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APPLICATION OF VERTICAL ELECTRICAL SOUNDING FOR GROUND WATER EXPLORATION AROUND BASEMENT COMPLEX TERRAIN. SOUTHWESTERN NIGERIA.

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ABSTRACT

Vertical Electrical Sounding was used for identification of potential groundwater zones in Akure, Ondo state and measurements were taken using Schlumberger Configuration along the four profiles at station intervals of 10 m. A total of 53 VES were conducted with half electrode spacing (AB/2) varying from 1-150 m. This geophysical work was carried out at around Federal housing estate Akure, South-western Nigeria known to be associated with the problems of groundwater aquifer. Many of the boreholes drilled in this area are either perched or later dried-up during the dry seasons including hand-dug wells. The geoelectric sections delineated a maximum of four subsurface geological layers consisting of the top soil, weathered layer, fractured basement and fresh basement. The top soil resistivity values vary from 30.9-257 Ωm with thickness ranging from 0.3-5.1 m. The weathered layer resistivity values range from 20.2-2832.3 Ωm. Its thickness varies from 1.1 and 10.5 m. The fractured basement resistivity range from 23.9 to 570 Ωm, the thickness varies from 2.6-65.6 m. The weathered and the fractured basement constitute the main aquifer units in the study area. The fresh basement resistivity values ranges from 582-64167 Ωm. The groundwater map generated was used to classify the study area into high, medium and low groundwater potential zones. VES methods have been successfully used to evaluate the groundwater potential of the Federal Housing Estate Akure.

Keyword: VES, Geoelectric Section, Acquifer, Deep fracture and Ground Water Potential Map

INTRODUCTION

The use of electrical resistivity method plays a prominent role in the study of earth crust. This method is commonly used in getting detailed information about hydro-geological setting, geological mapping and foundation study. It is routinely employed in groundwater exploration to locate zones of relatively high conductivity corresponding to saturated strata, as well as providing structural and litho logical information (Olayinka and Olorunfemi, 1992). It may also provide indications of ground water quality. The method has been employed successfully in locating sites for boreholes development in Nigeria Basement Complex (Olorunfemi and Olorunniwo, 1985). Geophysical methods are required as pre-drilling test for groundwater before embarking on drilling to reduce the possibility of wild-cat search, thus resulting in financial losses through drilling of abortive wells. This geophysical work was carried out at around Federal housing estate Akure, South-western Nigeria known to be associated with the problems of groundwater aquifer. Many of the boreholes drilled in this area are either perched or later dried-up during the dry seasons including hand-dug wells (Bayode, 2013; Olanrewaju *et al*., 2014). Therefore there is need to investigate the frequent causes of this aquifer failure in the area. The area is accessible through Owo-Ilesha express way and is located in the North-eastern part of Akure in Akure northeast local government of Ondo state. The area is relatively populated and can boast of internal road links and fairly distributed social amenities (Fig. 1).

The study area is bounded by Longitude 3˚56' 57" and Latitude 7˚26' 05". It lies within the tropical rain forest belt of hot, wet equatorial climate region characterized by wet and dry seasons with mean monthly temperature of about 27^0C. Some part of the layout has tick vegetation comprising of several evergreen leaves and trees. The area though exposed to effect of erosion. The area is characterized by high reliefs and consists of undulating hills and ridges with isolated rock bodies. It has a tropical climate and the natural vegetation is rain forest. The evaporation in the area is high due to humidity, relatively high sunshine hours and low precipitation. The area is covered in most places by secondary vegetation due to intense cultivation, thereby making the road accessible. Mean annual rainfall is between 1000 to 1500 m, and mean annual temperature is between 24 and 27^0C (Ileojo, 1980). The area has two seasons; wet and dry. The wet seasons begging from March to October, while dry season is characterized by hamattan which begging from November to February. The rainfall intensity usually has two peaks. The first peak is between June - July and the other is August – September. As a result of its low relief, the area tends to be sloppy. The erosional features of the area are mainly gully and sheets. It falls within the Precambrian Basement Complex terrain of the country (Rahaman, 1975). The main rock types found in the area include the undifferentiated granite gneiss, quartzite and porphyritic granite with schist impregnation. This consists of undulating hills and ridges. The Basement Complex rocks have nearly zero porosity for groundwater accumulation and movement. They have no pores and where few pores exist they are not interconnected. Due to this condition, their permeability is very low. However, due to tectonic activities that occur as a result of the movement of the earth crust, physical disintegration and chemical decomposition of rocks; faults, joints and pores (secondary porosities) are produced. The above process enhances the aquifer characteristics of the crystalline rocks. The occurrence of groundwater within the project area is highly variable and discontinuous depending on the rainfall, permeability of geological formation from the process of weathering or fracturing and groundwater revival (Bayode, 2014).

