Determination of Borehole Sites for Extensive Irrigation Work in Yobe State, Nigeria

Makinde, V.[1*], Alagbe, S.A.[2], Coker, J.O.[3], Bello, A.M.A.[4]

1. Department of Physics, University of Agriculture, Abeokuta, Nigeria.
2. Department of Geology, Ahmadu Bello University, Zaria, Nigeria.
3. Department of Physics, Lagos State Polytechnic, Ikorodu, Lagos.
4. Department of Physics, Kwara State Polytechnic, Ilorin.

victor_makindeii@yahoo.com, solayo@yahoo.com, cokerclara@yahoo.com, belloabdulmajeedfa@gmail.com

Abstract: Geo-electric resistivity soundings were carried out in Bursari, Bade and Jakusko Local Government Areas (LGAs) of Yobe State, Nigeria. This was aimed at determining favourable sites for drilling of boreholes, which will be used as recharge sources for the supply of water for use in irrigation works. The survey which delineated the various rock layers within the sub-surface at the sites, identified which of these layers would be promising for development; determined the thicknesses and depths of these aquiferous layers; and, identified borehole sites. The investigation showed that for an abundance of water supply for extensive irrigation purposes, a depth of between 90m and 110m would need to be drilled at each of these sites. [Journal of American Science 2010;6(2):58-61]. (ISSN: 1545-1003)

Key words: geo-electric resistivity soundings, aquiferous layers, borehole sites, vertical electrical soundings (VES)

1. Introduction

In the study of underground structures for the identification of water bearing layers, electrical resistivity method is usually found suitable. A study of the underground water bearing layers in parts of Yobe State of Nigeria was undertaken. The study area comprises four broad locations in Bursari, Bade and Jakusko Local Government Areas (LGAs) of the state. The following locations were investigated in this study:

(a) Jawa (Bursari LGA) — ten sites;
(b) Katuzu Ward in Gashua (Bade LGA) -- ten sites;
(c) Muguram (Jakusko LGA), — ten sites; and
(d) Jakusko (Jakusko LGA) — ten sites.

The study area is generally characterised by a flat topography. It is located within the North-East Arid Zone of Nigeria. The area is characterised by pockets of surface pools of water forming the wetland. The main objective of this study was to locate favourable sites for drilling of boreholes that would be pooled together to supply drinking water for the areas, and irrigate farmland at the peak period of the dry season. The result of the geo-electric resistivity soundings that were carried out in these parts of Yobe State, and favourable conditions for siting boreholes in the area under investigation are discussed.

1.1 Methodology

To achieve the objective, geophysical procedures were used to:

(i) delineate the various rock layers within the sub-surface at the project sites;
(ii) identify which of these layers would be promising for development;
(iii) determine the thicknesses and depths of these aquiferous layers; and
(iv) identify borehole sites.

2. Geology of the Area

The project area is located towards the western fringes of the Chad Basin and has some rocks of the Chad Formation underlying it. The Chad Basin is the largest area of inland drainage in Africa (Barber, 1965) occupying about 230,000 km^2 in the Central Sahara and the southern Sudan. About one-tenth of the basin is situated in the northern part of Nigeria. The stratigraphy and composition of the various formations are as discussed by Barber and Jones (1960), Carter et al. (1963), Reyment (1956), and Cratchley (1960). The Chad Formation is a sequence of lacustrine and fluviatile deposits of clays and sands of Pleistocene age. These sedimentary rocks dip gently and thicken eastwards towards the centre of the Chad Basin (Matheis, 1989).

The Chad Formation consists of three water-bearing horizons namely: the Upper, the Middle, and the Lower Zone (Matheis, 1989). The project area is directly underlain by the rocks of the Upper Member of the formation. Lithologically, the upper member is composed of layers of clayey grits and sands or sandstones of varying thickness. The rocks are largely concealed beneath a mantle of deposits. Artesian and sub-artesian conditions are present over wide areas of the basin having profound effect on the economy of this area (Matheis, 1989). The Upper Zone provides water for numerous dug wells throughout the rural areas.

