

## **EVALUATION OF GROUNDWATER POTENTIAL OF ODEDA LOCAL GOVERNMENT AREA, OGUN STATE, SOUTHWEST NIGERIA**

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### **ABSTRACT**

Evaluation of groundwater potential in Odeda Local Government Area, Ogun State, Southwestern Nigeria, has been carried out in this study using Vertical Electrical Sounding method. The study area is underlain by Precambrian Basement Complex rocks of Southwestern Nigeria. These rocks are inherently characterized by low porosity and permeability. The interpretation of thirty (30) vertical electrical sounding (VES) conducted using the Schlumberger electrode array shows four geo-electric layers in the subsurface within the study area. The overburden thickness varies from 5.9 to 39 m across the study area. This was used to prepare the groundwater potential map which assisted in the zoning of the area into low, medium and high groundwater potential zones. The study showed that about 60% of the study area falls within the low/medium rated groundwater potential zone while the remaining 40% constituted the high groundwater potential zone. Hence, the groundwater potential rating of the area is generally low.

**Keywords:** Geo-electric, Vertical Electrical Sounding, Overburden, Groundwater Potential

### **INTRODUCTION**

Water is one of the most valuable natural resources vital to the existence of any form of life (Topfer, 1998). As man's standard of living increase so does his need for consumption of water. However, the use of water has grown rapidly in modern times. Though, a significant portion of water resources have become unusable due to industrial and agricultural pollution. Diversions or transfer of watershed to other region have led to many ecological and human disasters (Gleick *et al.*, 2002). Groundwater exploration is gaining greater atten-

tion due to increasing demand for water supply (Olayinka, 1992; Coker, 2012), especially in areas with inadequate pipe-borne and surface waters such as Odeda Local Government Area. An adequate supply of water during dry season has always been a problem. This is worsened by the drying up of some of the hand dug wells in the area. The problem is also becoming progressively acute with growing population and industries. At present, only some parts of the municipal areas are provided with pipe-borne water supply or through pneumatic wells. An annual low rate of rainfall often leads to

drought that endangers the people and the environment.

### THE STUDY AREA

The study area, Odeda Local Government Area, Ogun State, Southwestern Nigeria, falls between longitude 3°23'23.8"E to 3°28'46.2"E and latitude 7°10'28.2"N to 7°12'54."N (Figs. 1 and 2). The study area is underlain by Precambrian Basement Complex rocks. These rocks are inherently characterized by low porosity and permeability. These rocks belong to the youngest of the three major provinces of the West African Craton recognized by Hurley and Rank (1976). These rocks are of Precambrian age to early Palaeozoic age and they extend from the north-eastern part of the Ogun State running southwest and dipping towards the coast (Ako, 1979). The basement complex metamorphic rocks are characterized by various folds, structures of various degrees of complexity, faults and foliation. These structural features have a predominant North-South or North-North-East-South-South-West (NNE-SSW) orientation which is particularly strong within the low grade metamorphic. The common metamorphic rocks encountered are gneiss, schist, quartzite and amphiboles. The study area is characterized by various rock types ranging from, granite gneiss to pegmatite.

### MATERIALS AND METHODS

The occurrence, storage, and distribution of groundwater in Precambrian basement complex are influenced by different geological factors (Amadi and Olasehinde, 2010; Olorunfemi *et al*, 1999). Most often, the occurrence of groundwater in basement complex terrains is localized and confined to weathered/fracture zones (Adiat *et al.*, 2009; Ariyo and Adeyemi, 2009; Mbiimbe *et al.*, 2010). The highest groundwater yield in basement terrains is found in areas where thick overburden overlies fractured zones; these zones are often characterized by relatively low resistivity values (Anudu *et. al.*, 2008; Abiola *et. al.*, 2013). The most probable use of the electrical resistivity survey is in hydrogeological investigation in relation to aquifer delineation, lithologic boundaries and geological structures to provide information about the subsurface. However, groundwater occurs either in the weathered mantle or in the joints and fractured system in the unweathered rocks. The aforesaid, among others, have necessitated the need for groundwater exploration in Odeda Local Government Area. Geophysical investigations were undertaken at thirty (30) locations which included FUNAAB, Oluwo Keesi, Isolu, Koto, CAMP, Osiele, among others (Fig. 2).

