INVESTIGATION OF SUBSURFACE LITHOLOGY AND GROUNDWATER TRANSMISSIVITY IN DELTA STATE UNIVERSITY, ABRAKA NIGERIA USING VERTICAL ELECTRICAL SOUNDING AND DEEP WELL LOGS

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Abstract
The subsurface lithology and groundwater distribution at Delta State University, Abraka were investigated using Vertical electrical sounding and deep well logs, with a view of delineating aquifer transmissivity and aquifer protective capacity using Dar-Zarrouk parameters within and around the location, Schlumberger electrode configuration was applied using ABEM Terrameter SAS 1000 AB. The resistivity of the lithologic layers was obtained, Brown lateritic Topsoil with resistivity range from 324 to 1092.5 Ωm and thickness varying from 0.5 to 1.5 m was delineated, this was followed by reddish laterite of 181.1 to 701.9 Ωm and thickness from 1.2 to 3.8 m, fine sand with 453.5 to 1357.8 Ωm and thickness from 10 to 22.1 m, and the coarse grain sand also whitish with 655 to 13607 Ωm, then a layer of gravelly sand was obtained at a depth of 27.5 m to 40.9 m which is the aquifer. Transmissivity of the aquifer varies from 46.2 m^2/day to 248.64 m^2/day. The results show fair longitudinal conductivity due to the near absence of clay formation. However, the depth to groundwater obtained in the analysis and subsequently correlated with available deep well records of 27.8 m to 39 m makes it safe for use due to progressive layer filtering. Also, the diagnostic parameter was evaluated, thus, the result reveals that the chance of groundwater is high and this area is fairly protected which is good for boreholes sinking due to the increase in transmissivity. Hence, the areas having high transmissivity are good and safe for productive deep well citing.

Keywords: Subsurface lithology, Deep well logs, Dar-Zarrouk parameters, Transmissivity, Vertical electrical sounding

INTRODUCTION

The quest for portable water is on increase, groundwater is stored in the present study area in the aquifer, which can only be accessed by drilling a deep well (borehole) into it. The aquifer may be in danger of contamination; therefore to ascertain the risk factors and delineate the level of protection of the aquifer against contamination or Pollution, it is crucial to see, not only, the sourcing for groundwater but also its protection against contamination from near-surface materials. Contamination of hydro-geologic systems has become a common occurrence within metropolitan areas. This is attributed to the availability of utilities such as septic tanks, underground storage tanks of petroleum products, refuse dumpsites, shallow subsurface piping utilities and landfills. Most times, these facilities are not equipped with the sole appropriate liners to prevent the percolation of contaminants into the underlying aquifer, particularly in areas where inhabitants rely mostly on groundwater as a source for domestic and industry usage (Olajide *et al*. 2020). Hence, geophysical surveys have proven to be very effective in aquifer protection studies in various areas (sedimentary and basement rocks), without interfering with the hydrogeologic system. It has been used in delineating hazardous wastes and groundwater-contaminated areas and is cost-effective. The aquifer protection studies using the resistivity method entail; transverse resistance, longitudinal

conductance, transmissivity, resistivity and hydraulic conductivity. It is of utmost importance that we learn how to protect the aquifer in our immediate environment from at least man-made contaminants to continue to enjoy the limited safe groundwater supply around us. It is not uncommon for investigators to employ more than one geophysical method to enhance accuracy in groundwater exploration. This study utilized both the electrical resistivity method, deep well logging, and flow direction to locate the aquifer level and direction of flow beneath the earth. The resistivity of the formation water depends on the temperature and the concentration of salt dissolved in the water, that is, salinity. The successful application of geophysical methods requires prior knowledge of the site under investigation. This research delineates transmissivity and ascertains subsurface lithology in relation to groundwater contamination risk factors, evaluates aquifer protective capacity for each litho-stratigraphic unit in model dataset using Dar-Zarrouk Parameter estimation against contamination or Pollution which poses serious health and environmental challenges for the inhabitant of Delta State University, Abraka and its environs and at the same time map out good sites for borehole citing using Vertical Electrical Sounding and deep good logs taking note of the groundwater flow direction to avoid borehole citing behind a refuse dump site, petroleum leakages from damaged underground storage tanks or pipes, sewage septic tank infiltrations and so on. Groundwater contamination has been one of the major challenges in Delta state. Most individuals rarely drink water from their deep wells due to natural and human-induced wastes found in groundwater. This has led to environmental degradation and waste of capital resources. It is therefore important to apply geophysical techniques to investigate subsurface lithology and groundwater-bearing bodies in relation to their protective capacity around this area. To do this, the electrical resistivity (ER) method and the deep well log were used to delineate lithology and access the aquiferous units of the study area.

MATERIALS AND METHODS

Delta State University, Abraka is located in the Ethiope-East Local Government Area. It is situated in the northeastern part of Isiokolo, in the Local Government Headquarters (Ofomola *et al.*, 2018). It lies between latitude 05° 45N and 05° 50N and longitude 6° 05E and 6° 05E of the equator. The study area was subjected to eleven geoelectric soundings using the vertical electrical sounding technique as shown in Figure 1.

