	0.200	149.0	152.7	-2.48		
10	10.00	0.200	139.0	138.0	0.652		
11	13.00	1.50	128.0	127.9	0.0102		
12	16.00	1.50	115.0	120.6	-4.87		
13	20.00	1.50	114.0	110.7	2.81		
14	25.00	1.50	94.00	97.91	-4.16		
15	30.00	1.50	80.00	85.12	-6.40		
16	40.00	1.50	65.00	63.00	3.06		
17	50.00	1.50	47.00	47.34	-0.731		
18	65.00	1.50	37.00	33.92	8.31		
19	80.00	1.50	26.00	27.65	-6.36		
20	100.0	1.50	24.11	24.17	-0.264		

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)

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VES C Page 2

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
1	767.2	1.51	-1.51	0.00198	1164.4
2	129.0	17.06	-18.57	0.132	2202.3
3	21.01		-18.57		

ALL PARAMETERS ARE FREE

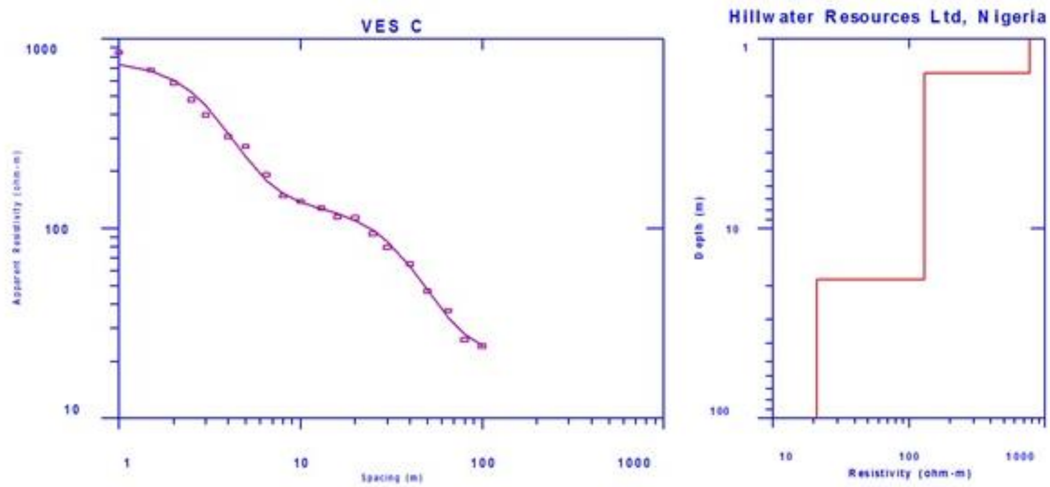

Fig 5. Showing interpreted data of VES C

Table 4: Field Data of Schlumberger Array for VES D

VES D

Schlumberger Array

Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	Layered Model: DIFFERENCE	Smooth Model: Synthetic Resistivity	Smooth Model: DIFFERENCE
1	1.00	0.200	1823.0	1420.4	22.08		
2	1.50	0.200	984.0	1206.4	-22.60		
3	2.00	0.200	878.0	969.3	-10.40		
4	2.50	0.200	711.0	761.3	-7.08		
5	3.00	0.200	650.0	601.1	7.51		
6	4.00	0.200	421.0	407.6	3.16		
7	5.00	0.200	368.0	319.8	13.09		
8	6.50	0.200	258.0	270.2	-4.74		
9	8.00	0.200	225.5	253.7	-12.51		
10	10.00	0.200	215.5	245.2	-13.81		
11	13.00	1.50	242.0	239.8	0.907		
12	16.00	1.50	244.0	236.4	3.11		
13	20.00	1.50	254.0	232.3	8.53		
14	25.00	1.50	224.0	226.4	-1.09		
15	30.00	1.50	232.0	219.1	5.51		
16	40.00	1.50	188.0	200.2	-6.52		
17	50.00	1.50	175.0	176.9	-1.09		
18	65.00	1.50	150.0	138.9	7.35		
19	80.00	1.50	109.0	103.5	4.97		
20	100.0	1.50	61.95	66.18	-6.83		

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
1	1565.2	1.10	-1.10	7.090E-04	1737.0
2	236.0	39.71	-40.82	0.168	9375.5
3	2.82		-40.82		