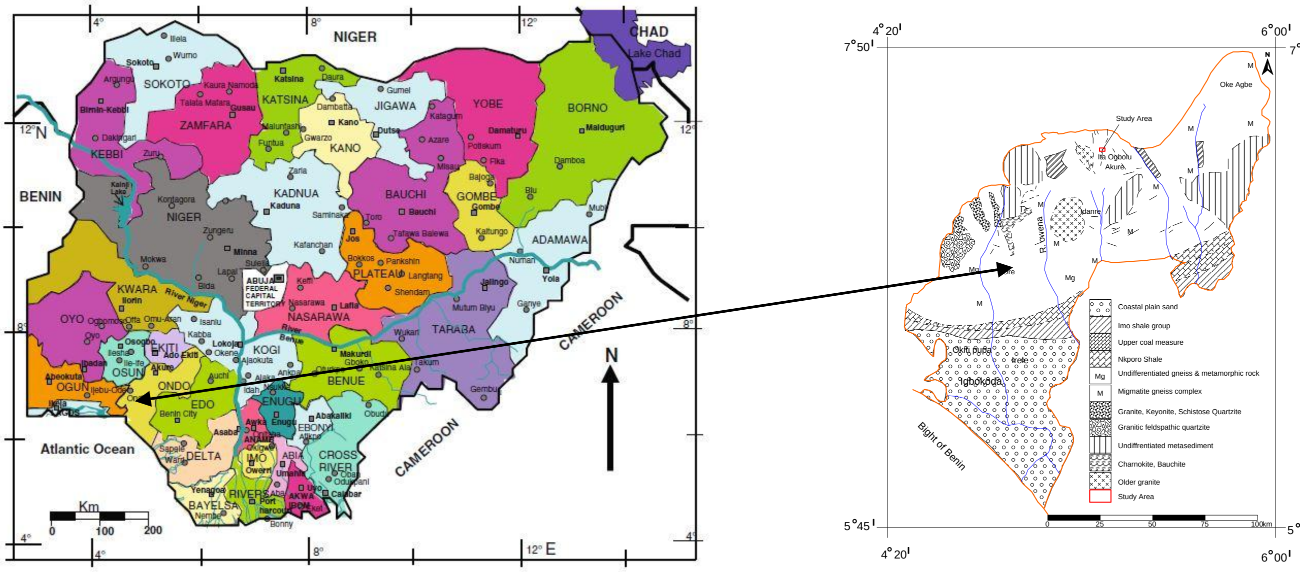

Fig: 1 Map of the Study area. (NGSA 1976)..

MATERIALS AND METHODS

For this research work, R50 DC Resistivity meters was used for data acquisition along with the metal electrode, connecting cables, hammers, compound/clinometers, measuring tapes and ropes. A total number of 53 Vertical Electrical Sounding (VES) stations were explore.

RESULTS AND DISCUSSION.

The summary of the 53 Vertical Electrical Sounding (VES) interpretation results are presented as table, Depth sounding curves and Geoelectric sections.

Depth Sounding Curves

The observed depth sounding curves were classified into different resistivity curve types. The typical depth sounding curve obtained from the study area are presented (Figs. 3.1 to 3.4) Curves types identified ranges from A,K, H, KH, HK, HA to HKH and AKH curve (Keller and Frisckriecht, 1996) with three to five geoelectric layers along the four traverses. The H curve type dominates, constituting 41% of the totals while the A-type constitutes 20.8%, HKH constitute 17%, KH and HK constitutes 7.5% each while HA, K and AKH constitute 2.3% each.

