Journal of Science, Technology and Mathematics Education (JOSTMED)
Volume 6, Number 1

May, 2009
ISSN 0748-4710

The Use of a Predictive Statistical Technique in Geo-Electrical Investigations

Jonah, S.A., Udensi, E.E., Baba-Kutigi A.N., Isah, K.U., Uno, U.E., Ahmadu, U., Crown, I.E., Umar, M.O., Gana, C.S., Kolo, M.T., Rafiu, A.A., *Unuevho, C.I., *Onoduku, U.S, *Aboa, F. M., Salako, K.A., Dangana, M.L., Adetona, A.A., Ibrahim, S.O., Ofor, N.P., Alhassan, D.U., Ezenwora, J. A., Ibrahim, A.G., Eze, C.N., Olarinoye, I. O., Agida, M., Igwe, K.C., Mukhtar, B. and Kimpa, M.I.

Department of Physics, Federal University of Technology, Minna
* Department of Geology, Federal University of Technology, Minna

Abstract
The method of simple regression analysis was employed to test for the correlation at the various depths of investigation between AB/2 and resistivity for the geoelectrical data collected from six VES points (i.e. A_1 - A_6). The VES dataset had been interpreted in the usual manner to obtain information about number of layers, their thicknesses, and depth to basement along the profile on which soundings were carried out. Having applied the method of regression analysis to for (i) maximum AB/2 = 100m, (ii) maximum AB/2=40m, it was found that the values of the standard error of estimates are within tolerable limits for VES points A_1, A_2, A_3, and A_4 (i.e. about 67% correlation). Thus it was recommended that between VES points A_1 and A_6, intermediate VES points (say 50m spacing) could be sounded with savings in time and cost. Now, instead of fourteen sounding sequences that are concerned with depth to basement, just the first six sequences could be sounded and the remaining dataset can be extrapolated to AB/2 = 40m.

Keywords: basement; regression; error; sounding; correlation

Introduction

The resistivity of the subsurface is a continuously varying property in relation to the depth surveyed. There are many methods of electrical surveying. Some make use of the naturally occurring fields within the earth while others require the introduction of artificially generated currents into the ground. More commonly, electrical methods involve the detection of signals induced in the subsurface conducting bodies by electric and magnetic fields generated above ground. Investigations in this category would exclude the self-potential method, but obviously would include the resistivity and electromagnetic methods. In the earth resistivity method, a direct commutated or low frequency alternating current is introduced into the ground by means of two electrodes (metal stakes or suitably laid-out bare wires) connected to the terminals of a portable source of e.m.f. The resulting potential distribution of the ground, mapped by means of two probes (metal stakes or preferably, non-polarizable electrodes), is capable of yielding information about the distribution of electric resistivity below the surface. The resistivity method is used in the study of horizontal and vertical discontinuities in the electrical properties of the ground, and also in the detection of three-dimensional bodies of anomalous electrical conductivity. It is routinely used in engineering, archaeological, and hydrogeological investigations to investigate the shallow subsurface geology. Other than the search for water-bearing formations, the method has been used mainly in stratigraphic correlation in oil fields and in prospecting for conductive ore bodies (Kearey and Brooks, 1984; Parasnis, 1986; Lowrie, 1997).

Two main types of procedures are employed in resistivity surveys, viz:

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(i) Vertical Electrical Sounding (VES): This method is also known as "electrical drilling" or "expanding probe" and is used mainly in the study of horizontal or near-horizontal interfaces. The current and potential probes are maintained at the same relative spacing and the whole spread is progressively expanded about a fixed central point. Consequently, readings are taken as the current reaches progressively greater depths. The technique is extensively used in geotechnical surveys to determine overburden thickness and also in hydrogeology to define horizontal zones of porous strata.

(ii) Constant Separation Traversing (CST): This method is also known as "electrical profiling" and the method is used to determine lateral variations of resistivity. The current and potential electrodes are maintained at a fixed separation and progressively moved along a profile. This method is employed in mineral prospecting to locate faults or shear zones and to detect localized bodies of anomalous conductivity. It is also used in geotechnical surveys to determine variations in bedrock depth and the presence of steep discontinuities.

The Research Question: This study seeks answer to the question, viz: could a technique be evolved such that the possible values of resistivities of the subsurface geological formation could be predicted to a high degree of accuracy?

The Geoelectric Survey

Project Location: The VES geoelectrical data extracted for this work was obtained from a geophysical survey that covered an area of 1km x 1/2km, and which formed part of the study area of Udensi et al (2006).

The Method Employed: The geophysical survey was based on the electrical resistivity method using the vertical electrical sounding (VES) technique (Kearey and Brooks, 1984; Parasnis, 1986). The VES data were collected via the Schlumberger array mode because this is the configuration most suited for VES investigation. Generally, an electrical resistivity method involves the artificial introduction of current into the ground through point electrodes. Potentials are subsequently measured at other electrodes in the vicinity of the current flow. By this means, it is then possible to measure or determine an effective or apparent resistivity of the subsurface. Low resistivity in a given area is a likely indicator of the presence of groundwater (Ako and Olorunfemi, 1982; Gana, 1995; Bonde, 1997; Dangana, 2002; Udensi et al, 2006). The VES determine the vertical sequence of the underlying strata (Okwueze et al, 1981; Okwueze and Ezeanyi, 1985; Olorunfemi and Okhue, 1992; Olorunfemi and Fasuyi, 1993; Shuaibu et al, 2004). Progressively increasing the distance between adjacent electrodes of the Schlumberger configuration will cause the current lines to penetrate to ever greater depths (Bhattacharya, 1986).

Vertical Electrical Depth Sounding Results

The summary of the results deduced from the digitised Zohdy curves derived from the interpretation of the VES field data set for Profile A are presented in Table 1.

Table 1: Summary of VES Interpretation of Digitised Zohdy Curves

VES POINT	LAYER NUMBER	AVERAGE RESISTIVITY (Ωm)	DEPTH (m)	LAYER THICKNESS (m)
A_1	1	241.62	0.00	0.54
	2	35.73	0.54	0.62
	3	371.27	1.16	10.47
	4	834.45	11.64	13.43
	5	281.01	25.07	11.72
	6	140.70	36.79	∞
A_2	1	138.30	0.00	0.49
	2	83.00	0.49	0.56
	3	90.97	1.05	14.32
	4	504.70	15.37	17.74
	5	656.12	33.11	∞
A_3	1	3562.62	0.00	0.44
	2	1525.88	0.44	0.95
	3	1232.68	1.38	12.45
	4	118.59	13.83	15.97
	5	205.48	29.80	∞
A_4	1	1.87	0.00	0.39
	2	2.38	0.39	0.85
	3	2.95	1.25	11.20
	4	1.72	12.45	14.37
	5	26.63	26.82	∞
A_5	1	6.34	0.000	0.39
	2	0.18	0.39	0.85
	3	0.46	1.25	11.20
	4	3.57	12.45	14.37
	5	46.45	26.82	∞
A_6	1	0.70	0.000	0.49
	2	1.22	0.49	0.56
	3	2.68	1.05	14.32
	4	2.28	15.37	17.74
	5	23.28	33.11	∞

