Division of Federal University of Technology, Minna, Bosso Campus into Groundwater Potential Zones using Electrical Resistivity Method

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ABSTRACT

Geophysical study using the electrical resistivity and well log methods was carried out in the Federal University of Technology, Minna, Bosso campus north-central Nigeria. The aim is to divide the area into groundwater potential zones. A total area of 4270 m^2 within longitude 6^0 31′ 30.1″ E to 6^0 31′ 32.0″ E and latitude 9^0 39′ 14.7″ N to 9^0 39′ 19.0″ N was surveyed. Ten (10) VES data revealed three (3) geoelectric layers; the topsoil (25 – 700 Ωm), weathered/fractured basement (60 – 400 Ωm) and slightly fractured/fresh bedrock (500 – 19000 Ωm) while the overburden thickness ranges from 3 – 17 m. the iso-resistivity and isopach maps of the overburden and bedrock relief shows that those areas with shallow overburden thickness corresponds to bedrock troughs. The results of geophysical investigation showed that prospect for groundwater is controlled mainly by the overburden and the presence of fractures in the bedrocks. The geometry of the failed/low yield boreholes was revealed from the study of the lithologs. This method has been used to divide the study area into the groundwater potential zones using electric resistivity method. This research has identified the Staff Quarters and Mosque areas as the high groundwater potential. The male hostel and dining hall area as intermediate groundwater potential and the Staff school/Bus Park area as low groundwater potential areas.

Keywords: Geophysical, Electrical resistivity method, Groundwater and Potential zones

1. INTRODUCTION

Groundwater has been explored in the study area over the past few years and over twelve boreholes are present in the study area. Some of these boreholes are characterised by low yield resulting in water shortages, most of them can only pump out water in small quantities because they are hand pump operated. Only few motorised boreholes are serving the campus and not all of them have high yield of water hence the need for proper evaluation of the groundwater potential of the campus. The focus of this work is to delineate the area into high, intermediate and low groundwater potential zones in order to increase the number of effective boreholes in the area. Groundwater occurrence in the crystalline basement terrain (study area) can be irregular due to abrupt discontinuity in lithology, thickness and electrical properties of the overburden and weathered bedrock (Saphathy and Kannge, 1976; Ofodile, 1983; Olorunfemi and Fasuyi, 1993). Groundwater explanation has always been critical since secondary features such as fractures control groundwater movement (Odoh *et al.*, 2012).

Groundwater exploration within the basement complex terrain requires integration of geophysical data types to effectively characterise the hydraulic zones and to enhance successful identification of well locations (Onosuyi *et al*., 2008). Hence any drilling program for groundwater development in such setting should be preceded by detailed hydrogeophysical investigation.
This present study focuses on an important investigation which would be very useful in future planning of the University (both campuses).

2. GEOLOGY OF THE AREA

The F.U.T. Bosso campus is part of the basement complex of Nigeria, which consist of older granites of varying exposures; some are just few meters in dimension.. The Basement Complex of Nigeria is considered by various workers to be Precambrian to Lower Paleozoic in age (Oyawoye, 1970; Grant, 1978 and Rahman, 1976).

