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Investigation of Groundwater Resources of Rafin Guza Area of Kaduna, Nigeria using Resistivity Method

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Abstract - The groundwater resources of Rafin Guza village near Kaduna, Nigeria was investigated using electrical resistivity method for the purpose of delineating suitable aquiferous geologic units for groundwater development. The field curves are the K-A-H types for layered sequence, and 5-layer sequences have been interpreted for the entire area investigated. Generally, the depth to Basement rock was observed to range between 11-35m. Vertical Electrical Sounding (VES) stations 1 to 3 were observed to have indicated the presence of only the shallow upper aquifer, and are not recommended for pumping wells. Conversely, the remaining VES points 4 to 9 indicated the presence of both the shallow upper and the deeper weathered-to-fractured basement aquifers, and are therefore recommended sites for productive pumping wells.

***Index Terms*- Apparent Resistivity, Aquifer, Geoelectric Section, Piezometric Surface.**

I. INTRODUCTION

The continuous growth in the demand for portable water has led to a more intensive search across Nigeria for groundwater, especially in the crystalline basement areas where groundwater occurrence is slow and is subject to geological control. A large part of the semi-urban and populations in Nigeria do not have access to adequate quantity and quality of water. The existing water supply projects in such areas are groundwater-based and this requires geophysical studies for efficient groundwater development and management.

II. THE STUDY AREA

Rafin Guza is a village located at the far end of Kawo New Extension in Kaduna North Local Government Area of Kaduna State, Nigeria. The geographical location of Rafin Guza is approximately longitude $10^0$35’ N and latitude $7^0$28’ E and between altitudes 550- 650m above the mean sea level. The climate is the tropical type which has distinctive rainy and dry seasons. Annual rainfall, ranging between 1000 – 1500mm, occurs between April and October, and the dry season takes place in the remaining months of the year. Maximum temperatures often rise to about 38^0C or more between March and April, and may drop significantly to about 24^0C or less during peak rainy periods (July/August) and during the cold, dry harmattan winds (November/February). The relief of the area is fairly undulating with gentle slopes characterized by gullies. The vegetation is of the savannah region type. It comprised of derived sparsely spaced trees with short and tall grasses and shrubs. Typical crops grown in the area comprised mostly of legumes, cereals and vegetables along the swamp margins [1], [2]. The geology of the area is typically basement complex rocks comprising of high-grade igneous and metamorphic rocks such as migmatite, mica and quartz-mica schists, granite-gneiss, biotite granite, porphyritic biotite granite and granodiorite. (Figure 1) shows the geological map of Kaduna State. Previous geological and hydro geological studies in the area include [3], [4], [5], [6], [7], [8] and [9]. Data availability on ground water in the area is scarcely available, but groundwater occurs mostly within the laterites and weathered zones of metasediments and granite-gneiss. While the poor grade amphibolites schists and green schist facies with extensive quartz veining are poor targets, the metabasalts provide good targets for groundwater exploration.

III. METHOD OF INVESTIGATION

The geophysical investigation was carried out in the dry season when water table elevation is assumed to be at the lowest level. A total of nine vertical electrical soundings were carried out within the study area using terrameter model SAS 300C and its accessories. The schlumberger configuration was used with a total array spread of 200m at all VES points. This spacing is expected to provide enough subsurface information considering the depth of penetration in the schlumberger array which normally ranges between ¼ to ⅓ of the current electrode separation [10],[11].

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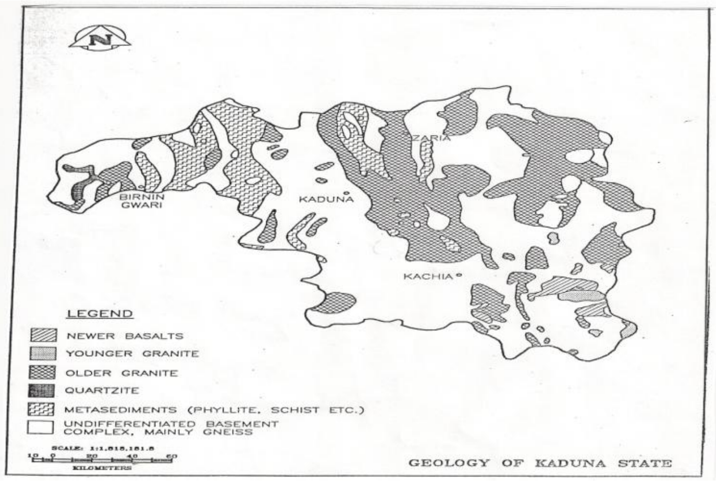

