Journal of Sustainable Development; Vol. 5, No. 7; 2012
ISSN 1913-9063 E-ISSN 1913-9071
Published by Canadian Center of Science and Education

Geoelectric Sounding for Evaluating Soil Corrosivity and the Vulnerability of Porous Media Aquifers in Parts of the Chad Basin Fadama Floodplain, Northeastern Nigeria

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Received: April 5, 2012 Accepted: June 15, 2012 Online Published: June 26, 2012

doi:10.5539/jsd.v5n7p111 URL: http://dx.doi.org/10.5539/jsd.v5n7p111

Abstract

A geoelectrical survey was carried out in parts of the Chad Basin Fadama Floodplain as a means of evaluating both the soil corrosivity and protective capacity. One hundred and six Schlumberger Vertical Electrical Sounding data were collected at the corners of a 225 x 225 m square grid network. Topsoil resistivity and topsoil longitudinal unit conductance maps were generated from the first and second order geoelectric parameters respectively. Areas considered as high corrosivity are the north central, southwestern, southern and northern parts with (ρ< 180 Ω-m). Part of the study area characterized by materials of poor to weak protective capacity has longitudinal conductance values of less than 0.1 and (0.1 - 0.19) mhos respectively. Values between (0.2 - 0.79 mhos - sandy clay cover) and (0.8 - 4.9 mhos - clay cover) correspond to moderate and good protective capacity respectively. It can thus be concluded that the flanks of the floodplain underlain by appreciable clayey topsoil thickness columns are susceptible to corrosion tendency. These same flanks are characterized by materials of moderate to good protective capacity and serve as sealing potential for the underlying hydrogeological system in the area.

Keywords: geoelectrical, survey, floodplain, corrosivity, protective, capacity, vulnerability, sealing

1. Introduction

Underground storage tanks for petroleum products, septic tanks, agricultural activities, municipal landfills, military installations, nuclear sites, waste infiltration systems and abandoned hazardous waste sites are generally considered major threats to groundwater/hydrogeologic system or porous media aquifers (Mohammed, 2007).

Fadamas floodplain is part of the wetland regions of the West Chad Basin located between Azare and Jama'are towns, northeastern Nigeria. In recent times, efforts by the Federal government and other governmental agencies in areas of water supply and crop production have led to improvement of the lives of the people around the area through farming and animal husbandry. Agricultural activities in many parts of the area may portend serious environmental/hydrogeological threats, particularly in respect of the accessibility of porous/alluvial sand water table aquifers to pollution. The vulnerability of these aquifers to pollution may be considerably high as the continuous and extensive use of chemical fertilizers/pesticides, the drainage or wash off of animal solid wastes disposal from nomadic grazing activities, and flood activities remained. Man's activities ranging from land fill solid wastes disposal to liquid wastes disposal etc. may also remain a contributory factor.

However, contamination of the hydrogeologic system in most porous media areas is a common global feature (Oladapo et al., 2004; Mohammed, 2007). The World Health Organization estimated that more than 20% of the world population (around 1.3 billion people) has no safe drinking water and that more than 40% of all population lack adequate sanitation (Oastridge & Trent, 1999). Many developing countries are still faced with difficult choices as they find themselves caught between finite and increasing polluted water supplies on one hand and rapidly rising demand from urbanization on the other hand (Forum Umwelt & Entwickling, 2001). The need then arises to assess the protective capacity of the superficial materials (topsoil overlying the alluvium aquifer) of aquifer to enable the evaluation of the level of protection of the hydrogeological systems against surface sourced pollution. Also, the degree of soil corrosivity may be evaluated should metal pipes be required for reticulation works in the groundwater development within the area.

Geoelectrical resistivity method has been adopted for this study since it is one of the most effective geophysical tools for groundwater and environmental investigations. The superiority of the method over other methods is confirmed in the work of Zohdy (1973); Zohdy, Eaton and Mabey (1974); Ako and Olorunfemi (1989); Mbonu, Ebeniro, Ofoegbu and Ekine (1991); Olayinka and Olorunfemi (1992); Olorunfemi and Fasuyi (1993); Mohammed (2007).

2. Description of the Study Environment

2.1 Location and Areal Extent

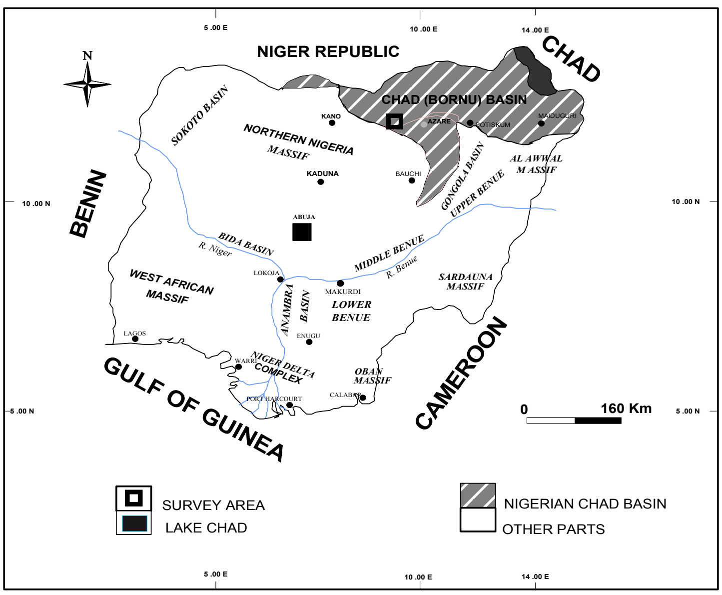
The study area is the River Jama'are floodplain in the West Chad Basin. It is situated on the northern side of the Azare – Jama'are highway, about 30 km West of Azare town in Katagum Local Government Area of Bauchi-State (Figure1). It is confined within longitudes 9°56'30"E and 9°58'00"E and latitudes 11°39'15"N and 11°41'15"N (FSN, 1978) which approximate eastings and northings of 602631.843 mE and 605356.818 mE and 1288367.009 mN and 1292062.197 mN of the Universal Traverse Mercator (UTM) Mina Zone 31 coordinates respectively.

The study area covers an areal extent of about 4.53 Kilometers square and situated on approximately flat terrain with average surface elevation of about 370 m above sea level. A local topographic high exist as the northern edge of the area at Yola settlement. This makes the entire area vulnerable to periodic flooding at the peak of rainy season.

2.2 Geology and Hydrogeology

The study area is underlain by Cretaceous-Tertiary Chad Formation and Recent alluvial Formation of Pleistocene age. The two formations directly rest on the basement bedrock rock (Figure 2). However, rocky hills and inselbergs of the basement rock occur around Geidam, Gumel and Shira, about 30 km southwest of the study area. This suggests that the study area is located within a transitional sedimentary/basement terrain. The major geological features in the area include approximately NW-SE trending geophysically identified suspected deeply buried regional parallel faults/fractured zones in the basement bedrock.

The alluvium deposits with the flood plain consist of silts, clays, and sands, while the Chad Formation is composed of Quaternary sediments of lacustrine origin (Carter et al., 1963). The basis of gravels constitute the main aquifer with which the silts clays the aquitard (GSN, 1978; BSADP, 1988; Matheis, 1989; Offodile, 1992, 2002).



