Geo-Electrical Survey of Groundwater Potential for Local Usage in Nuhu Bamalli Polytechnic, Zaria

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Abstract: Vertical Electrical Sounding (VES) employing the Schlumberger Electrode configuration was used to provide information about the subsurface lithology with the aim of evaluating its groundwater potential. The Schlumberger array was chosen because of the advantage it has over the other arrays such as higher resolution, greater probing-depth and consuming lesser time. The need for groundwater in the study area due to the rate of borehole failures, couples with the fast increases in population necessitate the need for this research. A total of 48 VES stations were made along the eight profiles with five sounding stations per profile within an area of about 10000 m^2. The result of the interpretation VES data was used to produce the coefficient of reflection and longitudinal conductance map. The VES curves were interpreted using DC INV resistivity computer software and the iso-maps of the coefficient of reflection and longitudinal conductance were produced using surfer11software. The processed information from the survey shows that the area is dominated by a maximum of four layers, namely, the top soil, the weathered basement, the fracture basement and the fresh basement. The result of the interpreted VES data showed that the excellent parts of the water bearing zones (aquifer) were found to be located around the south-west and south-east of the study area because of the positive correlation between the two maps produced. It is therefore recommended that a single industrial borehole be constructed within the identified zones that can serve the entire community of School of Applied Sciences that can easily be managed and is environmentally friendly.

Keywords: Aquifer, Coefficient of reflection, Geo-electric, Longitudinal conductance.

INTRODUCTION

The present water inadequacy experienced by inhabitant of Nuhu Bamalli Polytechnic (UPE) and its environs might be due to geometrical growth and development of the school, both in terms of academic infrastructures and social infrastructures. These have put high demand on water and subsurface utilization. The application of geophysical techniques has been extensively use nowadays for various purposes. Among the most frequent is the vertical electrical sounding (VES) as is use for water quality assessment and evaluation technique, this might be due to its simplicity and its computer software availability for its modeling. The electrical resistivity technique involved the sending of electrical current into the subsurface of the Earth and the corresponding effects of the flow of the current are recorded. The variability of these effects can then be interpreted by the use of computer software.

Numerous investigations for the use vertical electrical soundings in water investigation techniques were reviewed here as follows;
Abdullahi, Udensi, Iheakanwal and Elettal, (2014), have reported the use of depth Sounding applied in Engineering and hydrogeology investigation at Kaduna Polytechnic main campus from the finding, the researchers consider fractured and weathered basement rocks as the water bearing zone. In another study, Aboh, H., Dogara, M., &Alao, J. (2016), identified the spatial distribution, extent and nature of the aquifer within Chikun local government area, Kaduna State. Dogara , *et al.*, (2016); reported that about thirty(30) Sounding points at Danhonou Village (Kaduna millennium city) using Schlumberger Electrode spread, which aimed at detecting water saturated zone. The interpreted results show that the resistivity values ranging from 36 Ωm to 656 Ωm with thickness between 10.0 m to 48.7 m.is weathered/fracture basement. Alao, (2016)

investigate thirty Vertical Electrical Sounding points in Kaduna Millennium city, Kaduna, by the used of Schlumberger electrode spread with a maximum current-electrode spacing of 100 m. The results from the data interpreted data revealed the study area to consist of three five geologic formations. The researcher conclude that the weathered and fracture formation are target areas for groundwater exploitation.

MATERIALS AND METHODS

The instrument used for the measurement of resistivity was Ohmega resistivity meter while GPS was used to measure the elevation above the sea level, longitude and latitude of the Sounding points.

The current electrodes and the potential electrodes were driven into the ground at the marked point (VES POINT).The electrodes were hammered dip down into the ground so as to obtain contact between the ground and the electrodes. In each case at each VES point, the potential electrodes were fixed symmetrically about the VES point while the current electrode spacing was expanded symmetrically and progressively about the Centre of the array. When the measured potential difference between the potential electrodes became too small for the potential to be measured accurately, the half-potential electrode spacing (MN/2) will be increased and the measurement continued according to some selected (AB/2 versus MN/2) interval. This is known as changeover or cross over point. The half-current electrodes spacing (AB/2) range from 1m to 100 m while the half potential electrodes spacing (MN/2) range from 0.3 to 5 m.The array used for this survey is Schlumberger array because of the advantage it has over the others array such as higher resolution, greater probing-depth and consuming lesser time.

