INVESTIGATING THE GROUNDWATER POTENTIAL AT THE BOYS HOSTEL, BOSSO CAMPUS, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, USING ELECTRICAL RESISTIVITY METHOD

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ABSTRACT

Scarcity of water is a burning issue in most campuses in Nigerian Universities. Geophysical investigation for groundwater potential was carried out at the Boys Hostel, Bosso campus, Federal University of Technology Minna, Niger State. Horizontal Electrical Profiling (HEP) and Vertical Electrical Sounding (VES) were carried out using the Schlumberger configuration. About 25 HEP stations were established at an AB/2 depth of 20m and a total of 3 profiles across the study area using full Schlumberger array with maximum current electrode separation (AB/2) of 60m. The distance between profiles was 20m and the interval between VES stations was set at 30m and 10 VES stations were established. Qualitative and quantitative interpretation of the data was carried out with the aid of the traditional curve matching and the digital computer iteration. The pseudosections, isoresistivity map of depth to basement, isopach map of weathered layer, geoelectric sections and digital terrain model of the area were developed. The HK, QH, HA and H curve types were identified and stated in their order of dominance. The shallow weathered portion as well as the deep seated fracture zone forms the main water bearing zones in the area. Groundwater abstraction from deeper fractures was recommended for future boreholes in the area as the shallow regolith aquifer yield are poor due to over abstraction over the years which have resulted to seasonal static water level.

Keywords*:* Groundwater Potentials, Vertical Electrical Sounding, Horizontal Electrical Profiling, Bosso Campus, FUT-Minnna

INTRODUCTION

The Bosso Campus of Federal University of Technology Minna lies within latitude 9°38′55.8″N and 9°39′29.0″N of the Equator and longitude 6°31′19.7″E and 6°31′46.7″E of the Greenwich meridian with an average elevation of 250m (Figure 1). The Boys Hostel is a twin two floor story building located at the extreme northwestern portion of the Campus. Most student unrest in Nigerian higher institutions may be attributed to inadequate basic amenities such as potable water supply and electricity. The hostel initially has an alternative water supply from the Bosso Dam managed by the Niger State Water Board. This water supply scheme has not been sustained thereby placing more demand on the existing hand-pump boreholes and motorized borehole within campus.

One of the most feasible and reliable source of potable water supply in the Boys Hostel, Bosso Campus, FUT-Minna, is abstraction of groundwater and any effort targeted at locating this natural resources is a right step in the right direction. The establishment of more schools and departments by the university authorities recently has resulted to an increase in staff and students population with a corresponding increase in water demand on the campus and hence the need to for this study. The study is aimed at locating areas of high groundwater potential within the Bosso Campus, FUT-Minna with emphasis around the Boys Hostel area (Fig.1). It is also targeted at x-raying the causes of borehole failure in the area with the view of providing scientific based geosolutions. The study will fill the gap on groundwater potential of the Bosso Campus which will serve as a guide for future groundwater exploration and exploitation on the area, especially the Boys Hostel.

CLIMATE AND PHYSIOGRAPHY OF THE AREA

The vegetation of the study area belongs to the central savannah which is a transitional type between the forest zone of Southern Nigeria and the Guinea Savannah types of the Northern Nigeria. The area on a general note is characterized by tall grasses with sparsely distributed trees. The area mapped lies within the North central Nigeria with a mean annual rainfall of 1100mm and is low lying.