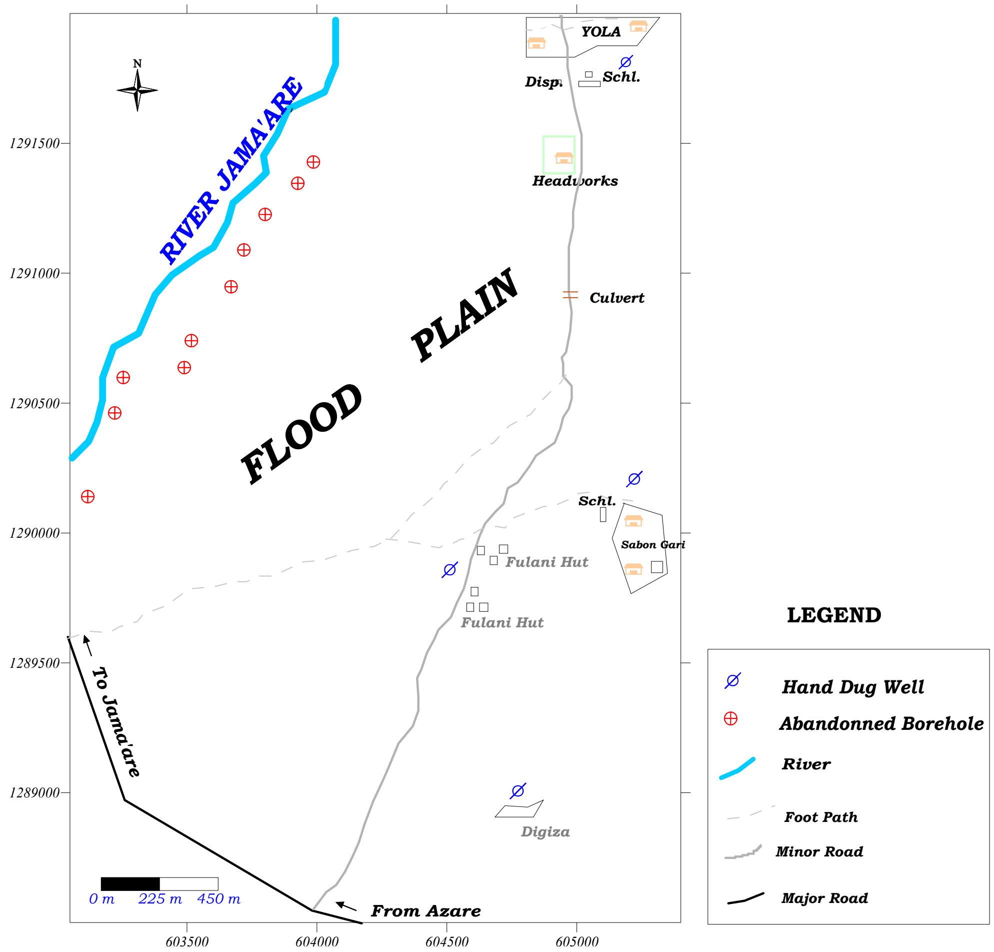


Figure 1. Map of the study area showing the floodplain of River Jama'are

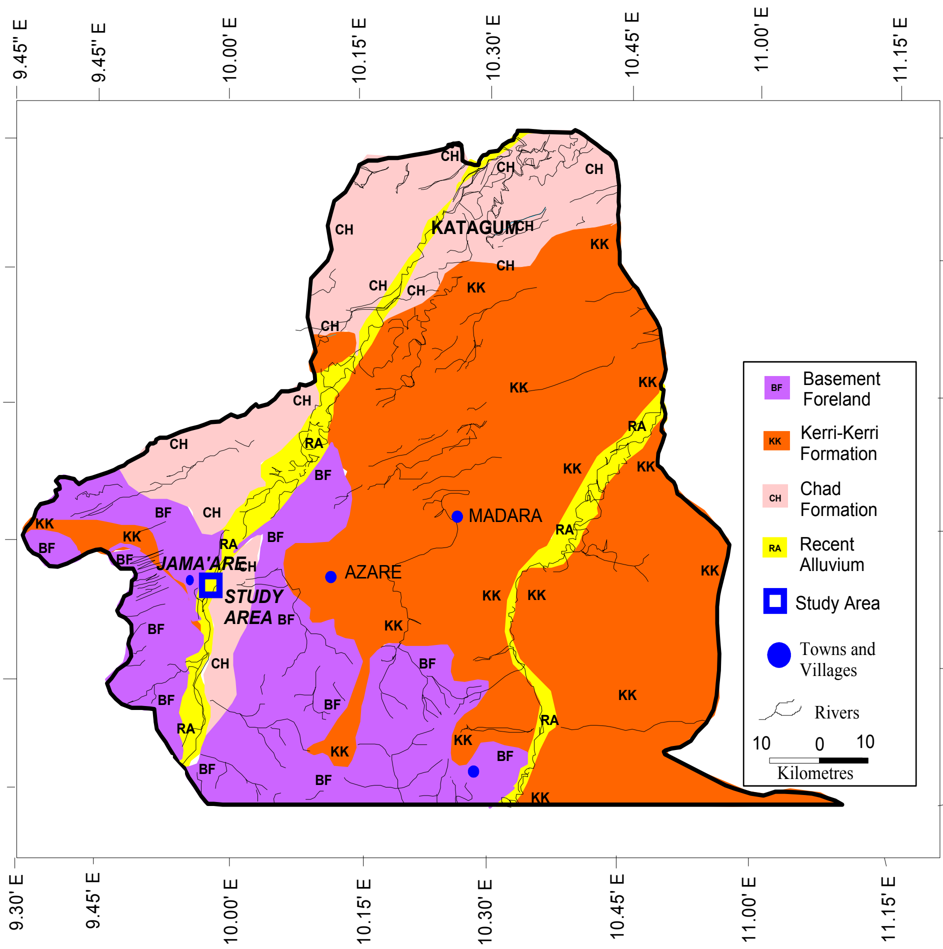


Figure 2. Geological/Hydrogeological map of the Northern Bauchi State showing the study area

3. Materials and Method of Study

3.1 Data Collection Techniques

Apparent resistivity data were collected at One hundred and six stations (Figure 3) by the use of the Schlumberger Vertical Electrical Sounding (VES) technique. The inter-electrode spacing (AB/2) of the array used was varied from 1-225 m with a maximum spread length of 450 m. The PASI 16 Digital Resistivity Meter was used for the data collection.

3.2 Data Processing/Interpretation Techniques

The quantitative interpretation of the sounding data involved partial curve matching and computer aided interpretation techniques. The VES interpretation results (layer resistivities and thicknesses) were later used to derive the second order geoelectric - the so-called Dar Zarrouk parameters (Maillet, 1947; Henriet, 1976, Niwas & Singhai, 1981; Oladapo et al., 2004). These parameters include the Longitudinal Unit Conductance (S_λ), Transverse Unit Resistance (T_λ), Longitudinal Resistivity (ρ_L), Transverse Resistivity (ρ_t) and Coefficient of Anisotropy (λ) (Zohdy et al., 1974).