The interpretation of the layering of Table 1 shows that VES points A_2, A_3, A_4, A_5, and A_6 are made up of five geoelectric units or layers while there are six layers for VES point A_1. Along profile A, the resistivity of the uppermost layer (topsoil) varies from a low of 0.70 Ωm (for A_6) to a high of 241.62 Ωm (for A_1). The resistivity extreme (upper) in this profile has its highest value of 3562.62Ωm in the first layer underneath VES point A_3. The second and third layers underneath VES A_3 also show very high resistivity values. The lowest resistivity value of 0.18Ωm is that of the second layer underneath VES A_5. The thickest layer that can be deduced from this profile is 17.74m, and this is the thickness of the fourth layer of VES A_2 and also the thickness of the fourth layer of VES A_6. The thinnest layer corresponds to the first layer of both VES points A_4 and A_5. The thickness of the top layer remains fairly constant in this profile (from 0.40m to 0.54m). Finally, *the depth to basement along this profile varies from 26.82m to 36.79m.*

Simple Regression Analysis

The method of simple regression analysis shows the relationship between an independent and a dependent variable, as well as providing a means for the derivation of an equation to predict the dependent variable based on the values of the independent variable (Morenikeji, 2006). The regression equation is expressed as

$$y^1 = a + bx \tag{1}$$

In Eq.1, y^1 is the predicted value of the dependent variable for any particular value of x, the independent variable. Before Eq.1 can be used the values of a and b (constants) have to be determined from the dataset under analysis. Generally,

$$a = \bar{y} - b\bar{x} \tag{2}$$

and

$$b = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2} \tag{3}$$

In Eq.2, $\bar{y}$ is the mean of the sum of the different values of y, while $\bar{x}$ is the mean of the sum of the different values of x. Usually, a table of values is produced so that the values of Σx, Σy, Σxy, Σx^2, and $(\Sigma x)^2$, as seen from Eq.3, can easily be computed. It is instructive to point out that in Eq.3, n is the total number of distinct values of the dependent or independent variable.

The Analytical Procedure: Ordinarily, the field data sheet for the six VES points of the Profile A that was surveyed would look like Table 2. Table 3 shows the relationship between resistivity and depth.

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Table 2: Field Data Sheet Layout Showing Resistance Values

AB/2 (m)	MN/2 (m)	Geom. Fac.. K	A_1 (Ω)	A_2 (Ω)	A_3 (Ω)	A_4 (Ω)	A_5 (Ω)	A_6 (Ω)
1	0.50	2.36	31.40	72.24	66.47	5.50	62.91	48.47
2	0.50	11.80	2.84	6.10	7.62	1.37	0.91	11.07
3	0.50	27.80	7.78	1.29	2.26	0.66	1.14	1.00
5	0.50	77.80	0.35	0.65	1.25	0.35	0.40	1.10
6	0.50	112.00	1.32	1.32	0.43	0.20	0.12	0.66
6	1.00	55.00	0.77	1.57	0.69	1.31	0.66	16.34
8	1.00	99.00	0.57	0.80	0.55	0.40	0.55	45.88
10	1.00	156.00	0.26	0.53	0.14	0.03	0.85	4.44
10	2.50	58.00	0.85	1.02	2.16	0.13	0.51	1.08
15	2.50	137.00	0.59	0.63	0.16	0.96	0.28	1.11
20	2.50	245.00	0.33	0.39	0.05	0.26	0.18	0.87
30	2.50	562.00	0.20	0.22	0.10	0.98	0.06	0.37
40	2.50	1001.00	0.01	0.18	0.04	0.08	4.84	4.74
40	7.50	323.00	0.52	0.55	0.52	0.10	0.32	5.50
50	7.50	512.00	0.49	0.40	0.28	0.14	0.24	0.94
60	7.50	742.00	0.38	0.42	0.24	0.12	0.27	1.20
70	7.50	1014.00	0.21	0.27	0.18	0.63	0.26	28.19
80	7.50	1329.00	0.24	0.16	0.16	1.33	0.08	6.65
80	15.00	647.00	0.57	0.42	0.33	0.24	0.21	1.90
90	15.00	825.00	0.46	0.39	0.29	0.22	0.23	4.90
100	15.00	1024.00	0.38	0.38	0.20	0.20	0.22	0.73

Table 3: Relationship between Resistivity and Depth

AB/2 (m)	A_1 (Ωm)	A_2 (Ωm)	A_3 (Ωm)	A_4 (Ωm)	A_5 (Ωm)	A_6 (Ωm)
1	73.49	170.49	156.87	12.98	148.47	114.39
2	33.51	71.98	89.92	16.17	10.74	130.63
3	216.28	35.86	62.83	18.35	31.69	27.80
5	27.07	50.57	97.25	27.23	31.43	85.58
6	147.84	147.84	47.94	22.62	13.66	74.26
6	12.52	86.35	38.01	72.05	36.19	898.70
8	56.23	79.20	54.55	39.11	54.45	4542.12
10	39.78	82.06	22.46	5.142	132.29	692.64
10	49.18	59.16	125.28	7.48	29.81	62.64
15	80.83	86.72	22.19	132.07	37.68	152.07
20	81.10	95.31	11.27	63.46	45.08	213.15
30	106.22	124.76	57.89	549.07	30.19	205.69
40	10.01	177.18	42.04	83.08	4844.84	4744.74
50	166.99	177.65	167.96	32.95	103.04	1776.50
50	248.32	201.22	142.85	75.26	121.86	480.26
60	279.73	308.67	179.56	89.04	199.60	890.40
70	209.90	270.74	186.29	633.75	262.63	28584.70
80	313.64	208.65	216.63	1767.57	102.33	8837.85
80	371.38	269.15	212.86	154.63	137.81	1229.30
90	378.68	317.63	236.78	183.15	187.28	4042.50
100	391.17	290.82	200.70	208.90	220.16	742.40

It is important, at the outset to produce, a comprehensive table of values for x and y. Generally, from Table 3, x corresponds to AB/2 and y corresponds to any of the columns of A_1 to A_6; we also note that any of the set of values of A_1 to A_6 is treated separately in relation to AB/2. That being the case, we begin by producing Table 4 in terms of AB/2 and A_1 only.