Geo-electric-Section

The interpretation of field resistivity data are in terms of resistivity's, depth to the bedrock and the interfaces across which a strong electrical contrast exists which can be interpreted as the geological strata. The electrical resistivity varies between different geological materials, depending mainly on variation in water contents and dissolved ions in the water. The analysis and interpretation of the survey data showed different geo-electric layers. The geo-electric sections generated across the study area are presented in (Figs. 3 and 4). Four subsurface geo-electric units were delineated. These are the topsoil, weathered layer, fractured basement and the fresh basement. The topsoil is the first layer with the resistivity values ranges from 73-267 Ωm. The thickness values ranges from 0.4-5.1 Ωm. The topsoil is made up of clay, sandy-clay, clayey-sand and laterite. The second layer is the weathered layer. The resistivity values ranges from 41-205 Ωm. The thickness varies from 1.1-8.4 Ωm. The weathered layer is composed of clay, sandy clay and clayey sand. The Third layer is the fractured basement. The resistivity values ranges from 85-570 Ωm. The thickness value varies from 23.9-54.9 Ωm. The fractured basement is made up of partly weathered/ fractured basement. The last layer is the fresh basement. The resistivity values ranges from 582-20614 Ωm. The weathered and the fractured basement constitute the aquifer units in the study area.