For n parallel layers of resistivities ρ_i, ,……… ρ_n, and thicknesses $h_{i,}$ ……… h_n as shown in a typical geoelectrical section (Figure 4).

The total longitudinal unit conductance (S) is defined as:

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

The total transverse unit resistance (T) is defined as:

$$T = \sum_{i=1}^{n} h_i \rho_i \tag{2}$$

The average longitudinal resistivity (ρ_L) is defined as:

$$\rho_L = \frac{H}{S} = \frac{\sum_{i=1}^{n} h_i}{\sum_{i=1}^{n} \frac{h_i}{\rho_i}} \tag{3}$$

The average transverse resistivity (ρ_t) is defined as:

$$\rho_t = \frac{T}{H} = \frac{\sum_{i=1}^{n} h_i \rho_i}{\sum_{i=1}^{n} h_i} \tag{4}$$

The coefficient of anisotropy (λ) is defined as:

$$\lambda = \sqrt{\frac{\rho_t}{\rho_L}} = \frac{\sqrt{TS}}{H} \tag{5}$$

The subscript i indicates the position of the layer in section.

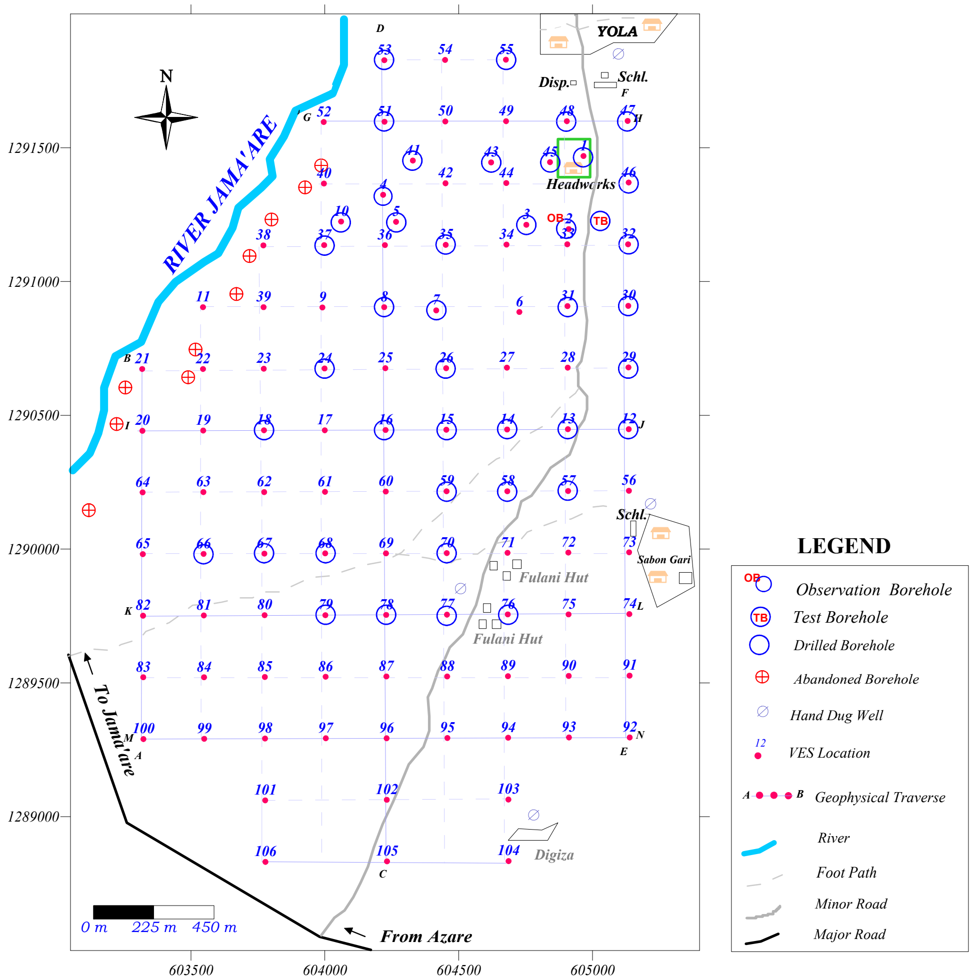
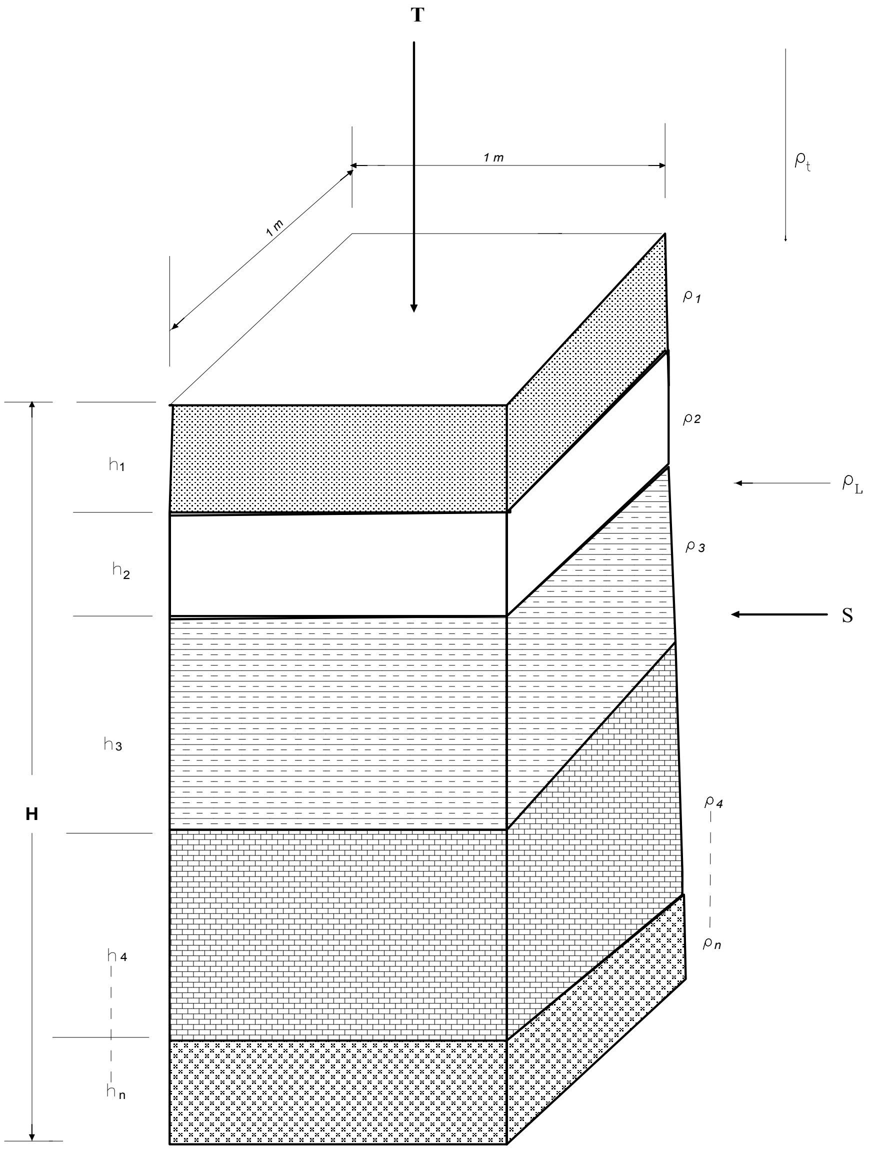