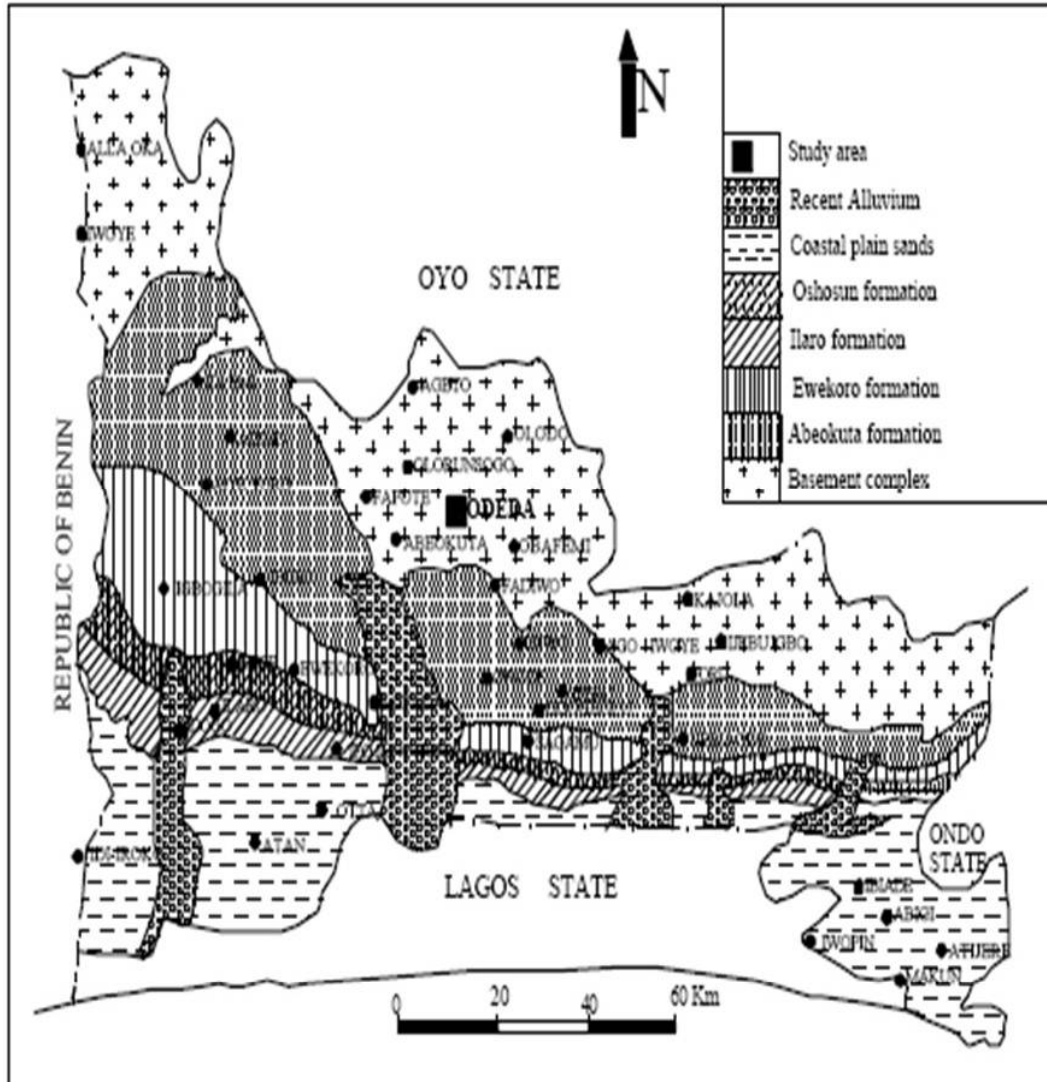


Fig. 1: Geological Map of Ogun State (modified after Badmus and Olatinsu, 2010)