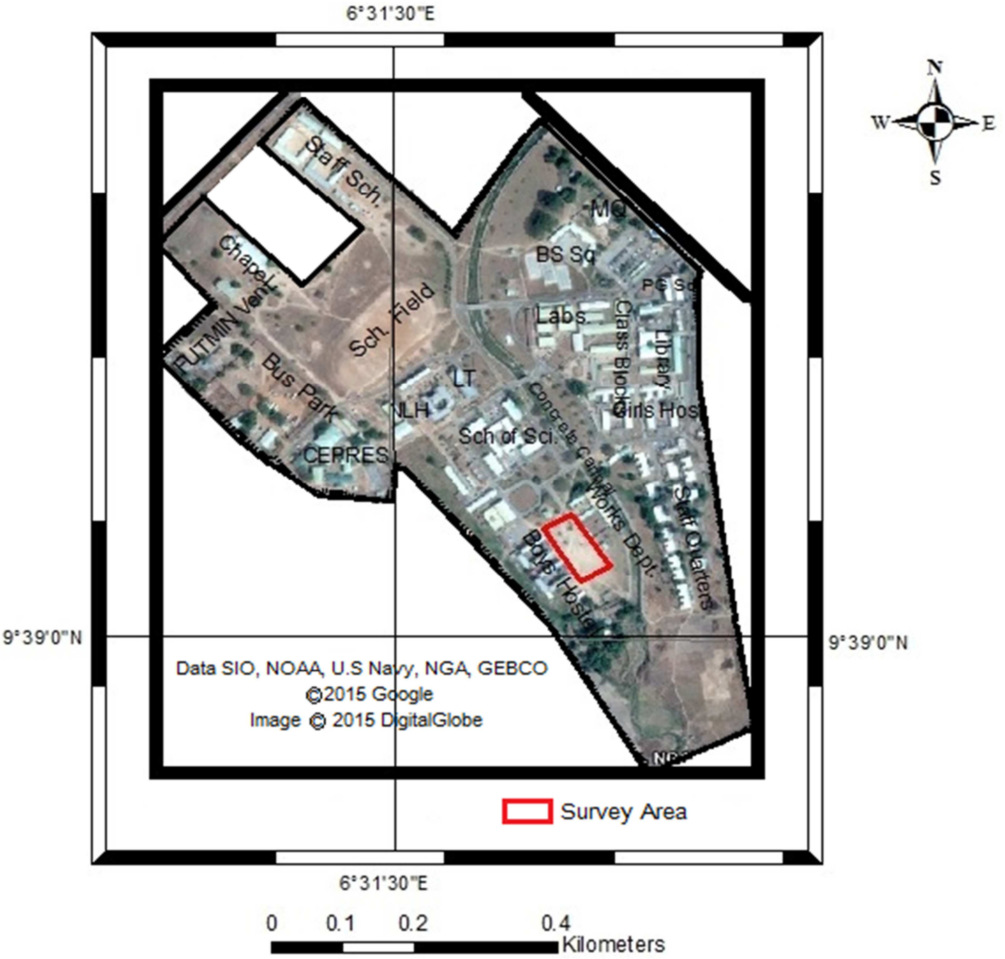


Fig.1: Map of the Bosso Campus showing the Study Area

GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The geological map of the study area is presented in fig.2. The study area lies within the north-central portion of the Nigerian Basement Complex, which is characterized by three lithofacies: the migmatite gneiss complex, the low-grade schist belt and the older granites (Olarewaju, *et al.*, 1996; Olasehinde, 1999; Oyawoye, 1972). Particular to the area is the granodiorite, granite-gneiss, schist and granitic rocks of different grain sizes and colour (Ajibade, 1980). The capacity of these crystalline rocks to store and allow movement and yield water largely depends on the extent, pattern, size, openness and continuity of the fracture, and the degree to which these fractures are hydraulically connected (Todd, 1980).

The study area is drained by the concrete walled canal which runs through Minna town passing through the entire length of Bosso campus. The aquifer in the area is recharged by precipitation and as a result, the discharges of the boreholes tapping from the regolith aquifers are higher during the rainy season than during the dry season (Amadi, *et al.*, 2013). The general trend of groundwater flow in the study area is northeast-southwest direction, which conforms to the regional structural trend in the area.

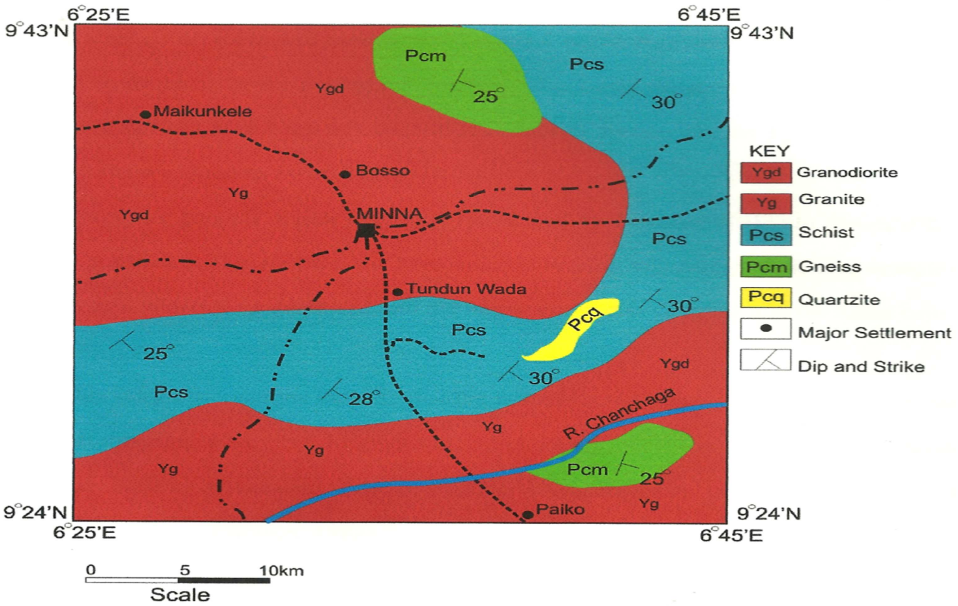


Fig.2: Geological Map of Minna

METHODOLOGY

In carrying out the geo-electric survey three different resistivity meters were used: MACOHM'S Resistivity meter, Campus Omega and a made in Nigeria resistivity meter of high accuracy and precision. The resistivity survey was completed with 3 profiles across the studied area using full Schlumberger array with maximum current electrode separation (AB/2) of 60m. The interval between profile lines was 20m while the interval between VES stations was set at 30m (Fig.3). Qualitative and quantitative interpretations of the obtained data were carried out. The data was plotted on the log-log graph, producing a manual curve for visual inspection. The generated curve was subjected to traditional curve matching involving the master and auxiliary curves to acquire the different layers at various depths and thereafter using the computer iteration

Winresist software (Van der Velpen and Sporry, 1992) to generate resolution curves. Global Positioning System (GPS) Etrex Legend was utilized to obtain coordinate of each sounded point. The coordinates and geoelectric parameters were used to generate the contour map and digital terrain model (DTM) of the study area with the aid of Surfer 11, pseudosection, isoresistivity map of depth to basement, isopach map of weathered layer. The interpreted curves were joined to bring out the geoelectric logs, geoelectric sections were then drawn from the logs for each of the profile lines.