2.1 Hydrogeology of the Area

The principal hydrological features in the project area are based on those delineating the geological units within the area. The principal features are the rocks of the upper member of the Chad Formation, which underlie the area. Groundwater potential in this upper member is estimated to be generally high, judging by the yields observed from existing boreholes in the area. Water level estimated from hand-dug wells was on the average, 20m. This shallow level is not surprising because of pools of water forming "wet-land" in the area of study. For an enhanced successful siting of boreholes, topographically higher areas were avoided due to the increased depth to water table that might be encountered.

2.2 Geophysical Investigation of the Area

In order to determine the layer thicknesses, distribution and nature of the overburden, and depth to fractured basement, two arrays of the electrical resistivity methods were used to probe the sub-surface. These are (i) the Schlumberger and (ii) the two-electrode arrays. For the Schlumberger array, an Abem Terrameter Model SAS 300 was used, while the instrument constructed for the Ajayi-Makinde Two-electrode Method (Makinde, 1996; Ajayi and Makinde, 2000), was used for the two-electrode array. VES sounding using these arrays were carried out at forty (40) sites to determine the different elements of the overburden, and also, the depth to basement. Typical methods of laying out (Koefoed, 1979; Breusse, 1983) with the adaptable methods of interpretation (Shiftan, 1970; Mooney, 1980; and Van Nostrand and Cook, 1966) were applied to arrive at meaningful deductions. In all the locations studied, the correlation coefficient of the two arrays was between 0.926 and 0.983, indicating a high confidence level in the results. This work however reports the VES result obtained using the Schlumberger array

3. Data Presentation, Interpretation, Results, and Recommendation

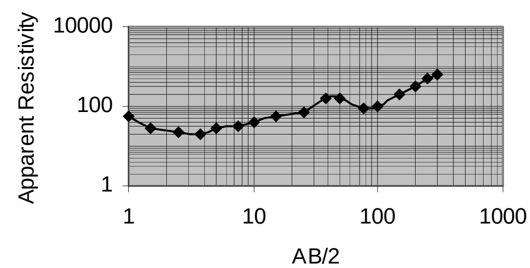
The VES data are presented as sounding curve plots of apparent resistivity, ρ (Ωm) against electrode spacing, AB/2 (m), on a log-log graph sheet. Figure 1 to 4 shows typical VES curves obtained at each of the four broad locations within the study area. In this section, attempts have been made to demarcate/emphasize only the horizon of interest for groundwater development. The depth to the aquifer and recommended drilling depth are also given. Apparent resistivity values with depth and corresponding VES curves obtained are tabulated for each site. Only the Schlumberger, and not the two-electrode data is discussed here.

3.1 Typical Results

3.1.1 Site Name: Jawa I (Bursari LGA)

Depth (m)	Resistivity (Ωm)	Lithology
0.6090693	35.2731	Dry Sand and Clay
0.8939916	19.32896	
1.3122	15.56736	Clay
1.926046	18.13284	
2.82705	23.64356	
4.149542	32.55106	Clay and Sand
6.090694	52.08189	
8.939917	101.8883	
13.122	192.7786	
19.26047	246.5311	
28.2705	181.8437	Sand
41.49542	103.2172	
60.90695	98.81796	
89.39919	261.2138	== Weathered Basement
99999	1372.104	Fresh Basement

Fig. 1: Graph of Apparent Resistivity against AB/2 for Jawa I (Bursari LGA)



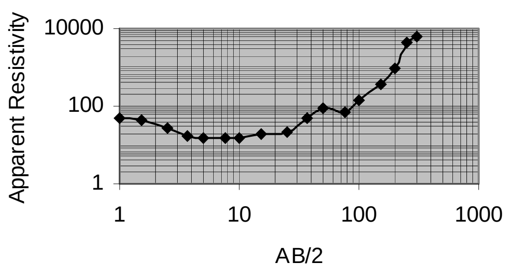
Recommendation

From the interpretation of the data related to this site, it is evident that for any appreciable volume of water to be pumped from this hole, and for that quantity to be sustained throughout the dry season, a depth not less than 90m would need to be drilled at this site.