Figure 3. Data acquisition map showing VES stations, traverses and location of boreholes drilled and completed



n=Number of layer

ρ_n=Layer resistivity

h_n=Layer thickness

H=Total depth

S=Total longitudinal conductance

T=Total transverse resistance

ρ_L=Average longitudinal resistivity

ρ_t=Average transverse resistivity

Figure 4. A typical geoelectrical section

4. Results and Discussion

4.1 Geoelectric Results

The results are presented as vertical electrical sounding curves displaying the geoelectric parameters (layer resistivities and thicknesses), corrosivity and longitudinal conductance maps.

The VES curves show a range of 4-geoelectric layers (KH, QH) to complex 5-geoelectric layers (HKH, KQH, QQH) and 6-geoelectric layers (QHKH and KHKH) (Figures 5a & b).

The topsoil resistivity shows values that range from 0-250 ohm–m with the higher frequency in the 0-250 ohm-m range. The mean is 325 ohm-m while the standard deviation is 892 ohm-m. This indicates a very high degree of dispersion with a coefficient of variation of 274.5%. This variation may be explained by the wide textural/compositional variation in the topsoil. Seasonal variations in the amount of available recharge and topographic elevation/depth of water table may have also affected the soil resistivity.

The topsoil resistivity values that are less than 100 ohm-m typify clay while high resistivity (ρ >100 ohm-m) may suggest sandy clay, clayey sand, sand, compact sand or lateritic column (Ako & Olorunfemi, 1989; Olayinka & Olorunfemi, 1992; Olorunfemi & Okhue, 1992; Omosuyi et al., 2003; Oladapo et al., 2004). Resistivity values in the range of (ρ>1000 ohm-m) white lateritic sand (hard pan) and sand observed at few places, particularly in the topographical high areas in the northern and western edges of the site. The thickness of the topsoil ranges from 0.4 to 6.7 m, but is generally less than 3 m with the most frequently occurring values in the 1.0-2.0 m range.

4.2 Soil Corrosivity Evaluation

Soil resistivity values can be classified in term of soil corrosions as shown in Table 1.

The first layer resistivity values obtained from the interpretation results were utilized in generating corrosivity map (Figure 6). The map is used in the evaluation of the degree of soil corrosivity, at shallow depth, in the area, should metal pipes/buried utilities be required for reticulation works in the groundwater development and other engineering utilities.

The areas considered to be of high corrosivity are the north central, southwestern southern and northern parts of the area. These areas are characterized by relatively low resistivity values (ρ< 180 Ω-m). Areas with high resistivity values (>180 ohm-m) are precisely non corrosive. These areas include the eastern, part of the southern and western parts of the area. The eastern flank is particularly overlain by lateritic hardpan with relatively high resistivity values.

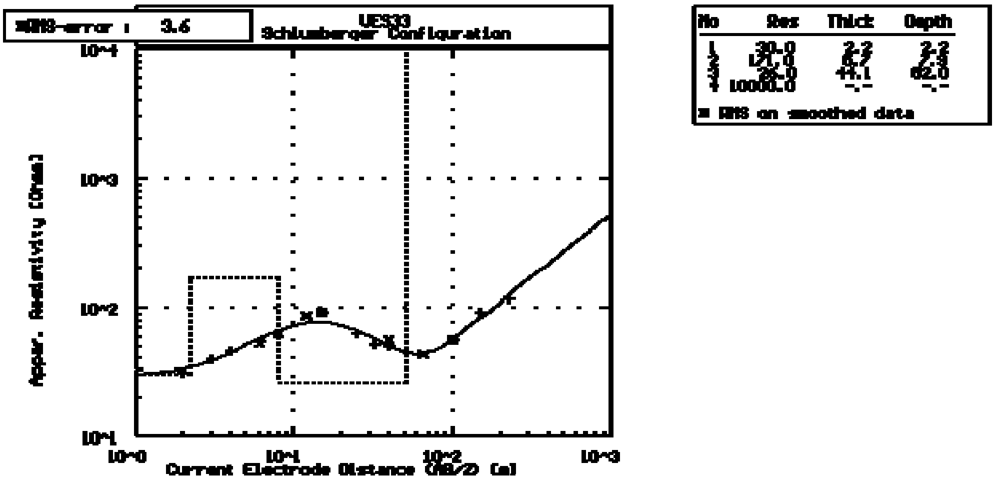
More than 60% of the study area displays a relatively low topsoil resistivity values with high tendency for corrosivity. Hence, metallic utilities/pipes etc buried within the areas with high degree of corrosivness are susceptible to corrosion.

4.3 Overburden Protective Capacity Evaluation

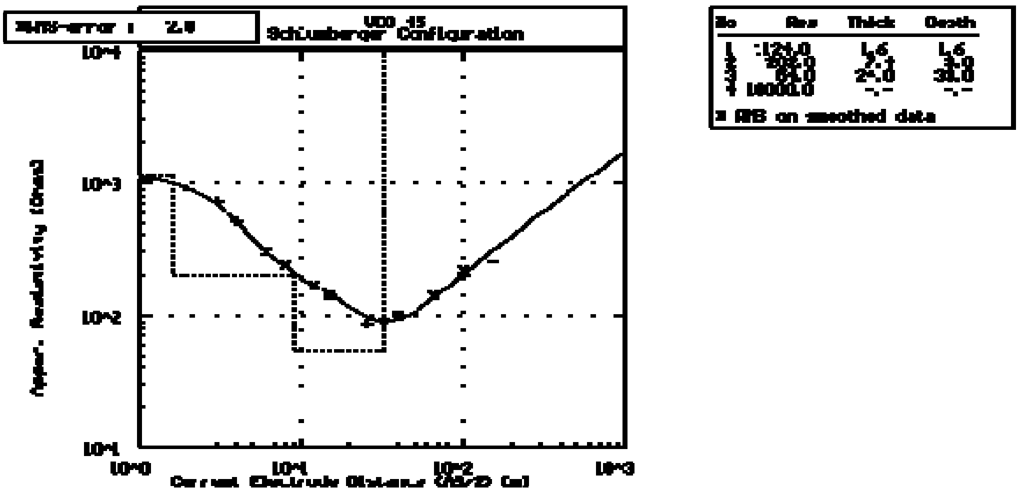
The ability of an earth medium to retard and filter percolating fluid is a measure of its protective capacity (Olorunfemi et al., 1999). Henriet (1976) described the protective capacity of an overburden exerted by retardation and filtration of percolating pollutants as being proportional to its thickness and inversely proportional to its hydraulic conductivity. Clayey material content is generally characterized by low permeability, low resistivity, low hydraulic conductivity and longitudinal unit conductance values. Hence the protective capacity can be considered as being proportional to the longitudinal conductance (S). That is, the higher the overburden longitudinal conductance of an area, the higher its protective capacity.