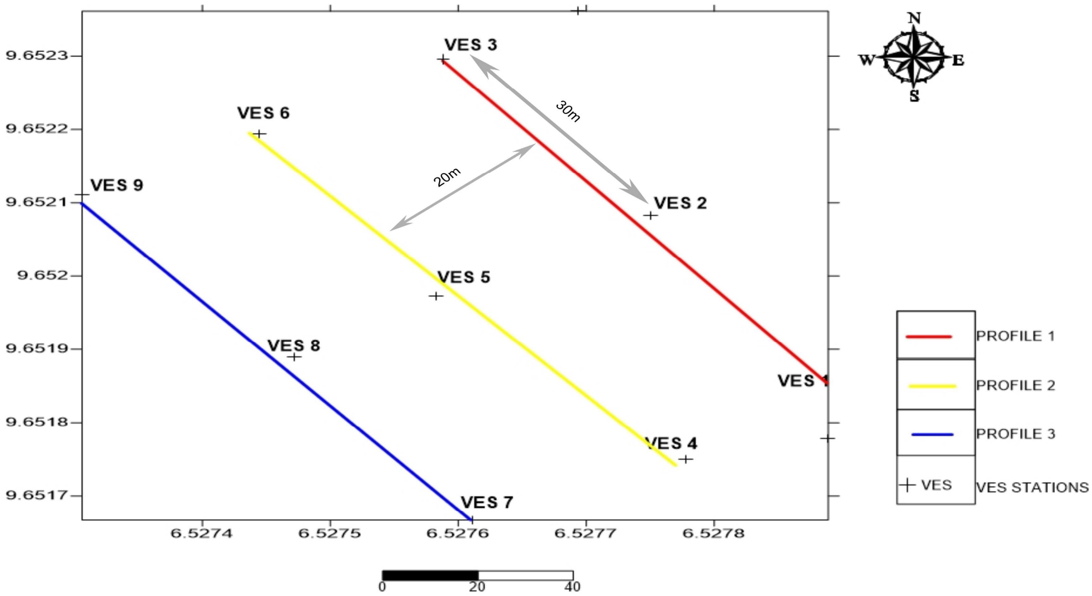


Fig.3: Digital map of the study area showing profile lines and VES station

RESULTS AND INTERPRETATION

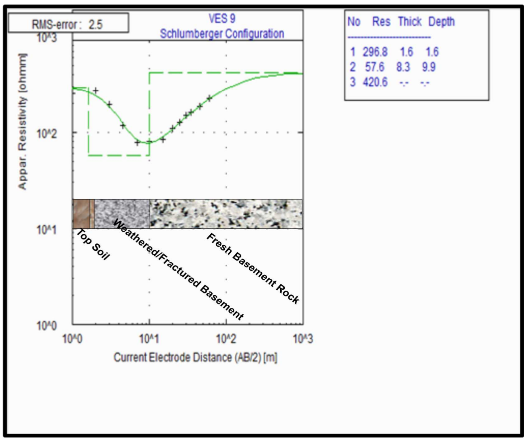
Summary of the resistivity data are shown in Table 1.

Table. 1: Vertical Electrical Sounding Data from 1-9

AB/2	MN/2	K	RESISTIVITY (Ohm-meter)								
			VES 1	VES 2	VES 3	VES 4	VES 5	VES 6	VES 7	VES 8	VES 9
1	0.5	7.54	229	301	1130	244	261	596	706	412	254
1.5	0.5	17.4	218	289	850	193	270	390	480	440	165
2	0.5	31.1	212	280	680	160	274	286	322	467	277
4.5	0.5	150.7	137	198	132	90	166	260	200	340	119
7	1	384.5	106	121	102	72	100	noise	182	noise	73
7	1	49.95	154	134	95	88	131	noise	193	193	79
10	1	102.4	109	126	98	130	123	122	177	158	80
15	2.5	223.3	108	134	113	223	134	135	172	130	85
20	2.5	416.5	133	172	136	256	175	195	200	140	110
30	2.5	940.1	174	183	137	280	235	282	235	171	135
30	2.5	190.96	142	190	162	283	220	225	215	170	149
35	2.5	263.9	180	192	1.8	176	277	290	240	245	160
45	7.5	443.4	185	214	210	277	233	266	270	340	187

From the model curve, four curve types were identified: the HK, QH, HA and H curve types. The H curve (Fig.4a and Table 2) is made of three layers; the first layer is the top unsaturated soil with resistivity value ranging from 297Ωm -1323Ωm with a thickness range of 0.7m-2.5m.The second layer is made up of variable degrees of weathered basement rock with resistivity value ranging from 56Ωm-169Ωm to a depth range of 9.9m-13.4m.This layer is also known as the overburden layer. Different school of thought exist regarding the definition of what overburden is, some will consider every material overlaying the fresh basement rock not excluding the weathered basement while others may consider only regolith materials as overburden (Walter and William, 1981, Olasehinde *et al.*, 2013). The third layer is made up of fractured/ fresh basement rock with resistivity value ranging from 304Ωm-922Ωm extending to an infinite depth.

The HK curve (Fig.4b and Table 2) is made up of four layers; the first and second layers have no much variation from the three layer curves. However the third layer may be considered to be the fresh basement rock with little or no pronounced fracture, the resistivity value ranges from 217Ωm-685Ωm to a depth range of 17.1m-32.3m. The resistivity value of the fourth layer ranges from 182-340Ωm. The fourth layer may be classified as the fractured/fresh basement rock. Systems of the various VES curves from the area are summarized in fig.5.



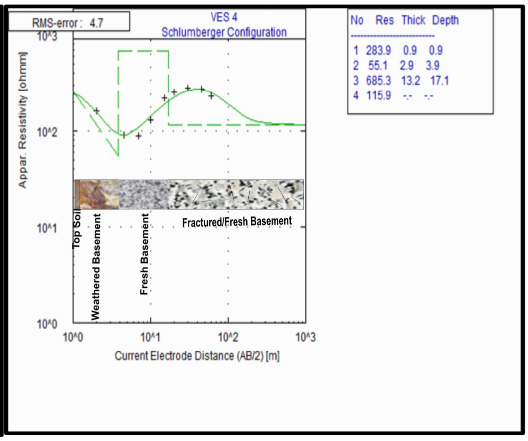


Fig.4a: A typical H curve (three layered) Fig.4b: A typical HK curve (four layered),