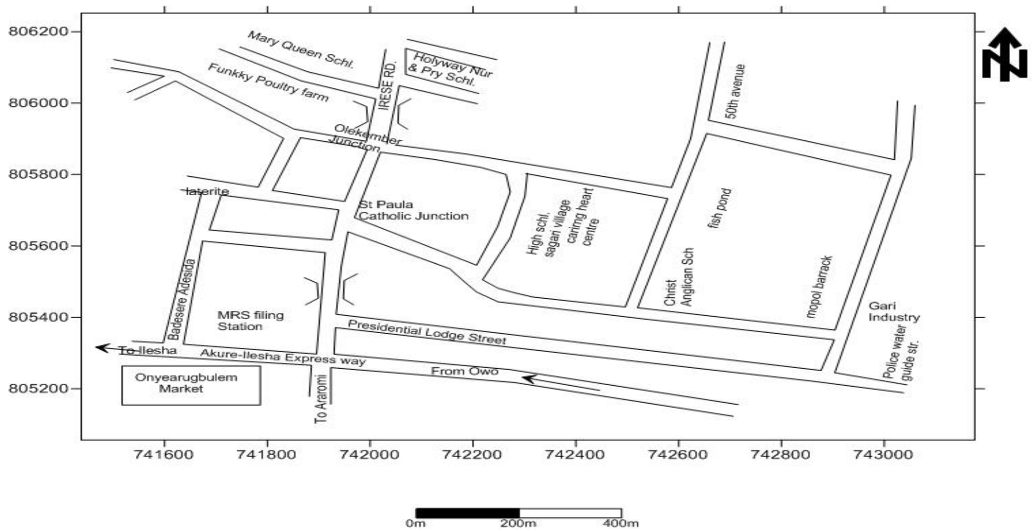

Fig 2a: Data acquisition map showing VES stations

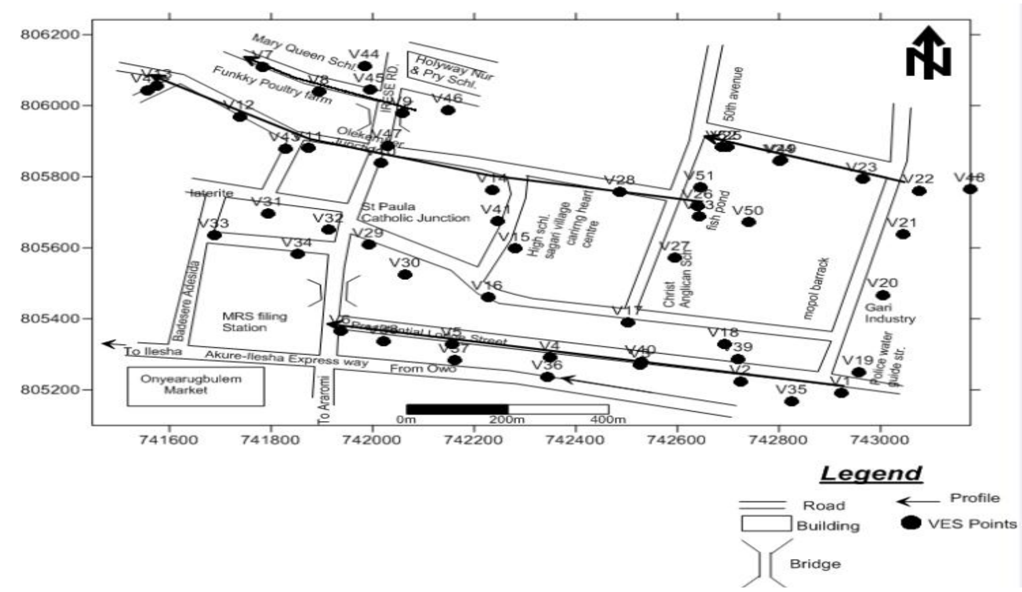

Fig 2b: Data acquisition map showing VES stations

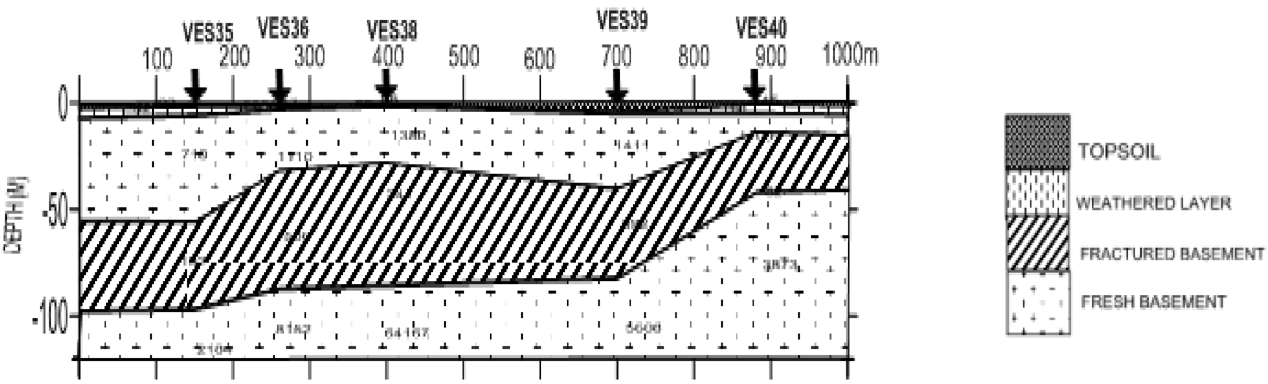

Fig. 3.a. Geoelectric Section Along Traverse 1