Fig 1: Geologic Map of Kaduna State, Nigeria

IV. RESULTS AND DISCUSSION

The field resistivity data were interpreted using the IX1D computer processing and interpretation software. The layer thickness and true formation resistivities obtained were used to delineate the probable subsurface rock lithologies and piezometric (or water table) surfaces as part of the borehole sitting procedures in the basement complex area. Figure 2(i - ix) shows the field curves for the nine VES points of the study area. The figure shows that the field curves are the K-A-H types for layered sequences. Generally, five-layer lithologic succession was delineated in the entire study area. The uppermost layer comprises of top soil with organic residues with a resistivity range of 16.97 – 570.3 Ωm and thicknesses from 0.311 – 1.44m. This layer is underlain by a second sandy layer that has a resistivity range of 8.52 – 267.2 Ωm and thickness range of 0.502 – 3.64m. The third layer is interpreted as a lateritic layer forming the upper aquifer with thicknesses ranging from 2.97 – 4.82m and resistivity values of 0.14 – 141.95 Ωm. This is followed by a fourth layer which is the finely-weathered basement with resistivity range of 23.50 – 222.50 Ωm, and thicknesses ranging between 3.58 – 23.32m. The fifth layer is the weathered to fractured basement lying on the fresh basement rock. The resistivity values range from 1344 Ωm at the uppermost fractured parts to as high as 26,293.20 Ωm in the deeper unfractured parts whose bottom could not be reached during the investigation. Table 1 provides a summary of the interpreted field data and the suggested depth of drilling at each VES point, while Table 2 shows the thicknesses of the first and second aquifers and their average interpreted resistivities. From the tables, it is apparent that the VES points 1, 2 and 3 would be poor locations for siting any pumping well, VES point 6 is a fairly good location, while VES points 4, 5, 7, 8 and 9 are the probable best locations for productive water wells in the area.

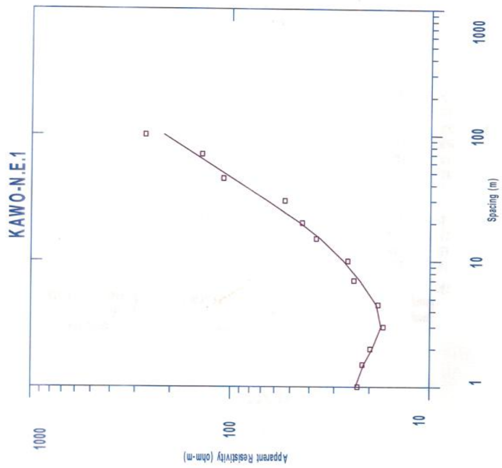

Fig 2(i)

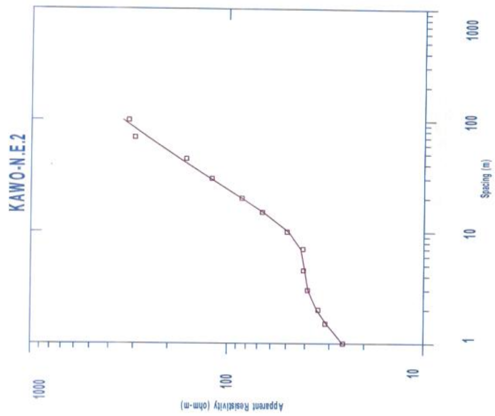

Fig 2(ii)

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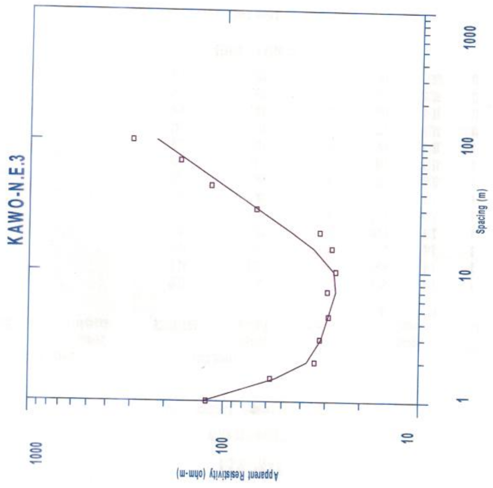