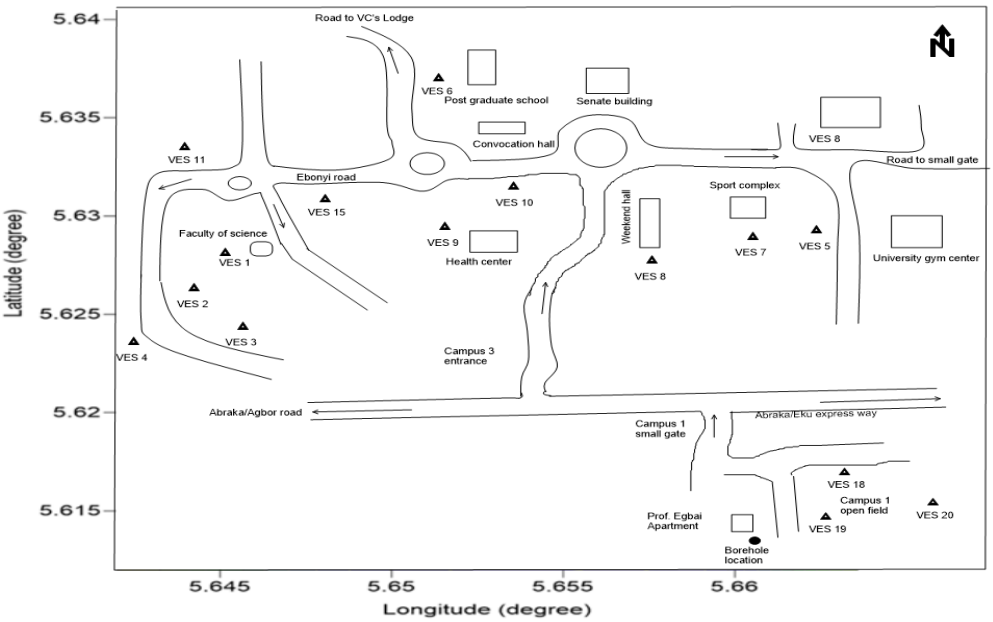


Figure 1: Base map of the Study area

Field procedure

The area was first studied, and sites of interest were mapped out. The equipment was then set up; the potential electrodes were connected through a short cable wire to the earth resistivity meter, while the current electrodes were connected through a longer cable wire to the earth resistivity meter. Data sheets were prepared before the sound was made. The power source where then switched on to generate current into the subsurface and resistivity was recorded on the datasheet. The current and potential electrodes were moved occasionally and measured. Readings were taken for every spread in each layer, a hammer was used to drive the electrodes into the ground at a point measured by the tape.

Principle of Method

The electrical resistivity method of the geophysical survey involves the use of artificial source current which is introduced into the ground through two electrodes (i.e. current electrodes) and the resulting potential differences are measured by another pair of electrodes (i.e. potential electrodes). (Kearey and Brooks 1991), thus one can determine the electrical property of the subsurface. The electrical resistivity method is based on the display of differences in resistivity by the various materials of the subsurface to the conductance of electric current. The materials are fluid content, soil and rock type and they depend on the density, chemical composition of the materials and so on (Parasnis, 1986).

Schlumberger array

In this configuration, four electrodes are used (Figure 2). Measurements of apparent resistivity were made by increasing the distance between the current electrodes while the potential electrodes remain constant, such that the distance AB between the electrodes is five times greater or equal to the separation distance between the potential electrodes MN. The Schlumberger array is widely used to study the variation of resistivity with depth.

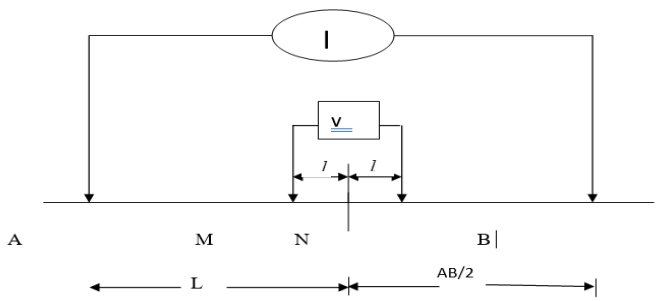


Figure 2: Schlumberger configuration

The apparent resistivity from absolute potentials is therefore

$$\rho_a = \frac{2\pi\Delta V}{I\left\{\left(\frac{1}{r_A}-\frac{1}{r_B}\right)-\left(\frac{1}{R_A}-\frac{1}{R_B}\right)\right\}} \quad (2.1)$$

Where $G = \dfrac{2\pi}{I\left\{\left(\frac{1}{r_A}-\frac{1}{r_B}\right)-\left(\frac{1}{R_A}-\frac{1}{R_B}\right)\right\}}$ (2.2)

Therefore, $\rho_a = G \times R$ (2.3)

Where ρ_a is the apparent resistivity, G is the geometric factor or known value and R is the resistance. Thus equation (2.3) also shows the apparent resistivity for the Schlumberger configuration.

Note: $AM = L - l$ $\quad$ $MB = L + l$

$AN = L + l$ $\quad$ $NB = L - l$

Considering the Schlumberger configuration of Figure 2, and from equation (2.3),

$$\rho = \frac{\Delta V 2\pi}{I}\left(\frac{1}{AM} - \frac{1}{MB} - \frac{1}{AN} + \frac{1}{NB}\right)^{-1} \quad (2.4)$$

$$\rho = \frac{\Delta V 2\pi}{I}\left(\frac{1}{L-1} - \frac{1}{L+l} - \frac{1}{L+1} + \frac{1}{L-1}\right)^{-1} \quad (2.5)$$

Taking the L.C.M of the denominator and simplifying, noting that since $AB >> MN (L >> l)$

$$\rho = \frac{\Delta V 2\pi}{I}\left(\frac{4l}{L^2}\right)^{-1} \quad (2.6)$$

$$\rho = \frac{\pi R L^2}{2l} \quad (2.7)$$

In depth probing, the potential electrodes remain fixed while the current electrode spacing is expanded symmetrically about the centre of the spread. For large values of L, it may be necessary to increase l to maintain a measurable potential. Equation (2.7) applies in this case. This procedure is more convenient than Wenner expanding spread because only two electrodes need to move at a time.

Plate 1: Geoelectric surface survey equipment setup

The tools used for the deep well logging are; a power source (battery), Electrodes, ABEM SAS 1000 terrameter (Plate 1), and a calibrated cable having a probe that sends signals to the tetrameter. The deep well (borehole) used for the study was drilled at E6.10875°, N5.791871° to a depth of 40 m to investigate the aquifer material of the subsurface, determine the nature and quality of the aquifer at the production zone in the area. Drill cuttings were taken every two meters and for every change in a geologic formation, the cuttings were placed on a plastic sheet with depth written on them for immediate and easy description. The cuttings were then analyzed based on the formation and grain size. After drilling, the drilling pipes were removed and geophysical logging was carried out by placing two electrodes 5 m apart from each other and connected to the terrameter. The electrical resistivity and spontaneous potential data from the deep well log were obtained using the direct method of exploration, done by drilling into the subsurface and using SAS 200 logging probe to log the uncased hole that is well conditioned with the drilling fluid (Ugbe *et al.*, 2021). The response of current from the terrameter to the aquifer material produces data for the geophysical logging as the

probe moves through the hole and at specified depths readings were taken.