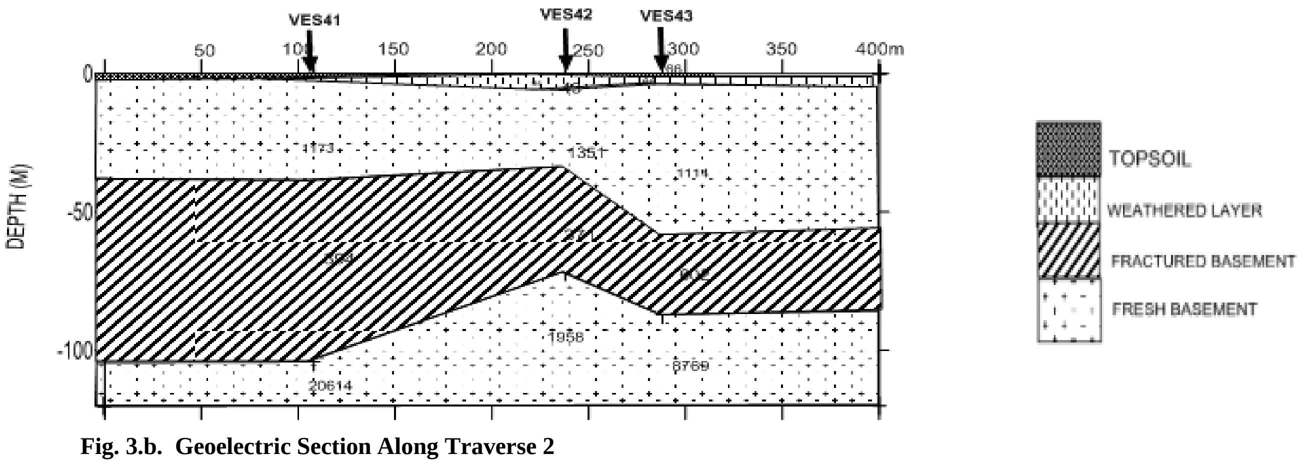

Fig. 3.b. Geoelectric Section Along Traverse 2

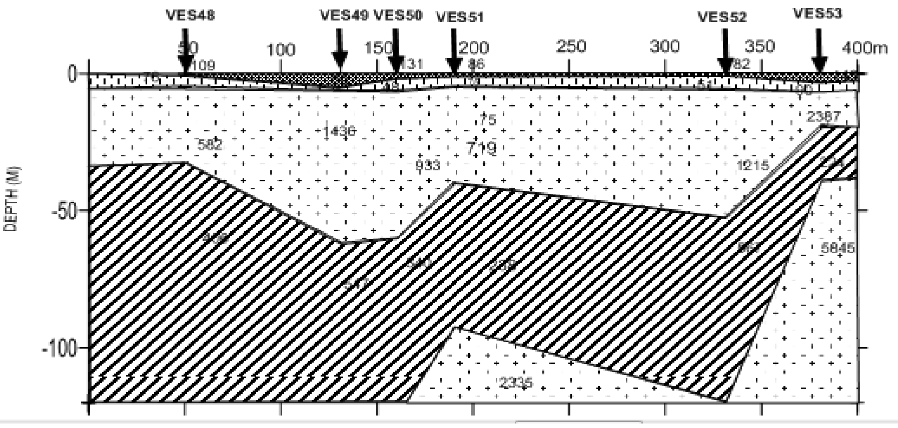

Fig. 3.4: Geoelectric Section Along Traverse 4

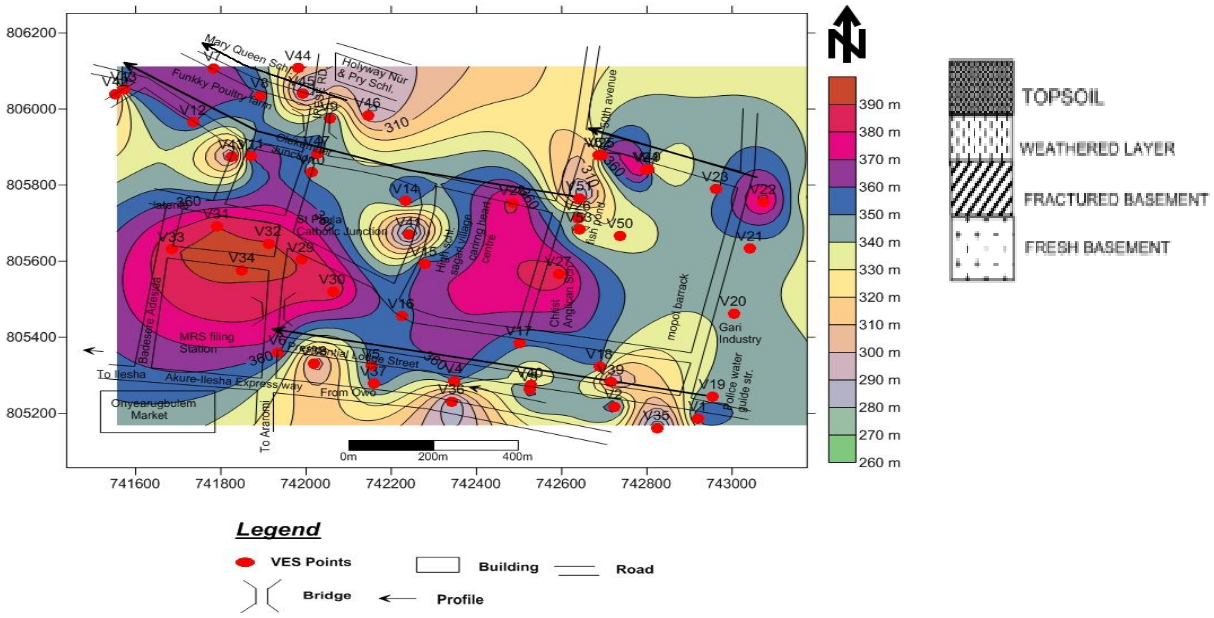

Fig. 4.1: Bedrock Relief Map of the Study Area.