Location of the Study

The area under study is Nuhu Bamalli Polytechnic, Zaria main campus (UPE). It is located in-between the school of applied sciences and the school of Vocational and Technical education (fig.1) with latitude of $10^{0}346^{1}$ N and longitude of $007^{0}265.87^{1}$ E,

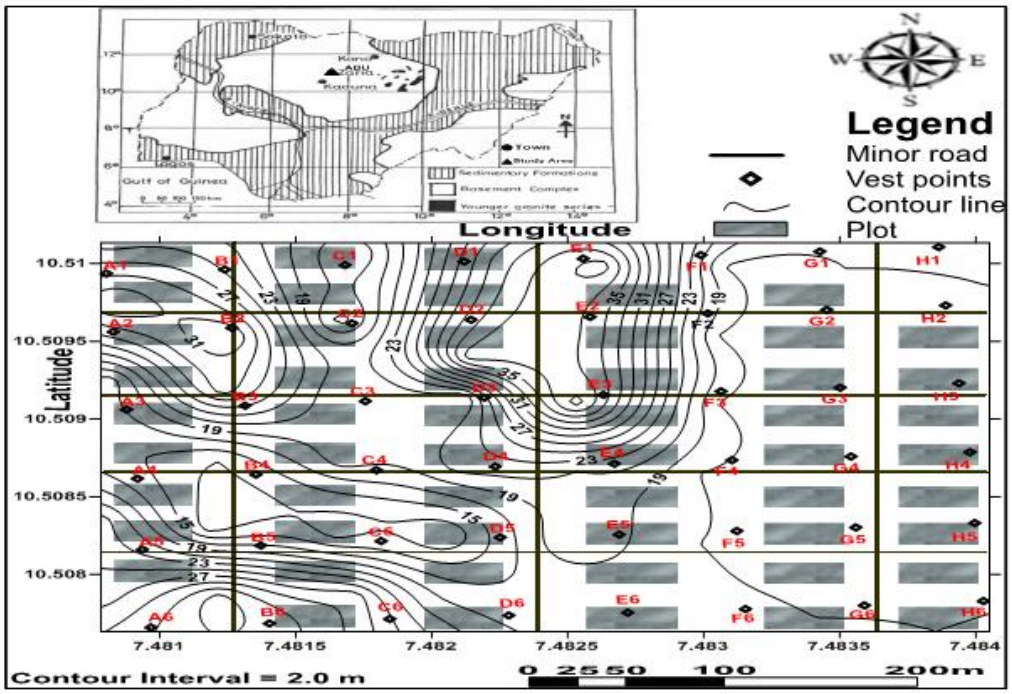

Figure 1: Map of the study area (source: field work modified from Google map , 2023)

RESULTS AND DISCUSSION

Geo-electric and Geologic Sections for Profile A

Fig 2 below shows that this profile was underlain by four subsurface layers. The resistivity and thickness of the top layer was found to be from 427 Ωm at VES A2 to 1006 Ωm at VES A4 and 0.35 m at VES A1 to 3.31 m at VES A6 respectively. The resistivity values suggest that the top layer is clayey and lateritic in nature. The indurated laterite which forms the second layer was identified to have resistivity values ranging from 370 Ωm at VES A6 to 1763 Ωm at VES A5 with maximum thickness of 11.64 m at VES A1.The weathered layer forms the third layer with resistivity values ranging from 21 Ωm at VES A3 to 395 Ωm at VES A2 while under VES A5 and VES A6 the sand, silty and clay defined the third layer with resistivity values varying between 6 Ωm at VES A6 to 27 Ωm at VES A5 with a mean thickness of 3.72 m. The last layer is characterize with resistivity values greater than 1000 Ωm is fresh basement with an infinite thickness except at VES A5 and VES A6 which is weathered basement with an infinite thickness.