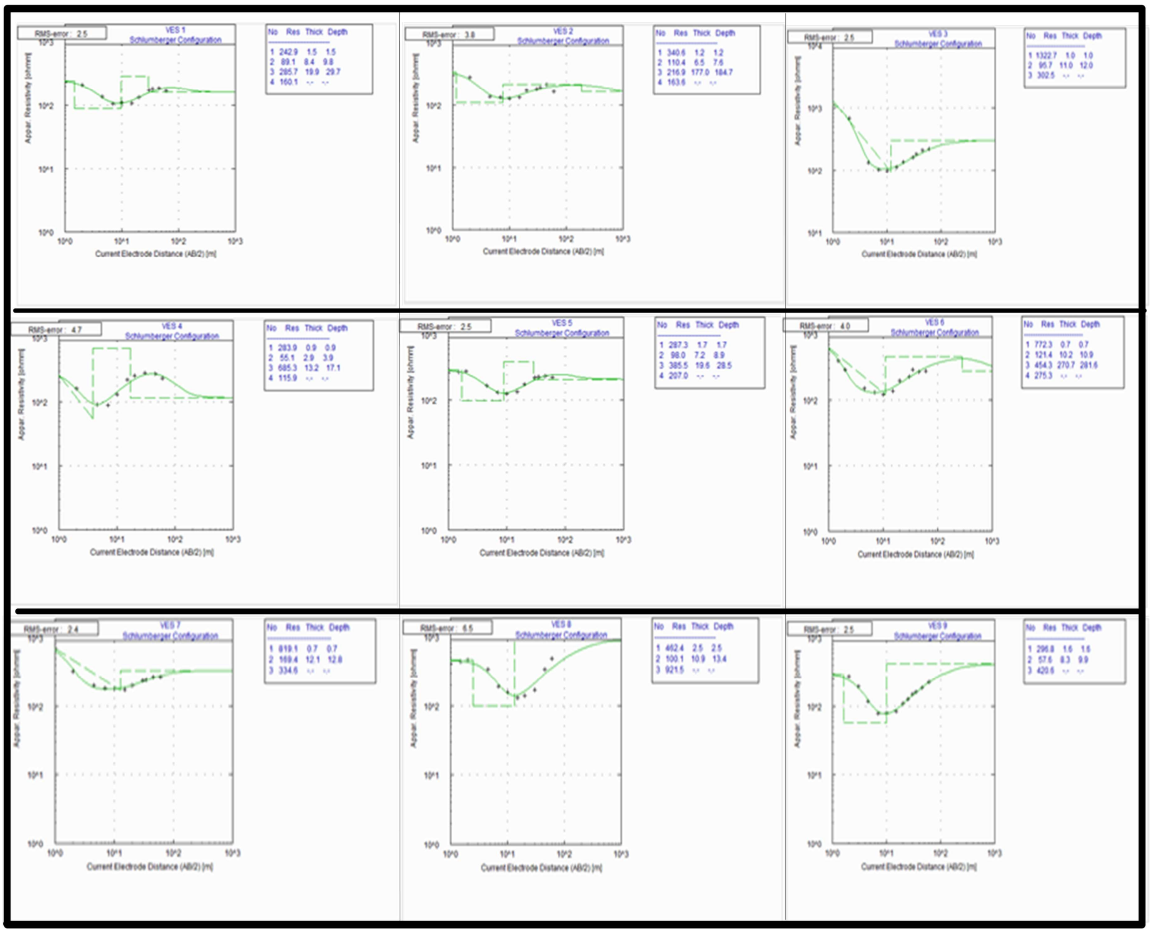


Fig.5: System of VES Curves

GEOELECTRIC SECTIONS

Geoelectric sections (Figs.6, 7 and 8) as derived from the geoelectric parameter (Table 2). The iterated curve are made up of three layers for VES 3, 7, 8, and 9, and four layers for VES 1, 2, 4, 5 and 6 (Fig.5). The summary of the geoelectric layer and the curve types are presented below.

Table 2: Geoelectric parameters indicating Geoelectric Layers and curve types for VES 1-9

LAYER	PROFILE 1			PROFILE 2			PROFILE 3		
	VES 1	VES 2	VES 3	VES 4	VES 5	VES 6	VES 7	VES 8	VES 9
Layer1 ρ1/d1	243/1.5	386/1.9	1323/1.0	284/0.9	287/1.7	772/0.7	819/0.7	462/2.5	297/1.6
Layer 2 ρ2/d2	89/9.8	81/6.8	96/12.0	55/3.9	98/8.9	121/10.9	169/12.8	100/13.4	56/9.9
Layer 3 ρ3/d3	286/29.7	268/32.3	304/∞	685/17.1	386/28.5	454/28.2	335/∞	922/∞	421/∞
Layer4 ρ4/d4	160/∞	111/∞		116/∞	207/∞	275/∞			
CURVE TYPE →	HK	HK	QH	HK	HK	HK	H	HA	HA

The geoelctric layer along profile one (Fig.6), shows four major layers with VES 3 having three layers with a minor layer of lateritic clay with resistivity value of 1323Ωm extending to the depth of about 1m. The second layer is the weathered basement(regolith) with an average resistivity value of about 85Ωm to an average depth of 9.5m. The third layer on this profile is a fresh basement rock with small fractures showing resistivity average of 277Ωm to an average depth of 25m. The Forth layer is the fractured/weathered basement rock, with an average resistivity value of about 115Ωm extending to an infinite depth.

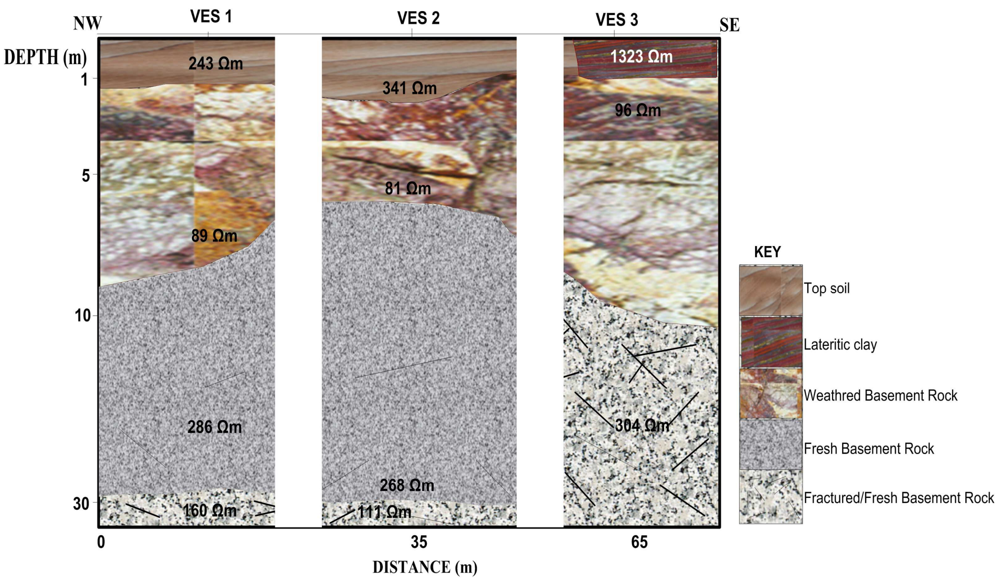


Fig.6:Geoelectric Section for Profile 1

All the VES stations in profile two (Fig.7) are composed of four geoelectric layers. The geoelectric layers of profile two are similar to that of profile one. Although VES 6, seems to have a thick weathered layer as the trend deepens from VES 4 to VES 6.