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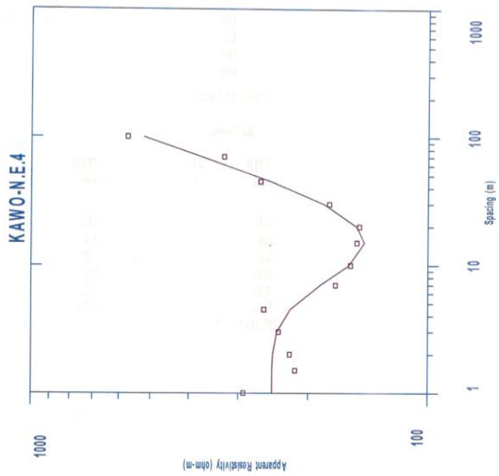
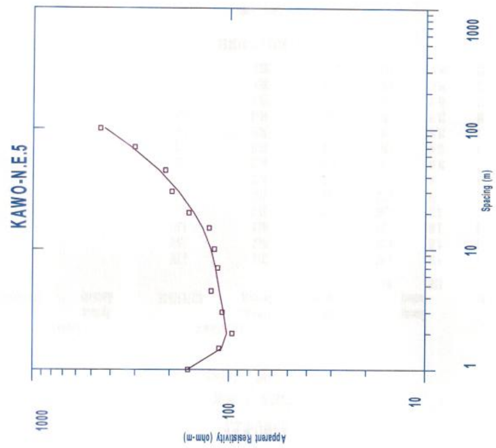


Fig 2(iv)



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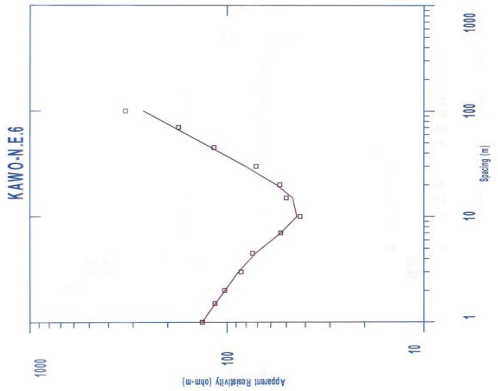

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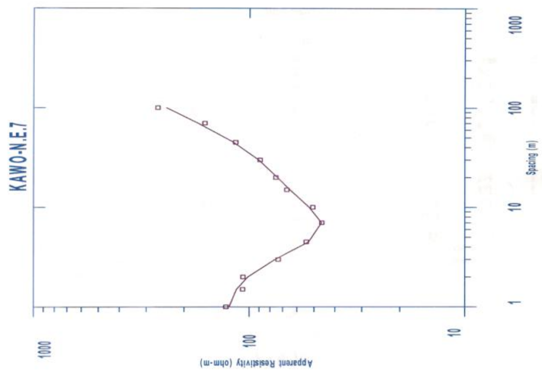

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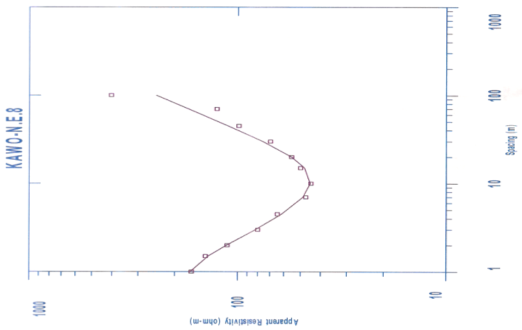

Fig 2(viii)

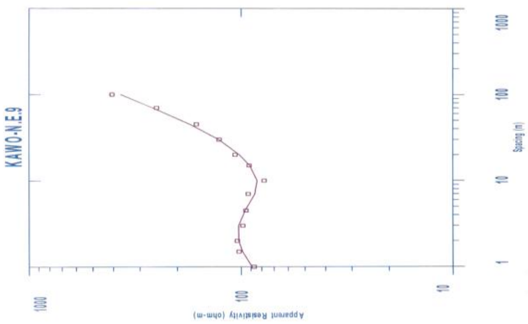

Fig 2(ix)

Fig 2: Interpreted Field Curves for Rafin Guza

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Table 1: Summary of the Interpreted Data

S/N	VES POINT	FIRST AQUIFER	SECOND AQUIFER	DEPTH TO BASEMENT	TOTAL DEPTH	DRILL DEPTH	ELEVATION	COORDINATE	REMARKS
1	Kawo New Extension 1	5 – 11m	NIL	11 – 12m	12m	NIL	578m	N10^{0}35.118’ E07^{0}28.222’	POOR
2	Kawo New Extension 2	4 – 12m	NIL	12 – 13m	13m	NIL	593m	N10^{0}35.009’ E07^{0}28.318’	POOR
3	Kawo New Extension 3	6 – 10m	NIL	10 – 11m	11m	NIL	588m	N10^{0}35.112’ E07^{0}28.537’	POOR
4	Kawo New Extension 4	5 – 12m	14 – 24m	25 – 26m	27m	27 – 30m	597m	N10^{0}35.262’ E07^{0}28.402’	GOOD
5	Kawo New Extension 5	9 – 19m	23 – 31m	32 – 35m	35m	30 – 35m	595m	N10^{0}35.256’ E07^{0}28.295’	GOOD
6	Kawo New Extension 6	5 – 9m	12 – 17m	17 – 18m	18m	17 – 20m	597m	N10^{0}35.223’ E07^{0}28.161’	FAIR
7	Kawo New Extension 7	6 – 12m	14 – 24m	26 – 27m	27m	28 – 30m	587m	N10^{0}35.992’ E07^{0}28.222’	GOOD
8	Kawo New Extension 8	5 – 9m	12 – 20m	20 – 21m	21m	20 – 25m	582m	N10^{0}35.011’ E07^{0}28.344’	GOOD
9	Kawo New Extension 9	6 – 13m	15 – 26m	27 – 28m	28m	27 – 30m	583m	N10^{0}35.947’ E07^{0}28.349’	GOOD