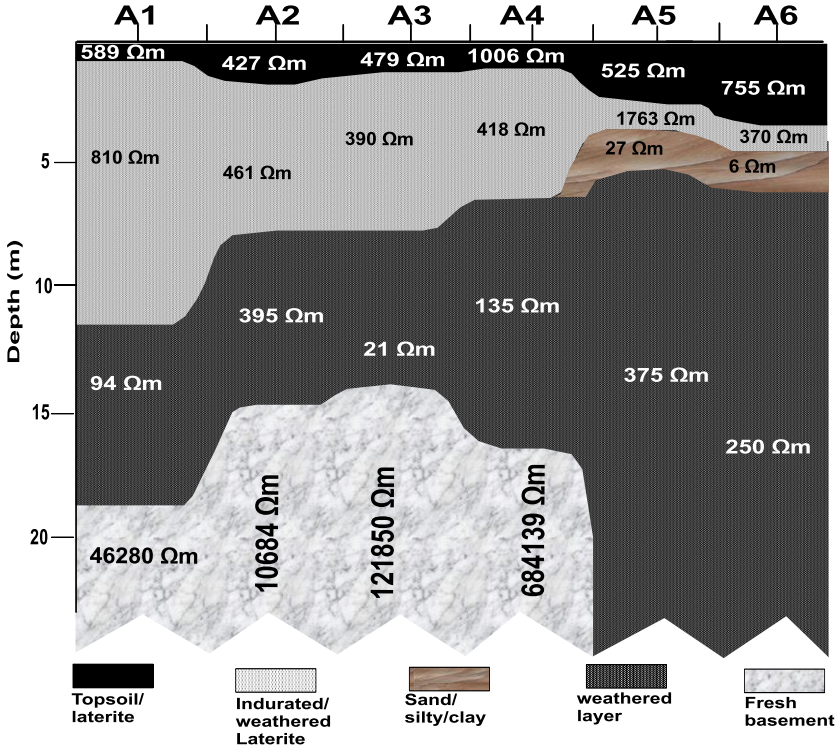

Figure 2: Geo-electric section of profile A.

Resistivity and Weathered Basement thickness

Fig .3 and fig.4 show resistivity of the weathered basement and the thickness map with a mean values of 134 Ωm and 23 m respectively which were in agreement with Aboh, (2016), Abdullahi *et al.*,2014) and Dogara, *et al.*, (2016),The weathered layer thickness is highly variable across the study area. The determination of thickness was done across all the VES points along the eight profiles within the study area. The thickness varies from 5.4 m to 63 m. (Ahmed *et al.*. 2019), asserts that the thick weathered basement layer containing less percentage of clay, which is found above the basement rock, might be a water-bearing layer. Optimum aquifer potential could be attained in the mid-range of Saprolite resistivity (100 Ωm to 400 Ωm) and resistivity values of less than 100 Ωm indicate clay with attendant poor ground water potential Aboh, (2016), Aizebeokhai and Oyeyemi (2018), Oladunjoye *et al.*, (2019) and Olorunfemi *et al.*, (2020) also noted that generally any area that is characterized with low weathered resistivity and relatively high weathered thickness are best for siting borehole for ground water exploitation. The weathered basement resistivity> 100 Ωm in fig. 2 with the thickness >15 m in fig 3 suggest high aquifer potential and are target for siting boreholes.

Coefficient of Reflection (C_R) map`

Figure 5 show the coefficient of reflection of the study area. The map was produced using contour interval of 0.01. According to (Olayinka *et al.*, 2000), sounding points with coefficient of reflection less than 0.9 are high density, water-filled, fracture zone. Based on the map produce the part of the area in the north-west, some part south-east and some small portion of the southern part of the study area are characterized with high density water-filled fractures.