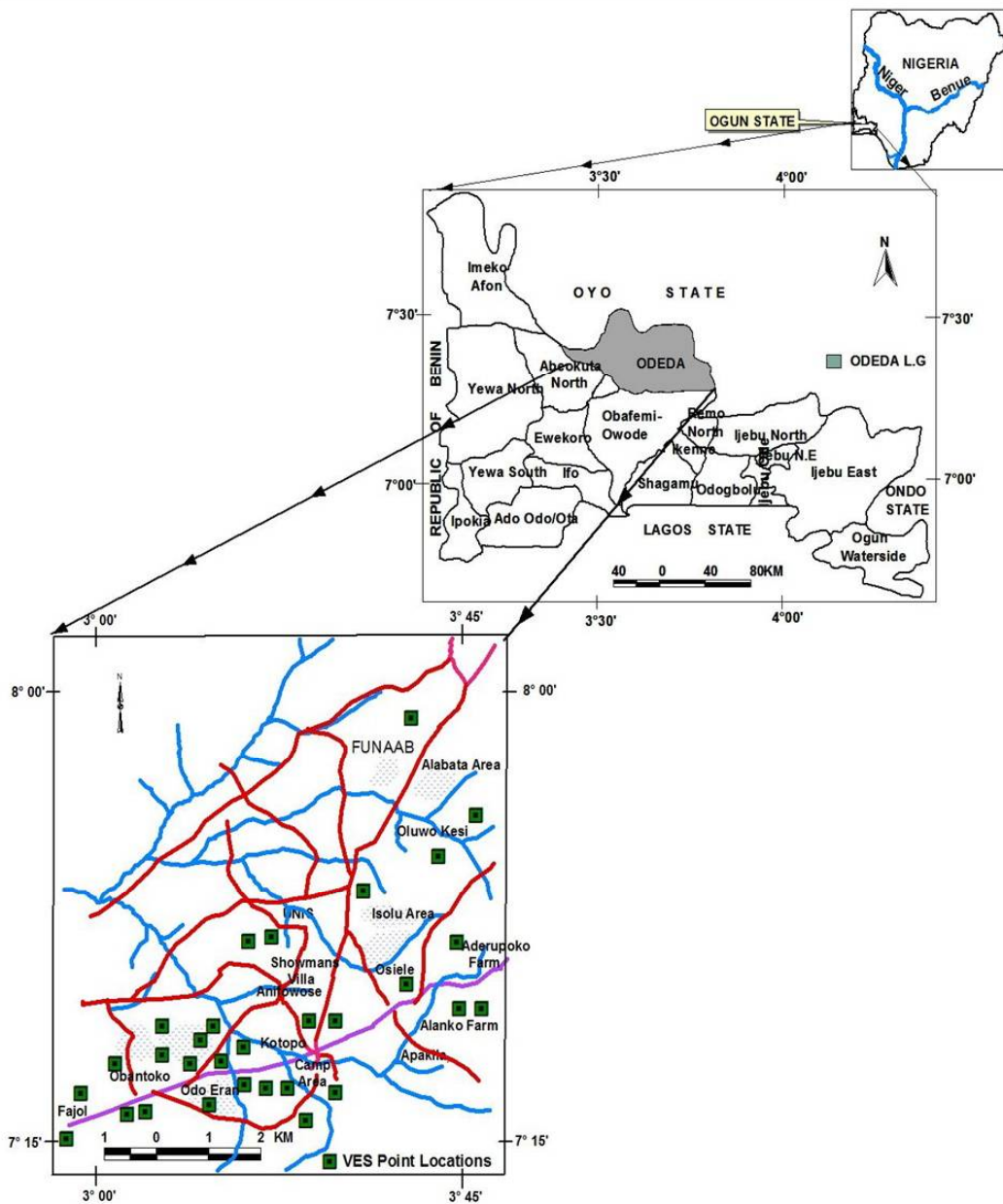


Fig. 2: Location Map showing the VES Points in the Study Area

The geophysical prospecting method adopted for this study is the Electrical resistivity method and Vertical Electrical Sounding (VES) techniques. The OHMEGA Terrameter was used along with four metal electrodes, hammer for driving the electrodes in the ground, and four reels of connecting cable, measuring tape, and clips. Global Positioning System (GPS) was used to ascertain the coordinate of the VES points. Calibrated rope and data sheet were used for recording the field data during geophysical data acquisition (Adiat *et al.*, 2012). The resistivity meter contains both the transmitter unit through which current enters the ground, and the receiver unit, through which the resultant potential difference is recorded.

The Schlumberger array was adopted for the study, the electrode spread AB/2 was varied from 1 to a maximum of 133m, where AB is the current electrode separation. Sounding data were presented as sounding curves, obtained by plotting apparent resistivity against AB/2 or half the spread length on a bi-log paper.