RESULTS AND DISCUSSIONS

The data obtained were interpreted qualitatively by curve matching as discussed above and by iteration comparing the curve obtained with a standard curve. This interpretation was essentially the comparison of the resistivity field curves with the standard or characteristic curves. These standard curves are determined from a three-layer earth model. Field curves/standard curves in vertical electrical sounding were classified into four types; the type K-curves rises to a maximum then decreases indicating that the intermediate layer has a higher resistivity than the top and bottom layers. The H-type curve shows the opposite effect. It falls to a minimum and then increases again due to an intermediate layer that is a better conductor (low resistivity) than the top and bottom layers. The A-type curve may show some changes in gradient, but the apparent resistivity generally increases continuously with measuring electrode spacing, indicating that the true resistivity increases with depth from layer to layer. The Q-type curve exhibits the opposite effect; it decreases continuously along with a progressive decrease of resistivity with depth. However, hybrid/combination curves also exist in a multiple-layered structure consisting of generally more than three layers. The hybrids, HK and HKH curves etc. are obtained from the combination of different types of curves. The characteristics curves can be summarily expressed mathematically as shown below

Type-A curve $\rightarrow \rho_1<\rho_2<\rho_3$
Type-Q curve$\rightarrow \rho_1>\rho_2>\rho_3$
Type-H curve$\rightarrow \rho_1>\rho_2<\rho_3$
Type-K curve$\rightarrow \rho_1<\rho_2>\rho_3$
Type-HK curve$\rightarrow \rho_1>\rho_2<\rho_3>\rho_4$

Result and discussion of vertical electrical sounding (VES)

A total of eleven (11) vertical electrical soundings were carried out at different mapped survey locations during the investigation. The observed field data were used to produce depth-sounding curves. The curves were interpreted quantitatively by curve matching using two-layer model curves and the corresponding auxiliary curves and computer-assisted iterative method using the WINresist software. The results of the investigation are presented below which shows the computer iteration results for both vertical electrical sounding and 2-D electrical resistivity interpretation graphs figures 4.2a – 4.2k. While figure 4.3a and 4.3b shows the geoelectric section in DELSU site III, Abraka for the various geoelectric sounding locations. Four to five distinct geoelectric layers namely topsoil, sandy clay, fine sand, fine to medium-grained sand and medium-grained sand were observed. The first layer consists of topsoil of resistivity values ranging from 324-1092.5 Ωm and thickness varying from 0.5 - 1.5 m. The second layer consists of lateritic sand with resistivity ranging from 181.1 - 701.9 Ωm and thickness varying from 1.2 - 2.8 m. This subsurface material is found along the back of the Faculty of Science, along the new earth road, along site III main gate from inside, and opposite the school sports centre subsurface second layers. The third layer consists of fine sand with resistivity ranging from 453.5 - 1357.8 Ωm and a thickness of 0.9 - 19.4 m. This layer forms the fine smooth sand unit which is deposited in most of the locations with a depth ranging from 12.5 - 27.1m; therefore, the aquiferous medium is found here with fine smooth sand which can be obtained from a depth ranging from 10.3 - 35 meters in this traverse. The fourth layer consists of fine to coarse sand with resistivity ranging from 343 Ωm to 13607 Ωm at depth of 27.5 – 40.9m and thickness varying from 10.7-32.0m. Here is the most prolific aquiferous zone with a high yield of safe water capacity, it can also be considered to have fine sand but a mixture of some coarse grain sand. The fifth layer is coarse grain sand with resistivity ranging from 655.1 – 10564 Ωm, the exact thickness of this layer cannot

be determined as the current electrode separation terminates within this layer. However, the result obtained from Dar-Zarrouk parameters in DELSU site III Abraka has aquifer resistivity ranges from 343 – 13257 Ωm and at depth of about 27.5 – 98 m. Also, the aquifer conductivity varies from 7.5432E-05 – 0.00291545 $(\Omega m)^{-1}$, and the longitudinal conductance varies from 0.00060044 – 0.06938776. However, the minimum transmissivity value of the study area is 46.2 m^2/day observed opposite the convocation hall while the maximum transmissivity was found at the back of faculty of science with a transmissivity value of 199.92 m^2/day. Thus, the first-order geoelectric and Dar-Zarrouk parameters of the study area show that the protective capacity rating of the aquifer is fair. The evaluation of the overburden protective capacity rating used in the study was compared with (Henriet, 1976) shows values as > 10 (excellent), 5 -10 (very good), 0.7 - 4.9 (good), 0.2 - 0.1 (moderate), and < 0.1 (fair). A deep well was drilled, logged and depth to groundwater was measured with a deep meter which possesses a probe that sends signals through a wireline to a terrameter on the surface, this measurement was used alongside other depth-to-groundwater measurements taken from several hydraulic heads around the drill location of site I and environ of Delta state university Abraka to produce a groundwater flow direction.