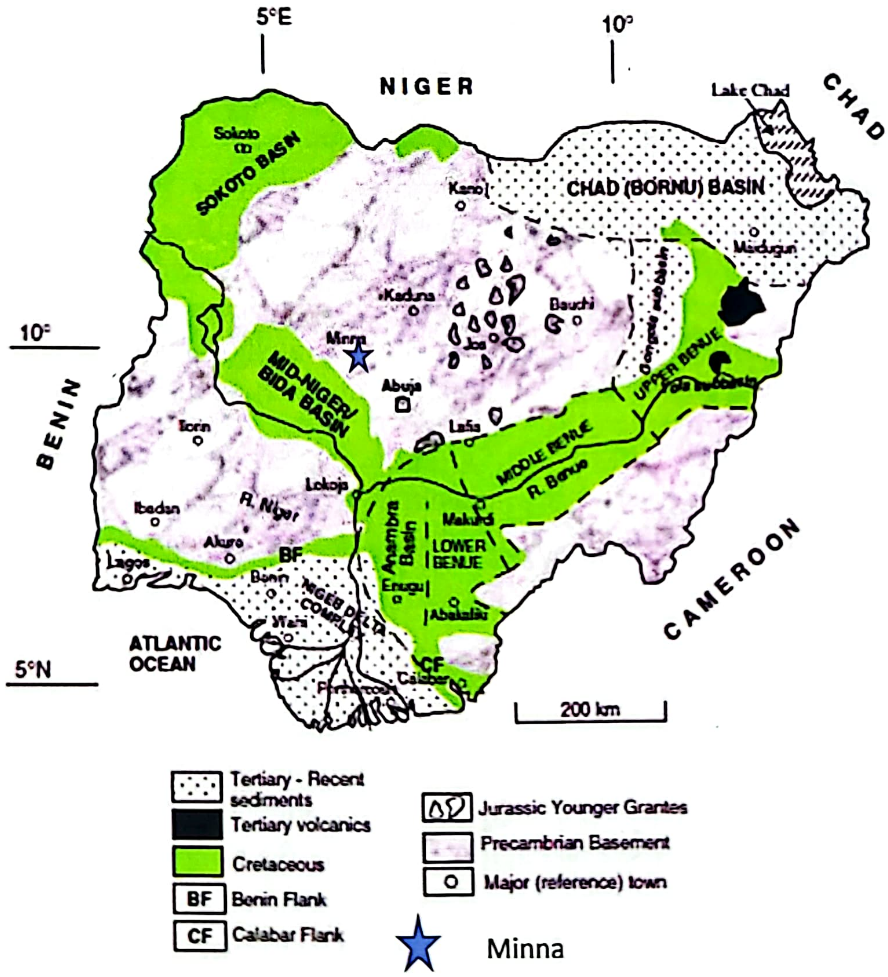


Figure 1: Geological Map of Nigeria showing the major geological components (After Obaje, 2009).

Crystalline rocks of the basement complex, outcrops over large area in Nigeria, in three broad regions separated by Mesozoic and Cenozoic sedimentary basins (Figure 1). The crystalline basement rocks occupy about half of Nigeria, while the Cretaceous to Recent sediments cover the remaining part.

The only rock type identified in the study area is igneous rock (Figure 2). The granite outcrops are highly jointed, fractured and in some places massive (Adeniyi, 1985).

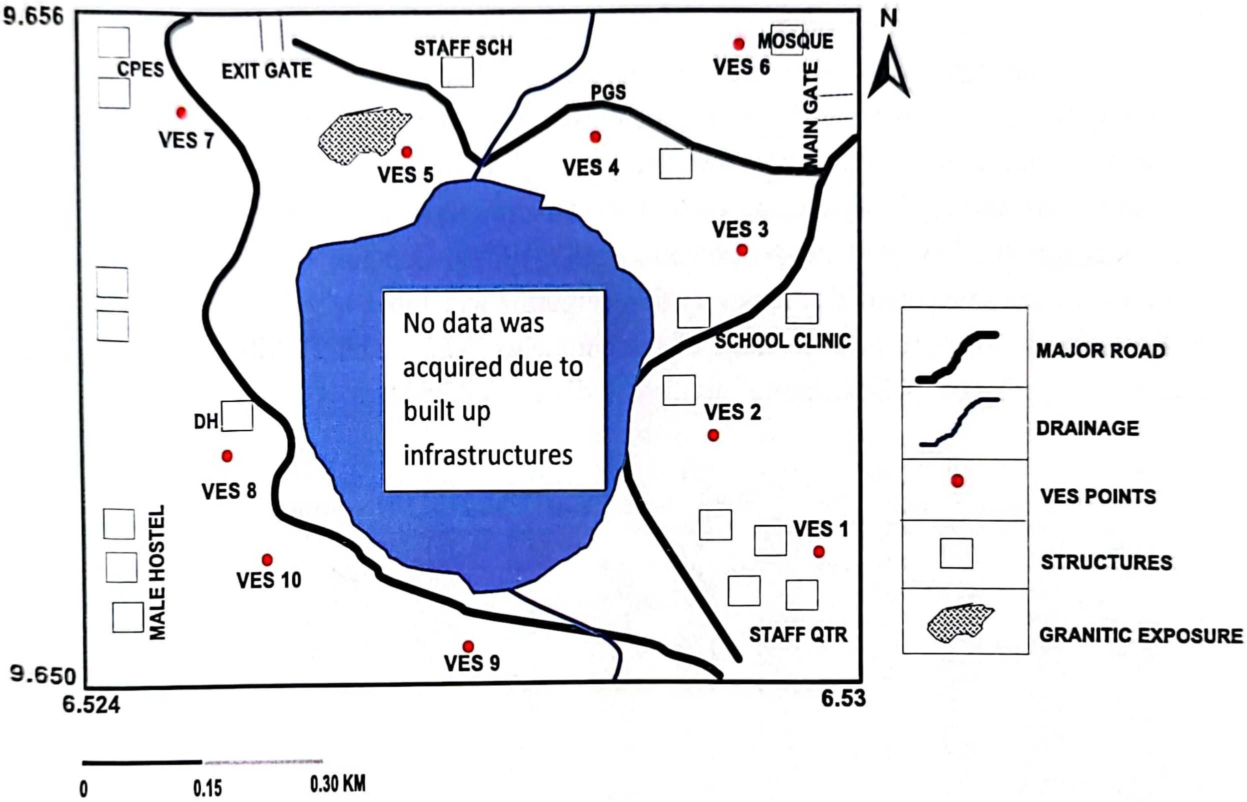


Figure 2: Location Map of FUT Minna Bosso Campus

3. FIELD PROCEDURE AND DATA COLLECTION

The scope of this study involves geological, geophysical investigations (characterisation of the subsurface rock mass of the study area and also using the information from the borehole logs) and the yields of all the boreholes in order to provide information on the groundwater potential of the Bosso Campus of the University.

