Application of Schlumberger Vertical Electrical Sounding for Determination of Suitable Sites for Construction of Boreholes for Irrigation Scheme within a Basement Complex

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Abstract– **In a bid to provide sustainable water supply for the proposed irrigation scheme at Tudun-dawa, Vertical Electrical Soundings (VES) were carried out with the aim of suggesting suitable sites for construction of boreholes. The Sting Resistivity/IP meter was used to acquire the data while the 1D Earth Imager iterative software was used to process the acquired data. With borehole information as control, the interpretation revealed the subsurface geology of the study area in succession of four subsurface resistivity layers. With the equivalent geologic layers that suggest the weathered and the underlain fractured basement as the aquiferous layers, sites that will provide appreciable volume of water were suggested base on vertical and lateral extent of the aquiferous layers.**

Keywords– Vertical Electrical Sounding (VES), Boreholes, Resistivity Layers and Aquifer

I. INTRODUCTION

Lack of water supply is what limits the inhabitants of the study area to seasonal farming that relies mainly on rain which falls between April to October, with its peak in July/August. To engage the inhabitants in dry season farming, sustainable water supply is inevitable. With sources of surface water; rivers, streams, dams, etc., at far distance from farms, the need for an economic, flexible and timeless sustainable water supply as an alternative source is essential.

This can be provided with proper exploitation of groundwater. Exploitation of this resource requires rapid and cost effective techniques of locating sustainable water bearing units (aquiferous zones) in a region (location of study area) where abortive boreholes are prevalent. Geophysical approach has, among others, been used to locate these zoneswith great successes (Arabi *et al.,* 2010, Sundararajan *et al.*, 2007, Raimi *et al.*, 2010).

In this work, Vertical Electrical Soundings were carried, at the request of the Upper Niger River Basin Development Authority – Minna, Niger State, to determine favorable sites for construction of boreholes at Tudundawa; a the marshy part of Kaduna south, Kaduna state, Nigeria (Fig. 1).

II. GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The proposed site falls within the north-central sector of the Nigerian basement complex. Details of the geology of the sector are contained in McCurry (1976). In nutshell, the site, which is characterized by top surface, is underlain by deep-seated basement rocks that bears the imprints of thermo-tectonic events of the Archean to early Paleozoic times (Oyawoye, 1972; Mccurry, 1976).

The main aquifer components of the basement complex of Nigeria are weathered and fractured basement (Olowu, 1967) and water yielding capacities of wells drilled to these components always vary. To avoid drilling abortive wells, geophysical investigation is imperative because it helps to reveal the presence or absence of potential water bearing geological unit(s) in the subsurface from which water may be abstracted.

III. DATA COLLECTION AND PROCESSING

A Sting Resistivity/IP meter was used to acquire Vertical Electrical Sounding (VES) data at stations spread across the proposed irrigation sites. The Schlumberger electrode configuration with maximum electrode configuration of 200m was adapted. The acquired data were processed and interpreted with 1D Earth Imager iterative software that interprets 1D electrical resistivity sounding data and produce layered resistivity model that reveals subsurface geology. Figures (3-8) are the iterated curves with layered resistivity models of the data acquired at the VES stations. Because, in some cases, geoelectric and geologic sections do not often correlate (Keller and Frischknecht, 1966), realistic geologic equivalent of the layered resistivity models of the acquired data were obtained with information from borehole, nature of superficial deposit (Tokarski; 1972, Wright and Mc Curry; 1970) and published resistivity data (Telford *et al*; 1990, Shemang, 1990) used as controls.