Resistivity Contrast (R_C) map

Resistivity contrast (R_C) map is presented in contour map (fig. 6) with contour interval of 1000 .The resistivity contrast values range from 0.007 to 22522.5 with mean value of 2086.1 .The northwest has resistivity contrast values range from 1.07 to 18.17 while southwest was found to have a resistivity contrast values range from 0.00068 to 10.37.These areas mention may indicate high density water filled fracture because, according to (Olayinka *et al.*, 2000), VES points with resistivity contrast (C_R) value <19 indicate high density water filled fracture.

Coefficient of anisotropy (λ) map

Fig 7 shows the coefficient of anisotropy map of the study area. The map produced with contour interval of 0.1. Looking at the northwest on the map of the study area, it was discovered to have varying values of coefficient of anisotropy from 1.05 to 1.21. While the southeast, northeast and the southwestern part of the study area have coefficient of anisotropy values that range from 1.01 to 1.32. These areas would be considered as water prospect zones. As confirmed by Rao & Hariskrisha (2003) that says areas with coefficient of anisotropy values less than 1.5 contained high porosity and permeability and are considered as areas of high groundwater potential.

Logitudinal conductance iso map

Fig.8 is a longitudinal coductance iso map with contour intervals of 150 Ω^{-1}.The coductance values increase toward , northeast, sourtheast and sourthwest of the contour map.From the literayure, as the conductance increases, the resistivity naturally decreases, pointing towards the groundwater potential aquifer (Gowd, 2004). Above areas mentioned was expected to be water bwaring zones (aquifer).