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…bles of Values for AB/2 (x) and A_1 (y)

	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
…45	1	5400.78	73.49	-83.36	6948.89	43.05	30.44	926.59
…51	4	1122.92	67.02	-123.34	15.212.76	46.44	-12.93	167.18
…28	9	46,777.04	648.84	59.43	3.531.92	49.83	166.45	27,705.60
…07	25	732.78	135.35	-129.78	16.842.85	56.61	-29.54	872.61
…84	36	21,856.67	887.04	-9.01	81.18	60.00	87.84	7715.87
…54	36	156.75	75.12	-144.33	20.831.15	60.00	-47.46	2252.45
…23	64	3161.81	449.84	-100.62	10.124.38	66.78	-10.55	111.30
…78	100	1582.24	397.80	117.07	13.705.38	73.56	-33.78	1141.09
…18	100	2418.67	491.80	-107.67	11,592.83	73.56	-24.38	594.38
…83	225	6533.49	1212.45	-76.02	5779.04	90.51	-9.68	93.70
…10	400	6577.21	1622.00	-75.75	5738.06	107.46	-25.36	694.85
106.22	900	11.282.69	3186.60	-50.63	256.34	141.36	-35.14	1234.82
10.01	1600	100.20	400.40	-146.85	21,561.99	175.26	-165.25	27,307.56
166.99	1600	27.885.66	6679.60	10.14	102.82	175.26	-8.27	68.39
248.32	2500	61,662.82	12,416.00	91.47	8366.76	209.16	39.16	1533.51
279.73	3600	78,248.87	16.783.80	122.88	15,099.49	243.06	36.67	1344.69
209.90	4900	44.058.01	14,693.00	53.05	2.814.30	276.96	-67.06	4497.04
313.64	6400	98,370.05	25.091.20	156.79	24,583.10	310.86	2.78	7.73
371.38	6400	137,923.10	29,710.40	214.53	46,023.12	310.86	60.52	3662.67
378.68	8100	143,398.54	34,081.20	221.83	49,208.55	344.76	33.92	1150.57
391.19	10000	153.013.97	39,117.00	234.32	54,905.86	378.66	12.51	156.50
Σ= 3293.89	Σ = 47,000	Σ= 852,264.27	Σ = 188,219.95		Σ = 333,310.77			Σ = 83,239.10

Visual inspection of Table 4 indicates that y is a continuously-varying function of x. However, as the value of x increases the value of the predicted variable (y^1) also increases. We can also observe that at greater depths of penetration, the values of y correlates appreciably with y^1. The mean values of x and y are determined from Table 4 as follows:

$$\bar{x} = 726 / 21 = 34.57 \quad (4)$$

and

$$\bar{y} = 3293.88 / 21 = 156.85 \quad (5)$$

The value of b, by Eq. 3, is

$$b = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2}$$

$$= \frac{21(188,219.95) - (726)(3293.89)}{21(47,000) - 527076}$$

$$= \frac{3,952,6189.95 - 2,391,364.14}{987,000 - 527,076}$$

$$= \frac{1,561,254.87}{459,924} \quad (6)$$

$$\therefore b = 3.39$$

Thus, by Eq. 2

$a = 156.85 - (3.39)(34.57)$

$a = 156.85 - 117.19$

or

$a = 39.66$ (7)

Now, by Eq. 1, the y^1 can be evaluated for each value of x.

Standard Error of Estimate (A_1). The standard error in the estimation of the predicted value, y^1, is evaluated from the expression

$$Syx = \frac{\sqrt{\Sigma\left(y - y^1\right)^2}}{n-2}$$

$$= \frac{\sqrt{83{,}239.10}}{19}$$

or $Syx = \pm 15.18\,\Omega m$ (8)

We continue our investigation by producing Tables 5, 6, 7, 8 and 9 for AB/2 versus A_2, A_3, A_4, A_5, and A_6.

[illegible] of Values for AB/2 (x) and A_2 (y)

y	x^2	y^2	Xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
170.49	1	29,066.84	170.49	7.78	60.53	69.39	101.1	10221.21
71.98	4	5181.12	143.96	-90.73	8231.93	72.17	-0.19	0.036
35.86	9	1285.94	107.58	-126.85	16,090.92	74.95	-39.09	1528.03
50.57	25	2557.32	252.85	-112.14	12,575.38	80.51	-29.94	896.40
147.84	36	21,856.67	887.04	-14.87	221.12	83.29	64.55	4166.70
86.35	36	7456.32	518.10	-76.36	5,830.85	83.29	3.06	9.36
79.20	64	6272.64	633.60	-83.51	6973.92	88.85	-9.65	93.13
82.06	100	6733.84	820.60	-80.65	6504.42	94.41	-12.35	152.25
59.16	100	3499.91	591.60	-103.55	10,722.60	94.41	-35.25	1242.56
86.72	225	7520.36	1300.80	-75.99	5774.48	108.31	-21.59	466.13
95.31	400	9084.00	1906.20	-67.40	4542.76	122.21	-26.9	723.61
124.76	900	15,565.06	3742.80	-37.95	1440.20	150.01	-25.25	637.56
177.18	1600	31,392.75	7087.20	14.47	209.38	177.81	-0.63	0.40
177.65	1600	31,559.52	7106.00	14.94	223.20	177.81	-0.16	0.026
203.78	2500	41,526.29	10,189.00	41.07	1686.74	205.78	-2.00	4.00
308.67	3600	95,277.17	18,520.20	145.96	21,304.32	233.41	75.26	5664.07
[illegible]	4900	73,300.15	18,951.80	108.03	11,670.48	261.21	9.53	90.82
[illegible]	6400	43.534.82	16,692.00	45.94	2,110.48	289.01	-80.36	6457.73
[illegible]	6400	72,441.72	21,532.00	106.44	11,329.47	289.01	-19.86	394.42
[illegible]	8100	100,888.82	28,586.70	154.92	24,000.21	316.81	0.82	0.67
[illegible]	10000	154,121.97	39,322.00	230.51	53,134.86	344.61	48.61	2362.93
Σ = 3416.97	Σ = 47,000	Σ = 760,623.23	Σ = 179,062.52		Σ =204,638.25			Σ = 35,112.03

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ISSN 0748-4710

As observed in Table 5, at greater depths of penetration, the values of y correlates appreciably with y^1. The mean values of x and y, as determined from Table 5 are $\bar{x} = 34.57$ and $\bar{y} = 162.71$. Further, a = 66.61 and b = 2.78.

Standard Error of Estimate (A_2). We use the expression given as follows:

$$Syx = \frac{\sqrt{\Sigma(y - y^1)^2}}{n-2}$$

$$= \frac{\sqrt{35{,}112.03}}{19}$$

$$= 9.86$$

or $Syx = \pm 9.86\ \Omega m$ (9)

Table of Values for AB/2(x) and A_3 (y)