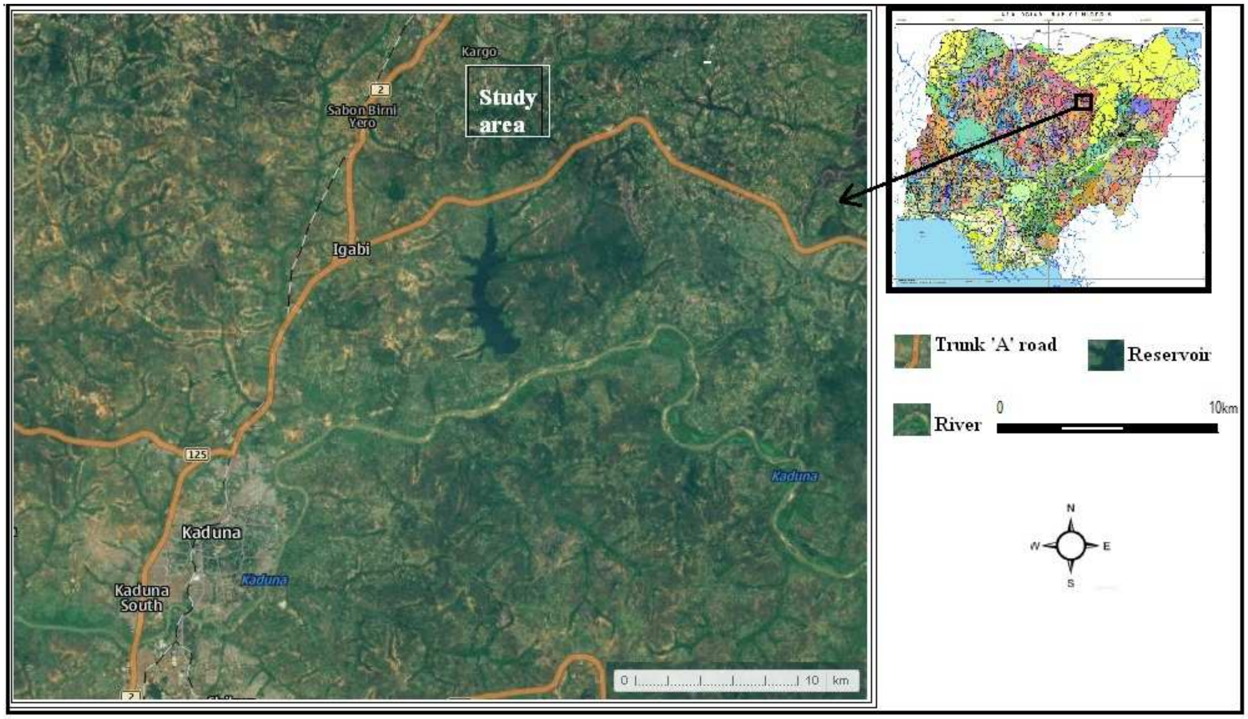

Fig. 1: A topographic map showing the location of study area

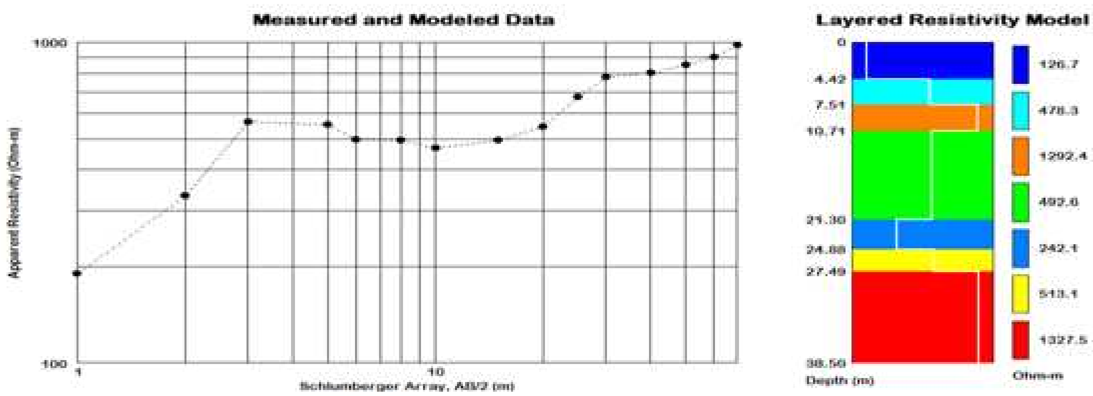

Fig. 2: Field curve and the apparent resistivity model of *VES 1*

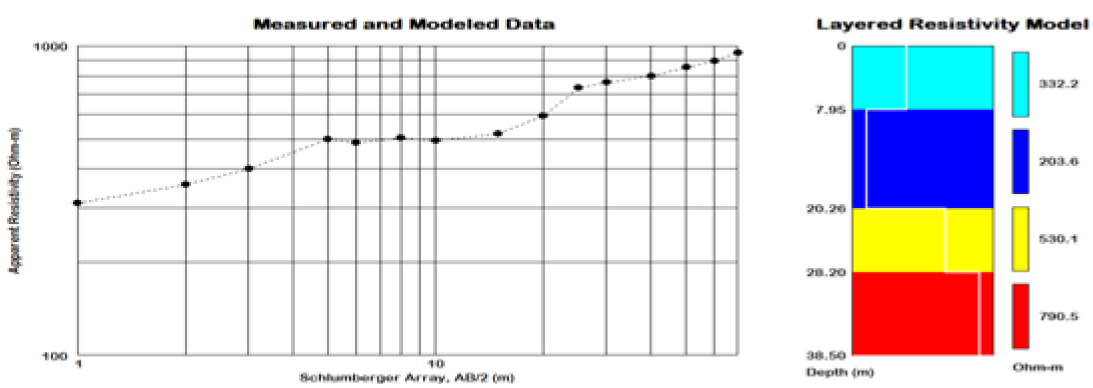

Fig. 3: Field curve and the apparent resistivity model of *VES 2*

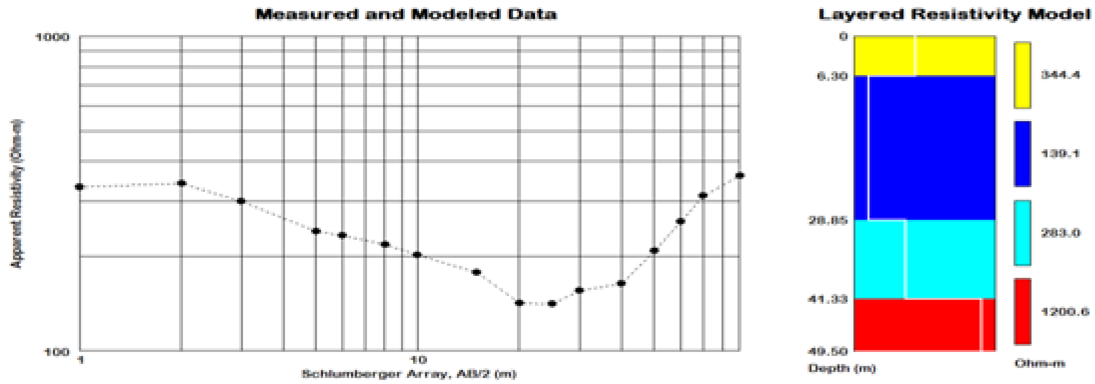

Fig. 4: Field curve and the apparent resistivity model of *VES 3*

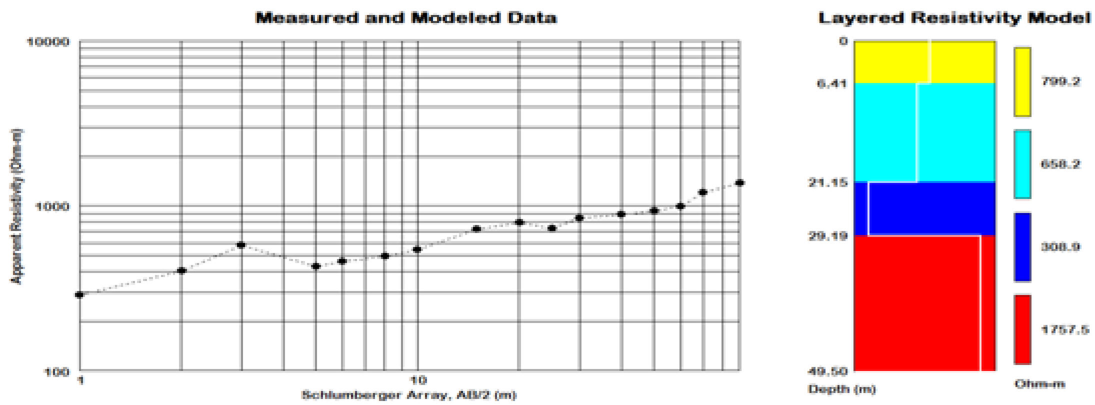

Fig. 5: Field curve and the apparent resistivity model of *VES 4*

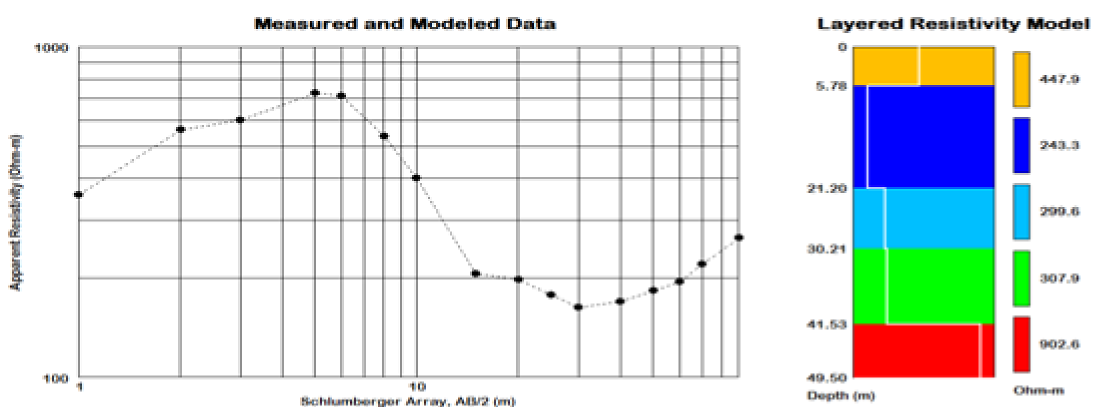

Fig. 6: Field curve and the apparent resistivity model of *VES 5*

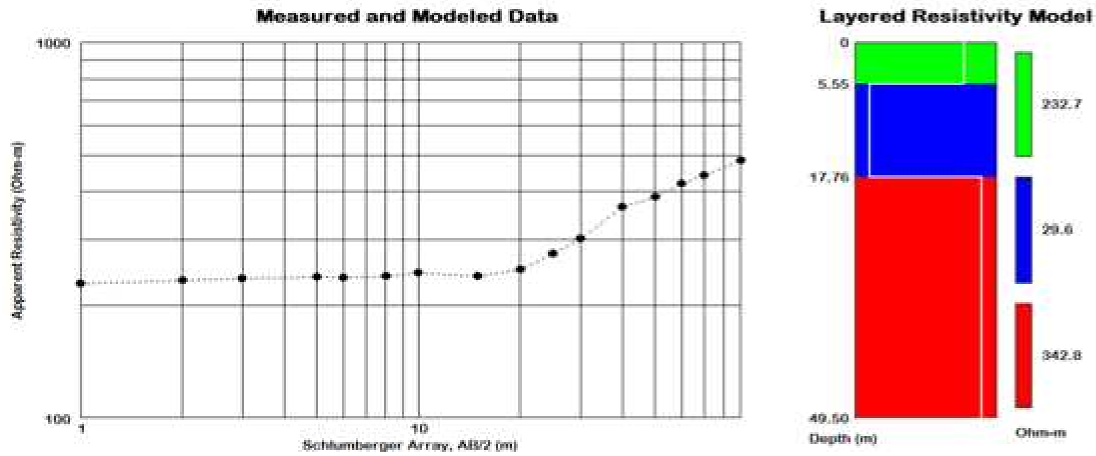

Fig. 7: Field curve and the apparent resistivity model of *VES 6*

IV. DISCUSSION OF RESULTS