Ground resistance (R) measurements were recorded with the OHMEGA Terrameter. The electrical resistances obtained were multiplied by the corresponding geometric factor (k) for each electrode separation to obtain the apparent resistivity ( $\rho = kR$ ) in ohm-meter. The models obtained from the calculations above were used for computer iteration to obtain the true resistivity and thickness of the layers. Computer-generated curves were compared with corresponding field curves by using a computer program "Resist" version 1.0. The software was further used for both computer iteration and modelling. Areas where the overburden thickness was greater than 17m and of low

clay content (resistivity above 100  $\Omega$ -m) were considered as zones of high groundwater potential, those less than 17m as zones of medium groundwater potential while those less than 10 m as low groundwater potential.

## RESULTS AND DISCUSSION

Thirty (30) Schlumberger depth sounding stations (Fig. 2) were covered within the study area. The data acquired were presented as sounding curves and maps. Table 1 shows VES results of some of the stations in terms of the geoelectric properties of the study area, while Figures 3, 4, 5 and 6 show VES curves of three, five, four and two layers.

### *Vertical Electrical Sounding Results*

The topsoil was made up of layers with resistivity values ranging from 23 to 329 ohms-m indicating that the topsoil was mainly sandy to lateritic in nature, with thickness of 0.5 to 8.6 m.

The weathered basement layer resistivity varied from 4 to 135 ohm-m and having thickness of about 3 to 35.5 m. The highest thickness was at VES 22 and the least occurred at VES 8. In respect of hydro-geology, the weathered layer had groundwater significance, where it was thick enough and the amount of water saturating it was high.

The fractured/weathered layer was delineated beneath seven (7) VES points: 9, 10, 12,15,20,21 and 26. The layer constitutes the main aquifer unit in the study area and resistivity falls between 93 and 532 ohm-m.

The fresh basement was made up of the layer with resistivity ranging from 192 to 2106 ohm-m at most of the VES stations; this high resistivity was due to the crystalline nature of the study area.

**Isopach Maps**

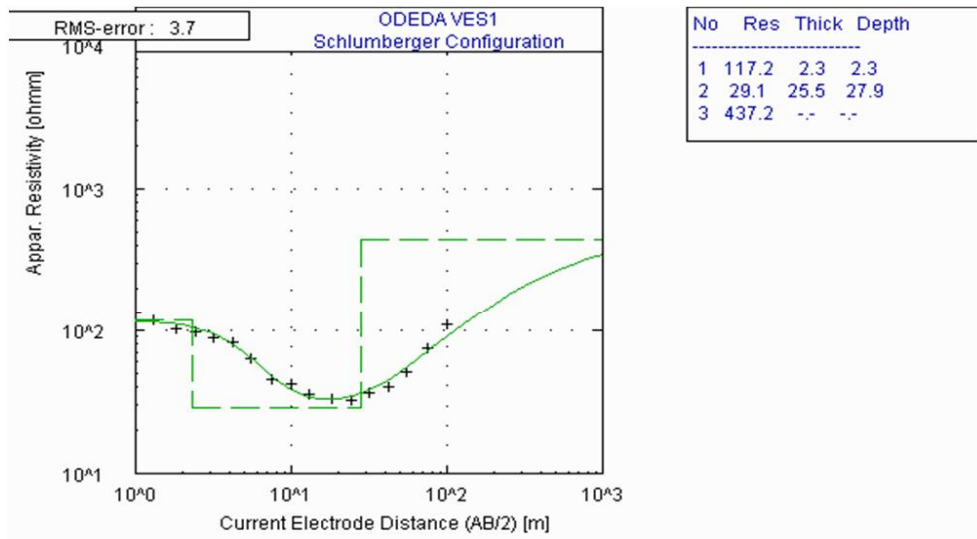
**Isopach map of topsoil**

The isopach map which shows the thickness distribution of the topsoil is presented in Fig. 7. It could be observed that the thickness was greater than 4m at VES 24.