Y	x^2	y^2	Xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
156.87	1	24,608.20	156.87	43.91	1928.09	53.54	103.33	10.677.09
89.92	4	8085.61	179.84	-23.04	530.84	55.31	34.61	1,197.85
62.83	9	3947.61	188.49	-50.13	2513.02	57.08	5.75	33.06
97.25	25	9.45.56	486.25	-15.71	246.80	60.62	36.63	1341.76
47.94	36	2298.24	287.64	-65.02	4227.60	62.39	-14.45	208.80
38.01	36	144.76	228.06	-74.95	5617.50	62.39	-24.38	594.38
54.55	64	2975.70	436.40	-58.41	3411.73	65.93	-11.38	129.50
22.46	100	504.45	224.60	-90.50	8190.25	69.47	-47.01	2209.94
125.28	100	15,695.08	1252.80	12.32	151.78	69.47	55.81	3114.76
22.19	225	492.40	332.85	-90.77	8239.19	78.32	-56.13	3150.58
11.27	400	127.01	225.40	-101.69	10,340.86	87.17	-75.90	5760.81
57.89	900	3351.25	1736.70	-55.07	3032.70	104.87	-46.98	2207.12
42.04	1600	1767.36	1681.60	-70.92	5029.65	122.57	-80.53	6485.08
167.96	1600	28,210.56	6718.40	55.00	3025.00	122.57	45.39	2060.25
142.85	2500	20,406.12	7142.50	29.89	893.41	140.27	2.58	6.66
179.56	3600	32,241.79	10,773.60	66.60	4435.56	157.97	21.59	466.13
186.29	4900	34,703.96	13,040.30	73.33	5377.29	175.67	10.62	112.78
216.63	6400	46,928.56	17,330.40	103.67	10,747.47	193.37	23.26	541.03
212.86	6400	45,309.38	17,028.80	99.90	9,980.01	193.37	19.49	379.86
236.78	8100	56,064.77	21,310.20	123.82	15,331.39	211.07	25.71	661.00
200.70	10000	40,280.49	20,070.00	87.74	7698.31	228.77	-2807	787.92
Σ = 2372.13	Σ = 47,000	Σ = 378,900.86	Σ = 120,831.70		Σ = 110,948.45			Σ = 42,126.36

The mean values of x and y, as determined from Table 6, are $\bar{x} = 34.57$ and $\bar{y} = 112.96$. Further, a = 51.77 and b = 1.77.

Standard Error of Estimate (A_3). We use the expression given as follows:

$$Syx = \frac{\sqrt{\Sigma(y - y^1)^2}}{n-2}$$

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$$= \frac{\sqrt{42{,}126.36}}{19}$$

$$= 10.8$$

or Syx $= \pm 10.8\ \Omega m$

(10)

Table of Values of AB/2 (x) and A_4 (y)

y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
[illegible]	1	168.48	12.98	-186.74	34,871.83	7.70	5.28	27.88
[illegible]	4	261.47	32.34	-183.55	33,690.60	13.42	2.75	7.56
[illegible]	9	336.72	55.05	-181.37	32.895.08	19.14	-0.79	0.62
[illegible]	25	741.47	136.15	-172.49	29,752.80	30.58	-3.35	11.22
[illegible]	36	511.66	135.72	-177.10	313,64.41	36.30	-13.68	187.14
[illegible]	36	5,191.20	432.30	-127.67	16,299.63	36.30	35.75	1278.06
[illegible]	64	1,529.59	312.88	-101.61	25,795.57	47.74	-8.63	74.48
[illegible]	100	26.42	514	-194.58	37,861.38	59.18	-54.04	2920.32
[illegible]	100	55.95	74.8	-192.24	36,956.22	59.18	-51.70	2672.89
[illegible]	225	17,442.48	1981.05	-67.65	45,76.52	87.78	44.29	1961.60
[illegible]	400	4,027.17	1269.20	-136.26	18.566.79	116.38	-52.92	2800.53
[illegible]	900	301,477.86	16,472.10	349.35	122,045.42	173.58	375.49	140,992.74
[illegible]	1600	6902.29	3323.20	-116.64	13,604.89	230.78	-147.70	21,815.29
[illegible]	1600	1085.70	1318.00	-166.77	27,812.23	230.78	-197.83	39,136.71
[illegible]	2500	5664.07	3763.00	-124.46	15,490.29	287.98	-212.72	45,249.80
[illegible]	3600	7928.12	534,2.40	-110.18	12,250.06	345.18	-256.14	65,607.70
[illegible]	4900	401,639.06	44,362.50	434.03	18,838.20	402.38	231.37	53,532.08
[illegible]	6400	3,124,303.71	141,405.60	1567.85	2,458,153.62	459.58	1307.99	1,710,837.84
[illegible]	6400	23,910.44	12,370.40	-45.09	2033.11	459.58	-304.95	92,994.50
[illegible]	8100	33,543.92	16,483,05	-16.57	274.56	516.78	-333.63	111,308.98
[illegible]	10000	43,639.21	20,890.00	9.18	84.27	573.98	-365.08	133,283.41
[illegible] 4194.06	Σ = 47,000	Σ = 3,980,386.99	Σ = 270,224.57		2,973,217.48			2,426,701.35

The mean values of x and y, as determined from Table 7, are $\bar{x} = 34.57$ and $\bar{y} = 199.72$. Further, a = 1.98 and b = 5.72.

Standard Error of Estimate (A_4). We use the expression given as follows:

$$Syx = \frac{\sqrt{\Sigma\left(y - y^1\right)^2}}{n-2} = \frac{\sqrt{2426701.35}}{19} = \frac{1557.79}{19} = 81.99$$

or Syx $= 81.99\ \Omega m$

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Table of Value for AB/2 (x) and A_5 (y)

x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
1	22,043.34	148.47	-174.45	30,432.80	226.24	-77.77	6048.17
4	115.35	21.48	-312.18	97,456.35	229.12	-218.38	47,689.82
9	1004.26	95.07	-291.23	84,814.91	232.00	-206.31	40,124.10
25	987.84	157.15	-291.49	84,966.42	237.76	-206.33	42,572.07
36	186.60	81.96	-309.26	95,641.75	240.64	-226.98	51,519.92
36	1,309.72	217.14	-286.73	82,214.09	240.64	-204.45	41,799.80
64	2,964.80	435.60	-268.47	72,076.14	246.40	-191.95	36,844.80
100	17,500.64	1322.90	-190.63	36,339.80	251.16	-119.87	14,368.82
100	888.64	298.10	-293.11	85,913.47	252.16	-222.35	49,439.52
225	1419.78	565.20	-285.24	81,361.86	266.56	-228.88	52,386.05
400	2032.21	901.60	-277.84	77,195.07	280.96	-235.88	55,639.37
900	911.44	905.70	-292.73	85,690.85	309.76	-279.57	78,159.38
1600	23,472,474.63	193,793.60	4521.92	20,447,760.49	338.56	4506.28	20,306,559.44
1600	10,617.24	4121.60	-219.88	48,347.21	338.56	-235.52	55,469.67
2500	14,849.86	6093.00	-201.06	40,425.12	267.36	-145.50	21,170.25
3600	39,840.16	11,976.00	-123.32	15,207.82	396.16	-196.56	38,635.83
4900	68,974.52	18,384.10	-60.29	3634.88	424.96	-162.35	26,351.03
6400	10,471.43	8186.40	-220.59	48,659.95	453.76	-351.43	123,503.04
6400	18,991.60	11,024.80	-185.11	34,265.71	453.76	-315.95	99,824.40
8100	35,073.80	16,855.20	135.64	18,398.21	482.56	-295.28	87,190.28
10000	48,470.43	22,016.00	-102.76	10,559.62	511.36	-291.20	84,797.44
Σ=47,000	Σ=23,777,128.29	Σ = 297,601.07		Σ=21,581,362.52			Σ=21,360,093.20

The mean values of x and y, as determined from Table 8, are $\bar{x} = 34.57$ and $\bar{y} = 199.72$. Further, a = 223.36 and b = 2.88.