3.1.2 Site name: Muguram I (Jakusko LGA)

Depth (m)	Resistivity (Ωm)	Lithology
0.6090693	57.14253	Dry Sand and Clay
0.8939916	42.64517	
1.3122	21.33805	
1.926046	12.048	
2.82705	13.55722	
4.149542	13.75339	Clay
6.090694	10.41828	
8.939917	13.84922	
13.122	30.49892	
19.26047	63.30762	
28.2705	123.900	Sand
41.49542	275.9972	
60.90695	712.3772	== Weathered Basement
89.39919	2066.193	Fresh Basement
99999	7084.676	

Fig. 2: Graph of Apparent Resistivity against AB/2 for Muguram I (Jakusko LGA)



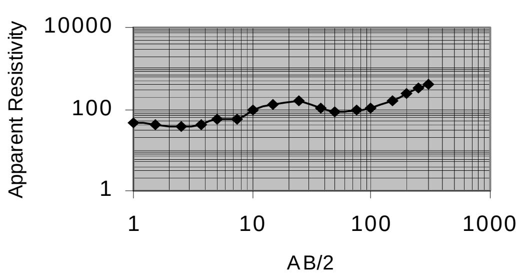
Recommendation

Based on the interpretation of the data obtained for this site, it is deduced that the hole at this site would have to penetrate to at least 90m for any appreciable volume of water to be pumped from this hole, and for that quantity to be sustained throughout the dry season,. The sandy layer (about 22m thick) should be developed.

3.1.3 Site Name: Jakusko I (Jakusko LGA)

Depth (m)	Resistivity (Ωm)	Lithology
0.6767437	48.12582	Dry Sand and Clay
0.993324	33.61568	
1.458	29.13827	
2.140052	34.94838	Clay
3.141167	56.65019	
4.610602	110.3181	
6.767439	198.0973	
9.933242	261.9577	
14.58001	220.0541	
21.40052	116.7784	
31.41167	57.21749	Sand
46.10603	55.62742	
67.6744	123.217	
99.33244	354.2248	== Weathered Basement
99999	1055.852	Fresh Basement

Fig. 3: Graph of Apparent Resistivity against AB/2 for Jakusko I (Jakusko LGA)



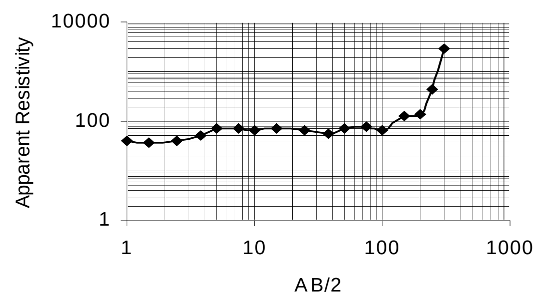
Recommendation

It is evident from the interpretation of the data collected for this site, that about 100m of hole need to be drilled here, to tap the sandy aquifer located between 12m and about 68m depth, and the weathered basement horizon that extends beyond more than 100m depths.

3.1.4 Site Name: Katuzu Ward I (Gashua, Bade LGA)

Depth (m)	Resistivity (Ωm)	Lithology
0.7519375	37.1452	Dry Sand and Clay
1.103693	35.62498	
1.62	45.17773	
2.377836	69.88837	
3.490185	93.76022	
5.122891	95.76368	
7.519376	80.38897	
11.03693	61.18612	
16.2	52.0777	
23.77835	59.54622	Sand
34.90185	63.30951	
51.22891	53.4198	
75.19376	72.48947	
110.3694	227.4889	Weathered Basement
99999	1326.941	Fresh Basement

Fig. 4: Graph of Apparent Resistivity against AB/2 for Katuzu Ward I, Gashua (Bade LGA)



Recommendation

From the interpretation of the data collected for this site, a depth of about 110m will have to be drilled at this site; so as to incorporate the weathered basement horizon for development.

4. Conclusion

The electrical resistivity geophysical investigation carried out in the study area comprising of 40 sites in four broad locations in Bursari, Bade and Jakusko Local Government Areas (LGAs) of Yobe State, and the VES interpretation made showed that the area contains thick overburden ranging from 90m to 110m.