The field Curves of the study, which are of type QH, KH and HKH, generally suggest four geoelectric layers. From the apparent resistivity model of the curves and information from a borehole log and published resistivity data(Telford *et al*; 1990), their equivalent geologic units are the top soil, weathered basement, fractured and fresh basement rock. The weathered and the fractured were considered as the aquiferous components of the study area because of their role as water bearing geologic units in basement complex (Olowu, 1967). The aquiferous unit (The weathered and the fractured), with a thickness range of 8-35m, is overlain by top soil that is characterized by resistivity and depth range of 126 – 1292Ωm and 5.5 – 10.7 m respectively. The resistivity value range suggests composition of sand, silt, clay and laterite. According to Eigbefo (1978), superficial deposits (or top soils) act as recharge materials, especially where they are underlain by weathered basement. The fourth layer, which underlain the aquiferous unit, has an infinite thickness and resistivity values that are greater than 790 Ωm.

V. CONCLUSION AND RECOMMENDATIONS

The investigation has addressed its intended purpose. In all the delineated geologic layers, the weathered and fractured basement, considered as the aquifer unit, has been interpreted to vary in thickness across the VES stations. Amongst these stations, VES 3 and VES 5 are the promising points with sustainable volume of water for construction of boreholes because the aquifer thicknesses are highest at the stations (about 35m for each station). It is thus recommended that, for appreciable volume of water to be pumped, boreholes should be constructed at VES3 and VES 5.The borehole drilling can be terminated between 37-40m or as deemed right by site geologist.

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