The modification of Henriet (1976) and Oladapo et al. (2004) classifications shown in Table 2 is adopted to suite the evaluation of the protective capacity of this basement/sedimentary transition environment. Figure 7 is the map of the longitudinal unit conductance (S) of the superficial materials (topsoil) constructed from the topsoil longitudinal unit conductance (s) values. The values vary between 0.00044 and 0.61 mhos. Values between 0.2 and 0.79 mhos typically correspond to moderate protective zones (sandy clay cover), such zones are distinguished as small pockets or closures found scattered within the map region, while pockets of blank found at the southeastern and northern ends typify good protective capacity (0.8 and 2.2 mhos) on the map. The remaining segments of the map constitute about 95 % of the total areal extent of the study area are characterized by materials of poor to weak protective capacity (< 0.1 and 0.1 - 0.19) mhos respectively. This area may be highly proned to pollution.

(KH)



(QH)



(QQH)

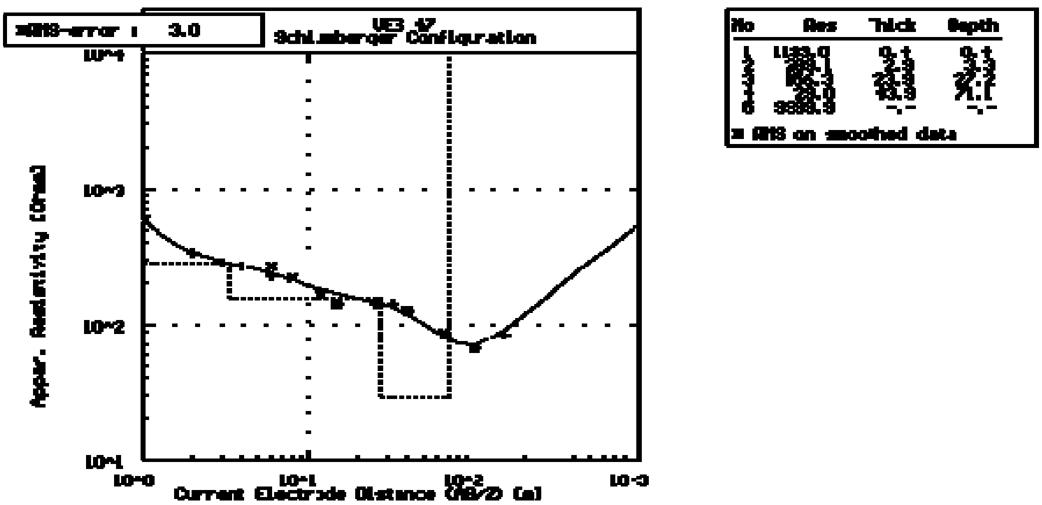
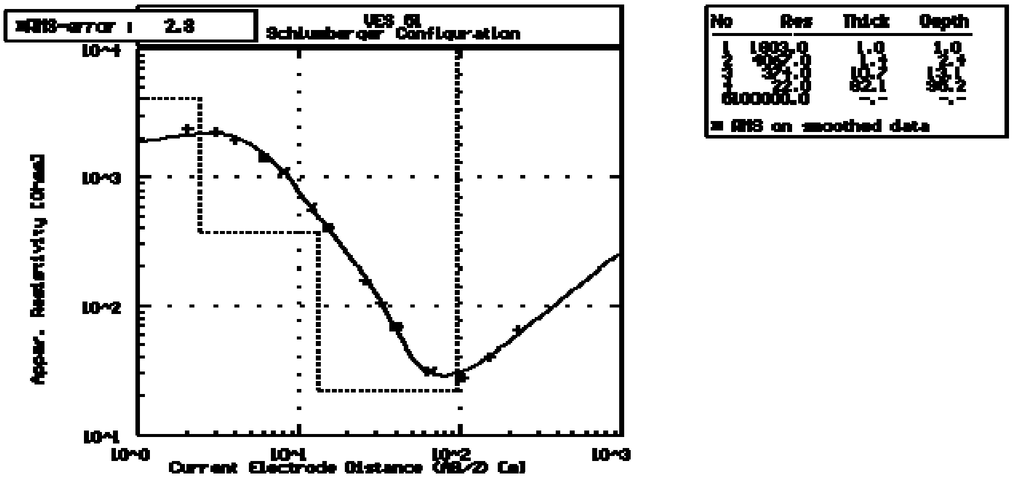
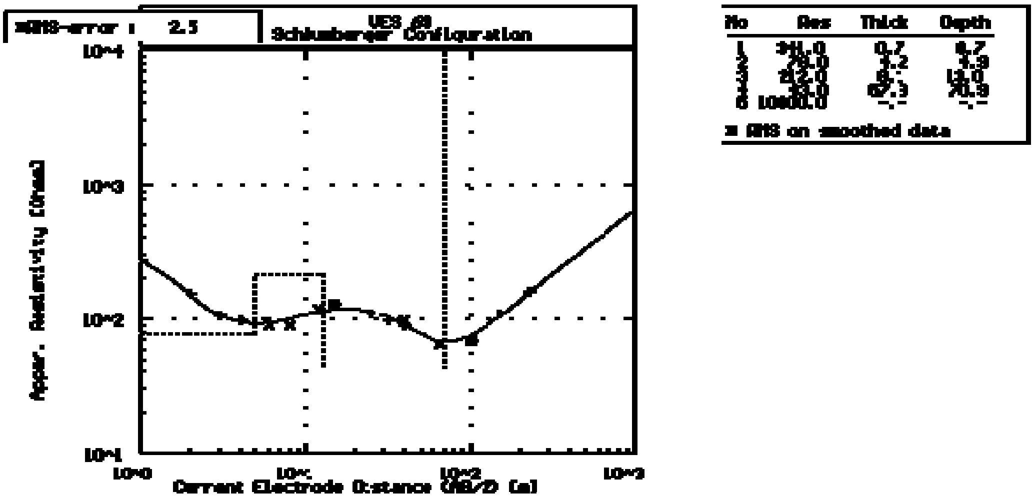


Figure 5 (a). Computer interpretation results and curve types

(KQH)



(HKH)



(KHKH)