Surface geological field mapping was first carried out to study the rocks and the possible presence of fractures on the outcrops and this was followed by electrical resistivity sounding method. The use of lithologs in combination with geophysical investigation (Vertical Electric Sounding) has been observed to be an appropriate technique for groundwater exploration among other techniques in the basement complex terrain (Ajibade *et al.*, 2012). Measurement of the electrical resistivity of the earth has been employed as a tool for groundwater exploration due to its high resolution of near surface materials and the ease of operation of the equipment. However, when resistivity methods are used, there may be some expected limitations (Senosmatias, 2002). To give room for this, data from the borehole logs with their information was incorporated during the interpretation to enhance the results and the problems of ambiguity from resistivity models with geological layers.

A total of ten soundings were carried out on the existing boreholes in the study area using Schlumberger configuration with a view to determine the overburden thickness, thickness of the aquiferous layer and the degree of fractured bedrock.

4. RESULTS AND DISCUSSION

The study area is characterised by limited exposure with most of the exposures being slightly weathered. The exposures concentrated within the Staff School/Chapel area NW/W part of the map (Figure 2), are weakly weathered and there's one borehole with very low yield (0.2 litres per second) situated here. Another borehole that is not documented (because of unavailability of borehole data) has very low yield and a 1,000 litre tank has never been filled with water for years. This is tagged the low groundwater potential area of Bosso Campus, FUT Minna. Overburden thickness of this low potential area is very thin (Figure 3 and Table 1). Further, there is evidence of fracturing in the third layer in some of the boreholes (VES 1 and 2) drilled within the Staff Quarters area (Figure 3). Bedrock resistivities hardly exceed 250 Ωm.