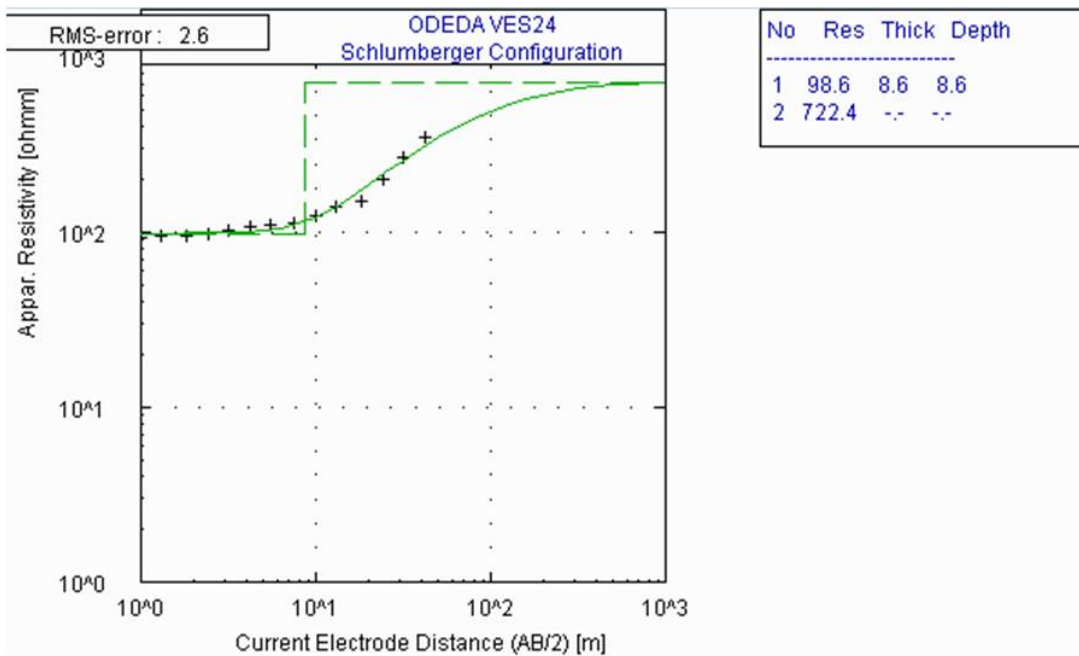
This was of high thickness when compared to the rest of the points in the study area. The distribution of the topsoil thickness was low except at VES22 which is of moderate thickness.

**Table 1: VES Interpretation showing the Geo-electric Layers for some of the stations**

VES	Layers	Resistivity (ohm-m)	Thickness (m)	Depth (m)	Probable lithology
1	1	117	2.3	2.3	Topsoil
	2	29	25.5	27.8	Weathered basement
	3	437	-	-	Fresh Basement
6	1	134	0.6	0.6	Topsoil
	2	35	1.8	2.4	Sandy Clay
	3	79	3.4	5.8	Clayey sand
	4	17	8.8	14.6	Weathered Basement
	5	318	-	-	Fresh basement
9	1	94	1.2	1.2	Topsoil
	2	120	6.6	7.8	Lateritic clay
	3	60	11.8	19.6	Weathered basement
	4	342	-	-	Fresh basement
24	1	99	0.8	0.8	Topsoil
	2	722	-	-	Basement



**Fig. 3: VES curve over Station 1 showing three layers**



**Fig. 6: VES curve over Station 24 showing two layers**

**Vertical Electrical Sounding Results**

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The weathered basement layer resistivity varied from 4 to 135 ohm-m and having thickness of about 3 to 35.5 m. The highest thickness was at VES 22 and the least occurred at VES 8. In respect of hydrogeology, the weathered layer had groundwater significance, where it was thick enough and the amount of water saturating it was high.