ALL PARAMETERS ARE FREE

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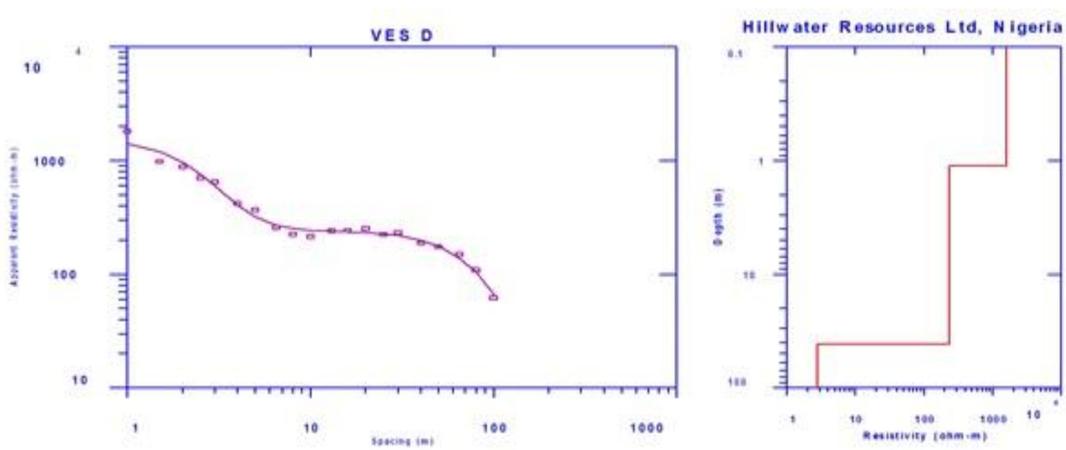

Fig 6. Showing interpreted data of VES D

Table 5: Field Data of Schlumberger Array for VES E

VES E

Schlumberger Array

Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	Layered Model: DIFFERENCE	Smooth Model: Synthetic Resistivity	Smooth Model: DIFFERENCE
1	1.00	0.200	2864.0	1883.3	34.24		
2	1.50	0.200	1153.0	1312.2	-13.81		
3	2.00	0.200	588.0	821.6	-39.73		
4	2.50	0.200	411.0	488.1	-18.75		
5	3.00	0.200	292.0	288.1	1.31		
6	4.00	0.200	168.0	117.3	30.13		
7	5.00	0.200	68.00	70.89	-4.26		
8	6.50	0.200	53.00	56.85	-7.26		
9	8.00	0.200	50.00	55.19	-10.38		
10	10.00	0.200	53.00	55.90	-5.48		
11	13.00	1.50	61.00	58.96	3.33		
12	16.00	1.50	73.00	63.49	13.01		
13	20.00	1.50	69.00	71.10	-3.04		
14	25.00	1.50	82.00	82.03	-0.0451		
15	30.00	1.50	95.00	93.58	1.49		
16	40.00	1.50	104.0	116.2	-11.82		
17	50.00	1.50	135.0	137.3	-1.70		
18	65.00	1.50	179.0	165.3	7.63		
19	80.00	1.50	197.0	189.7	3.69		
20	100.0	1.50	209.0	217.6	-4.12		

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)

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VES E Page 2

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
1	2380.8	0.865	-0.865	3.633E-04	2059.5
2	51.01	13.81	-14.67	0.270	704.6
3	449.3		-14.67		