The Standard Error of Estimate (A_5). We use the expression given as follows:

$$Syx = \frac{\sqrt{\Sigma\left(y-y^1\right)^2}}{n-2} = \frac{\sqrt{21,360,093.2}}{19} = \frac{4621.70}{19} = 243.25$$

or Syx $= \pm 243.25\Omega m$ (12)

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[illegible] of Values for AB/2 (x) and A_6 (y)

y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
[illegible]14.59	1	13,085.07	114.39	-2672.67	7,143,164.93	299.86	-185.47	34,399.12
[illegible]30.63	4	17,064.20	261.26	-2656.43	7,056,620.35	373.95	-243.32	59,204.62
[illegible]27.80	9	772.84	83.40	-2759.26	7,613,515.75	448.04	-420.24	176,601.66
[illegible]85.58	25	7323.94	427.90	-2701.48	7,297,994.19	596.22	-510.64	260,753.21
[illegible]74.26	36	5514.55	445.56	-2712.80	7,359,283.84	670.31	-596.05	355,275.60
[illegible]898.70	36	807,661.69	5392.20	1888.36	3,565,903.49	670.31	228.39	52,161.99
[illegible]542.12	64	20,630,854.09	36,336.96	1755.06	3,080,235.60	818.49	3723.63	13,865,420.38
[illegible]92.64	100	479,750.17	6,926.40	-2094.42	4,386,595.14	966.67	-274.03	75,092.44
[illegible]61	100	3923.77	626.4	-2724.42	7,422,464.34	966.67	-904.03	817,270.24
[illegible]2.07	225	23,125.28	2,281.05	2634.99	6,943,172.30	1337.12	-1185.05	1,404,343.50
[illegible]13.15	400	45,432.92	4263.00	-2573.91	6,625,012.69	1707.57	-1494.42	2,233,291.14
[illegible]05.69	900	42,308.38	6,170.70	-2581.37	6.663,471.08	2448.47	-2242.78	5,030,062.13
[illegible]744.74	1600	22,512,557.67	189,789.60	1957.68	3,832,510.98	3189.37	1555.37	2.419,175.84
[illegible]776.50	1600	3,155,952.25	71.060.00	-1010.56	1,021,231.51	3189.37	-1412.87	1,996,201.64
[illegible]0.26	2500	230,649.67	24,013.00	-2306.80	5,321,326.24	3930.27	-3450.01	11,902,569.00
[illegible]0.10	3600	792,812.16	53,424.00	-1896.66	3,597,319.16	4671.17	-3780.77	14,294,221.79
[illegible]8,584.70	4900	817.085,074.1	2,000,929.00	25,797.64	665,518,229.60	5412.07	23,172.63	536,970,781.10
[illegible]837.85	6400	78,107,592.62	707,028.00	6050.79	36,612,059.62	6152.97	2711.88	7,354,293.13
[illegible]229.30	6400	1,511,178.49	98,344.00	-1557.76	2,426,616.22	6152.97	-4923.67	24,242,526.27
[illegible]2.50	8100	16,341,806.25	363,825.00	1255.44	1,576,129.59	6893.87	-2851.37	8,130,310.88
[illegible]	10000	551,157.76	74,240.00	-2044.66	4,180,634.52	7634.77	-6892.37	47,504,764.22
Σ=58,528.32	Σ=47,000	Σ=962,365,597.90	Σ = 3,645,981.82		Σ=7,99,243,491.10			Σ=679,178,719.90

The mean values of x and y, as determined from table 9, are $\bar{x} = 34.57$; $\bar{y} = 2787.0$. Further, a = 225.77 and b = 74.09.

The Standard Error of Estimate (A_6). We use the expression given as follows:

$$S_{yx} = \frac{\sqrt{\Sigma\left(y - y^1\right)^2}}{n-2}$$

$$= \frac{\sqrt{679{,}178{,}719.9}}{19}$$

$$= \frac{26{,}061.06}{19}$$

$$= 1371.63$$
$$= \pm 1371.63\ \Omega m$$

or Syx
(13)

Discussion
The result of the analysis for VES A_1 indicates that the standard error of estimate is ± 15.18 Ωm; an error of ± 15.18Ωm means that the simple regression model provides an adequate avenue for determining the corresponding values of resistivities for a given value of AB/2; this error is really insignificant at AB/2 ≥ 60m. For VES point A_2, the standard error of estimate is ± 9.86 Ωm; the error for A_2, would seem to be insignificant at a much shallower depth (circa AB/2 = 6m, second segment) than for A_1. Herein, the regression model is in stronger agreement with the field data. The standard error of estimate for VES point A_3 is determined to be ± 10.8 Ωm; from Table 6, it is seen that the error in really insignificant at AB/2 ≥ 50m.

It is observed that for VES point A_4, the error of estimate has gone up significantly to ± 81.99 Ωm. Suffice to point out once again that the VES soundings A_1 to A_6 were done on an approximately straight course in a south-easterly direction, and each VES point is 10m apart from the next. Why the discrepancy? We refer to Table 7. Whereas in Tables 4, 5 and 6, the resistivity is observed to be a smoothly varying function of depth, in Table 7 this same argument cannot be made for the resistivity values occurring between AB/2 = 15m – 40m, and AB/2 = 60m – 80m. Actually, there is a huge spike or jump in value of the resistivity at AB/2 = 30m and at AB/2 = 80m (first segment); each of these occurrences appear to be out of norm. The result of the analysis of VES point A_5 indicates that the standard error of estimate is ± 243.25 Ωm; this result can be explained away by noting that in Table 8, AB/2 = 30 – 40m are characterised by very large fluctuation in resistivity values. From Table 9, it is observed that AB/2 = 6m, 8m, and 10m are characterised by very large fluctuation in resistivity values, this is also true for AB/2 = 30m – 100m. It is no surprise, therefore, that the standard error of estimate is ± 1371.63 Ωm.

Resistivity Values of Rock Types
The resistivity values of various rock types in the Basement Complex of Nigeria (the area of study is part of the BCN) are presented in Table 10.