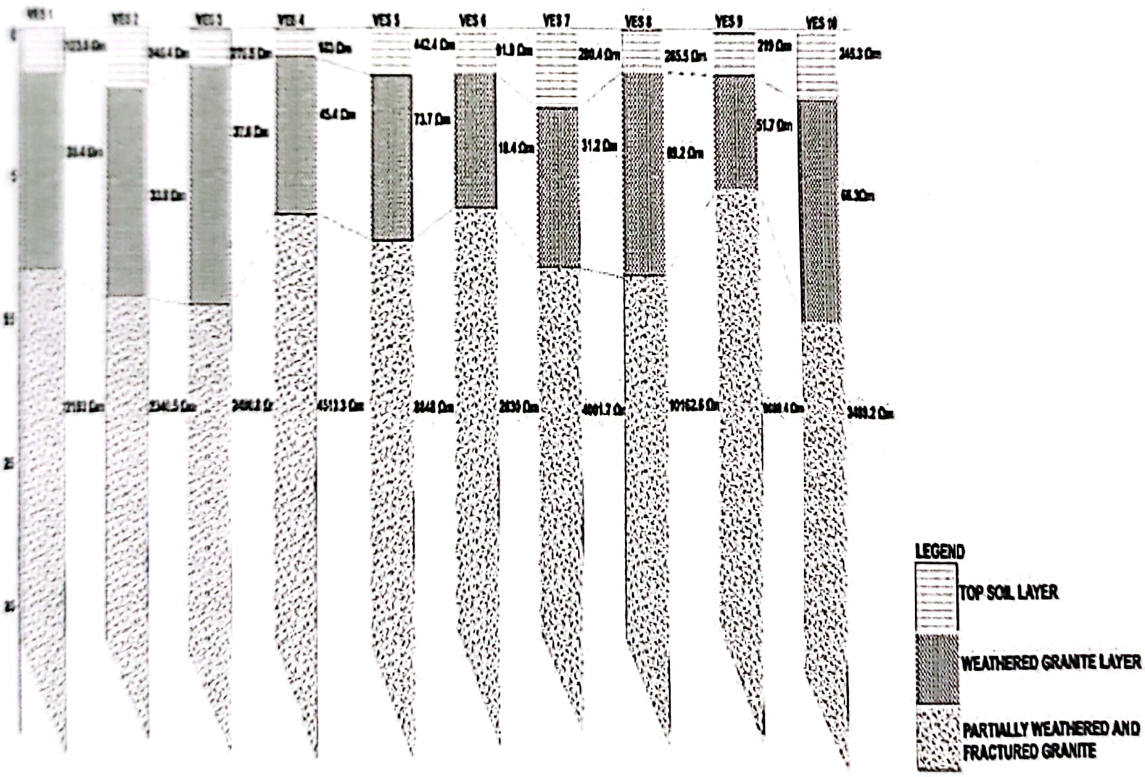


Figure 3: Geoelectric section of the study area

4.1 Geophysical Result

The VES results revealed that three layered type curve (H) ($\rho_1 > \rho_2 < \rho_3$) is what is present. This may infer that the layer two with lower apparent resisitivity is where we have aquifer (Omosuyi *et al.*, 2008). The thicker it is, the higher the possibility in having enough groundwater (Table 1 and Figure 4). This is the criteria used in dividing the campus into groundwater zones. The thickness of unconsolidated materials (overburden) overlying the basement was also an important factor considered in the determination of the groundwater potential of the area.

Table 1: Summary of results of interpretations for the VES stations and the Borehole Data

VES No	VES Locations	No. of Layers	Type of Curve	Depth of Layer (m)	Thickness of Layer (m)	Resistivity (Ωm)	Borehole Yield (l/s)	Borehole Type	Remark
1	9°39'04" N	1	H	1.7	1.7	124	0.6	HP	Medium
	6°31'44" E	2		11.2	9.5	28			
		3		∞	∞	2220			
2	9°39'0.69" N	1	H	2.2	2.2	346	0.9	Motorised	High
	6°31'46.4" E	2		12.9	10.6	34			
		3		∞	∞	3325			
3	9°39'14.7" N	1	H	1.3	1.3	276	0.6	Motorised	Medium
	6°31'43.8" E	2		12.6	11.3	38			
		3		∞	∞	2491			
4	9°39'15.4" N	1	H	1.5	1.5	184	0.5	HP	Medium
	6°31'41.2" E	2		9.4	7.9	46			
		3		∞	∞	4549			
5	9°39'14.3" N	1	H	1.8	1.8	442	0.4	Motorised	Medium
	6°31'40.4" E	2		11	9.2	74			
		3		∞	∞	9110			
6	9°39'21.7" N	1	H	1.6	1.6	92	0.5	HP	Medium
	6°31'43.2" E	2		8.3	6.7	19			
		3		∞	∞	2653			
7	9°39'17.4" N	1	H	2.8	2.8	330	0.2	Motorised	Low
	6°31'27.6" E	2		12.9	10.1	128			
		3		∞	∞	9110			
8	9°39'0.79" N	1	H	1.1	1.1	1	0.4	HP	Medium
	6°31'38.8" E	2		13.2	12.1	31			
		3		∞	∞	4001			
9	9°39'05.1" N	1	H	1.1	1.1	280	0.8	Motorised	High
	6°31'42" E	2		8.6	7.5	52			
		3		∞	∞	9058			
10	9°39'04.8" N	1	H	2.6	2.6	244	0.6	HP	Medium
	6°31'43.7" E	2		17.3	14.7	244			
		3		∞	∞	3330			

Evaluation of groundwater potential in the crystalline basement area (Carruthers and Smith, 1992). The representative geoelectric sections all cut across the thickest and thinnest overburden areas (Figure 3 and 4).