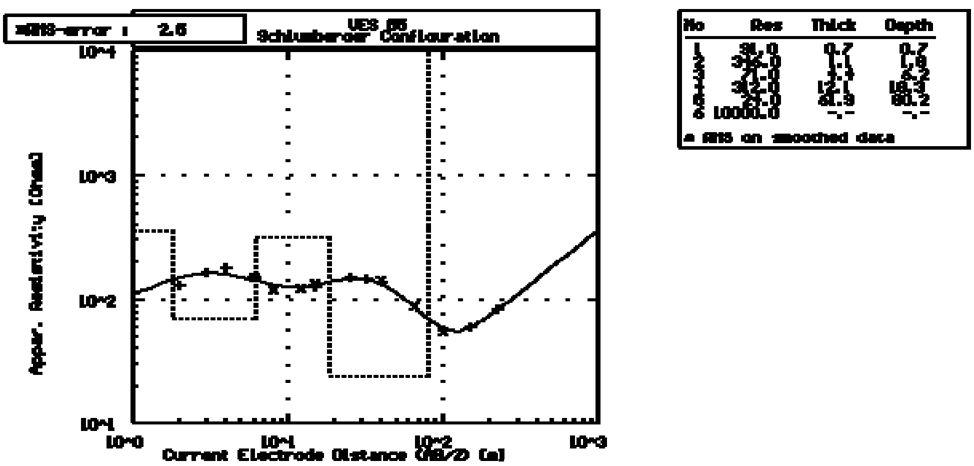


Figure 5 (b). Computer interpretation results and curve types

Table 1. Classification of soil resistivity in terms of corrosivity (based on Baeckmann & Schwenk, 1975; Agunloye, 1984; Oladapo et al., 2004)

Soil Resistivity (ohm-m)	Soil Corrosivity
Up to 10	Very Strongly Corrosive (VSC)
10 – 60	Moderately Corrosive (MC)
60 – 180	Slightly Corrosive (SC)
180 and above	Practically Non – Corrosive (PNC)

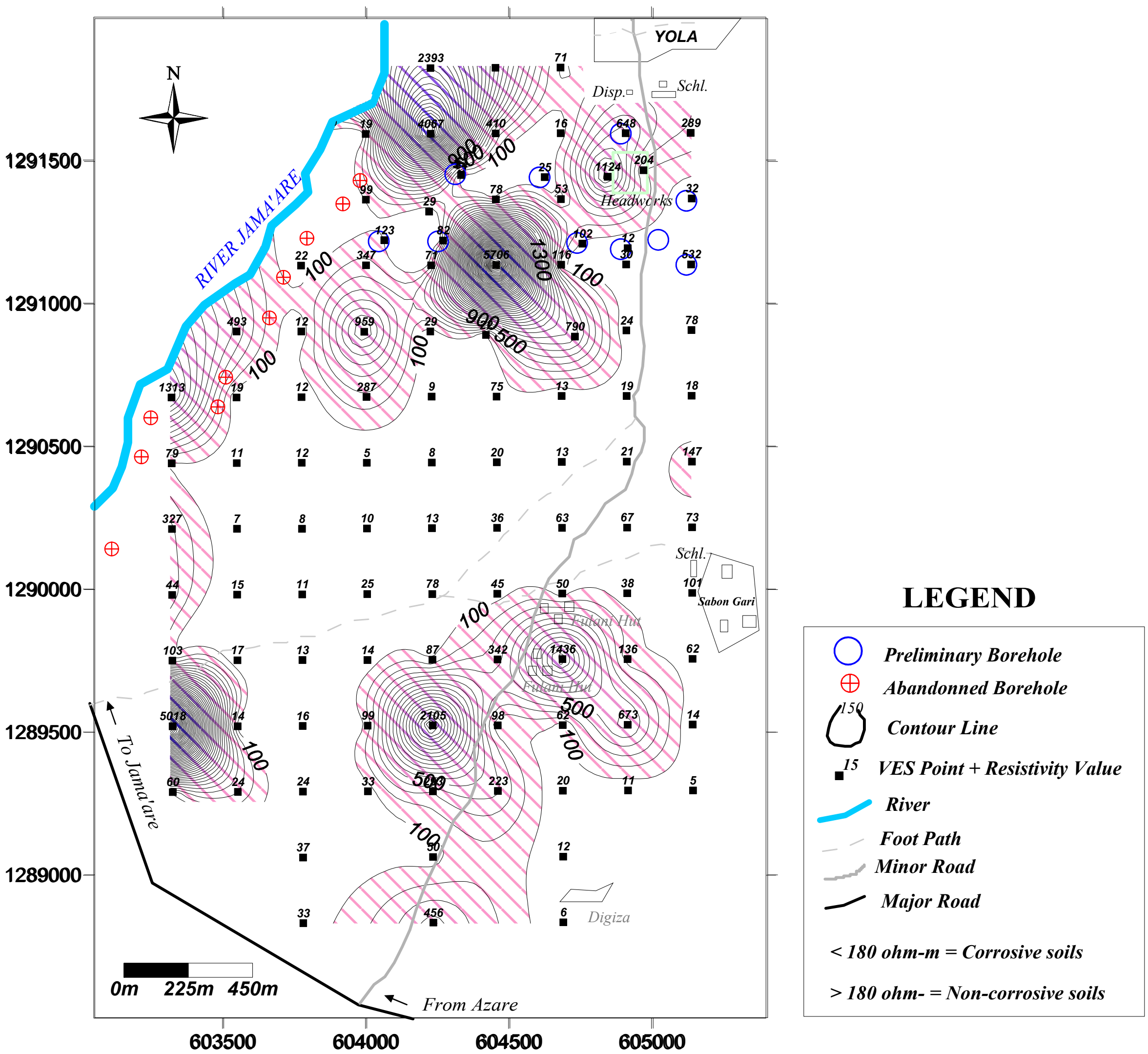


Figure 6. Corrosivity map of the study area

Table 2. Modified longitudinal conductance/protective capacity rating (after Henriet, 1976; Oladapo et al., 2004)

Longitudinal Conductance (mhos)	Protective Capacity rating
>10	Excellent
5-10	Very good
0.8-4.9	Good
0.2-0.79	Moderate
0.1-0.19	Weak
<0.1	Poor

