

Geophysical Investigation of Groundwater Potential in Ahmadu Bello University (Abu) Farm Area

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Hydrogeophysical investigation was carried out in Ahmadu Bello University Farm Area. The results obtain from the field were converted to response curves; depth of penetration of current to layers, resistivities, thicknesses, and groundwater potential were deduced. Water potential in the area shows three unit of water system at various depths (10 meter, 42 meter, and 82 meter). The apparent resistivity values ranges from as low as 29 ohm meter to as high as 25,027 ohm meter. This is an indication that some area might be clay formation while other areas are highly consolidated. IXID curve modeling of the area reveal 6–7 lithologic sequences with various thicknesses consisting of Top soil, Sandy clay, Fine to Medium sand, Coarse sand, Weathered Basement, Fractured Basement, and Fresh Basement. Water bearing zones are within the third to sixth lithologic layer; this is due to the moderate resistivity values obtain. The lithostratigraphy controls the occurrence, type, and behaviour of the aquifer units in the area. Three aquifer systems were demarcated from the lithologic sequences: Soft Overburden Aquifer, Weathered Aquifer, and Structural Controlled Aquifer. The three aquifer unit flows through a ground channel to River Shika. The Soft Overburden Aquifer towards the Kubanni Dam was divided to three members; Fine grained sand, Medium grained sand, and Coarse grained sand. The groundwater in the members flows towards the Kubanni Reservoirs. Their water level varies with regional rainfall as input and output (recharge and evaporation). The three aquifer type (Soft Overburden, Weathered, and Fractured Aquifer) of the area depict varied water potential form one spot to another.

Keywords:- lithostratigraphy, Soft Overburden, Weathered Basement, Fractured Basement, and Fresh Basement.

I. INTRODUCTION

Ahmadu Bello University Zaria (ABU) is facing serious water challenges. For the water available in various parts of ABU to be properly harness and to serve for now and the future generations, hydrogeophysical investigation was carried out in Ahmadu Bello University Farm Lake drainage basin to determine its groundwater potentials. The Farm Lake is situated in Samaru, a residential district in Zaria, Kaduna State, Nigeria. Loss to evaporation in the Farm Lake is 194,560m³/a. Water level in the Lake varies with regional rainfall. Volume of rainfall over the drainage Basins is 12,569,037m³/d and the rate of erosion is 0.56 mm/m²/a (Adama, 2007). The sub-lake (Bomo Lake) serves as sediment trap to the Farm Lake (Figs. 1 and 2). The study area is bounded with Longitudes and Latitudes 11° 12' 25.4"N, 7° 35' 44.6"E and 11° 12' 20.3"N, 7° 35' 41.5"E

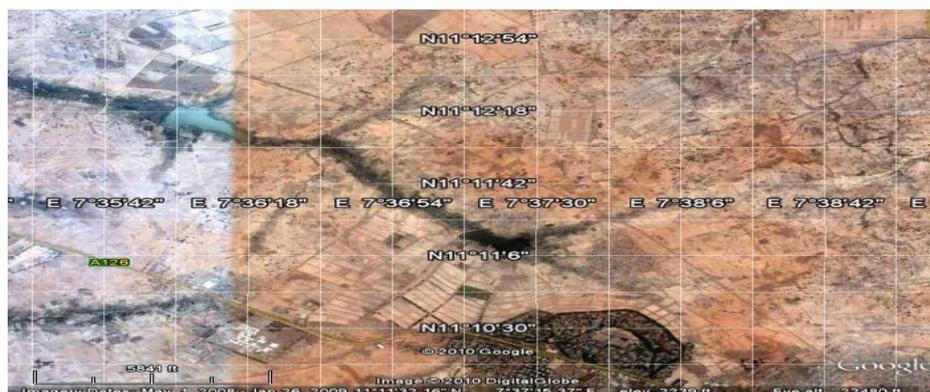


Fig. 1: Satellite image showing the study area

II. GEOLOGY OF THE STUDY AREA

The area under study is underlain by Precambrian rocks of the Nigerian Basement Complex. Groundwater localization within the Basement Complex occurs either in the weathered mantle or in the fracturing, fissuring and jointing systems of the bedrock (Jones, 1985; Ako and Olorunfemi, 1989; Olayinka and Olorunfemi, 1992). These unconsolidated materials are known to reflect some dominant hydrologic properties, and the highest groundwater yield in Basement Complex area are found in areas of thick overburden overlying fractured zones and are characterized by relatively low resistivity (Aderinto, 1986; Olorunniwo and Olorunfemi, 1987; Olorunfemi and Fasuyi, 1993).