Resulting curves of resistivity data

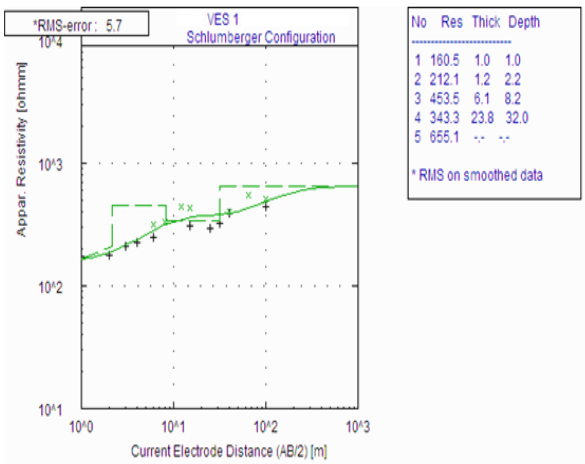


Figure 4.2a: Back of faculty of science

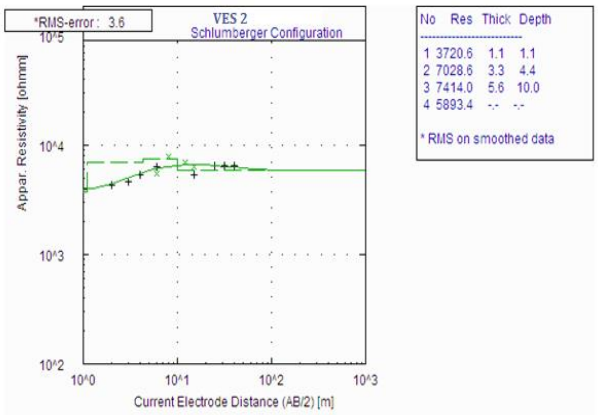
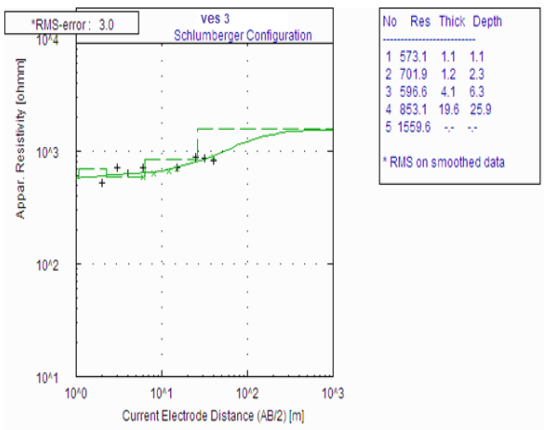


Figure 4.2b: Along the new earth road



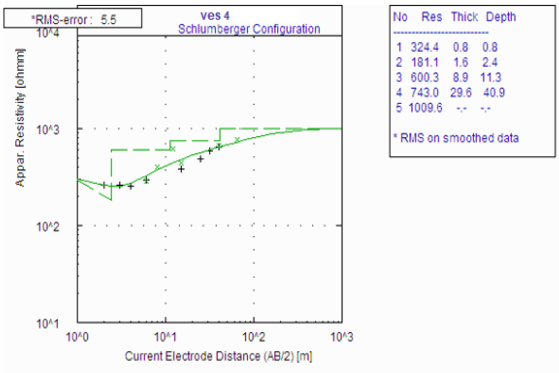
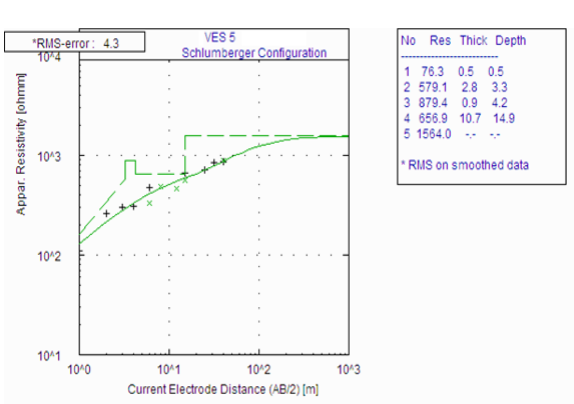


Figure 4.2c: Along the new earth road

Figure 4.2d: Along site III main gate fence from inside



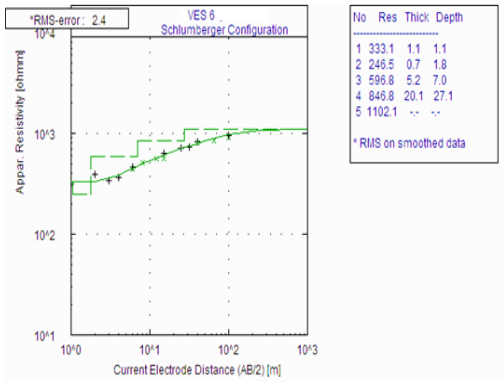
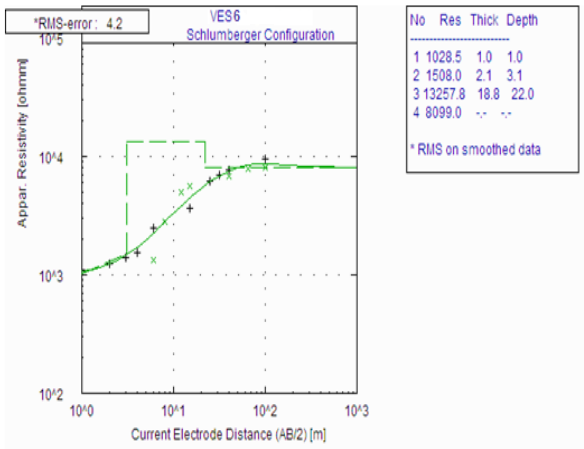