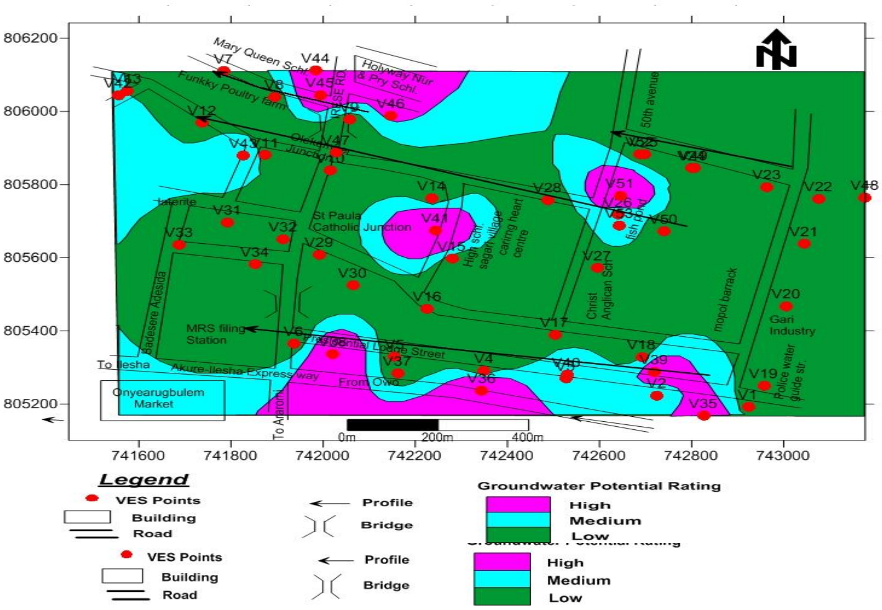

Fig 4.2: Groundwater Potential Map of the Study Area

CONCLUSION

The results of the interpretation of the data obtained from geo-electric exploration for favorable groundwater conditions in hard rock environment of Federal Housing Estate, Akure were deduced in this study and a maximum of five subsurface geologic layers were delineated from the 53 Vertical Electrical Sounding stations along the four traverses established These include the topsoil, clayey-sand or sandy-clay, weathered layer, fractured basement and fresh basement. Also, the Vertical Electrical Sounding carried out randomly is to have the basic knowledge of the lithologic characteristics of the environment under study. The topsoil resistivity values ranges from 32.0 Ωm to 4347 Ωm and overburden thickness values vary from 0.4m to 2.4 m. The Weathered layers resistivity values range from 57.6 Ωm to 783 Ωm and thickness values vary from 1.3 to 14.9 m. Some fractured zones were identified on VES 35, 47 and 50. The fresh basement has resistivity value ranging between 458 Ωm to 4743 Ωm. The electrical resistivity has been employed successfully in locating sites for borehole development in the south-western part of the Nigerian basement (Olorunfemi and Olorunmiro, 1985). Since the weathered basement and the fractured basement are considered to be the major aquifer units in the study area, and based on the final interpretation of the 53 vertical electrical sounding along the four traverses, VES locations 35, 47, and 50 may be suitable for borehole development as a result of their low resistivity value. In the bedrock relief map, topographic depressions and ridges identified. The bedrock relief gives the trend of topography (Fig 4.1). In ground water exploration, depression, zone is one the targets. The groundwater potentials of the study area now classified into high, medium and low potential zones (Fig.4.2).

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Table 1: Summary of Interpreted VES Curve