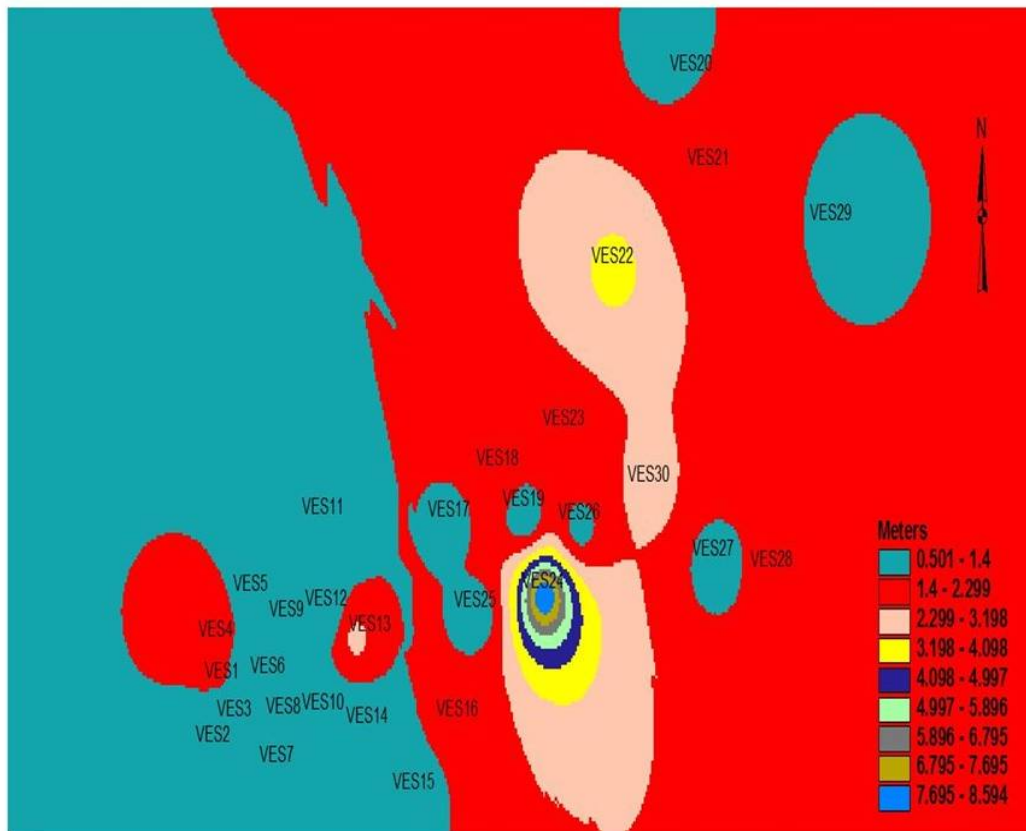
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**Isopach Maps**

**Isopach map of topsoil**

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**Fig. 7: Isopach map of topsoil thickness**

***Isopach map of overburden thickness***

The overburden is assumed to include all materials above the presumably fresh basement. Figure 8 shows the Isopach map of the overburden with thickness ranging from 5.9 to 39.0m. At the Northern part spreading to the central portion of the study area, the thickness ranged from 17 to 39 m. The central portion of the area extending eastward to westward was observed to be of

low overburden with thickness of 8 to 15 m.

Generally, areas with thick overburden usually coincide with basement depressions and low percentage of clay in which intergranular flow is dominant. Such areas are known to have high groundwater potential particularly in basement complex terrain (Okhue and Olorunfemi, 1991).