Table 2: Summary of the Interpreted Data

S/N	VES POINT	1ST AQUIFER THICKNESS	AVERAGE RESISTIVITY (ohm-m)	2ND AQUIFER THICKNESS	AVERAGE RESISTIVITY (ohm-m)	TOTAL THICKNESS	TOTAL DEPTH	COORDINATE	REMARKS
1	Kawo N/Extn 1	6m	70	NIL	23392	11m	12m	N10^{0}35.118’ E07^{0}28.222’	POOR
2	Kawo N/Extn 2	8m	172	NIL	1345	12m	13m	N10^{0}35.009’ E07^{0}28.318’	POOR
3	Kawo N/Extn 3	7m	82	NIL	26293	11m	11m	N10^{0}35.112’ E07^{0}28.537’	POOR
4	Kawo N/Extn 4	7m	103	15m	243	23m	28m	N10^{0}35.262’ E07^{0}28.402’	GOOD
5	Kawo N/Extn 5	10m	116	17m	225	30m	30m	N10^{0}35.256’ E07^{0}28.295’	GOOD
6	Kawo N/Extn 6	5m	46	11m	131	16m	24m	N10^{0}35.223’ E07^{0}28.161’	FAIR
7	Kawo N/Extn 7	6m	68	12m	107	18m	25m	N10^{0}35.992’ E07^{0}28.222’	GOOD
8	Kawo N/Extn 8	5m	37	10m	147	20m	25m	N10^{0}35.011’ E07^{0}28.344’	GOOD
9	Kawo N/Extn 9	7m	113	12m	144	21m	25m	N10^{0}35.947’ E07^{0}28.349’	GOOD

V. WATER TABLE MAP

The inferred water table depths at the VES stations were used to prepare the piezometric surface (or water table) contour map of the study area. This is presented as Figure 3. The figure shows at a glance the variation in the water table depths across the area. This serves as a good reference data for prospective borehole drillers in the area.

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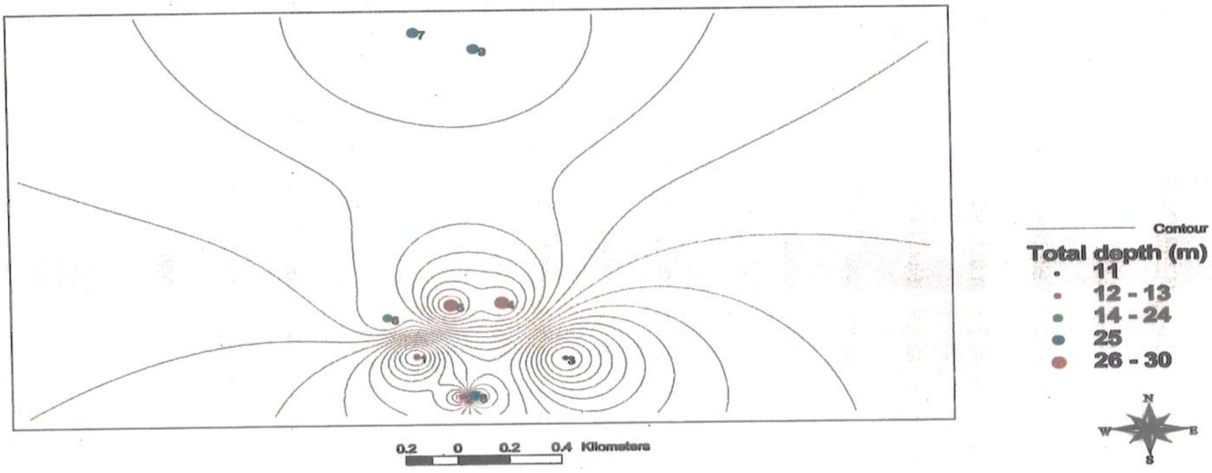

Fig 3: Water Table Map of Rafin Guza

VI. CONCLUSION

This investigation has shown that Rafin Guza area has a good potential for groundwater development. While VES stations 1, 2 and 3 exhibited poor aquiferous conditions, the remaining VES points were found to be potential good locations for productive well development for water supplies. This study will provide a ready reference document for potential borehole drillers in Rafin Guza area of Kaduna.

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