Table 10: Resistivity Values of Rock Types (After Udensi et al, 2006)

Rock Type	Resistivity (Ωm)
Fadama loam	30 – 90
Sandy clay and sandy silt	100 – 200
Sand and gravel laterite	150 – 1000
Weathered laterite	150 – 900
Fresh laterite	900 – 3500
Weathered basement	20 – 200
Fractured basement	500 – 1000
Fresh basement	> 1000

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An inspection of Table 4 for VES point A_1 would indicate that, beginning from a depth of AB/2 ≡ 1m below the surface and down through to AB/2 ≡ 100m below the surface, the rock types are mainly of the fadama loam, clayey, sandy silt, lateritic and weathered basement kinds. The value of resistivities for VES A_1 is a representation of the classic "soil profile" type of classification. The very topsoil material that can be identified in Table 5 is the sandy clay and sandy silt type followed by the fadama loam type, the laterites, and weathered basement. The various rock types for VES points A_1 and A_2 can be correlated at roughly the same depth in Tablea 4 and 5. As in Table 5, the topmost material identified at VES A_3 is the sandy clay and sandy silt (as seen from Table 6); there follows a deep sequence of fadama loam type, followed by laterites and weathered basement types. There is a correlation of rock types for VES A_1 through A_2 and A_3. Table 7 (for VES point A_4) indicates fadama loam material up to the 20m depth with a showing of sandy clay and silt at the 15m depth; however, there is the presence of a lateritic or fractured basement material at the 30m depth and at the 70m depth. At the 80m depth is a material that correlates strongly with fresh basement. Beyond this depth to the 100m depth are possible lateritic or weathered basement materials. The sandy clay and sandy silt material is seen again as the topsoil of VES point A_5 (Table 8) before switching nature to fadama loam. At the 40m depth, there is the "sudden appearance" of a material that is definitely fresh basement. The rock types beyond this depth correlate strongly with lateritic and fresh basement types. The fresh basement material is encountered at an even shallower depth at VES A_6 (Table 9) i.e. at the 8m depth point; subsequent occurrences are at the 40m, 70m, 80m, and 90m depth points. Other depth points are characterized by the fadama loam, sandy clay, sandy silt, lateritic, fractured basement, and weathered basement types.

Aquiferous Prospects

It has been reported that the aquifer system in the Basement complex consists of weathered and fractured basement rocks (Salako and Udensi; 2005; Udensi et al, 2006). Further, where the fractured zones are saturated, relatively high yield of groundwater can be sustained from borehole penetrating such a sequence. Further, Salako and Udensi (2005) pointed out that a minimum overburden thickness of 15m over the weathered and fractured basement would suffice to form an aquifer. In the original work of Udensi et al (2006), VES point, A_3 – A_5 were identified as locations that are characterised by ground water potentials.

Information from Borehole Logs on Depth to Basement in the Study Area

It has been pointed out earlier that, after due analysis by the Zohdy interpretation software, the depth to basement along the profile of the study area is between 26.82m and 36.79m (with a mean value of 31.81m). Furthermore, the study area is just about centrally located in the middle of a large swath of land where information on lithology and depths to basement are readily available from six wells drilled as part of the Petroleum Trust Fund (PTF) – sponsored projects (Jimoh, 1998). In the drilling-for-water report of Jimoh (1998), the well around the School of Environmental Technology (S.E.T.) encountered the basement at about 31m. The well around the Students' Centre (now Temporary Administration Complex) encountered the basement at 34m, while the well around the Students' Hostel indicated a depth of 37m to the basement. Furthermore, the wells drilled

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around the Staff Quarters, the planned Administration Complex, and Library Complex encountered the basement at depths of 37m, 34m, and 31m. Thus, it means that the six boreholes encountered the fresh basement at an average depth of 34m, which correlates strong with the result of the Zohdy interpretation. Geological information from Jimoh (1998) indicates that a depth range of 31-34m is beyond the water- bearing zones characterised by weathered and fractured basement rocks. Thus, as the search for water goes, it is inappropriate to explore beyond 34m in the core area of study and in the outlying vicinity that could well stretch for over 2km x 2km. If this is the case, then the simple regression model could be tested for a maximum depth of AB/2 = 40m instead of the limit of AB/2 = 100m that was used in the analysis of Tables 4 to 9.

Further Analytical Procedure (i.e. Limit = AB/2 = 40m)

Table 11 is a table of values for AB/2 and A_1 down to a depth of AB/2 = 40m.

Table 11: Table of Values for AB/2(x) and A_1 (y) down to 40m

X	Y	x^2	y^2	xy	$y - \bar{y}$	$(y - \bar{y})^2$	y^1	$y - y^1$	$(y - y^1)^2$
1	73.49	1	5400.78	73.49	-5.16	26.63	73.88	-0.39	0.15
2	33.51	4	1122.92	67.02	-45.14	2037.62	73.97	-40.46	1,637.01
3	216.28	9	46,777.04	648.84	137.63	18,942.02	74.36	141.92	20,141.29
5	27.07	25	732.78	135.35	-51.58	2,660.50	75.14	-48.07	2,310.72
6	147.84	36	21,856.67	887.04	69.19	4,787.26	75.53	72.31	5,228.74
6	12.54	36	157.25	75.24	-66.11	4,370.53	75.53	-62.99	3967.74
8	56.3	64	3161.81	449.84	-22.42	502.66	76.31	-20.08	403.21
10	39.78	100	1582.45	397.80	-38.87	1510.88	77.09	-37.31	1,392.04
10	4918	100	2418.67	391.80	-29.47	868.48	77.09	-27.91	778.97
15	80.83	225	6533.49	1212.45	2.18	4.75	79.04	1.79	3.20
20	81.10	400	6577.21	1622.00	2.45	6.00	80.99	0.11	0.012
30	106.22	900	11,282.69	3186.60	27.57	760.10	84.89	21.23	450.71
40	10.01	1600	100.20	400.40	-68.64	4711.45	88.79	-78.78	6,206.29
40	166.99	1600	27,885.66	6679.60	88.34	7803.96	88.79	78.20	6,115.24
Σ = 196	Σ = 1101.07	Σ = 5100	Σ = 135,589.62	Σ = 16,327.47		Σ = 48,992.84			Σ = 48,635.32

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The mean values of x and y, as determined from Table [illegible] are $\bar{x}$ = [illegible] and $\bar{y}$ = 78.65. Further, a = [illegible] and b = [illegible].
The Standard Error of Estimate [illegible] the expression given as follows:

$$S_{yx} = \sqrt{\frac{\sum (y - y')^2}{n-2}}$$

$$= \sqrt{\frac{48{,}635.32}{12}}$$

$$= 18.38$$

$$\text{or } S_{yx} = \pm 18.38\,\Omega m \qquad (14)$$

Tables 12 to 16 are tables of values for AB/2 and A_2 to A_6 down to the 40m depth. For each of the tables, the error of estimate is determined.