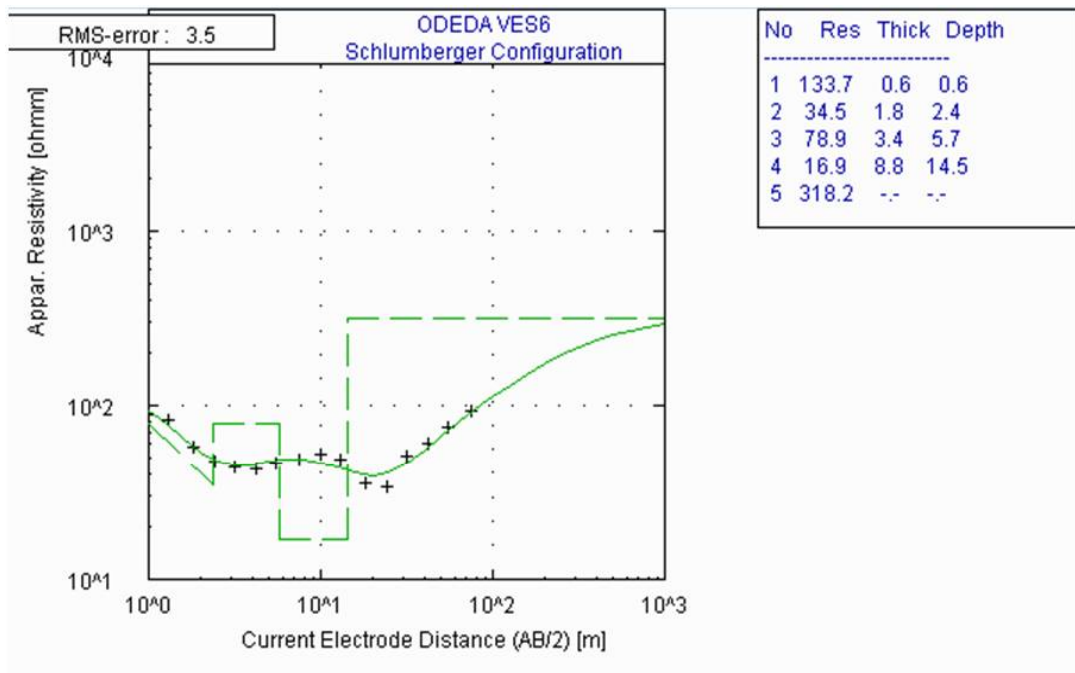


Fig. 4: VES curve over Station 6 showing five layers

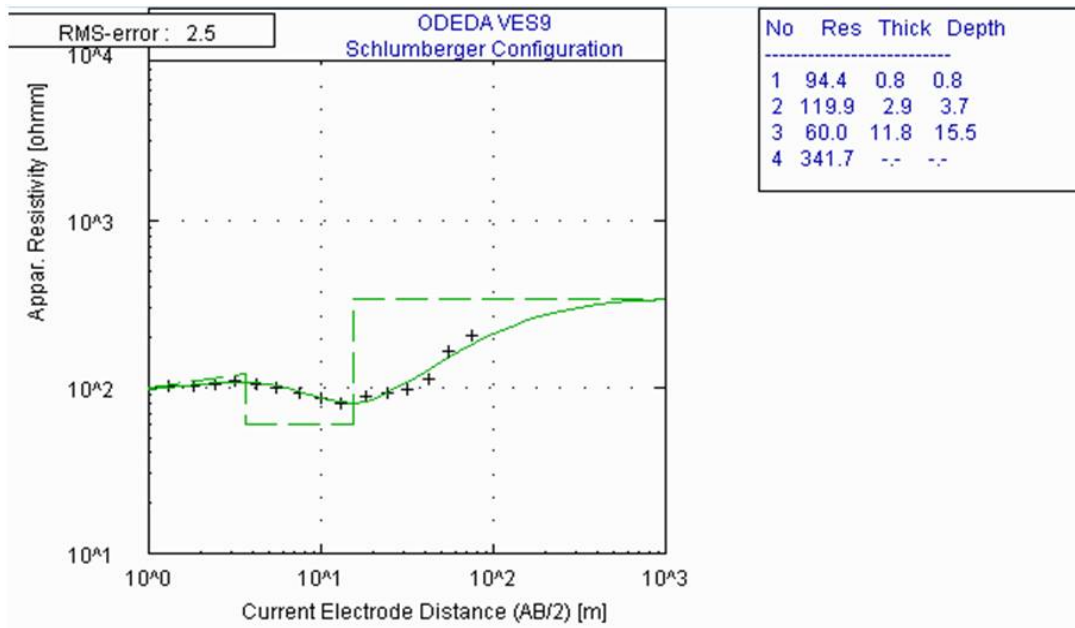
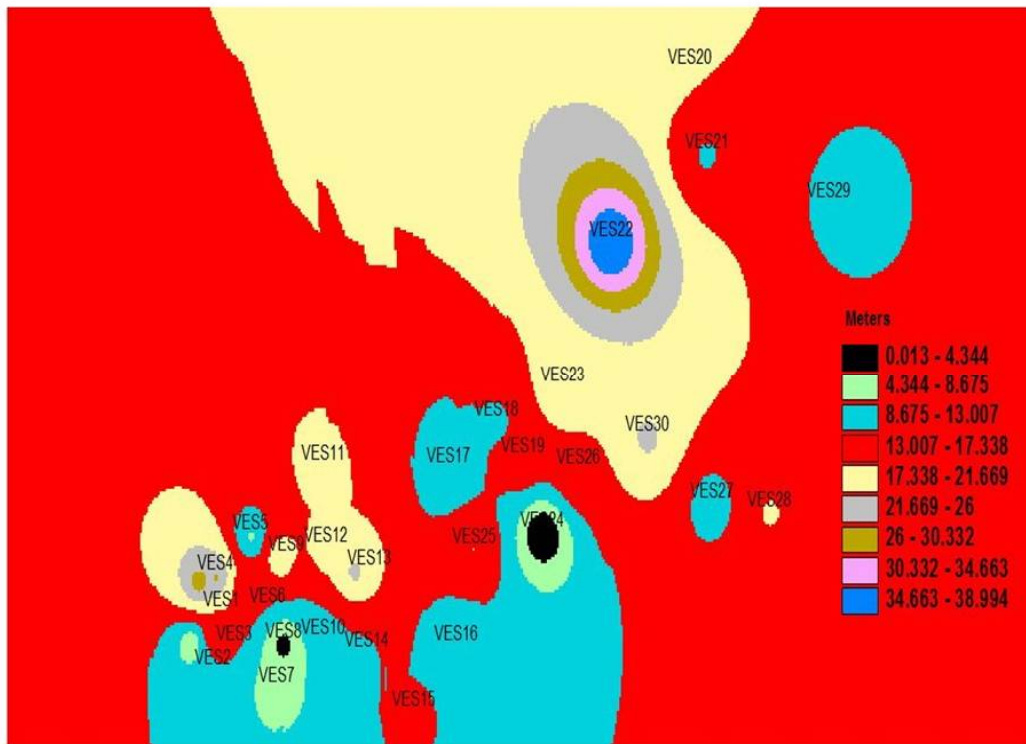