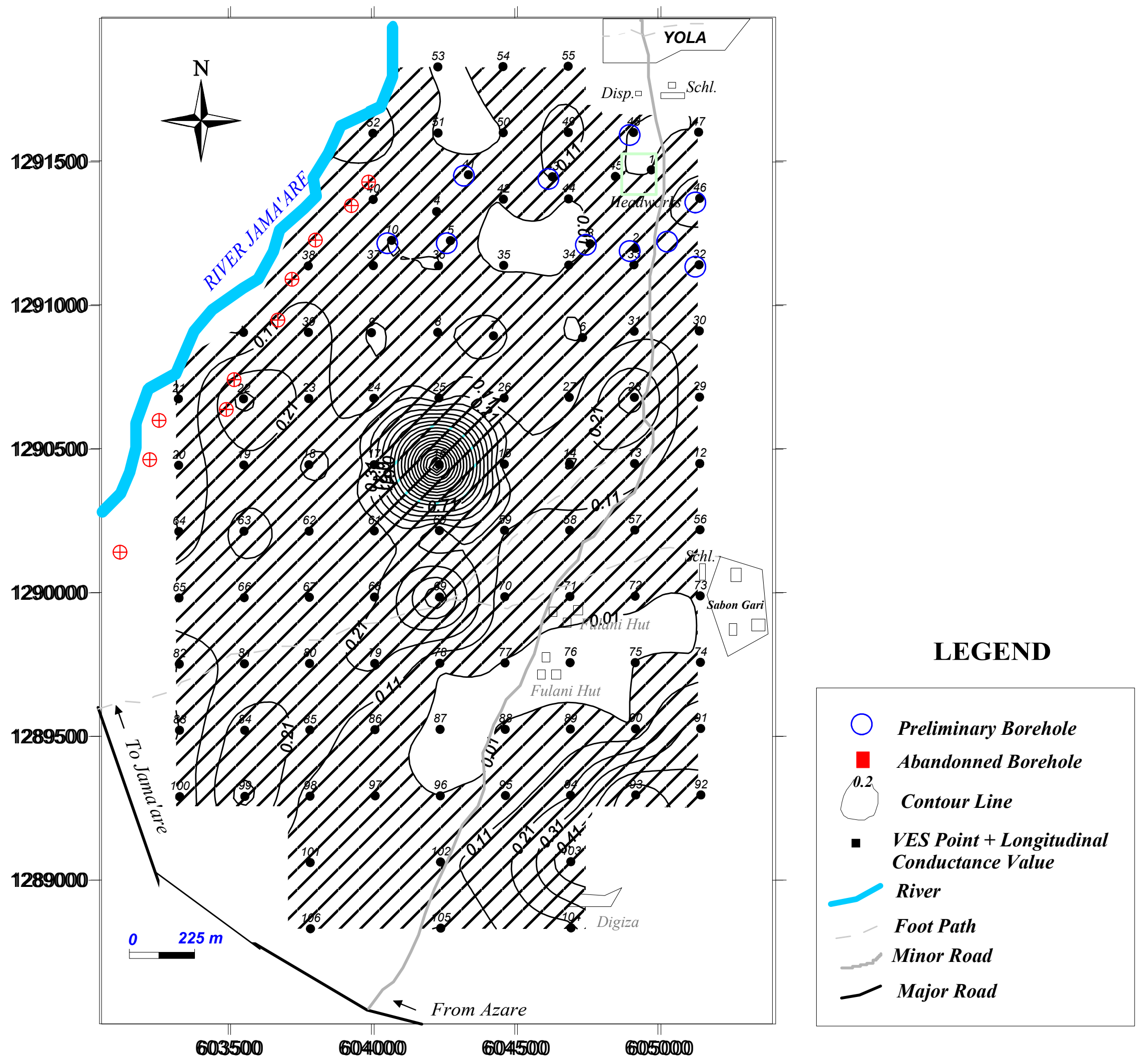


Figure 7. Topsoil longitudinal unit conductance map

5. Conclusion

5.1 Conclusion

The north central, southwestern, southern and northern parts of the study area contain corrosive topsoils with low resistivity (ρ< 180 Ω-m), while the eastern, the southern and western parts of the area with high resistivity topsoils are precisely non corrosive. Hence, metallic utilities/pipes etc required for reticulation works buried within the superficial layer in the area are susceptible to corrosion suggesting a significant contribution of clayey matrix in the layer.

The longitudinal conductance map reveals that above 95% of the study area are characterized by topsoil with poor to weak protective capacity. This implies that alluvium aquifers, the most prolific in the basin are not protected enough from surface pollutant(s) in most part of the area, while the remaining other few areas even at relatively shallow depth are significantly protected by variably thick clay/sandy clay topsoil which is annually reinforced by the flood activities of the meandering Jama'are river.

The study, therefore, has helped to evaluate the superficial topsoil materials overlying the alluvium aquifer in the study area and enables the assessment of the vulnerability of aquifer(s) to surface pollutants such as chemical fertilizers frequently used by farmers within the Fadama floodplain basin.

5.2 Recommendation

However, the challenges of long - term safe rate of the aquifers vis-à-vis ever changing climatic factors are important considerations in the assessment of the vulnerability of aquifer(s) to surface pollutants in any parts of the basin. While it is recommended that further study be carried out to assess the long - term safe rate of aquifers from a combination of hydrometerological, geophysical and geochemical techniques, the geochemical tool can be used in such a study.

Acknowledgement

The management of Aim Consultants, Lagos is appreciated for financing and providing logistic support for the data acquisition.

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Appendix

Dar Zarrouk Parameters obtained from First Order Geoelectric Parameters.

VES Station	Topsoil $s=\frac{h_{ts}}{\rho_{ts}}$	$S=\sum_{i=1}^{n}\frac{h_i}{\rho_i}$	$T=\sum_{i=1}^{n}h_i\rho_i$	$\rho_L=\frac{\sum_{i=1}^{n}h_i}{\sum_{i=1}^{n}\frac{h_i}{\rho_i}}$	$\rho_t=\frac{\sum_{i=1}^{n}h_i\rho_i}{\sum_{i=1}^{n}h_i}$	Coefficient of Anisotropy $\lambda=\sqrt{(\rho_t/\rho_L)}$
1	0.00294	0.47228	2810.6	56.3228	105.662	1.36967
2	0.11667	2.61013	5437.2	38.1973	54.5356	1.19488
3	0.00784	1.95654	5014.9	41.1952	62.2196	1.22897
4	0.04483	2.91979	4368.9	29.5912	50.566	1.30722
5	0.02195	1.22022	4239.6	41.7956	83.1294	1.4103
6	0.00253	2.34481	6959.9	37.0179	80.1832	1.47176
7	0.16818	2.79149	4463.5	27.8704	57.3715	1.43475
8	0.10689	1.70883	5361.5	45.1186	69.5396	1.24148
9	0.00146	1.20580	5912.3	51.7497	94.7484	1.35311
10	0.00894	0.62933	1612.3	76.2714	194.583	1.59725
11	0.00081	0.26385	1612.6	69.736	87.6413	1.12105
12	0.01497	2.78253	13424.4	54.914	87.856	1.26486
13	0.16191	1.93377	6368.1	48.2995	68.1809	1.18812
14	0.22308	4.62863	7763.3	37.9162	44.2353	1.08012
15	0.165	2.71483	4128	35.3244	43.0448	1.10388
16	2.225	1.87408	4223.9	42.3675	53.1977	1.12055
17	0.26	1.73279	2327	23.2573	57.7419	1.57567
18	0.09167	2.34469	5913.8	46.232	54.5554	1.08629
19	0.19091	2.62051	8323.1	52.0128	61.0646	1.08353
20	0.01139	1.80258	11871.5	22.4125	293.849	3.6209
21	0.00129	2.27867	7694.2	40.1111	84.1816	1.44869
22	0.35263	2.12974	2885	33.3374	40.6338	1.10402
23	0.19167	1.77088	4101.4	45.2318	51.2035	1.06397
24	0.01603	0.90812	5786.9	62.1064	102.605	1.28533
25	0.12222	2.59733	2307.6	21.9071	40.5554	1.3606
26	0.03067	2.27481	5388.9	38.4208	61.6579	1.26681
27	0.06154	1.65986	3921.8	31.8702	74.1361	1.52519
28	0.37895	2.9901	5819.7	40.5338	48.0173	1.0884
29	0.01278	2.58527	9399.8	52.1029	69.7832	1.1573
30	0.07308	1.80700	13808.5	78.2512	97.6556	1.11713
31	0.08333	5.04665	8506.9	34.4981	48.8621	1.19011
32	0.00658	0.57368	4562.2	71.6427	111.002	1.24474
33	0.07333	1.80282	2187.3	28.8437	42.0635	1.20761
34	0.01034	2.24827	6024.4	31.2241	85.8177	1.65784
35	0.00438	1.82338	22421.7	60.163	204.391	1.84317