Profile three (Fig.8) comprising VES 7, 8, and 9, all have three geoelectric layers each. Although there is a tiny layer in between layer one and two, it can be neglected due to the ambiguity principle of suppression that accompanies electrical resistivity interpretation.

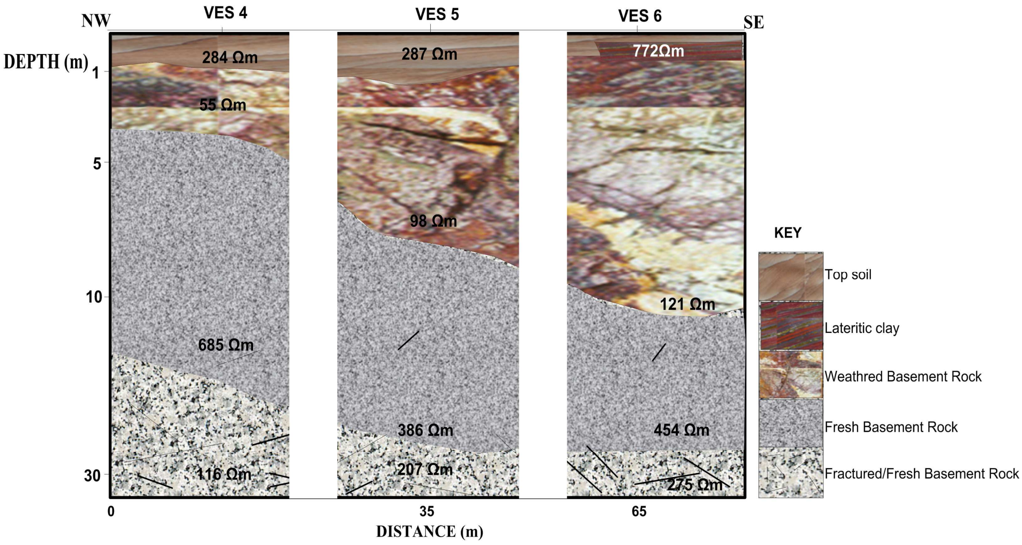


Fig.7:Geoelectric Section for Profile 2

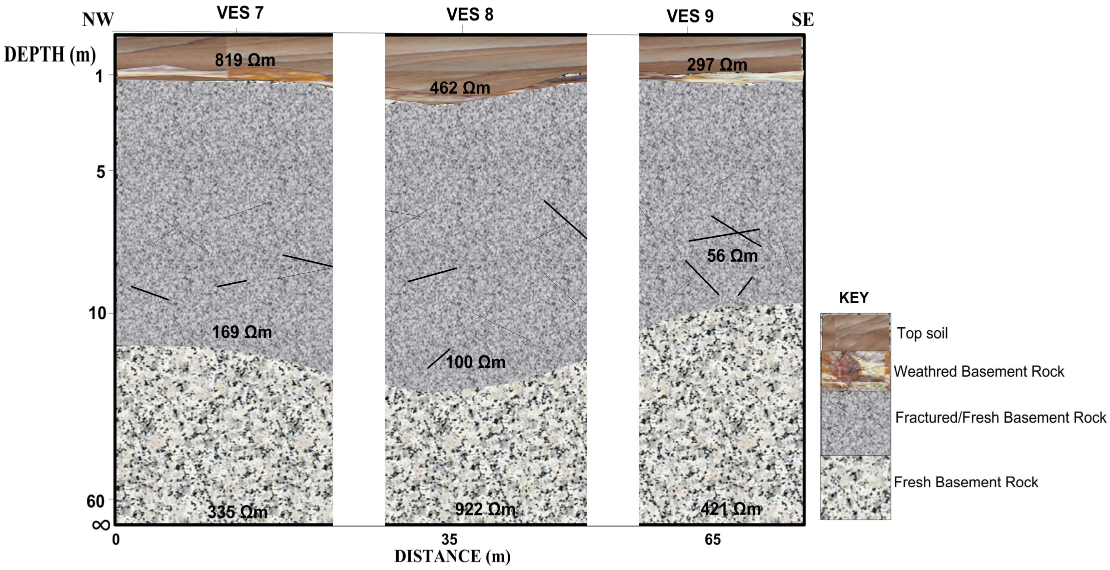


Fig.8: Geoelectric Section for Profile 3

Isoresistivity Map

Isoresistivity map at AB/2 of 20m (Fig.9) was prepared to show the trend of resistivity at this depth. 20m AB/2 was chosen based on the consideration that it has been used as the signature depth for Horizontal Resistivity Profiling within and around the study area.