ALL PARAMETERS ARE FREE

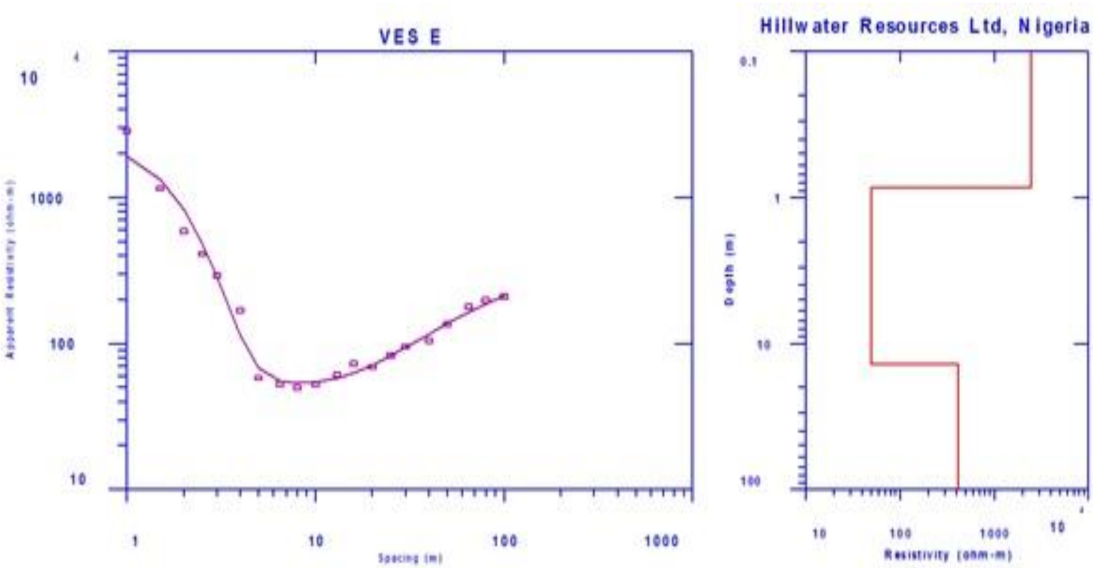

Fig 7. Showing interpreted data of VES E

Table 6: Field Data of Schlumberger Array for VES F

VES F

Schlumberger Array

Northing: 0.0 Easting: -999.0 Elevation: 0.0

No.	Spacing (meters) AB/2	MN	Data Resistivity	Layered Model: Synthetic Resistivity	DIFFERENCE	Smooth Model: Synthetic Resistivity	DIFFERENCE
1	1.00	0.200	1604.0	1046.8	34.73		
2	1.50	0.200	829.0	933.7	-12.64		
3	2.00	0.200	689.0	792.6	-15.04		
4	2.50	0.200	515.0	653.1	-26.82		
5	3.00	0.200	455.0	532.9	-17.12		
6	4.00	0.200	423.0	365.6	13.56		
7	5.00	0.200	325.0	275.4	15.23		
8	6.50	0.200	227.0	216.2	4.74		
9	8.00	0.200	209.0	193.9	7.17		
10	10.00	0.200	189.0	181.8	3.79		
11	13.00	1.50	175.0	172.4	1.45		
12	16.00	1.50	165.0	164.7	0.143		
13	20.00	1.50	134.0	154.0	-14.92		
14	25.00	1.50	123.0	139.4	-13.35		
15	30.00	1.50	115.0	124.5	-8.30		
16	40.00	1.50	98.00	97.91	0.0905		
17	50.00	1.50	82.00	78.10	4.74		
18	65.00	1.50	64.00	60.08	6.11		
19	80.00	1.50	58.00	50.97	12.10		
20	100.0	1.50	39.00	45.44	-16.52		

NO DATA ARE MASKED

Layered Model

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
1	1115.2	1.30	-1.30	0.00117	1451.2
2	174.5	17.75	-19.05	0.101	3099.5
3	39.60		-19.05		

ALL PARAMETERS ARE FREE

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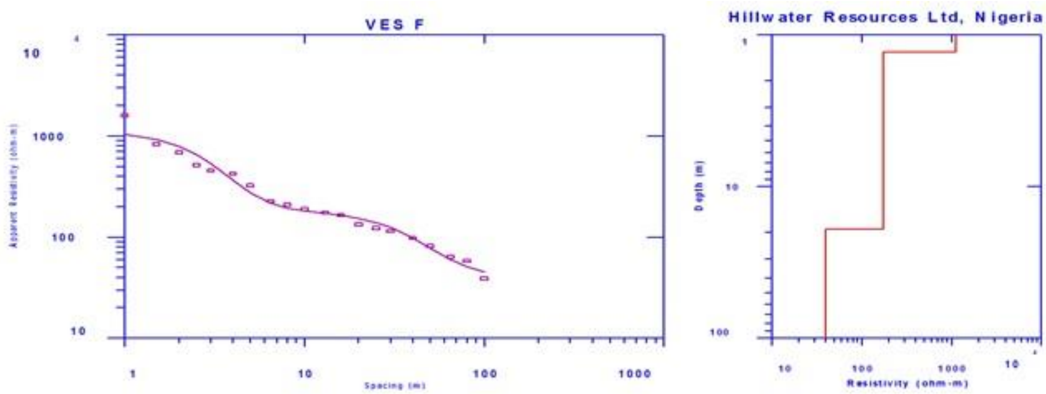

Fig 8. Showing interpreted data of VES F

Table 7: Summary of the Result Analysis of VES A – VES F

S/N	Location	VES No	Recommend Depth (M)	Latitude N	Longitude E
1	Adjacent to Chief Lecturer Office Federal Polytectnic Mubi	VES A	100 ±5	10° 28' 67"	13° 29' 27"
2	Beside School of Environmental Federal Polytechnic Mubi Campus	VES B	150 ± 5	10°.28' 8"	13°.29' 33"
3	Besides / Adjacent to School of Environmental Federal Polytechnic Mubi	VES C	180±5	10° 28' 89"	13° 29' 49"
4	Arround the School of Environmental Federal Polytechnic Mubi	VES D	180±5	10° 17' 79"	13°. 17' 44"
5	Animal farm close to School of Enviromental Federal Polytecnic Mubi	VES E	20 ± 5	10° 17' 25"	13° 17' 51"
6	Close to School of Environmental Federal Polytechnic Mubi	VES F	150±5	10° 17' 28"	13° 17' 55"

Discussion of the Table of Results

VES A, B, C, D and F Resistivity model shows 3 layered earth model with the Q Curves shapes of data interpretation and VES E indicated 3 layered earth model with H Curve of data interpretation. Base on the interpreted results, there is possibility of groundwater exploration from the VES points. Recommended Depth (m) for drilling of these VES points A,B, C, D, E and F are 100 ±5 m, 150 ± 5 m, 180±5 m, 180±5 m, 20 ± 5 m and 150 ± 5 m respectively.

Conclusion

Investigation of groundwater potential zones using Schlumberger techniques at the Federal Polytechnic Mubi Farm Land, Adamawa State Northeastern Nigeria was conducted. Vertical Electrical Sounding (VES) techniques was used, Schlumberger array has proved to be effective base on the result obtained. Six (6) Vertical Electrical Soundings (VES) points were carried out on the study area, the six (6) VES points were found to be viable for groundwater exploration. Recommended depth (m) for drilling these VES points A, B, C, D, E and F were found to be at 100 ±5 m, 150 ± 5 m, 180 ± 5 m, 180 ± 5 m, 20 ± 5 m and 150 ± 5 m respectively due to the presence of fracture/weathered zone and low resistivity despite the study area is in complex basement terrain.

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