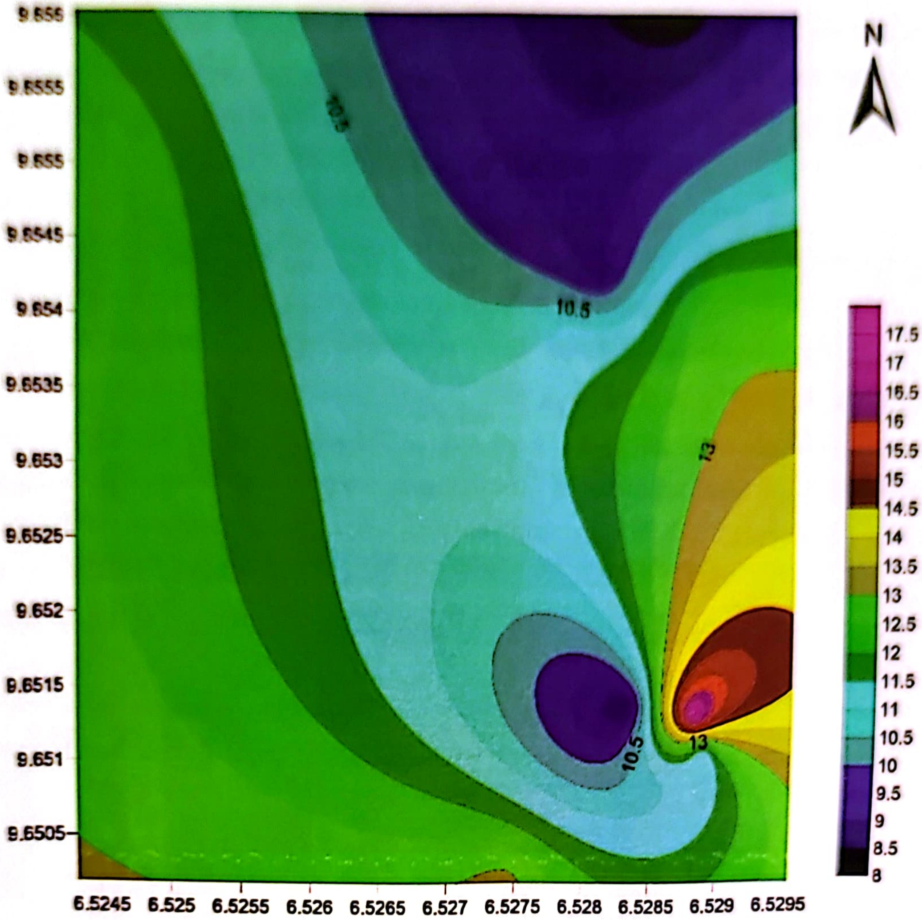
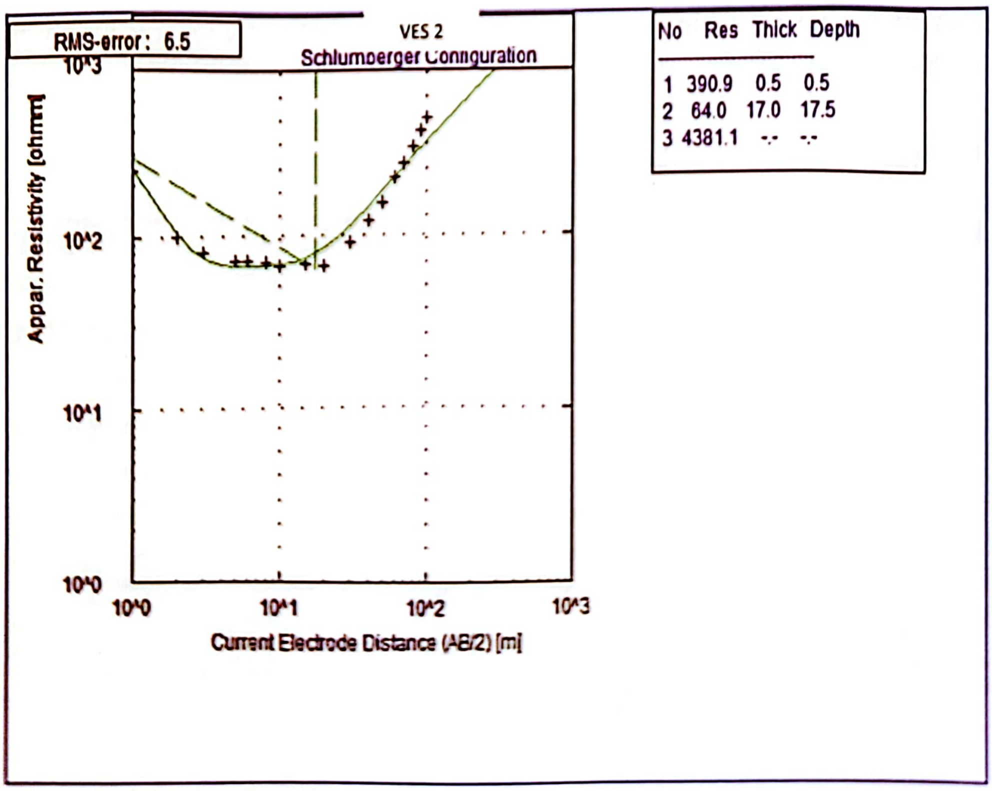


Figure 4: Overburden Isopach map FUT Minna, Bosso Campus.

The isopach map of the surveyed area which shows the thickness variation of the overburden is presented in the (Figure 4). The overburden as used in this work includes all materials presumably above the fresh rock. This ranges from 3 – 17 m. The overburden is relatively thick around the Staff Quarters area; overburden at the Staff School area is shallow while the overburden thickness is intermediate around the Male Hostel/Dining Hall and the Mosque area. Related hydrogeophysical studies in similar geologic terrains (Bala and Ike, 2001) have identified areas with thick overburden thickness as high groundwater potential zones. When the overlying layer is clayey the yield of such borehole will be low.