III. DATA COLLECTION

The methods of data collection include; literature review, topographical, geological, geophysical, hydrological, hydrogeological, lithologic observation, field survey using traditional and Geographic Information System (GIS). The geophysical survey was carried out along transverses (Fig. 3) using Campus Omega Resistivity Meter from Allied Associate Geophysical Limited Serial number 0070. It is a compact, one box unit consisting of the transmitter and the receiver integrated circuiting boards with digital display. The curves were interpreted based on the principle 'that all points of maxima, minima, and inflection indicate the existence of boundaries'. The fresh rock is indicated wherever the resistivity values trend to infinity (Telford et al, 1976). The fresh bedrock resistivity exceeds $1000\Omega m$, but where it is fractured and saturated the resistivity reduces to less than $1000\Omega m$ (Olayinka and Olorunfemi 1992).

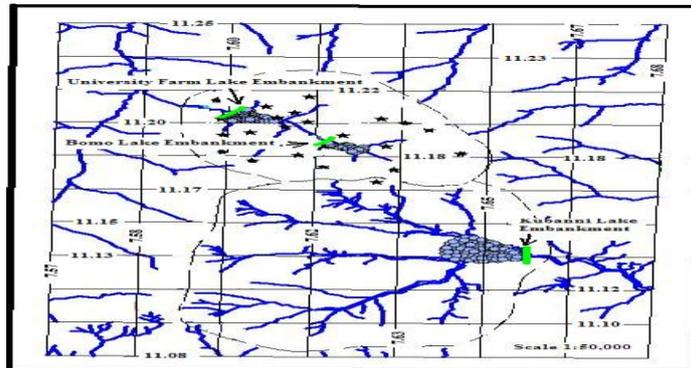


Figure 2: Map showing drainage of the three Ahmadu Bello University Zaria impounding reservoir: Kubanni, Bomo and ABUFarm Lakes. The black stars symbols are the VES points.

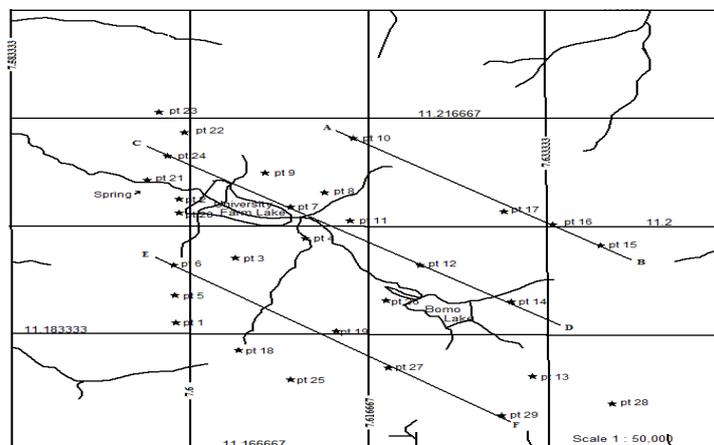


Figure 3: Sampling points(sounding locations) in the study area along and around the transverse lines

IV. FIELD CURVES

The apparent resistivities obtained were plotted against electrode spacing ($AB/2$) and the field curves were produced on a log graph sheet. The sounding curves were evaluated using IXID processing package(2004). The field curves were subjected to series of curves matching with the numerous curves in the package and the software automatically selects curves with models that suit the apparent resistivity values or

field curves. The package displays the interpreted curve matching and model data showing the number of lithologies intercepted, corresponding thicknesses, depth to basement, and the apparent resistivities value of the lithologies at each sounding point.

V. DATA ANALYSIS

The interpreted result reveals six to seven lithologic layers with their thicknesses, apparent resistivities, depths, sub-terranean lateral extent, probable depths of the overburden, weathered, basement, and geologic structure as may influence groundwater condition. (Figs. 4 ,5 and 6).

VI. APPARENT RESISTIVITY MAPS

From the analysis of the interpreted data, the total depth to basement is between 10 m to 82 m, shallow in some places and deeper in other areas with varying apparent resistivity values. Low resistivity values indicate the presence of water in a formation, too low or high of it may not favour the flow of groundwater as is attributed to clayey formation or dry consolidated formation which acts as aquiclude and aquitard (Telford et al, 1976).