Appendix continued

Dar Zarrouk Parameters obtained from First Order Geoelectric Parameters

VES Station	Topsoil $s = \frac{h_{ts}}{\rho_{ts}}$	$S = \sum_{i=1}^{n} \frac{h_i}{\rho_i}$	$T = \sum_{i=1}^{n} h_i \rho_i$	$\rho_L = \frac{\sum_{i=1}^{n} h_i}{\sum_{i=1}^{n} \frac{h_i}{\rho_i}}$	$\rho_t = \frac{\sum_{i=1}^{n} h_i \rho_i}{\sum_{i=1}^{n} h_i}$	Coefficient of Anisotropy $\lambda = \sqrt{(\rho_t/\rho_L)}$
36	0.05634	2.59374	10251	32.1543	122.914	1.95515
37	0.01844	3.61291	10308.6	20.5098	139.117	2.60442
38	0.06364	1.36262	676.8	21.2091	23.4187	1.0508
39	0.2	1.25489	936.3	18.0893	41.2467	1.51002
40	0.01919	1.20485	9887.7	78.3499	104.743	1.15622
41	0.025	2.17961	3076.2	24.3163	58.0415	1.54497
42	0.00897	3.54129	5611.8	34.6766	45.6987	1.14798
43	0.12	2.79793	3386.6	17.9061	67.5968	1.94295
44	0.00317	1.95447	4410.8	44.5645	50.6406	1.06599
45	0.01423	0.48250	4589.2	68.3936	139.067	1.42595
46	0.18125	2.50062	2981.3	25.1937	47.3222	1.37052
47	0.01142	1.67842	5955.2	42.3018	83.8761	1.40812
48	0.00339	1.00701	5746	55.7097	102.424	1.35593
49	0.15625	1.71645	3300.2	32.6254	58.9321	1.344
50	0.00366	1.41644	6246.8	60.0097	73.4918	1.10665
51	0.00059	3.75674	15604	25.3411	163.908	2.54324
52	0.18421	5.14708	4278.5	25.8594	32.145	1.11493
53	0.00213	2.27537	18729.3	26.3693	312.155	3.44061
54	-	-	Bad data	-	-	-
55	0.08732	2.70111	5698.6	29.6915	71.0549	1.54697
56	0.04521	2.25561	11355.6	59.3188	84.87	1.19614
57	0.03582	0.30692	8582.8	154.436	181.072	1.08281
58	0.07619	2.49774	9304.6	55.0098	67.7191	1.10952
59	0.11389	1.32503	5262.9	38.9426	101.994	1.61836
60	0.1	1.02458	4397.3	60.2197	71.269	1.08788
61	0.12	0.75790	3737.3	51.5898	95.5831	1.36116
62	0.175	0.95751	3613.6	46.4745	81.2045	1.32185
63	0.25714	1.13708	3850.3	49.2488	68.7554	1.18156
64	0.00275	1.51219	15058.2	54.0273	184.311	1.84701
65	0.21136	1.42295	5040.6	42.1659	84.01	1.41151
66	0.16	1.71177	2251.9	22.4913	58.4909	1.61264
67	0.13636	1.53675	6280.7	55.2464	73.9776	1.15717
68	0.184	1.82410	4407.8	45.6663	52.9148	1.07644
69	0.6282	1.44707	4567.9	48.9956	64.4274	1.14672
70	0.06	2.17757	4496.1	35.6361	57.9394	1.27509

Appendix continued

Dar Zarrouk Parameters obtained from First Order Geoelectric Parameters

VES Station	Topsoil $s = \frac{h_{ts}}{\rho_{ts}}$	$S = \sum_{i=1}^{n} \frac{h_i}{\rho_i}$	$T = \sum_{i=1}^{n} h_i\rho_i$	$\rho_L = \frac{\sum_{i=1}^{n} h_i}{\sum_{i=1}^{n} \frac{h_i}{\rho_i}}$	$\rho_t = \frac{\sum_{i=1}^{n} h_i\rho_i}{\sum_{i=1}^{n} h_i}$	Coefficient of Anisotropy $\lambda=\sqrt{(\rho_t/\rho_L)}$
71	0.03	0.84686	13267.7	105.803	148.077	1.18303
72	0.01842	2.60283	6303.4	35.0004	69.1921	1.40602
73	0.01188	0.65846	3922.8	73.6573	80.8825	1.0479
74	0.16129	2.59516	5113.1	19.151	102.879	2.31776
75	0.01029	0.75159	6199.4	44.5722	185.057	2.03761
76	0.00216	2.62614	7219.9	17.1354	160.442	3.05994
77	0.00499	1.67093	7506	27.8287	161.419	2.40841
78	0.01494	1.91777	6374	24.5597	135.329	2.34738
79	0.23571	4.56231	6321.9	34.259	40.4472	1.08657
80	0.19231	4.05397	2987.9	23.1378	31.8539	1.17333
81	0.14118	2.24836	4423.9	32.3792	60.7679	1.36995
82	0.00971	1.61246	9961	63.1954	97.7527	1.24372
83	0.00062	1.68924	19606.3	49.0161	236.791	2.19793
84	0.26429	2.31413	1964.8	19.2729	44.0538	1.51188
85	0.18125	1.58725	3784.2	42.2115	56.4806	1.15674
86	0.03838	1.71446	6190.6	34.7048	104.044	1.73146
87	0.00143	1.53058	18515.8	67.2946	179.765	1.63442
88	0.01633	1.37328	6821.2	37.8654	131.177	1.86126
89	0.04839	2.26972	3555.2	30.8848	50.7161	1.28145
90	0.00847	2.31775	10420.3	45.9497	97.8432	1.45923
91	0.38571	2.73644	12584.2	63.4766	72.4479	1.06833
92	0.42	4.80761	3295	19.9059	34.4305	1.31517
93	0.60901	3.89332	3147.4	24.7861	32.6155	1.14712
94	0.195	1.87181	1218.1	23.7203	27.4347	1.07545
95	0.03408	1.91341	14297.4	80.9025	92.3605	1.06847
96	0.00921	2.26561	5169.2	25.9092	88.0613	1.8436
97	0.04242	1.18012	4880.2	53.6385	77.0964	1.19889
98	0.075	2.15479	6859.8	50.121	63.5167	1.12573
99	0.35833	3.00111	3993.2	21.9919	60.503	1.65866
100	0.01	3.67137	6427	20.7824	84.2333	2.01323
101	0.02162	0.91509	9533.8	95.0725	109.584	1.07361
102	0.106	0.67539	4411.5	57.4486	113.698	1.40682
103	0.5	1.74308	2548	32.127	45.5	1.19007
104	0.17619	2.38709	19015.2	35.9853	221.364	2.48023
105	0.00789	1.00137	10146.4	80.8896	125.264	1.24442
106	0.06969	1.24910	3995	46.8337	68.2906	1.20754