Table 12: Table of Values for [illegible](x) and $A_2(y)$ down to 40m

X	y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y'	y − y'	$(y-y')^2$
1	170.49	1	29,066.84	170.49	67.27	4525.25	75.40	95.09	9042.11
2	71.98	4	5181.12	143.96	-31.24	975.94	77.54	-5.56	30.91
3	35.86	9	1285.94	107.58	-67.36	4537.37	79.68	-43.82	1920.19
5	50.57	25	2557.32	252.85	-52.65	2772.02	83.96	-33.39	1114.89
6	147.84	36	21,856.67	887.04	44.62	1990.94	86.10	61.74	3811.83
6	86.35	36	7456.32	518.10	-16.87	284.60	86.10	0.25	0.0625
8	79.20	64	6272.64	633.60	-24.02	576.96	90.38	-11.18	124.99
10	82.06	100	6733.84	820.60	-21.16	447.75	94.66	-12.6	158.79
10	59.16	100	3499.91	591.60	-44.06	1741.28	94.66	-35.5	1260.25
15	86.72	225	7520.36	1300.80	-16.5	272.25	105.35	-18.63	347.08
20	95.31	400	9084.00	1906.20	-7.91	62.57	11116.06	-20.75	430.56
30	124.76	900	15,565.06	3742.80	21.54	463.97	137.46	-12.7	161.29
40	177.18	1600	31,392.75	7087.20	73.96	5470.08	158.86	18.32	335.62
40	177.65	1600	31,559.5	7106.00	74.43	5539.82	158.86	18.79	353.06
Σ = 196	Σ = 1445.13	Σ = 5100	Σ = 179,032.29	Σ = 25,268.82		Σ = 29,860.80			Σ = 19,091.60

The mean values of x and y, as determined from Table 12, are: $\bar{x} = 14$; $\bar{y} = 103.22$. Further, a = 73.26 and b = 2.14.

The Standard Error of Estimate (A_2). We use the expression given as follows:

$$Syx = \sqrt{\frac{\Sigma\left(y - y^1\right)^2}{n-2}} = \sqrt{\frac{19{,}091.6}{12}} = 11.51$$

$$\text{or } Syx = \pm 11.51\,\Omega m \qquad (15)$$

Table 13: Table of Values for AB/2 (x) and A_3 (y) down to 40m

X	y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
1	156.87	1	24,608.20	156.87	85.69	7342.78	70.15	86.72	7520.36
2	89.92	4	8085.61	179.84	18.74	351.19	70.23	19.69	387.70
3	62.83	9	3947.61	188.49	-8.53	69.72	70.31	-7.48	55.95
5	97.25	25	9457.56	486.25	26.07	679.64	70.47	26.78	717.17
6	47.94	36	2298.24	287.14	-23.24	540.10	70.54	-22.60	510.76
6	38.01	36	1444.76	228.06	-33.17	1100.25	70.54	-32.53	1058.20
8	54.55	64	2975.70	436.40	-16.63	276.56	70.70	-16.15	260.82
10	22.46	100	504.45	224.60	-48.72	2373.64	70.86	-48.40	2342.56
10	125.28	100	15,695.08	1252.80	54.10	2926.81	70.86	54.42	2961.54
15	22.19	225	492.40	332.85	-48.99	2400.02	71.26	-49.07	2407.86
20	11.27	400	127.01	225.40	-59.91	3589.21	71.65	-60.38	[illegible]
30	57.89	900	3351.25	1736.70	-13.29	176.62	72.44	-14.55	211.70
40	42.04	1600	1767.36	1681.60	-29.14	849.14	73.23	-31.19	972.82
40	167.96	1600	28,210.56	6718.40	96.78	9366.37	[illegible]	94.73	[illegible]
$\Sigma = 196$	$\Sigma = 996.46$	$\Sigma = 5100$	$\Sigma = 102,965.79$	$\Sigma = 14,135.90$		$\Sigma = 32,042.05$			$\Sigma = 32,026.95$

The Standard Error of Error of Estimate (A_3). We use the expression given as follows:

$$Syx = \sqrt{\frac{\Sigma(y-y^1)^2}{n-2}}$$

$$= \sqrt{\frac{32,026.95}{12}}$$

$$= \frac{178.96}{12} = 14.91$$

$$\text{or } Syx = \pm 14.91\,\Omega m$$

Table 14. Table of Values for AB/2 (x) and A_4 (y) [illegible]

X	y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
1	12.98	1	168.48	12.98	-64.2[illegible]	4133.20	19.55	-6.57	43.16
2	16.17	4	261.47	32.34	-61.10	3733.21	23.99	-7.82	61.15
3	18.35	9	336.72	55.05	-58.92	3471.57	28.43	-10.08	101.61
5	27.23	25	741.47	136.15	-50.0.4	2504.00	37.31	-10.08	101.61
6	22.62	36	511.66	135.72	-54.65	2986.62	41.75	-19.13	365.96
6	72.05	36	5191.20	432.30	-5.22	27.25	41.75	30.3	918.09
8	39.11	64	1529.59	312.88	-38.16	1456.19	50.63	-11.52	132.71
10	5.14	100	26.42	51.40	-72.13	5202.74	59.51	-54.37	2956.10
10	7.48	100	55.95	74.80	-69.79	4870.64	59.51	-52.03	2707.12
15	132.07	225	17,442.48	1981.05	-54.80	3003.04	81.71	50.36	2536.13
20	63.46	400	4027.17	1269.20	-13.81	190.72	103.91	-40.45	1636.20
30	549.07	900	301,477.86	16,472.10	471.80	222,595.24	148.31	400.76	160.608.58
40	83.08	1600	6902.29	3323.20	5.81	33.76	192.71	-109.63	12,018.74
40	32.95	1600	1085.70	1318.00	-44.32	192.71	192.71	-159.76	25.523.26
Σ = 196	Σ = 1081.76	Σ = 5100	Σ = 339,758.46	Σ = 25,607.17		Σ = 246,172.44			Σ = 209,710.42

The Standard Error of Estimate (A_4). We use the expression given as follows:

$$Syx = \sqrt{\Sigma\frac{(y-y^1)^2}{n-2}}$$

$$= \sqrt{\frac{209,710.42}{12}}$$

$$= 38.16$$

$$\text{or } Syx = \pm 38.16\Omega m \qquad (17)$$

Table 15: Table of Values for AB/2(x) and A_5 (y) down to 40m

x	y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
1	148.47	1	22,043.34	148.47	-247.93	61,469.28	-295.33	443.80	196,958.44
2	10.74	4	115.35	21.48	-385.66	148,733.64	-242.12	252.86	63,938.18
3	31.69	9	1004.26	95.07	-364.71	133,013.38	-188.91	220.60	48,661.36
5	31.43	25	987.84	157.15	-364.97	133,203.10	-82.49	113.92	12,977.77
6	13.66	36	186.06	81.96	-382.74	146,489.91	-65.28	78.94	6231.52
6	36.19	36	1309.72	217.14	-360.21	129,751.24	-65.28	101.47	10,296.16
8	54.45	64	2964.80	435.60	-341.95	116,929.80	77.14	-22.96	514.81
10	132.29	100	17,500.64	1322.90	-264.11	69754.09	183.56	-51.27	2628.61
10	29.81	100	888.64	298.10	-366.59	134,388.23	183.56	-153.75	23,639.06
15	37.68	225	1419.78	565.20	-358.72	128,680.04	449.61	-411.61	169,686.32
20	45.08	400	2032.21	901.60	-351.32	123,425.74	715.66	-670.58	449,677.54
30	30.19	900	911.44	905.70	-366.21	134,109,76	1247.76	-11217.57	1,482,176.71
40	4844.84	1600	23,472,474.63	193,793.60	4448.44	19,788,618.43	1779.86	3064.98	9,394,102.49
40	103.04	1600	10,617.24	4121.60	-293.36	86,060.09	1779.86	1676.82	2,811,725.41
Σ = 196	Σ = 5549.56	Σ = 5100	Σ = 23,534,456.49	Σ = 203,065.57		Σ = 21,331,626.73			[illegible]