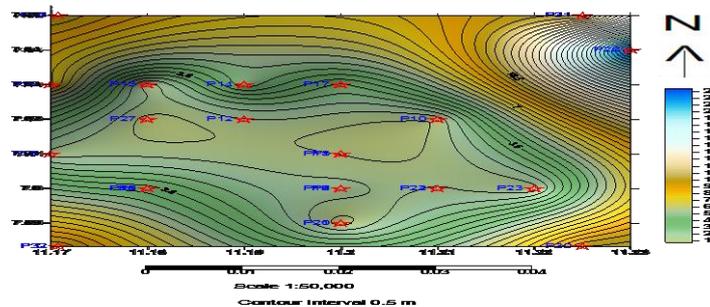


Fig. 4: Map of depth of overburden aquifer of the ABU farm lake

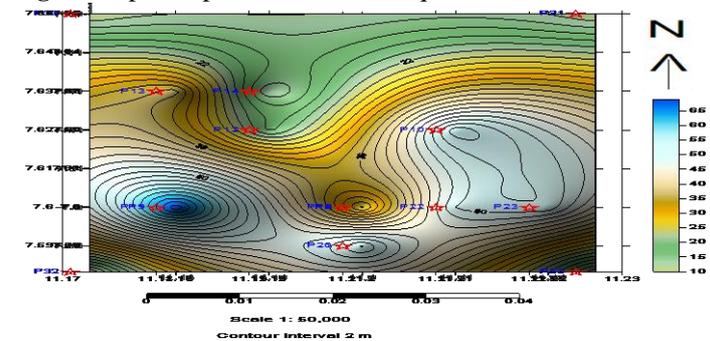


Fig. 5: Map of the depth of weathered aquifer of the ABU farm lake

Apparent resistivity map were produce at various intervals. This is to actually see the trend of the different formation and water potential in the basin. Different resistivity values have been assigned to particular type of formation in different literatures; this could be due to the different conditions at which they were measured. Moderate resistivity values are obtainable in good aquiferous zones. The clayey sand-sand layer has a high sand content which increases the resistivity value, and perhaps the hydraulic conductivity and transmissivity (Odusanya and Amadi, 1990). The sand clay layer with high clay content imposes some confining characteristics on the aquifer zone (Dan Hassan and Olorunfemi 1990). A high degree of saturation may be responsible for the low range of resistivity. Resistivity map therefore, link areas with similar potentials which also show the flow direction.

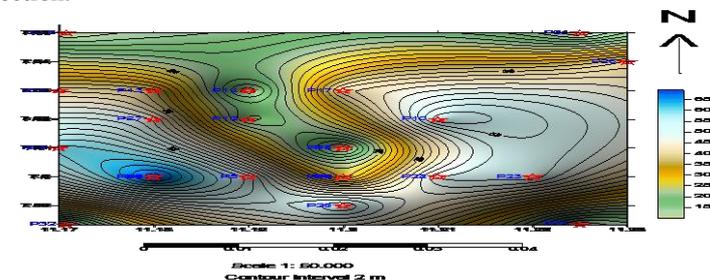


Fig. 6: Basement Topography of the ABU farm Lake

The resistivity at various depths is an indication of highly potential zone. The groundwater depth from the map shows a good groundwater potential spread over the area. This conforms to the undulating nature of the topography. At sounding point 13, 27, and 28 which correspond to depth 36 m, 38 m and 45 m the groundwater flow directions is shown. At these depths the groundwater flows away from the study area (Fig.7).