VES	RESISTIVITY (Ωm)	THICKNESS (m)	CURVE TYPE	NO OF LAYERS	REMARK
1	96	1.4	A	3	TOPSOIL
	74.9	2.7			WEATHERED LAYER
	3079.1				FRESH BASEMENT
2	178.0	2.1	H	3	TOPSOIL
	125.3	4.2			WEATHERED LAYER
	588.6				FRESH BASEMENT
3	302.4	1.6	H	3	TOPSOIL
	86.5	5.7			WEATHERED LAYER
	820.9				FRESH BASEMENT
4	90.2	1.3	H	3	TOPSOIL
	47.0	3.8			WEATHERED LAYER
	749.7				FRESH BASEMENT
5	65.6	0.8	A	3	TOPSOIL
	150.1	4.8			WEATHERED LAYER
	1566.9				FRESH BASEMENT
6	124.5	0.5	H	3	TOPSOIL
	58.0	4.2			WEATHERED LAYER
	1002.4				FRESH BASEMENT
7	239.4	2.2	A	3	TOPSOIL
	353.8	2.6			WEATHERED LAYER
	2141.0				FRESH BASEMENT
8	144.4	1.3	A	3	TOPSOIL
	200.1	9.1			WEATHERED LAYER
	7598.8				FRESH BASEMENT
9	98.7	2.0	H	3	TOPSOIL
	58.5	4.6			WEATHERED LAYER
	5066.1				FRESH BASEMENT
10	71.2	1.6	H	3	TOPSOIL
	37.4	2.6			WEATHERED LAYER
	6885.5				FRESH BASEMENT
11	144.2	2.4	H	3	TOPSOIL
	100.2	4.3			WEATHERED LAYER
	1358.8				FRESH BASEMENT
12	51.9	1.1	A	3	TOPSOIL
	86.2	5.1			WEATHERED LAYER
	7271.7				FRESH BASEMENT
13	30.9	2.0	A	3	TOPSOIL
	341.7	3.0			WEATHERED LAYER
	2811.8				FRESH BASEMENT
14	69.1	0.9	H	3	TOPSOIL
	46.7	2.8			WEATHERED LAYER
	1200.9				FRESH BASEMENT
15	122.5	2.7	A	3	TOPSOIL
	129.7	2.5			WEATHERED LAYER
	7099.6				FRESH BASEMENT
16	68.4	1.6	K	3	TOPSOIL
	2832.3	5.0			WEATHERED LAYER
	984.9				FRESH BASEMENT
17	75.1	2.0	A	3	TOPSOIL
	108.2	4.0			WEATHERED LAYER
	3742.4				FRESH BASEMENT

18	30.9	0.5	KH	4	TOPSOIL
	214.2	1.3			WEATHERED LAYER
	29.9	3.1			FRACTURED
	2369.9				FRESH BASEMENT
19	71.3	2.0	H	3	TOPSOIL
	67.1	4.7			WEATHERED LAYER
	1124.7				FRESH BASEMENT
20	80.2	3.2	H	3	TOPSOIL
	36.1	6.7			WEATHERED LAYER
	876.4				FRESH BASEMENT
21	181.8	2.4	H	3	TOPSOIL
	33.8	8.3			WEATHERED LAYER
	444.8				FRESH BASEMENT
22	234.5	1.0	H	3	TOPSOIL
	52.2	1.8			WEATHERED LAYER
	561.3				FRESH BASEMENT
23	108.8	2.7	A	3	TOPSOIL
	160.4	10.5			WEATHERED LAYER
	828.4				FRESH BASEMENT
24	104.8	0.5	H	3	TOPSOIL
	78.0	4.0			WEATHERED LAYER
	471.8				FRESH BASEMENT
25	184.3	0.6	H	3	TOPSOIL
	32.3	1.6			WEATHERED LAYER
	2800.3				FRESH BASEMENT
26	38.8	1.9	A	3	TOPSOIL
	319.5	1.1			WEATHERED LAYER
	8501.6				FRESH BASEMENT
27	74.8	0.6	KH	4	TOPSOIL
	111.4	1.2			WEATHERED LAYER
	23.9	2.6			FRACTURED LAYER
	3802.7				FRESH BASEMENT
28	69.3	3.3	A	3	TOPSOIL
	119.3	4.2			WEATHERED LAYER
	2784.2				FRESH BASEMENT
29	165.3	1.6	H	3	TOPSOIL
	20.2	3.0			WEATHERED LAYER
	3421.4				FRESH BASEMENT
30	136.6	1.4	H	3	TOPSOIL
	41.2	4.4			WEATHERED LAYER
	1609.9				FRESH BASEMENT
31	84.4	2.1	H	3	TOPSOIL
	75.0	3.8			WEATHERED LAYER
	2337.6				FRESH BASEMENT
32	82.5	1.0	H	3	TOPSOIL
	50.7	4.8			WEATHERED LAYER
	1389.1				FRESH BASEMENT
33	114.4	0.9	H	3	TOPSOIL
	75.8	6.2			WEATHERED LAYER
	1603.3				FRESH BASEMENT
34	131.5	0.8	H	3	TOPSOIL
	50.7	5.1			WEATHERED LAYER
	1329.4				FRESH BASEMENT
35	92	1.1	HKH	5	TOPSOIL
	52	4.4			WEATHERED LAYER
	719	49.5			FRESH BASEMENT
	192	41.1			FRACTURED BASEMENT
	2184	-			FRESH BASEMENT
36	257	0.9	HKH	5	TOPSOIL
	205	1.7			WEATHERED LAYER
	1110	28.6			FRESH BASEMENT
	500	54.9			FRACTURED BASEMENT
	8152	-			FRESH BASEMENT
37	42	0.5	HA	4	TOPSOIL
	263	6.4			WEATHERED LAYER
	315	3.5			LATERITIC/WEATHERED LAYER
	1659	-			FRESH BASEMENT
38	98	1.3	HKH	5	TOPSOIL
	66	2.1			WEATHERED LAYER
	1380	24.5			FRESH BASEMENT
	341	46.3			FRACTURED BASEMENT
	64167	-			FRESH BASEMENT
39	120	4.2	KH	4	TOPSOIL/WEATHERED LAYER
	1411	35.9			FRESH BASEMENT
	392	41.8			FRACTURED BASEMENT
	5608	-			FRESH BASEMENT
40	146	0.4	HKH	5	TOPSOIL
	61	4.2			WEATHERED LAYER
	1101	9.0			FRESH BASEMENT
	82	28.4			FRACTURED BASEMENT
	3873	-			FRESH BASEMENT
41	73	1.5	KH	4	TOPSOIL/WEATHERED LAYER
	1173	37			FRESH BASEMENT
	394	65.6			FRACTURED BASEMENT
	20614	-			FRESH BASEMENT
42	43	0.3	AKH	5	TOPSOIL
	94	5.5			WEATHERED LAYER