Table 2: The typical borehole log for highly productive groundwater zone (VES 2 around the Clinic vicinity)

DEPTH RANGE (m)	LITHOLOGY/OBSERVATION /DESCRIPTION	TIME OF PENETRATION (min)	INTERPRETATION AND JUSTIFICATION
0 – 7	Lateritic Topsoil	3	Topsoil
7 – 14	Highly weathered basement	4	Wet sand/clay
14 – 21	Weathered basement	4	Low water bearing
21 – 28	Fractured pegmatite	4	High water bearing
28 – 35	Weathered basement	5	Low water bearing
35 – 42	Weathered basement	5	Low water bearing
42 – 49	Highly fractured pegmatite (Pink)	4	High water bearing
49 - 56	Fractured pegmatite (Pink)	4	High water bearing
56 – 63	Weathered basement	8	High water bearing



(a)

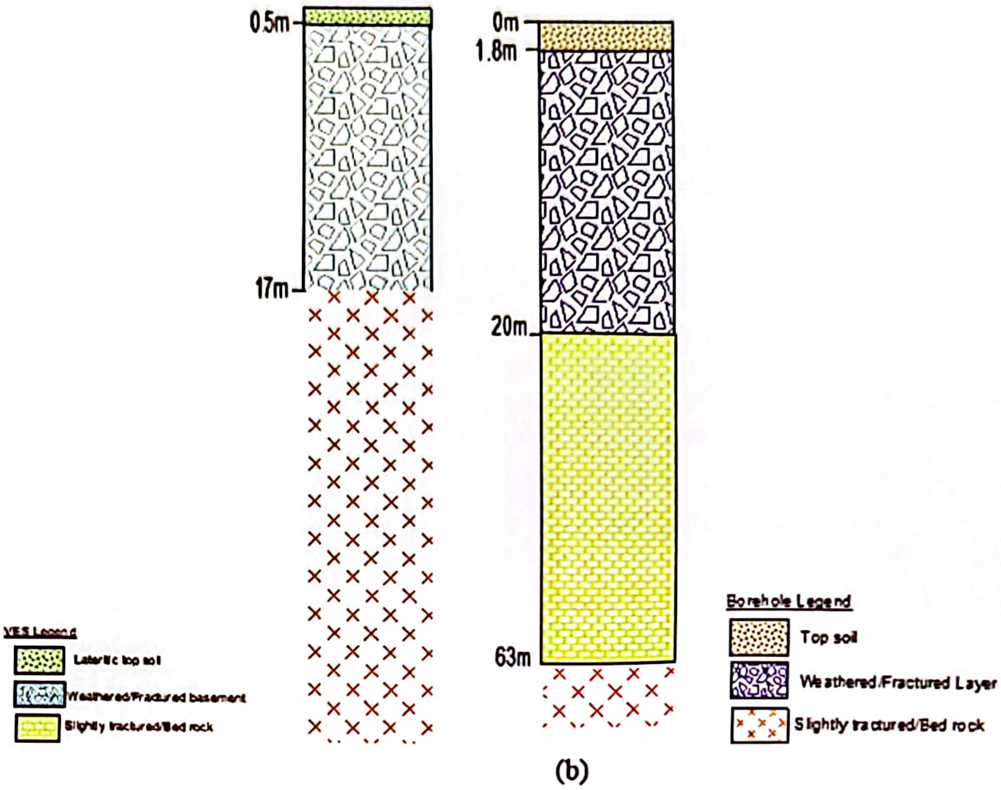
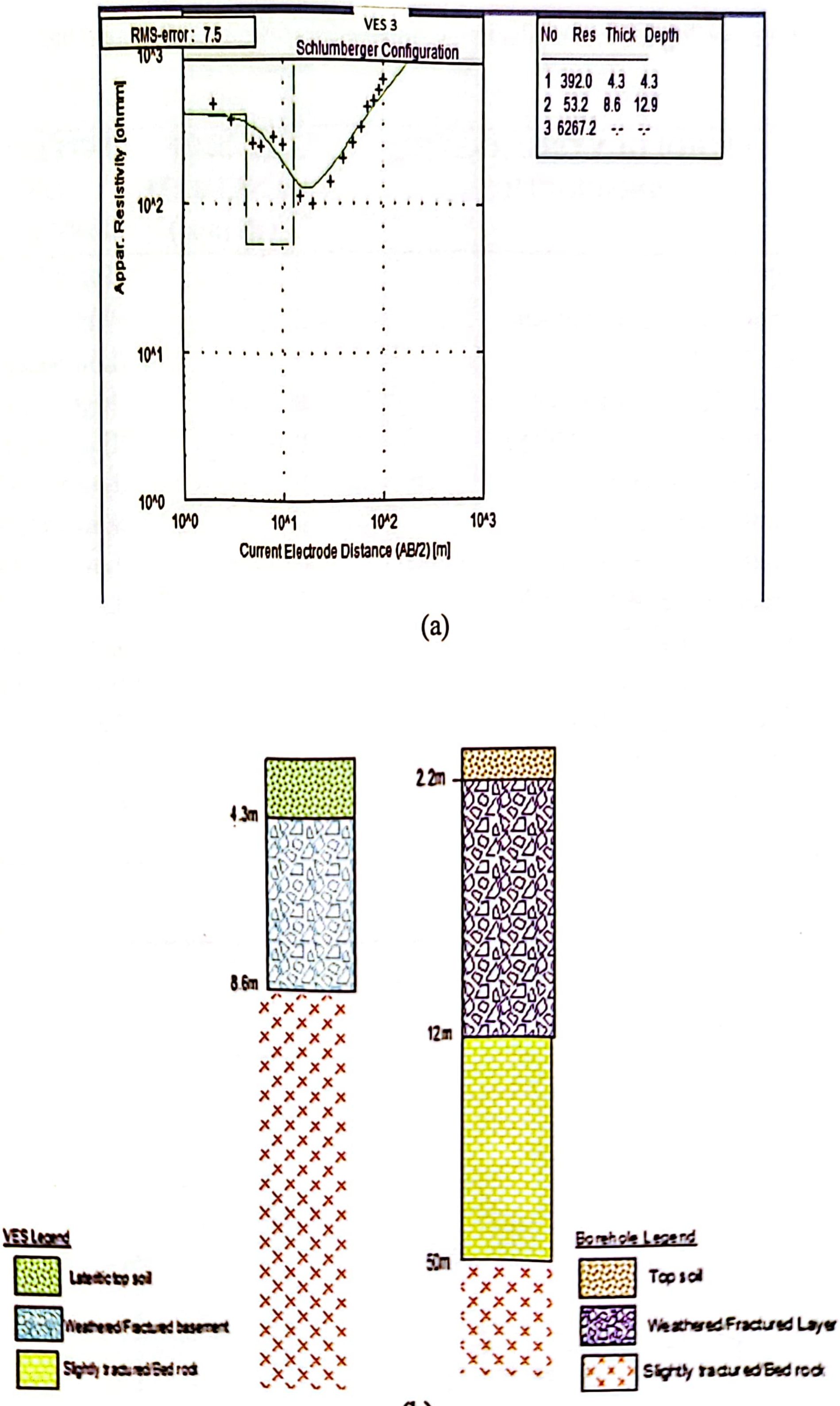