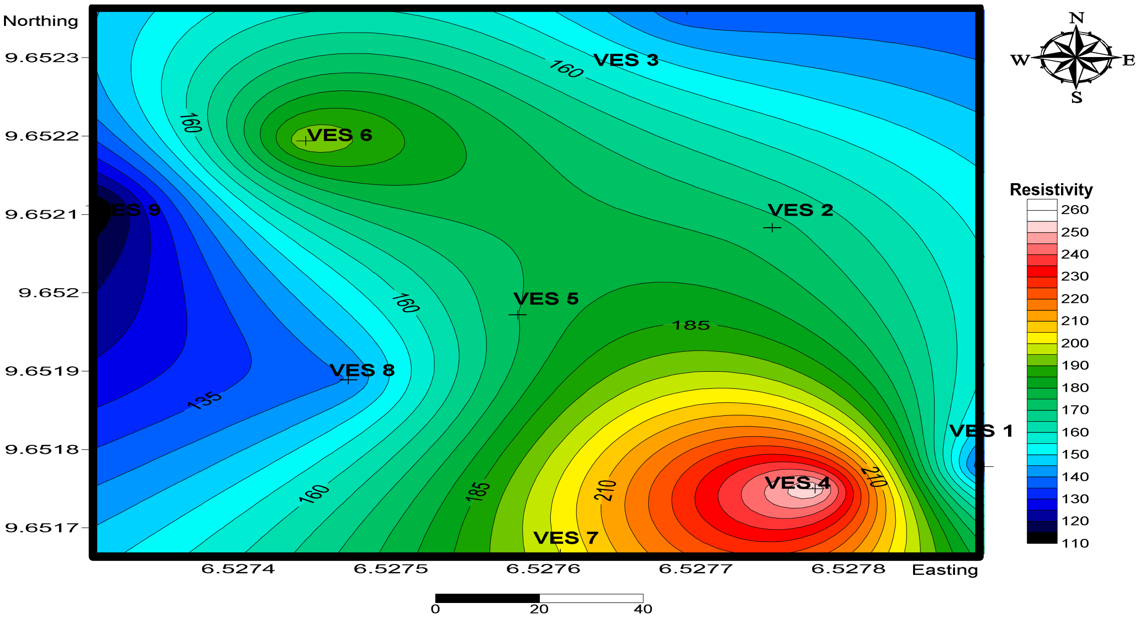


Fig.9: Isoresistivity map at AB/2=20m

At 20m, the lowest resistance is found around the western part of the study area, favouring VES 9 while VES 4 has the highest resistivity value at 20m. An isoresistivity map at AB/2 of 60m (Fig.10) was generated. VES 8 has the highest resistivity value, whiles VES 7,6 and 5 have moderate resistivity values and VES 1,2,3,4 and 9 show lower resistivity value, indicating good groundwater potential.

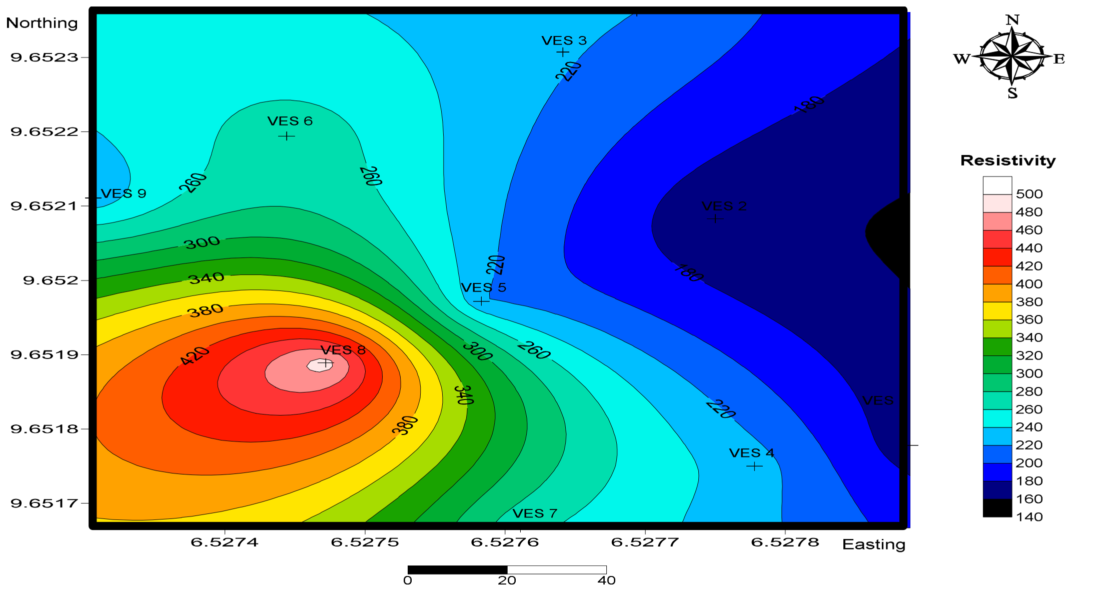


Fig.10: Isoresistivity map at AB/2=60m

Isopach Map of Depth to Basement

From the isopach map of depth to basement (Fig.11), it was noticed that the basement is at a shallow depth at the southeastern part of the study area (VES 4, 5, 2 and 1). The basement is at an average depth of 10m at the northwestern portion of the mapped area (VES 9, 6 and 3). The depth to basement is deeper at the southwestern and northern part of the study area at an average depth of 12m.