Figure 4.2e: Opposite school sports centre

Figure 4.2f: Along post-graduate road site III



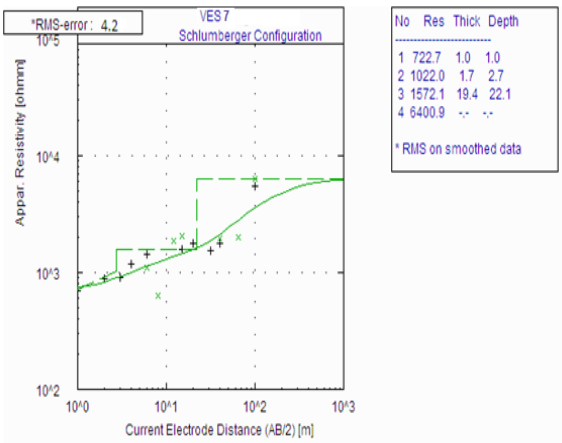


Figure 4.2g: Along post-graduate road site III

Figure 4.2h: Back of sport complex

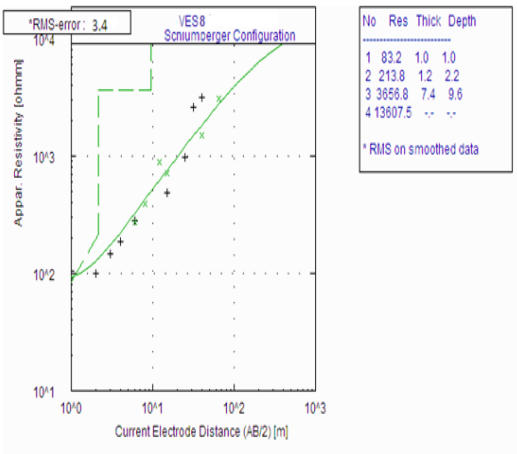


Figure 4.2i: Behind weekend hall

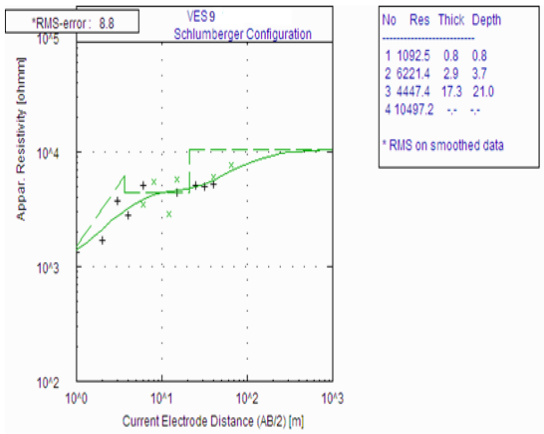


Figure 4.2j: Behind health center campus 3

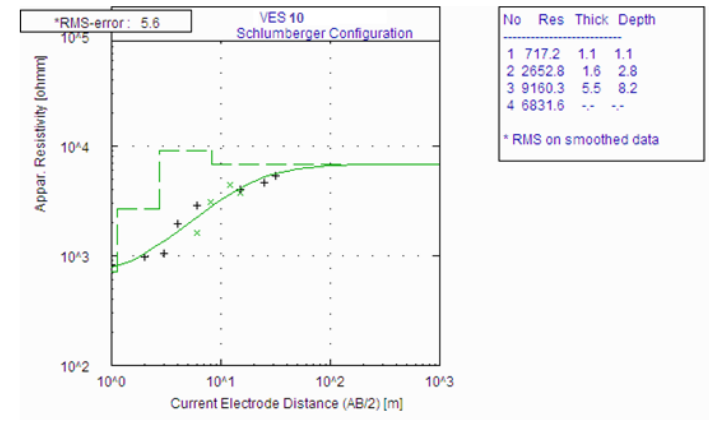


Figure 4.2k: Opposite the convocation hall

Table 1: Summary of results obtained from computer iteration

VES No	Layer No	Resistivity (ohm-m) $\ell_1/\ell_2/\ldots\ell_{n-1}$	Thickness (m) $h_1/h_2/\ldots h_{n-1}$	Depth (m) $d_1/d_2/\ldots d_{n-1}$	Curve Type	Inferred Lithology
1	1	160	1.0	1.0	AKH	Topsoil
	2	212	1.2	2.2		Lateritic sand
	3	453	6.1	8.2		fine sand
	4	343	23.8	32.0		fine to medium grain sand
	5	655				medium grain sand
2	1	3720	1.1	1.1	AK	Topsoil
	2	7028	3.3	4.4		Lateritic Sand
	3	7414	5.6	10.0		fine sand
	4	5813				fine to medium-grained sand
3	1	573	1.1	1.1	KHA	Topsoil
	2	701	1.2	2.3		lateritic sand
	3	596	4.1	6.3		fine grains and
	4	853	19.6	25.9		fine sand
	5	1559				fine to medium-grained sand
4	1	324	0.8	0.8	HAA	Topsoil
	2	181	1.6	2.4		lateritic sand
	3	600	8.9	11.3		fine grain sand
	4	743	29.6	40.9		fine sand
	5	1009				fine to medium-grained sand
5	1	76	0.5	0.5	AKH	Topsoil
	2	579	2.8	3.3		lateritic sand
	3	879	0.9	4.2		fine grain sand
	4	656	10.7	14.9		fine sand
	5	1564				fine to medium-grained sand
6	1	333	1.1	1.1	HAA	Topsoil
	2	246	0.7	1.8		lateritic sand
	3	596	5.2	7.0		fine grain sand
	4	846	20.1	27.1		fine sand
	5	1102				fine to medium-grained sand
7	1	1028	1.0	1.0	AK	Topsoil
	2	1508	2.1	3.1		Lateritic Sand
	3	13257	18.8	22.0		fine sand
	4	8099				fine to medium-grained sand
9	1	722	1.0	1.0	AA	Topsoil
	2	1022	1.7	2.7		Lateritic Sand
	3	1572	19.4	22.1		fine sand
	4	6400				fine to medium-grained sand
10	1	83	1.0	1.0	AA	Topsoil
	2	213	1.2	2.2		sand
	3	3656	7.4	9.6		fine sand
	4	13607				fine to medium-grained sand
11	1	1092	0.8	0.8	KH	Topsoil
	2	6221	2.9	3.7		Lateritic Sand
	3	4447	17.3	21.0		fine sand
	4	10497				fine to medium grain sand