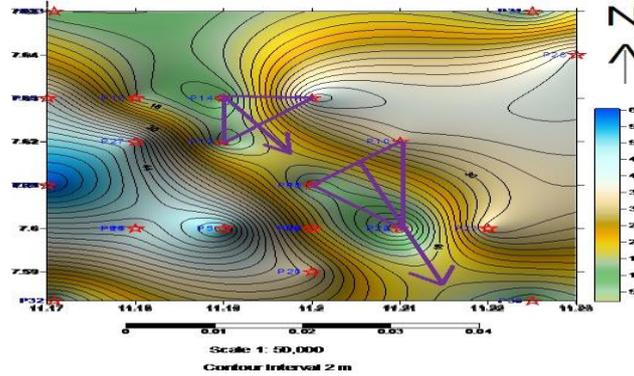


Fig.7: Piezometric map of the ABU farm lake showing groundwater flow direction

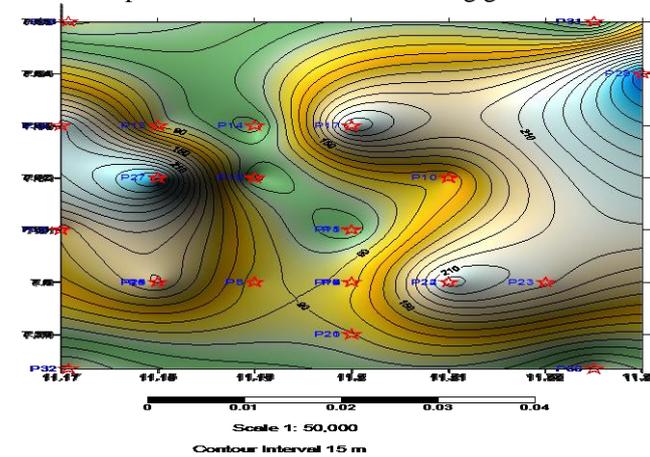


Fig.8: Iso-resistivity map of the structurally controlled aquifer.

VII. THICKNESS OF THE OVERBURDEN

Hand-dug wells in the Farm Lake area were used for the lithologic and geologic studying of the subsurface. Thickness of the Overburden of the Farm Lake is divided into: the top layer, overburden, and weathered. The true groundwater table resistivity differs from the ground surface water table. The ground surface water table is being influenced by the topography of the ground which gives the surface water body in the area. Figs. 8 and 9 shows areas of intersections of Basement and Ground surface which is refer as spring (groundwater discharge points).

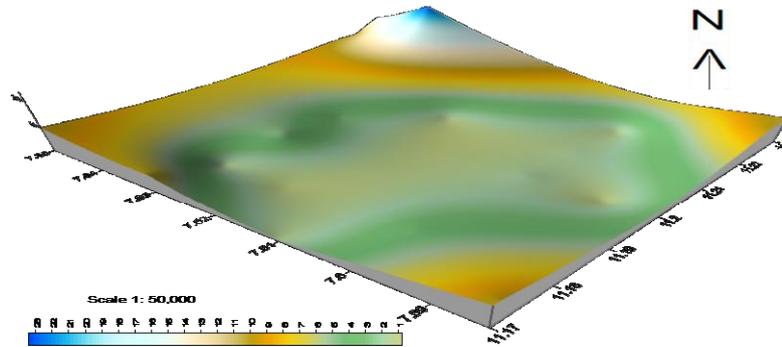


Fig. 9: 3-D of the overburden aquifer of the ABU farm lake

VIII. DEPTH TO BASEMENT MAP

Depth to basement shows areas with thicker overburden and probably aquifer which implies more water potential. VES point 8, 26, and 19 have a depth to basement ranging between 0 m to 82 m which are the deepest area, this is followed by VES point 13 ranging between 0 m to 47 m. VES point 19 show a depth range

between 0 to 82 m. Depth to Basement gives the topography of the basement of the place. The Farm Lake bedrock topography shows that the aquifer is structurally controlled. (Figs. 10, 11, 12, 13, and 14)