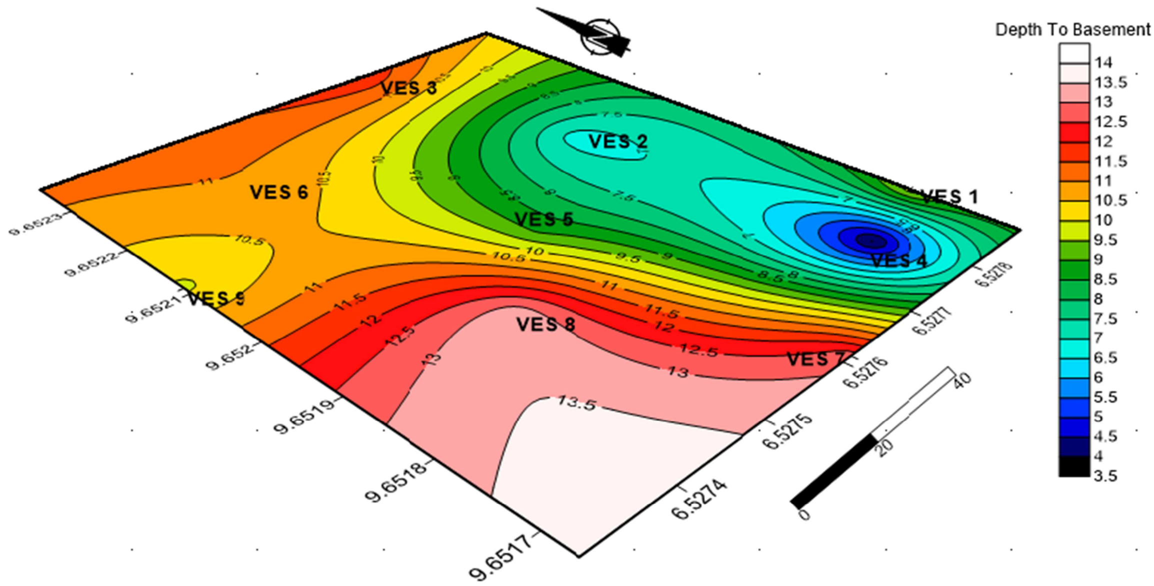


Fig.11:Isopach map of depth to Basement

Pseudo-section

The pseudosection for profile one (Fig.12), reveal lower resistivity values at the NW and central portion of the profile both at near surface and at an average depth. The SE part of the section, VES 3 indicates a high resistivity and the shallow subsurface and lower resistivity at an average depth.

The pseudo-section for profile two (Fig.13), shows lower resistivity at shallow substratum for VES 4 and 5 and high resistivity for the shallow substratum of VES 6 at the SE portion. The two pseudo-sections indicate average resistivity values which implies fair groundwater potential.

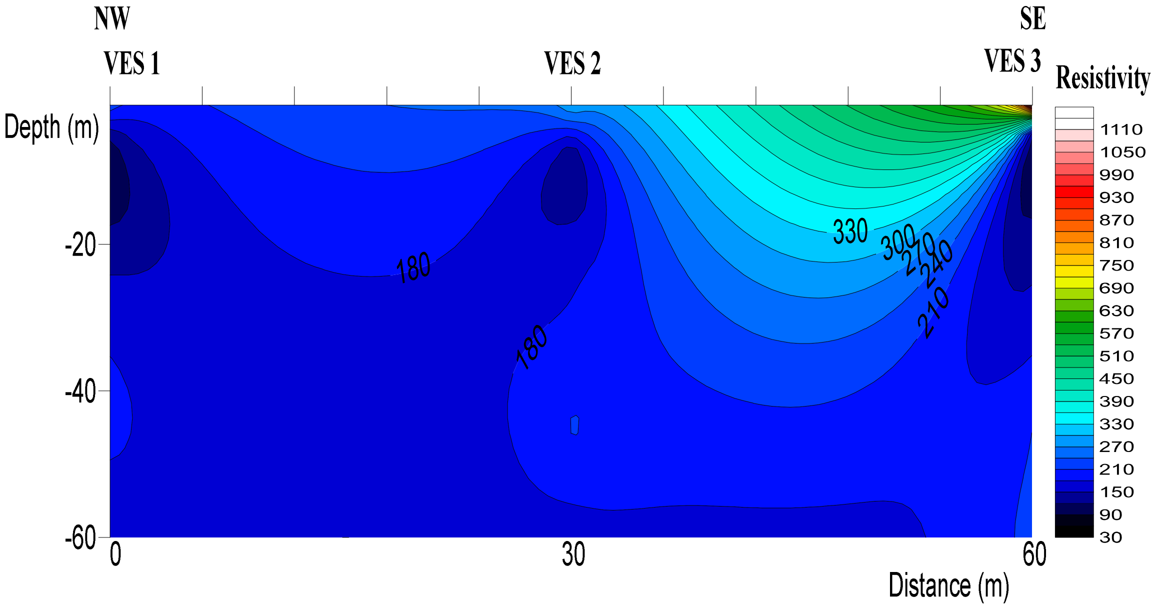


Fig.12:Pseudosection for Profile 1.

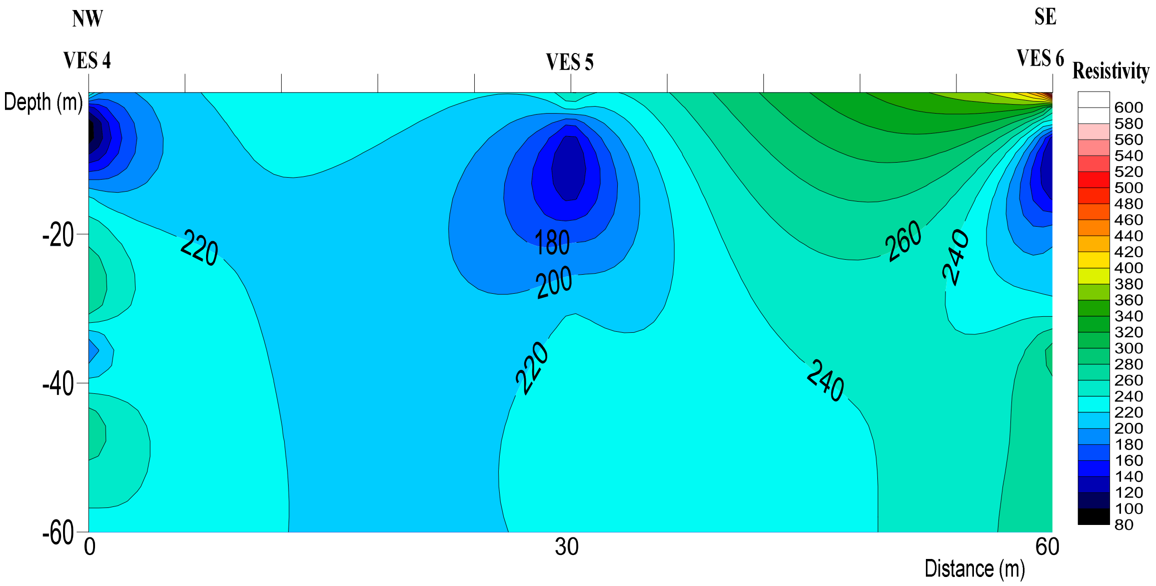


Fig.13:Pseudosection for Profile 2.