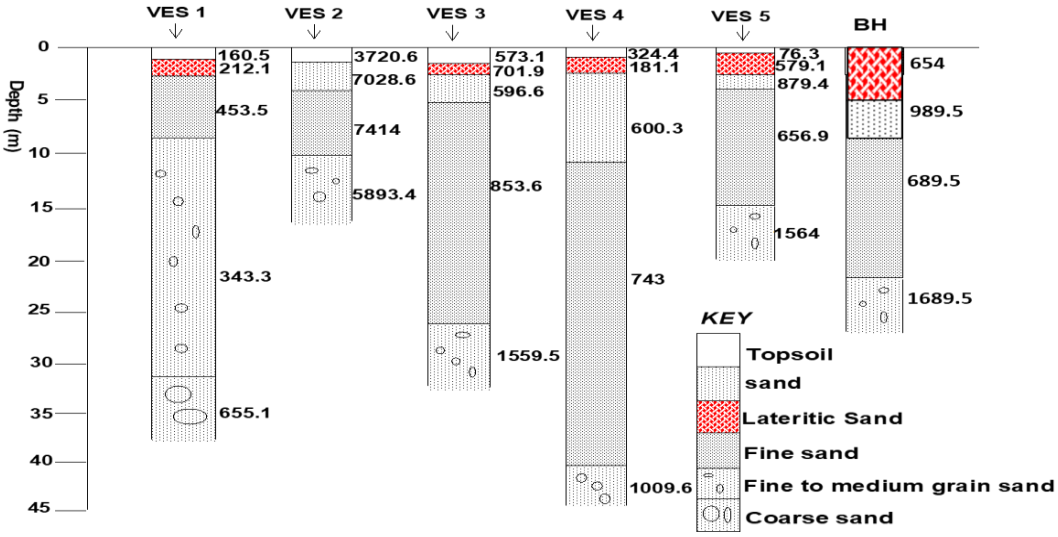


Figure 5a: Geoelectric section of the study area from VES 1 to VES 5

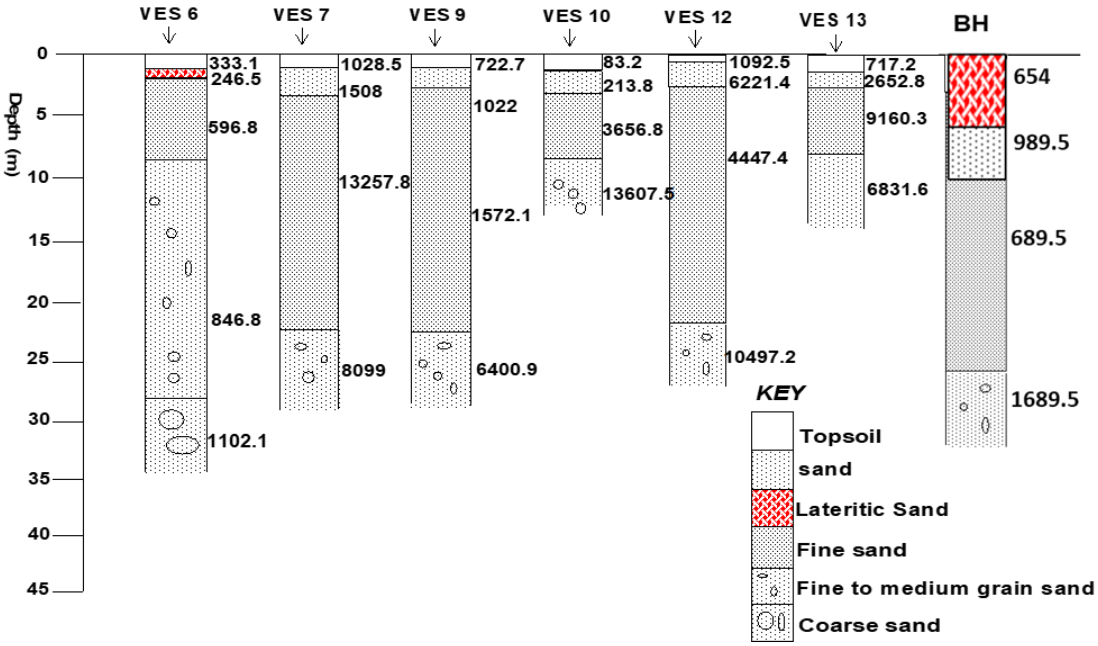


Figure 5b: More geoelectric section of the study area from VES 6

Table 2: Dar-Zarrouk Parameters at site III

VES		Aquifer Thickness (h)m		Longitudinal Conductance S = σh		Transmissivity T_r = kh	Diagonostic Parameters kσ
1	343	23.8	0.00291545	0.06938776	8163.4	199.92	0.0244898
2	7414	11.6	0.00013488	0.00075533	41518.4	47.04	0.00113299
3	853	19.3	0.00117233	0.02262603	16462.9	162.12	0.0098476
4	743	29.6	0.0013459	0.03983849	21992.8	248.64	0.01130552
5	656	10.7	0.00152439	0.01631098	7019.2	89.88	0.01280488
6	846	20.1	0.00118203	0.02375887	17004.6	168.84	0.00992908
7	13257	18.8	7.5432E-05	0.00141812	249231.6	157.92	0.00063363
8	1572	19.4	0.00063613	0.01234097	30496.8	162.96	0.00534351
9	3656	11.6	0.00027352	0.00202407	27054.4	62.16	0.00229759
10	4447	17.3	0.00022487	0.00389026	76933.1	145.32	0.00188891
11	9160	11.5	0.00010917	0.00060044	50380	46.2	0.00091703

K=8.4m/day, and T_{ave} = 135.545455 4m^2/day

Table 2 shows that the Dar-Zarrouk parameters in Delsu Abraka have aquifer resistivity ranges from 343 – 13257 Ωm and aquifer thickness varies from 11.5 – 29.6m. Also, The aquifer conductivity varies from 7.5432E-05(Ωm)$^{-1}$– 0.00291545(Ωm)$^{-1}$ while the longitudinal conductance varies from 0.00060044 – 0.06938776. However, the minimum transmissivity value of the study area is 46.2 m^2/day at the opposite convocation hall while the maximum transmissivity was found along site III main gate fence from the inside with a transmissivity value of 248.64m^2/day. Also, the diagnostic parameter was evaluated as shown in table 4.2. Thus, the result reveals that the chance of groundwater is high and this area is fairly protected which is good for boreholes sinking due to the increase in transmissivity. Hence, the areas having high transmissivity are good and safe for productive deep well citing. Also, table 3 shows the first-order geoelectric parameters and Dar-Zarrouk parameters of the study area, this was used to delineate the aquifer protective capacity rating. The result revealed that the study area has a fair protective capacity rating. The longitudinal conductance S were obtained from Dar-Zarrouk parameters (Mailet, 1974) and given by

$$S = \sum_{i=1}^{n} \frac{h_i}{\rho_i}.$$

Where h_i is the aquifer thickness and ρ_i is the aquifer resistivity.

The evaluation of the overburden protective capacity rating (Henriet, 1976) shows values as > 10 (excellent), 5-10 (very good), 0.7 - 4.9 (good), 0.2- 0.69 (moderate) and < 0.1 (fair). These values were used for the interpretation of the protective capacity ratings.