This gives a wide range of water-bearing thickness and layer that can be developed for effective supply of borehole water for human and animal drinking, and irrigation work during the dry season. The investigation showed that a large expanse of the area has high potential to support this interconnected borehole programme.

The lithologies encountered showed that most of the area is characterised by dry sand and clay underlain by intercalation of sand and clay, followed by sand (usually), then by the weathered basement, underlain by the fresh basement. The figures shown bear much relationship with those of other sites, not shown. Deductions about the earth layerings within the region were in line with observations made by Okwueze et al. (1988) and, Idornigie and Olorunfemi (1992). As designed, for this project, tube wells are to be used with the pumping machines, usually fuel powered, adequately secured to ensure regular pumping of water from the wells with less human effort. For adequate supply of water, if the entire thickness of the aquifer at each site will not be screened, then whatever the length of screen to be used (usually two-thirds of the aquifer thickness) must be installed at the lower part of the aquifer. This is to allow for horizontal flow of groundwater into the well, thereby reducing the cost of energy that will be needed to lift the water to the surface. Furthermore, it will keep the aquifer away from surface contamination.

Correspondence to:
Victor Makinde
P.O.Box 94, UNAAB Post Office,
Alabata, Abeokuta.
e-mail: victor_makindeii@yahoo.com

References

[1] Ajayi, C.O. and Makinde, V. The “Ajayi-Makinde” Two-Electrode d.c. Resistivity Array. (A Brief Brochure on the Method to the Patent Office, Abuja.) March, 2000.

[2] Barber, W. and jones, D.G. The Geology and Hydrology of Maiduguri, Bornu Province. Rec. Geol. Surv. Nigeria. 1958: 5 – 20.

[3] Barber, W. Pressure Water in the Chad Formation of Bornu and Dikwa Emirates, north-Eastern Nigeria. Geol. Surv. Nigeria Bull. No 35. 1965.

[4] Breusse, J.T. Modern Geophysical Methods for Subsurface WaterExploration. Geophysics, Vol. 28. (1963): 633 - 657.

[5] Carter, J.D., Barber, W., and Tait, E.A. The Geology of parts of Adamawa, Bauchi and Bornu Provinces in North-Eastern Nigeria. Geol. Surv. Nigeria Bull. No 30. 1963: 109p.

[6] Cratchley, C.R. Geological Survey of the South Western Part of the Chad Basin. C.C.T.A. Publ. No 31. 1960.

[7] Koefoed, 0. Geosounding Principles 1, Resistivity Sounding Measurement. Methods in Geochemistry and Geophysics. Elsevier. Press, Netherlands. 1979.

[8] Makinde, V. Laboratory and Field Investigations of a Variant of the Two-Electrode d.c. Resistivity Array. Unpublished Ph.D. Thesis, Ahmadu Bello University, Zaria. 1996.

[9] Matheis, G. Short Review of the Geology of the Chad Basin in Nigeria. In: Geology of Nigeria. Ed. C.A Kogbe. Rock View (Nigeria) Ltd., Jos Nigeria. 1989: 341 – 346.

[10] Mooney, H.M. Handbook of Engineering Geophysics, Vol.2: Electrical Resistivity. Bison Instruments incorporated, Minnesota, United States of America. 1980.

[11] Okwueze, E.E., Umego, M.N, Baimba, A.A, Ntayi, F.A., and Ajakaiye, D.E. Application of Geophysical Methods to Groundwater Exploration in Northern Nigeria. Stylogia, Vol. 4, No.2. 1988: 103 -115.

[12]Reyment, R.A. On the stratigraphy and palaeontology of the Cretaceous of Nigeria and the Cameroon, British West Africa. Geol. Foren Stockh Forth, 78. 1956: 17 – 06.

[13]Shiftan, Z. Interpretation of Geophysics and Hydrogeology in the Solution of Regional Groundwater Problems. In Monroey, L.W. (Editor), Mineral and Groundwater Geophysics. Economic Geological Report, Ottawa, Canada. 1970: 507 - 516.

[14] Van Nostrand, R.G. and Cook, K.L. Interpretation of Resistivity Data. United States Geological Survey Professional Paper, 499. 1966.

06/09/2009