	1351	27.6			FRESH BASEMENT
	371	38.2			FRACTURED BASEMENT
	1958	-			FRESH BASEMENT
43	66	1.2	HKH	5	TOPSOIL
	44	2.5			WEATHERED LAYER
	114	54.6			FRESH BASEMENT
	602	28.7			FRACTURED BASEMENT
	8769	-			FRESH BASEMENT
44	113	1.0	HK	4	TOPSOIL
	73	5.7			WEATHERED LAYER
	1369	46.6			FRESH BASEMENT
	570	-			FRACTURED BASEMENT
45	83	0.9	119	5	TOPSOIL
	59	4.6			WEATHERED LAYER
	685	46.1			FRESH BASEMENT
	312	43.0			FRACTURED BASEMENT
	1938	-			FRESH BASEMENT
46	184	2.2	HKH	5	TOPSOIL
	41	8.4			WEATHERED LAYER
	284	48.0			FRESH BASEMENT
	94	23.9			FRACTURED BASEMENT
	2389	-			FRESH BASEMENT
47	138	0.8	H	3	TOPSOIL
	45	4.9			WEATHERED LAYER
	2382	-			FRESH BASEMENT
48	109	0.5	HK	4	TOPSOIL
	76	4.3			WEATHERED LAYER
	582	27.5			FRESH BASEMENT
	406	-			FRACTURED BASEMENT
49	69	5.1	K	3	TOPSOIL/ WEATHERED LAYER
	1436	56.1			FRESH BASEMENT
	547	-			FRACTURED BASEMENT
50	131	1.4	HK	4	TOPSOIL
	48	4.7			WEATHERED LAYER
	983	53.6			FRESH BASEMENT
	340	-			FRACTURED BASEMENT
51	86	1.6	HKH	5	TOPSOIL
	75	3.7			WEATHERED LAYER
	719	34.9			FRESH BASEMENT
	238	52.7			FRACTURED BASEMENT
	2335	-			FRESH BASEMENT
52	82	1.0	HK	4	TOPSOIL
	51	4.7			WEATHERED LAYER
	1215	46.3			FRESH BASEMENT
	567	-			FRACTURED BASEMENT
53	143	2.9	HKH	5	TOPSOIL
	90.4	3.8			WEATHERED LAYER
	2387	12.4			FRESH BASEMENT
	224	20.4			FRACTURED BASEMENT
	5845				FRESH BASEMENT