Figure 5: (a) VES 2 for borehole log 2 (b) The typical borehole litholog for highly productive borehole in the study area

Table 3: The typical borehole log for medium productive groundwater zone

DEPTH RANGE (m)	LITHOLOGY/OBSERVATION /DESCRIPTION	TIME OF PENETRATION (min)	INTERPRETATION AND JUSTIFICATION
0 – 7	Lateritic Topsoil	2	Topsoil
7 – 14	Highly weathered basement	3	Low water bearing
14 – 21	Weathered basement	5	Low water bearing
21 – 28	Fractured pegmatitic basement	4	High water bearing
28 – 35	Fractured basement	5	High water bearing
35 – 42	Weathered basement	7	Low water bearing
42 – 50	Weathered basement	8	Low water bearing



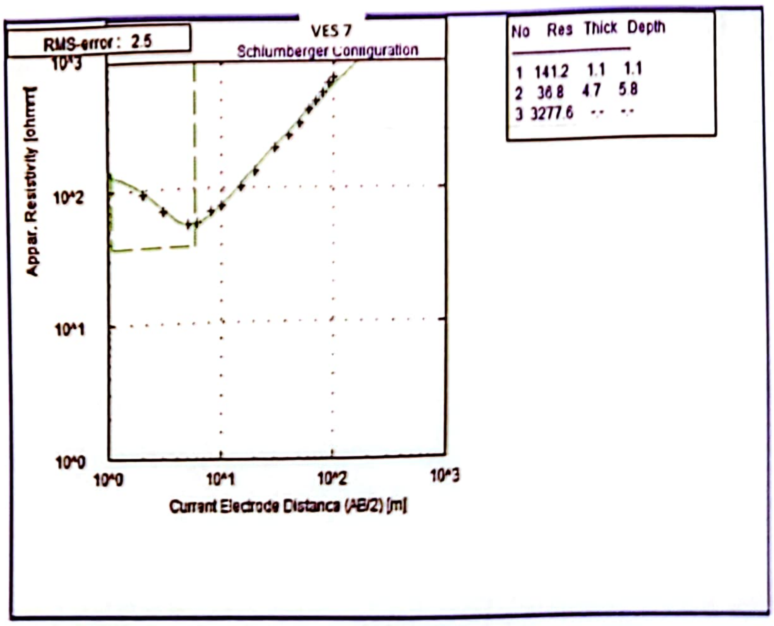
(a)