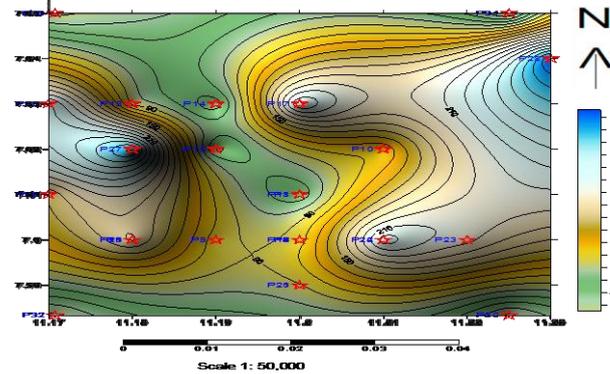


Fig.10: Iso-resistivity map of the structurally controlled aquifer

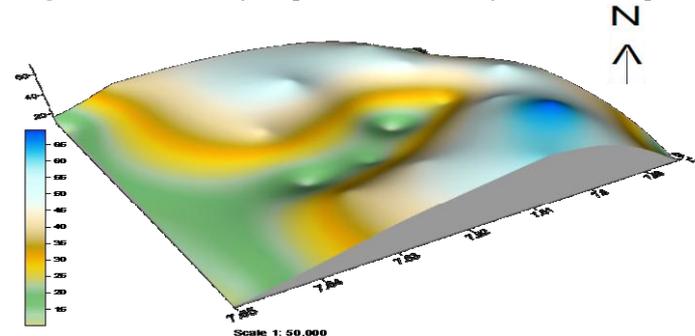


Fig.11: 3-Dof the total depth to basement of the ABU farm lake

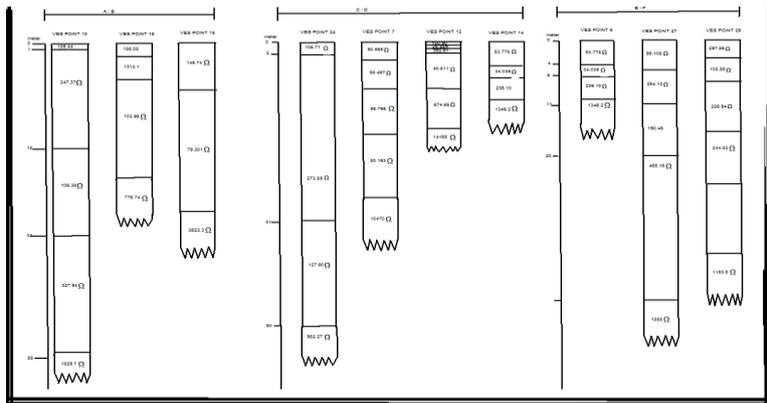


Fig. 12: Geoelectric section showing the inferred lithologies of the VES stations for A – B, C – D, AND E – F of the ABU farm lake area

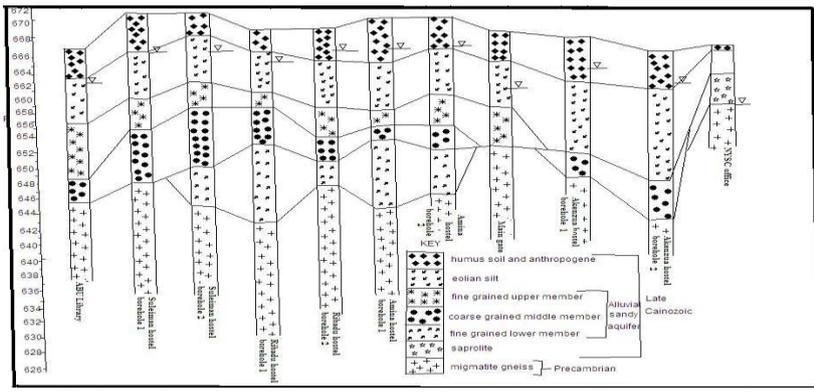


Fig.13: Hydrogeological correlation of the Boreholes in the study area (Baba,2007).

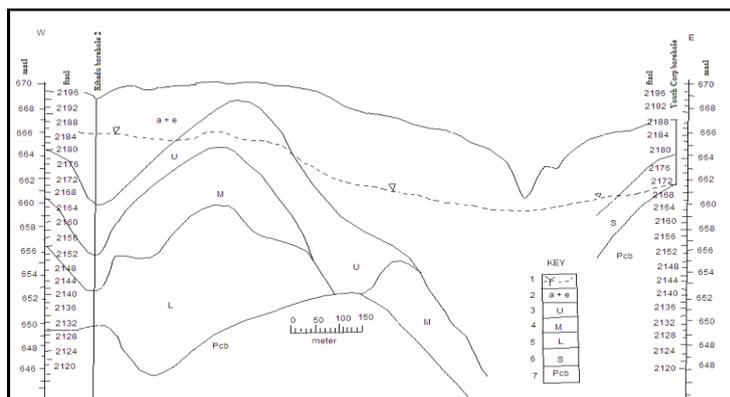


Fig.14: Hydrogeological cross-section of the study area. Explanations: 1-Water table; 2–Anthropogene and Eolian silt; 3- Upper, Fine grained Member of the older alluvial aquifer; 4– Middle, coarse grained Member of the older alluvial aquifer; 5–Lower, Fine grained Member of the older alluvial aquifer; 6–Saprolite; 7– Precambrian, crystalline undifferentiated (Baba, 2007).