The pseudosection for profile three (Fig.14) indicates higher resistivity at the topmost part of the subsurface, and at a shallow depth of about 5m to28m which may be indicative of weathered part of the sounded points. The SE portion of the section shows lower resistivity value, which may be an indication for groundwater potential.

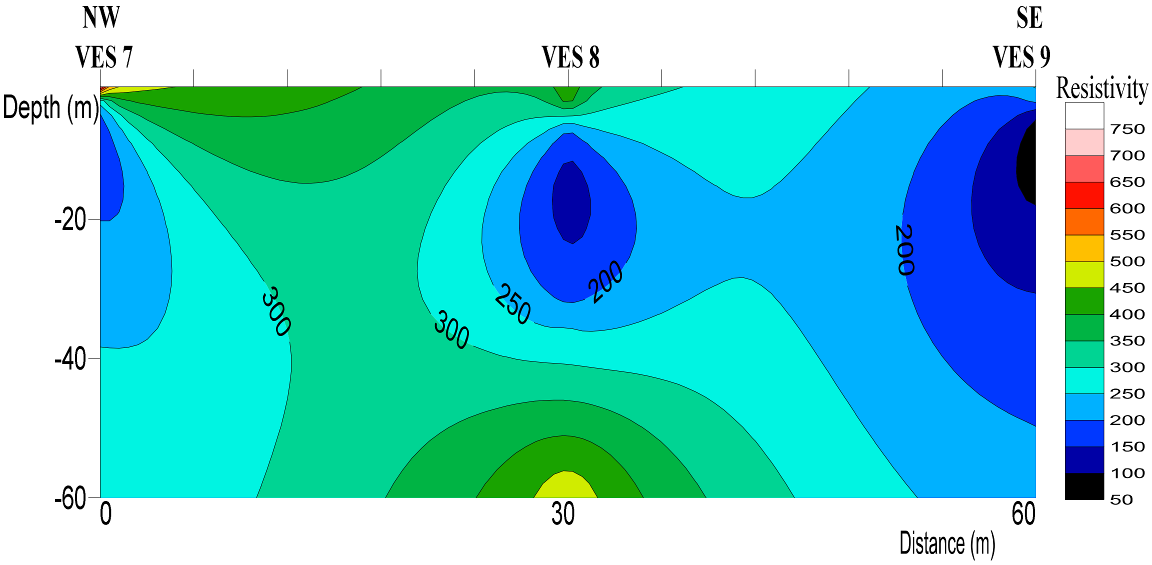


Fig.14: Pseudosection for Profile 2

DISCUSSION

Electricity is said to follow a path of least resistance as well as water. The electrical resistivity investigation (VES) displayed the inhomogeneous subsurface characteristics of the study area. The three layer curves from the study area are characterised by the QH, HA and H curves while the four layer curves are characterised by HK. The resulting variation in the potential difference of the different subsurface lithology in response to electric current is what gives rise to the different curve type. The geoelectric sections indicate a thin unsaturated top soil with a relatively high resistivity forms the first layer. The relatively high resistivity of the first layer may be related to the high level of compaction of the clayey and lateritic soil as a result of anthropogenic interference. The second layer is the weathered basement rocks (Regolith) characterised by low resistance. This layer is likely to contain some water but not in appreciable quantity especially during the peak of dry season. From the pseudo section and isopach map of depth to basement, the basement is generally considered to be of shallow depth with the deepest depth occurring at the southwestern and northern part of the study area at an average of 12m. Third layer which range between 17m to 32m in the four layer curves shows no appreciable amount of fractures. Boreholes terminated at this layer may not yield water in sufficient quantity. This may have led to the low yield experience by the existing borehole within the hostel vicinity. The third layer in the three layer curves and the forth layer in the four layered curves, are found to have deep seated fractures which may yield water in economic quantity. These layers are characterized with relative low resistivity compared to the overlaying layer. These layers may serve as the aquiferous units in the area. An increase in resistivity with depth is an indication of a shallow basement, while decrease in resistivity with depth is indicative of the presence of thick regolith (Olasehinde, 1999). The geoelectric sections from the study area depict an uneven subsurface layering reflecting various degrees of weathering and fracture intensities which is characteristic of a crystalline basement environment.

CONCLUSION AND RECOMMENDATION

Schlumberger array of electrical resistivity method was used to investigate the subsurface configuration of the Bosso Campus, Federal University of Technology, Minna because of its effectiveness in delineating groundwater potentials of an area. A total of 9 VES stations were established along 3 profiles. Field data were acquired with the aid of 3 different resistivity meters. The data were interpreted both quantitatively and qualitatively. From the curve generated: four major curve types were identified the HK, QH, HA and H. The QH, HA and H curves are of three layers while the HK curve type shows four layers and more dominant.

A combination of different interpretation models were employed in the data interpretation to present the best picture of the substratum. Using the geoelectric and coordinate parameters, many maps that will unravel the subsurface structural signatures were developed and they include: isoresistivity map, isopach map of depth to basement, pseudosection and geoelectric sections. Ambiguities accompanying electrical resistivity data interpretations were put into considerations and the synergy from the combination of these maps greatly enhanced the data interpretation. The principles of suppression, equivalence and anisotropy were also employed in the study in order to elucidate the burden of interpretation. The raw field data obtained were filtered so as to eliminate noise data which might have resulted from the interference of current from the three meters which were sending current simultaneously into the subsurface at close range.

From the variable models of data interpretation used in this study, the groundwater potential of the study area is visible in an increasing order of VES 4 > 3 > 1 > 9. This VES points corresponds to the positions of the existing functional boreholes within the study area. VES 1 is closer to the hand pump borehole while VES 9 is near to the submersible pump borehole, which is the borehole currently supplying the hostel with water. From the interpreted data in order to get an optimum groundwater potential, the following VES points can be considered for drilling in the order od: 9 > 1 > 3 > 4 to a depth not less than 60m. Proper development of the borehole should be carried out for optimal groundwater performance under the supervision of a competent and certified hydrogeologist.

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