Table 3: Geoelectric parameters and Dar-Zarrouk parameters for the study of aquifer protective capacity rating

VES	Layers	Resistivity ρ (Ωm)	Thickness (m)	Conductivity σ = 1/ρ	$S = \sum_{i=1}^{n} \frac{h_i}{\rho_i}$	Longitudinal Conductivity of the protective layer	Protective Capacity rating
1	1	160	1	0.00625	0.00625		
	2	212	1.2	0.004717	0.00566		
	3	453	6.1	0.0022075	0.013466	0.01895278	Fair
	4	343	23.8	0.0029155	0.069388		
	5	655		0.0015267			
2	1	3720	1.1	0.0002688	0.000296		
	2	7028	3.3	0.0001423	0.00047		
	3	7414	5.6	0.0001349	0.000755	0.00038014	Fair
	4	5813		0.000172			
3	1	573	1.1	0.0017452	0.00192		
	2	701	1.2	0.0014265	0.001712		
	3	596	4.1	0.0016779	0.006879	0.0066977	Fair
	4	853	19.6	0.0011723	0.022978		
	5	1559		0.0006414			
4	1	324	0.8	0.0030864	0.002469		
	2	181	1.6	0.0055249	0.00884		
	3	600	8.9	0.0016667	0.014833	0.01319615	Fair
	4	743	29.6	0.0013459	0.039838		
	5	1009		0.0009911			
5	1	76.3	0.5	0.0131579	0.006579		
	2	579	2.8	0.0017271	0.004836	0.00574995	Fair
	3	879	0.9	0.0011377	0.001024		
	4	656	10.7	0.0015244	0.016311		
	5	1564		0.0006394			
6	1	333	1.1	0.003003	0.003303		
	2	246	0.7	0.004065	0.002846	0.00772651	Fair
	3	596	5.2	0.0016779	0.008725		
	4	846	20.1	0.001182	0.023759		
	5	1102		0.0009074			
7	1	1028	1	0.0009728	0.000973		
	2	1508	2.1	0.0006631	0.001393	0.00094586	Fair
	3	13257	18.8	7.543E-05	0.001418		
	4	8099		0.0001235			
9	1	722	1	0.001385	0.001385		
	2	1022	1.7	0.0009785	0.001663		
	3	1572	19.4	0.0006361	0.012341	0.00384735	Fair
	4	6400		0.0001563			
10	1	83	1	0.0120482	0.012048	0.00492652	Fair
	2	213	1.2	0.0046948	0.005634		
	3	3656	7.4	0.0002735	0.002024		
	4	13607		7.349E-05			
12	1	1092	0.8	0.0009158	0.000733		
	2	6221	2.9	0.0001607	0.000466		
	3	4447	17.3	0.0002249	0.00389	0.00127226	Fair
	4	10497		9.527E-05			
13	1	717	1.1	0.0013947	0.001534		
	2	2652	1.6	0.0003771	0.000603	0.00068448	Fair
	3	9160	5.5	0.0001092	0.0006		
	4	6831		0.0001464			