IX. RESULTS OF THE WORK

A total of twenty nine (29) sounding points were established in the basin. The water bearing units with considerable thickness is exposed in some part of the basin giving rise to springs in wet season and sometimes in dry season depending on the volume of the water stored in the aquifer. From the result of the interpreted data using the apparent resistivity and thickness, the basin is a groundwater potential area although the groundwater flows away from the Farm Lake basin into the bigger basin which is the Shika River through ground channel. The entire area shows 6 to 7 lithologic layers of various thicknesses which consist of Top Soil, Sandy Clay, Fine to Medium Sand, Coarse Sand, Weathered Basement, Fractured Basement, and Fresh Basement. Different aquifer unit and type were identified namely; Overburden, Weathered, and Structurally Controlled Aquifer. The Overburden Aquifer is the major aquifer unit, thickness, and resistivity value obtained at these unit shows that the area has a good permeability and porosity. The apparent resistivity maps shows area with same water potential. The lithostratigraphy of the basin is controlled by the occurrence, type, and behaviour of the aquifer unit. The maps of the resistivity of the Basement, Top layer, True Aquifer, Overburden Aquifer, Weathered Aquifer, and Structurally Controlled Aquifer were plotted. The maps of the depth to the Basement, Weathered Aquifer, Overburden Aquifer, True Aquifer, Top layer, and Structurally Controlled Aquifer of the Farm Lake were determined. The hydro geological correction, hydro geological cross section, and the geoelectrical section show the inferred lithologies of the VES stations of the Farm Lake area, depth to water table, and aquifer thickness. The geoelectric data for the sections A – B, C – D, and E – F are shown in Table 1.

Table 1: Geoelectric section data for VES Stations A – B, C – D, AND E - F

Geoelectric data for A – B			Geoelectric data for C – D			Geoelectric data for E – F		
Resistivity (Ω)	Thickness (m)	Depth (m)	Resistivity (Ω)	Thickness (m)	Depth (m)	Resistivity (Ω)	Thickness (m)	Depth (m)
VES station 10			VES station 24			VES station 6		
105.44	1.0920	1.0920	106.71	1.9203	1.9203	53.778	4.8517	4.8517
247.37	17.770	18.862	273.89	29.417	31.337	34.035	2.6275	7.4793
106.38	15.421	34.283	127.60	18.915	50.253	236.10	4.6592	12.138
327.94	21.269	55.552	982.27	-	-	1346.2	-	-
1529.7	-	-	-	-	-	-	-	-
VES station 16			VES station 7			VES station 27		
186.08	2.7359	2.7359	90.565	3.2377	3.2377	95.108	0.80381	0.80381
1312.1	3.9463	6.6822	58.467	4.9296	8.1673	254.12	4.0919	4.8957
103.96	17.147	23.829	98.795	8.0480	16.215	190.46	6.7656	11.661
776.74	-	-	80.163	11.256	27.471	465.16	9.0089	20.670
-	-	-	10470	-	-	307.73	25.163	45.833
-	-	-	-	-	-	1888.0	-	-
VES station 15			VES station 12			VES station 29		

145.74	0.44213	0.44213	180.90	0.60530	0.60530	297.86	3.3112	3.3112
79.301	7.4281	7.8702	25.489	0.86581	1.4711	105.56	4.3725	7.6837
113.20	21.560	29.430	392.61	2.5816	4.0527	226.94	9.6911	17.375
2623.3	-	-	40.811	6.0199	10.073	263.12	9.0860	26.461
-	-	-	674.65	7.3302	17.403	244.82	12.943	39.403
-	-	-	14168	-	-	1193.5	-	-
-	-	-	VES station 14			-	-	-
-	-	-	53.778	4.8517	4.8517	-	-	-
-	-	-	34.035	2.6275	7.4793	-	-	-
-	-	-	236.10	4.6592	12.138	-	-	-
-	-	-	1346.2	-	-	-	-	-

X. CONCLUSION

Estimation of groundwater resources requires data on aquifer water level fluctuation and changes in water elevation with time. This work provide basis of understanding groundwater potential of the study area using the basin resistivity, thickness, and aquifer characteristics. To achieve optimal environmental balance in protecting groundwater and surface water there should be reservoir operating plan especially for multipurpose reservoirs. Therefore integrated approach is important in solving water problems. IXID curve modeling of the area reveal 6–7 lithologic sequences with various thicknesses consisting of Top soil, Sandy clay, Fine to Medium sand, Coarse sand, Weathered Basement, Fractured Basement, and Fresh Basement were delineated at subsurface. Water bearing zones are within the third to sixth lithologic layer; this is due to the moderate resistivity values obtain. The lithostratigraphy controls the occurrence, type, and behaviour of the aquifer units in the area. Three aquifer systems were demarcated from the lithologic sequences: Soft Overburden Aquifer, Weathered Aquifer, and Structural Controlled Aquifer. The three aquifer unit flows through a ground channel to River Shika.

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