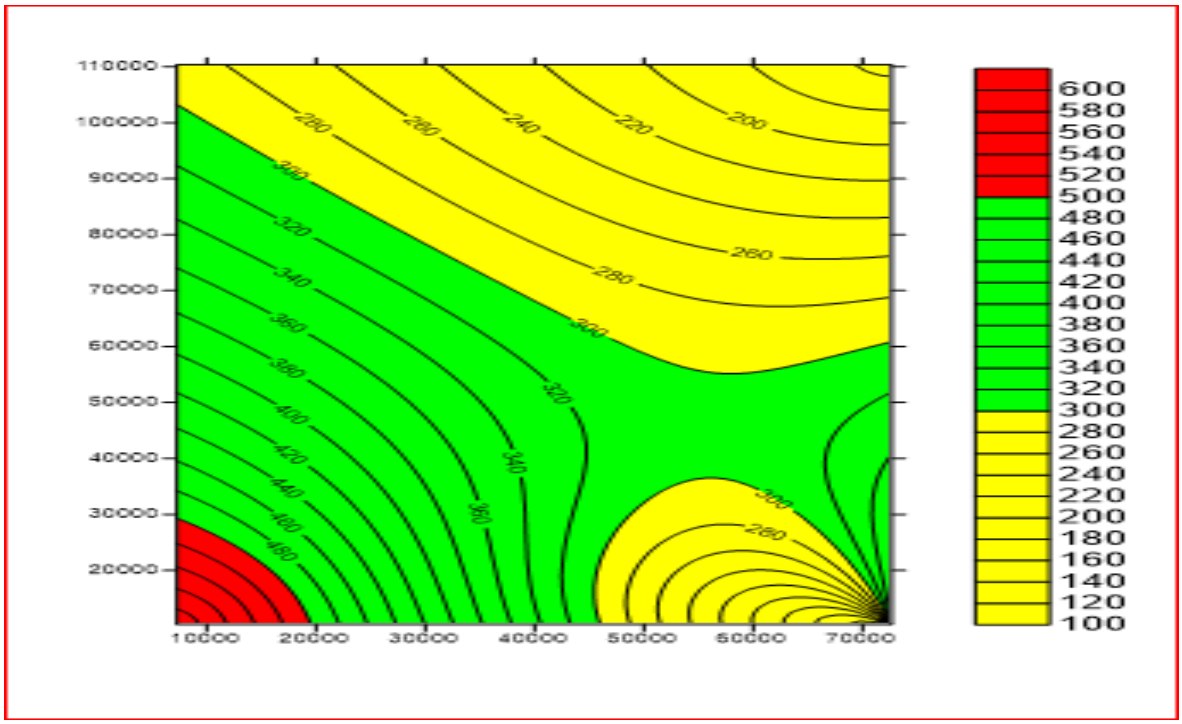

Fig.3 Resistivity Map of the Weathered Basement

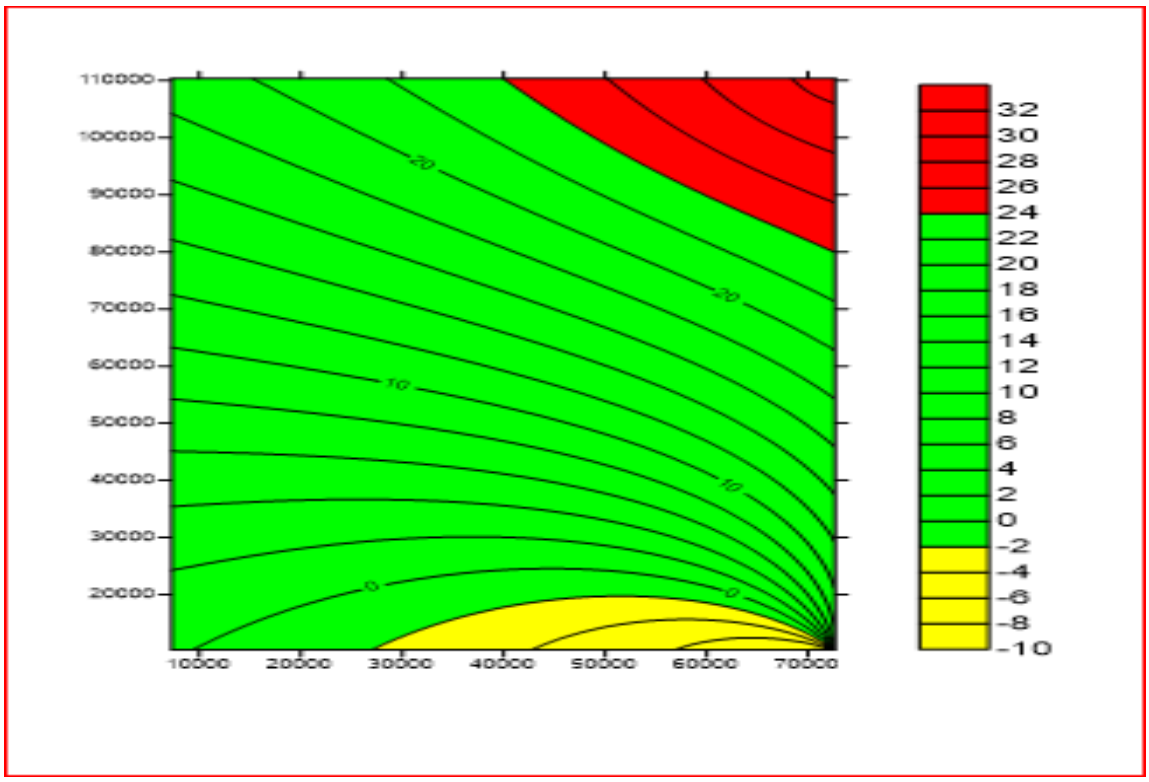

Fig.4. Map showing thickness of Weathered Layer

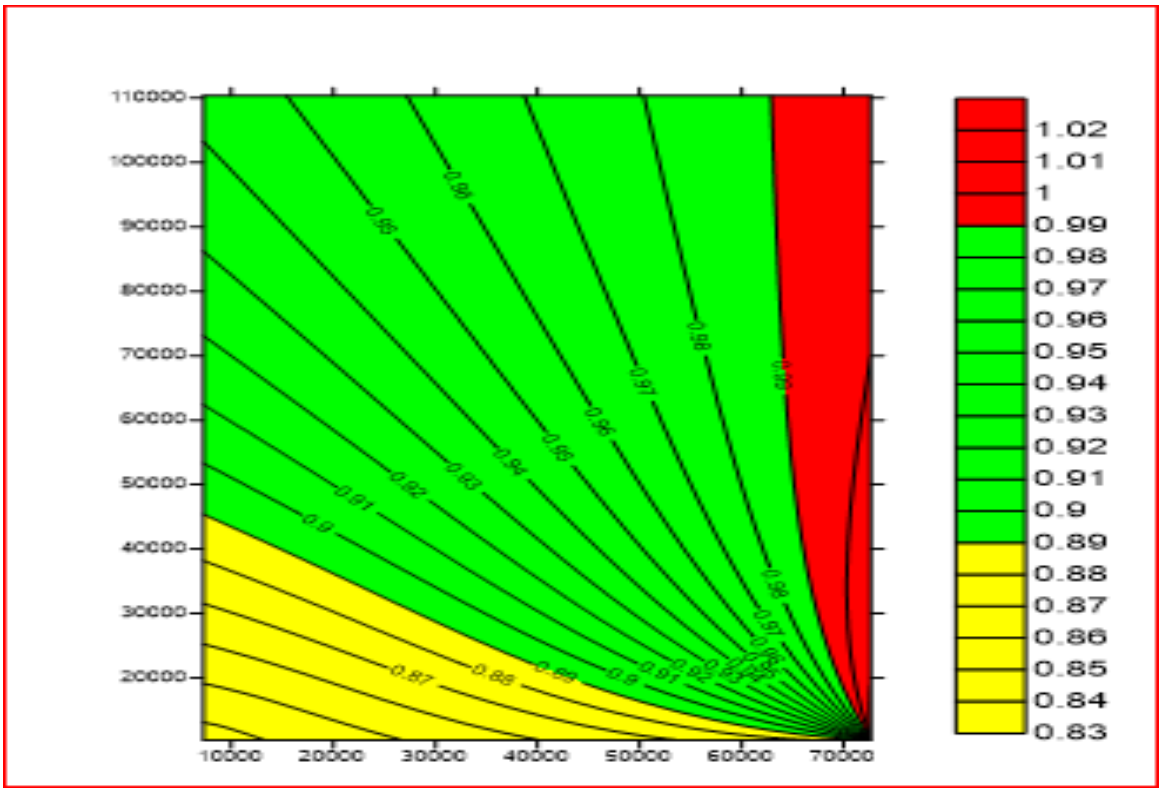

Fig 5 Reflection coefficient map

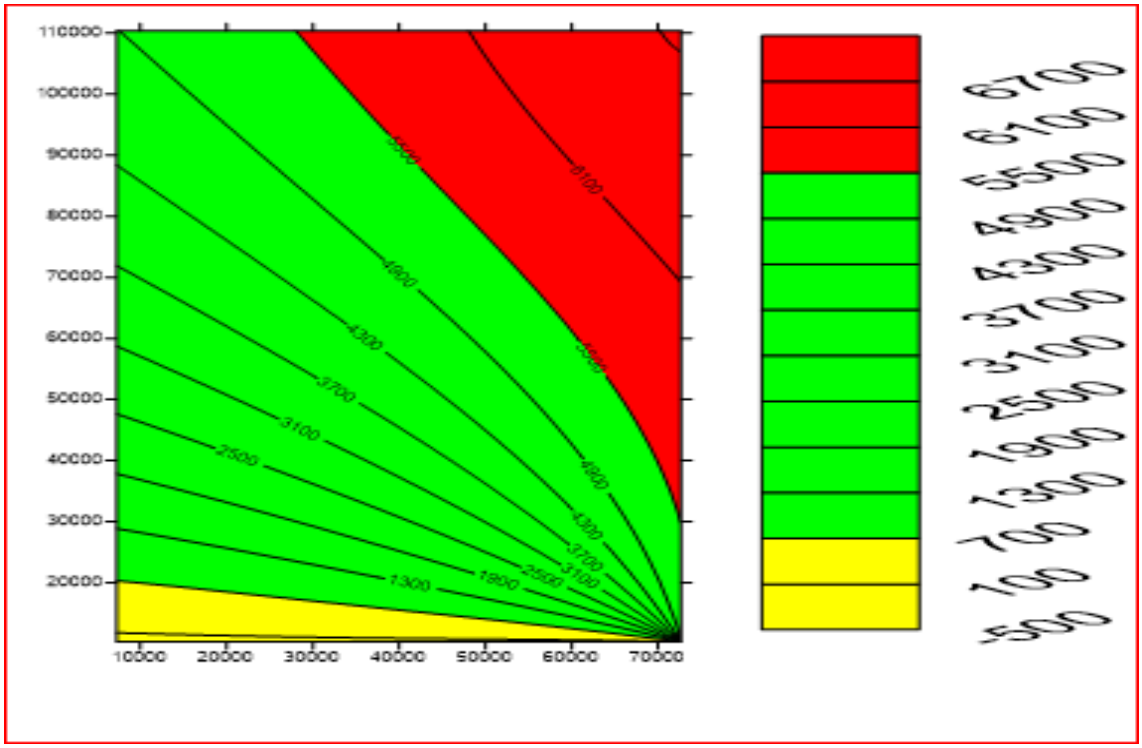

Fig 6 Resistivity contrast (R_C) map

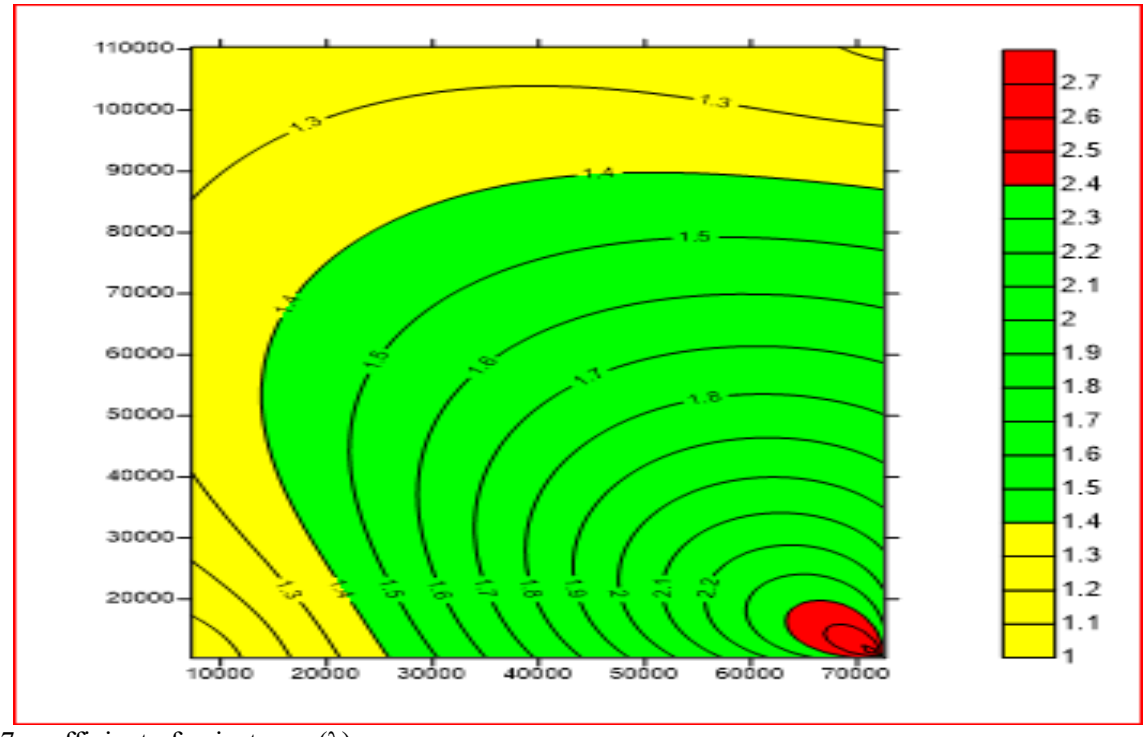

Fig.7 coefficient of anisotropy (λ) map