Fig. 5: VES curve over Station 9 showing four layers



**Fig. 8: Isopach Map of Overburden Thickness**

***Groundwater potential evaluation***

The weathered layer is regarded as a significant water-bearing layer especially if significantly thick and the resistivity parameters suggest saturated conditions.

The groundwater potential of the study area was zoned into high, medium and low potential zones. In this study, zones where thickness of the aquifer was greater than 17 m with average resistivity values between 40 and 162 ohm-m was of high groundwater potential. The Northern part spreading towards the central part fell within the high potential zone.

Zones with average resistivity values lying between 5 and 66 ohm-m, which were less

than 17 m thick, were classified as medium groundwater potential zones. The central portion extending to the western and eastern part fell into this zone.

It was observed that about 60% of the study area fell within the low/medium groundwater rating while about 40% constituted the high potential rating. This was due to the basement aquifers of the area which were distinctive, in that, the occurrence and characteristics were largely a consequence of the interaction of the weathering process related to recharge and groundwater through flow.

## CONCLUSION

In this study, the groundwater prospects of the rock units of some parts of Odeda Local Government Area, Ogun State, Southwestern Nigeria was undertaken using thirty (30) Schlumberger Vertical Electrical Soundings (VES). The computer iterated sounding interpretation revealed 2-5 subsurface sequence composing topsoil with limited hydrologic significance, weathered layer, fractured/fresh basement and the fresh basement. The weathered layer constituted the sole aquifer unit in the area; the yield being dependent on degree of the clay content. The higher the clay content, the lower the groundwater yield. The characteristic geo-electrical parameters of the delineated aquifer at each sounding station were used to produce the groundwater potential map of the area. About 60% of the study area fell within the low/medium rated groundwater potential zone while the remaining 40% constitute the high groundwater potential zone. Hence, the groundwater potential rating of the area was considered generally low due to high content of clay in the aquiferous layer and the thin thickness of the layer. The results of this study have provided reliable information for an elaborate groundwater abstraction.

## RECOMMENDATION

The groundwater potential of the parts of Odeda Local Government Area studied is generally low. The area also suffers from inadequate pipe-borne and surface water supply. This is worsened by the low yield or complete failure of many boreholes, and drying up of some of the hand dug wells in the area during the dry season. The problem of having an adequate supply of water is becoming progressively acute with growing population and industries. At present, only some parts of the municipal areas are pro-

vided with pipe-borne water supply. In order to meet the water requirements of the people, it is recommended that adequate pipe-borne water supply scheme should be considered for the area. This will help in mitigating the possible effect of epidemic that could arise as a result of use of water from unhealthy sources, especially during the dry season.

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