The Standard Error of Estimate (A_5). We use the expression given as follows:

$$Syx = \sqrt{\frac{\Sigma\left(y-y^1\right)^2}{n-2}}$$

$$= \sqrt{\frac{14,673,517.22}{12}} = \frac{3830.60}{12} = 319.22 \quad (18)$$

or $Syx = \pm\ 319.22\ \Omega m$

Table 16: Table of … B/2 (x) and A_6 (y) … 40m

x	y	x^2	y^2	xy	$y-\bar{y}$	$(y-\bar{y})^2$	y^1	$y-y^1$	$(y-y^1)^2$
[illegible]	114.39		13,085.07	114.39	-865.68	749,401.86	251.29	[illegible]	18,741.61
[illegible]	13063	1	17,064.2	261.26	-849.44	721,548.31	307.35	-176.72	31,229.96
3	27.80	9	772.84	83.40	-952.27	906,818.15	363.41	-335.61	112,634.07
5	85.58	25	7323.94	427.90	-894.49	800,112.36	475.53	-389.95	152,061.00
6	74.26	36	5514.55	445.56	-905.81	820,491.76	531.59	-457.33	209,150.73
6	898.70	36	807,661.69	5392.20	-81.37	6621.08	531.59	367.11	134,769.75
8	4542.12	64	20,630,854.09	36,336.96	3562.05	12688,200.20	643.71	3898.41	15,197,600.53
10	696.64	100	479,750.17	6,926.40	-287.43	82,616.00	755.83	-63.19	3992.98
10	62.64	100	3923.77	626.40	-917.43	841,677.80	755.83	-693.19	480,512.38
15	152.07	225	23,125.28	2,281.05	-828.00	685,584.00	1036.13	-884.06	480.512.08
20	213.15	400	45,432.92	4263.00	-766.92	588,166.29	1316.43	-1103.28	1,217,226.76
30	205.69	900	42,308.38	6,170.70	-774.38	599,664.38	1877.03	-1671.34	2,793,377.40
40	4744.74	1600	22,512,557.67	189,789.60	3764.67	14,172,740.21	2437.63	2307.13	5,322,756.55
40	1776.50	1600	3,155,952.25	71,060.00	796.43	634,300.74	2437.63	-661.13	437,092.88
Σ = 196	Σ = 13,720.91	Σ = 5100	Σ = 47,745,326.82	Σ = 324,178.82		Σ = 34,297,943.14			Σ = 26,892,708.68

The Standard Error of Estimate (A_6): We use the expression given as follows:

$$Syx = \sqrt{\frac{\Sigma\left(y - y^1\right)^2}{n-2}}$$

$$= \sqrt{\frac{26,892,708.68}{12}} = \frac{5185.82}{12} = 432.15$$

$$\text{or } Syx = \pm\ 432.15\ \Omega m \qquad (19)$$

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ISSN 0748-4710

Now, the standard error of estimate for VES point A_1 down to a relatively shallower depth of 40m has increased slightly from ±15.18Ωm to ±18.38Ωm; this error appears to be a tolerable value for the relevant section of the resistivity profile (i.e. for AB/2 ≥15m). The standard error of estimate has also increased for VES point A_2 from ±9.86Ωm to ±11.51Ωm, not appreciably though; this error could really be tolerated for the whole of the spread of resistivity profile from AB/2 = 1m to AB/2 =40m. VES point A_3 is also characterized by a not too significant increase in the value of the standard error of estimate from ±10.8Ωm to ±14.91Ωm, which obviously, is not a very large departure from the observable trend.

For VES point A_4 the standard error of estimate has decreased markedly from ± 81.99 Ωm to 38.16Ωm for resistivity values down to the 40m depth. This reduction or decrease in error value can be explained away by remarking that in Table 7, at the 80m depth, fresh basement material was encountered while in Table 14 the material of highest resistivity (circa 550Ωm, possibly lateritic or fractured basement material) was encountered at the 30m depth point. The relatively high error value of ± 38.16Ωm for VES A_4 compared to ±18.38Ωm, ±11.51Ωm and ±14.91Ωm for VES points A_1, A_2, A_3, could be explained by the presence of the material at the 30m depth point. The standard error of estimate for VES point A_5 increased from ±243.25Ωm to ±319.22Ωm; the increment from ±243.25Ωm to ±319.22Ωm is very significant. The "culprit" in this case is the very high resistive material (4844.84Ωm, obviously fresh basement) at the 40Ωm depth point. When the resistivity data were considered down to the 100m depth, the low resistivity values for AB/2 ≥ 40m sort of "obscured" the effect of the 4844.84Ωm material but this was not the case when the greatest depth was 40m. This obviously explains the rise in value in the standard error of estimate. However, the standard error of estimate for VES point A_6 reduces from ±1371.63Ωm to ±432.15Ωm. In Table 16 (analysis down to 40m) only at depth points 8m, 40^1m, 40^2m are very high resistive materials encountered whereas in Table 9 (analysis down to 100m) very high resistive materials are encountered at the 70m, 80^1m, 80^2m and 90m also. This obviously explains the fall in value in the standard error of estimate.

Conclusion

On application of the regression analysis method to the dataset of the six VES points (i.e. A_1 – A_6) it is seen that the values of the standard error of estimate are within tolerable limit for analyses at both the 100m and 40m depth points. However, for VES point A_4, because the spike in error value for analysis at the 100m depth point was due to the material at the 80m depth and since this was not taken into account for the analysis at the 40m depth, the error is just tolerable at the relevant section of the resistivity profile (i.e. AB ≥15m). Thus, whilst the error value is tolerable for VES points A_1 – A_3 at both the 40m and 80m depth points, it is just tolerable for VES A_4 at the relevant section for analysis down to the 40m depth only. The error values are too large to be considered tolerable for VES points A_5 and A_6 because of the presence of very resistive materials at relatively shallow depths. Nonetheless, since the regression model is in strong agreement with the field dataset for VES A_1 – A_4 we have about 67% correlations for profile A.

Thus between VES points A_1 and A_6 (which is 500m in extent) with about 100m spacing between adjacent VES points, intermediate VES points (say 50m spacing)

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ISSN 0748-4710

could be sounded with saving in time and cost. Now, instead of fourteen sounding sequences that are concerned with depth to basement, just the first six sequences could be sounded and the remaining dataset can be extrapolated to AB/2 = 40m. Sounding VES points at 5m spacing implies detailed subsurface survey that would enable better mapping of the trend of underground water reservoirs. With this correlative analyses, it is recommended that the field resistivity dataset for profiles B - K be subjected to the regression analysis. Where there are high correlations, intermediate VES points could be sounded at shallow depths, interpolated, and the resulting data integrated with the existing field dataset. The new dataset can now be interpreted in the usual manner. By this means the trend of the subsurface aquifers in the study area can be properly delineated.

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