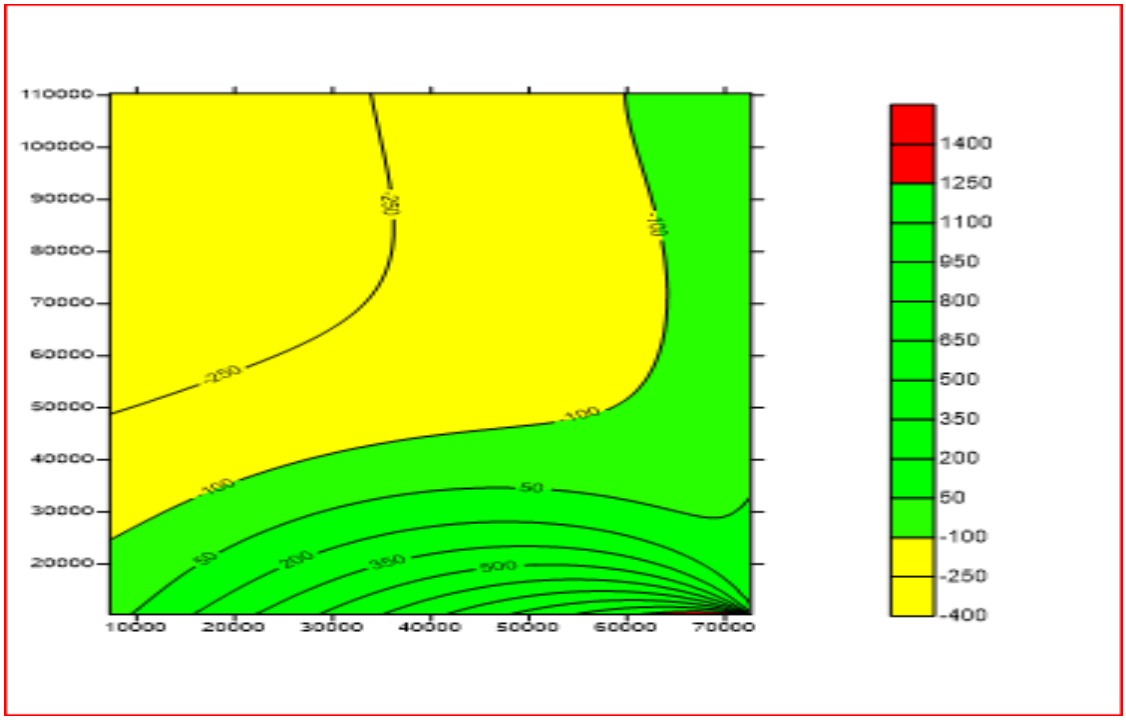

Fig.8 Longitudinal conductance iso map

CONCLUSION

The results obtained from different parameters measured revealed that the survey area is characterized mainly by four layers; the topsoil, weathered basement, fractured basement and fresh basement rocks. The fractured/weathered basement mostly constitutes the aquiferous zones. Within the southwest and southeastern part of the maps produced, there was a strong positive correlation of the calculated parameters. Hence, the promising water bearing zones (aquifer) was found to be located within the VES points of C4, E4, F6, C5, C6, D6 and G4 in industrial quantity. Similarly, in the other parts of the study area, VES points A1, C1, C3, D2, E1, E2, E3, C2, D1, D3, G1, G2, and G3 found to be in domestic quantities.

RECOMMENDATIONS

Based on the findings of this research, the researchers are of the view that boreholes should not be drilled wildly within the institution, as that has a serious long-term environmental degradation, it promotes rate of borehole failure and consumes a lot of resources. It is therefore recommended that; a single industrial borehole be drilled within the identified areas that can serve the whole School of Applied Sciences which is environmentally friendly.

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