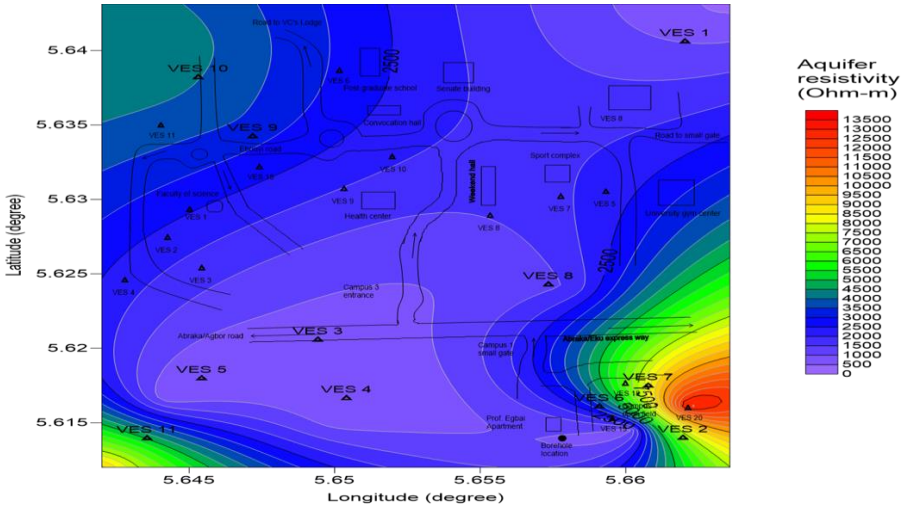


Figure 6: Aquifer resistivity contour map of DELSU site III Abraka

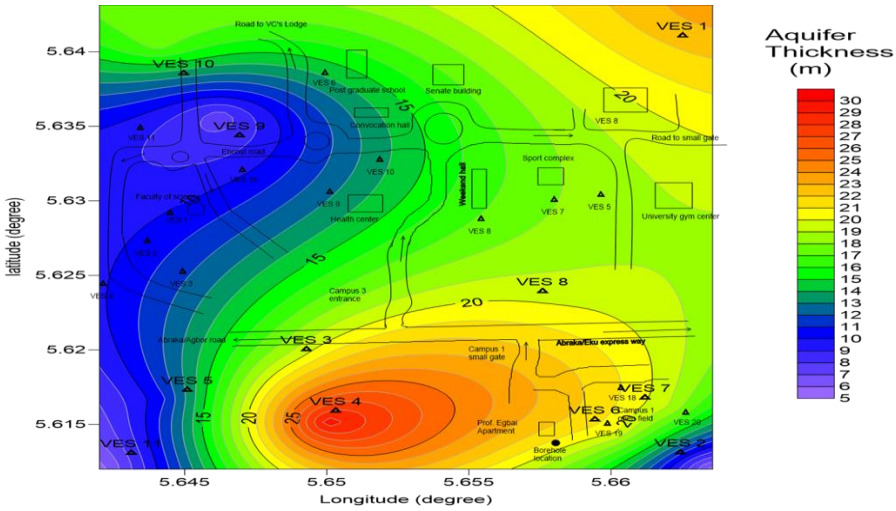


Figure 7: Aquifer thickness contour map of DELSU site III Abraka

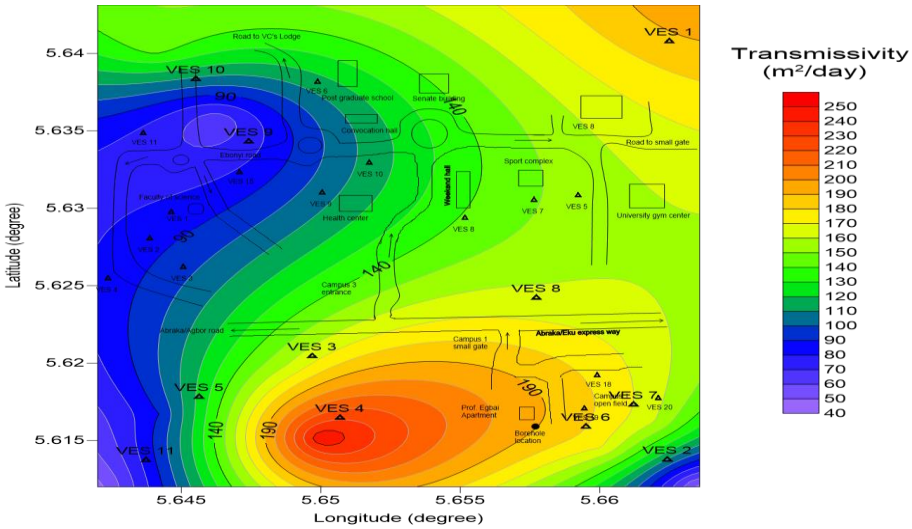
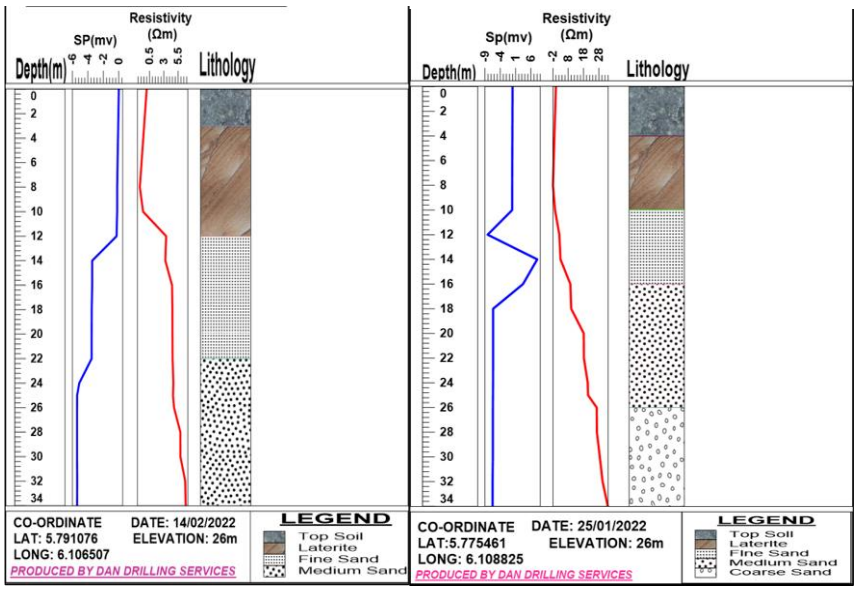


Figure 8: Transmissivity contour map of DELSU site III Abraka

Presentation of deep well result

During the drilling of the 40 m deep well, well cuttings were collected at a depth interval of 2 m, and the formation composition was noted and recorded. This was used to construct the lithologic strata of the well. At the end of the drilling, spontaneous potential and resistivity logs were conducted on the well and the result is presented in Table 4. A graphical comparison was made for the logs by plotting them side by side and the result is presented as shown in Figure 9. Based on observation of the drill cuttings, the lithology of the study area was delineated from top to bottom, the drilled lithological sediment sequence is topsoil, laterite, fine sand, and medium sand at the base. The topsoil is brownish with a thickness of 1.5 m, the laterite is reddish with a thickness of 3.8 m, the fine sand is whitish with a thickness of 10 m, and the medium sand is also whitish with a thickness >12 m. The medium sand is the zone of saturation where the borehole screen is situated, hence, the primary aquifer of the drilled well has a high resistivity value and deflection curve towards the high value. However, an increase in the resistivity value starts from 12 m as shown in the study area deep well log in figure 9, the zone of high resistivity shows the conductivity of the formation fluid. The resistivity curve shows that the productive aquiferous zone is free from dissolved ions which makes it safe for usage. The low resistivity is evidence of dissolved ions in the formation fluid. The fine grain is a great help in the natural attenuation process, which is the absorption of contaminants into aquifer grains or the surface preventing dissolved ions to percolate beneath the water table.



9a 9b

Figure 9a: Deep well log obtained from a drilled observation well

Figure 9b: Deep well log obtained from existing deep well record\from a drill

Conclusion

In general, the Vertical electrical sounding result showed a thick homogeneous layer of fine to medium grain sand formation exists in most locations investigated. The most prolific and viable aquifers of Delta State University Abraka are at the depth of 28 to 40 m. Therefore, the result correlated with available borehole records of 27.5 – 39.5 meters around Abraka inland region from a driller and with previous work conducted by Okolie (2010) and Oseji (2010). Hence in this study, we do not see a significant difference between the observation and existing deep well records, thus geoelectrical results show a similar trend between them. The deep well log of the study area indicates laterite, fine sand and medium sand (aquifer unit), the lithologies

show how vulnerable the primary aquifer source is with fair protection due to the characteristics of the formations before the aquifer unit (fluids can easily infiltrate through them and are low in attenuation process). Also, the aquifer is shallow, with minimal clay material that was supposed to act as a seal cap to the primary aquifer making the infiltration of contaminants into the aquifer faster. While this found aquifer unit is to be fairly protected it is recommended that water chemistry should be carried out from time to time to confirm safety. Residents of the study area should be sensitized properly on waste and chemical disposal management to avoid man-made infiltrations of the aquifer unit with unhealthy substances since the aquifer is shallow and not completely protected. Other geophysical exploration methods such as seismic refraction, electromagnetic (EM), ground penetrating radar (GPR), well logging etc. should be used to correlate the result obtained from the investigation.

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