(b)

Figure 6: (a) VES 3 for borehole log (b) The geologic section of the VES data interpreted and the litholog based on borehole drilling

Table 4: The borehole log for low productive groundwater zone (VES 5 around the Staff school area)

DEPTH RANGE (m)	LITHOLOGY/OBSERVATION /DESCRIPTION	TIME OF PENETRATION (min)	INTERPRETATION AND JUSTIFICATION
0 – 7	Topsoil	3	Topsoil
7 – 14	Highly weathered basement	5	Wet
14 – 21	Weathered basement	7	Low water bearing
21 – 28	Highly fractured basement	8	High water bearing
28 – 35	Fractured pegmatite (Milky)	8	High water bearing
35 – 42	Weathered basement	9	Low water bearing
42 – 49	Weathered basement	9	Low water bearing
49 – 56	Weathered pegmatite (Reddish brown)	8	Low water bearing
56 - 63	Weathered pegmatite (Reddish brown)	8	Low water bearing
63 - 70	Fractured pegmatite (Reddish brown)	8	Low water bearing
70 - 77	Weathered pegmatite (Reddish brown)	9	Low water bearing
77 - 84	Weathered pegmatite (Reddish brown)	9	Low water bearing
84 - 91	Weathered basement	10	Dust
91 - 98	Weathered basement	14	Dust
98 – 100	Weathered basement	15	Dust



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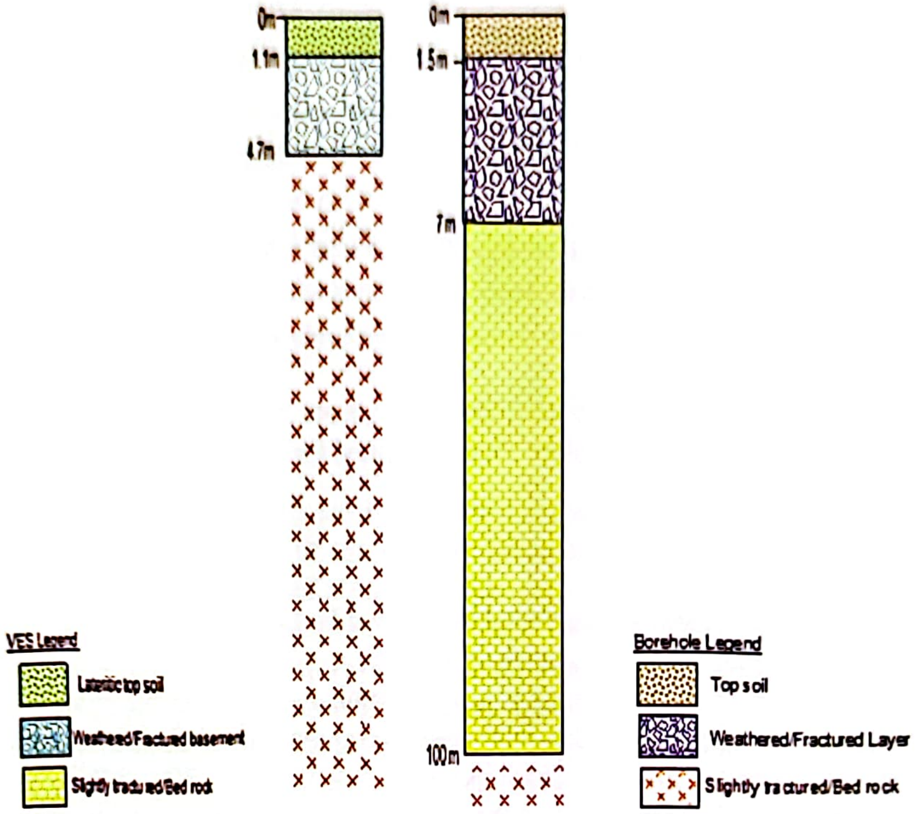

(b)

Figure 7: (a) VES 7 for borehole log (b) The geologic section of the VES data interpreted and the **litholog** based on borehole drilling

Figure 8: Model for the Division of FUTMINNA Bosso Campus into Groundwater Potential Zones

5.0 Conclusion

The hydrogeophysical evaluation of the Bosso Campus of the FUT Minna has been attempted, dividing it into groundwater prospect zones using a combination of hydrogeological and geophysical methods. The borehole drilled logs from the study area showed that the weathered and fractured basement occur between 4 m – 17 m with the fresh basement occurring below the fractured basement. Therefore, the study area has been divided into three zones based on the available thickness of the weathered/fractured layer. Here zones with 1 – 5 meters are tagged low, 6 – 10 meters medium and above 10 meters is termed high groundwater potential.

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