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Extraction of Depth-to-Basement Information from the Interpretation of a Vertical Electrical Sounding Data of Gidan Kwano Campus Phase II, Federal University of Technology, Minna, Nigeria

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Abstract

The Windows-compatible suite of WinResist® tools was used to garner information from *circa* 309 vertical electrical sounding (VES) points on variation of overburden thickness (that is, depth-to-basement) on a constant plane across the area of study for the VES survey. The isopach map of the area of study under consideration here indicates that, across the areal extent, overburden thickness of the sub-5m depth range predominates except at a scattering of isolated locations mostly in the southern half and favouring the southwest where overburden thicknesses of between 5m and 12m can be discerned. It is observed from the field survey that the southwest portion of the area of study is criss-crossed by seasonal streams and is generally characterised by valley morphology. The "sub-5m depth range" designations are the ideal locations for facilities expansion because the comparatively shallow nature of the overburden materials means that structural foundations could be conveniently and cost-effectively sunk deep into the local solid bedrock. The northwestern and northeastern segments of the area of study under consideration here are the areas of this half-portion Gidan Kwano Campus (GKC) Phase II Development that is strongly recommended for facilities expansion; the northeastern segment actually subsumes the whole of the present hostel facilities, and expansion due west of these students' hostels (that is, to the northwest) would minimise risks to the mapped groundwater sources in the southwestern and southeastern segments in the near-term.

Keywords: VES; overburden; basement; isopach

Introduction

A 4km^2 dual vertical electrical sounding (VES)-induced polarisation (IP) survey has been completed at the planned Gidan Kwano Campus (GKC) Development Phase II, Federal University of Technology, Minna, Nigeria. The grid of the 4km^2 tranche of New Development at 100m station-spacing in relation to Phase I is shown as Figure 1. There have been a number of limited-extent geophysical surveys at the Gidan Kwano Campus that were chiefly devoted to hydrogeological prospecting, and others that were devoted to a combined hydrogeological/geotechnical surveys (Abdulrashid, 2005; Udensi *et al.*, 2005; Udensi *et al.* 2006; Salako *et al.*, 2010). However, the series of studies by Jonah and workers at the GKC Development Phase II (Jonah and Jimoh, 2013; Jonah *et al.* 2015A; 2015B; Jonah and Olasehinde, 2015C; Jonah

et al. 2015D; 2015E) was the first systematic, large-scale, dedicated suite of investigations to thoroughly map a designated portion in order to build a database for the area of interest that would be archived for reference purposes.

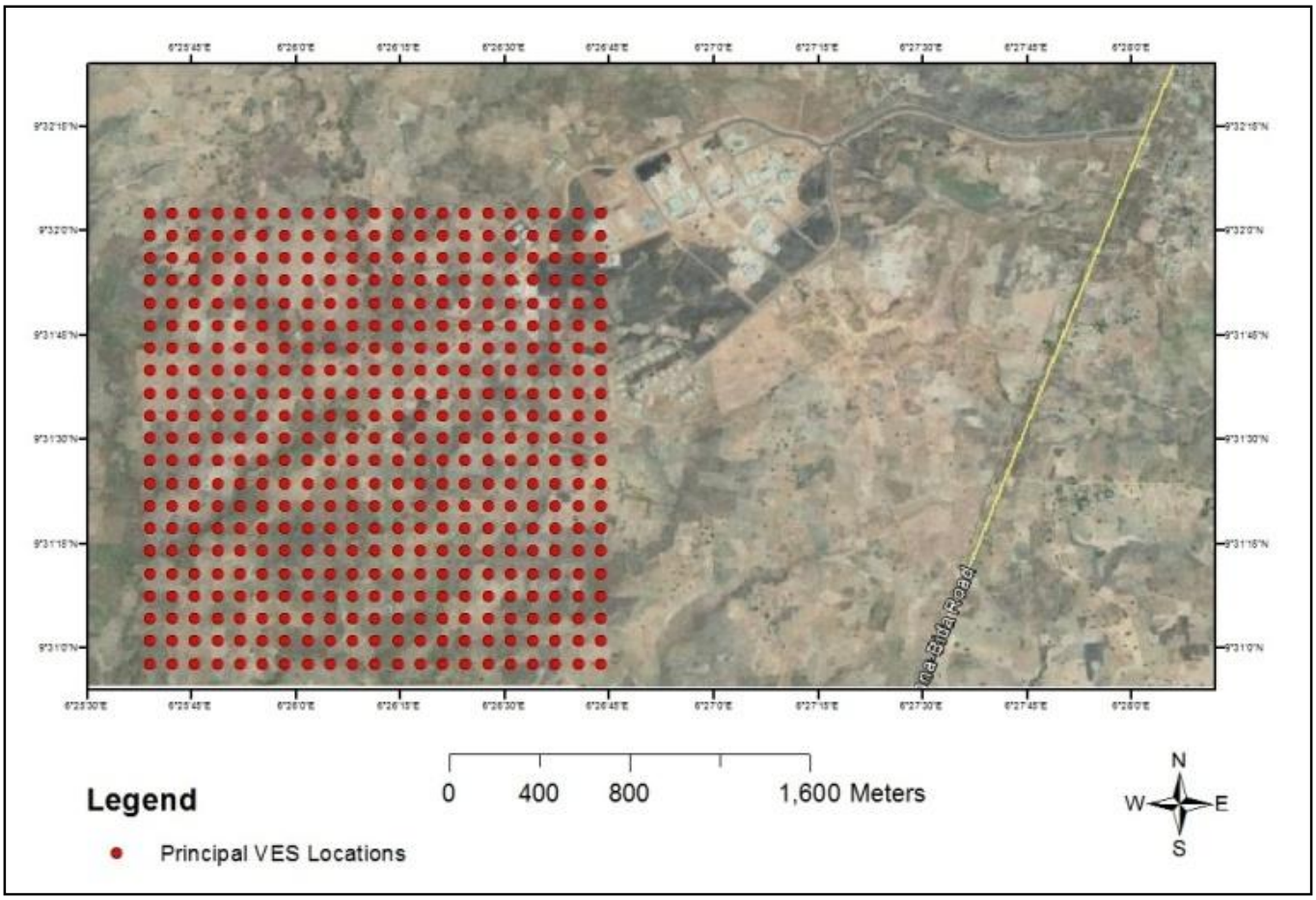

Figure 1. Grid of the 4km^2 tranche of New Development at the GKC. (The tadpole-shaped feature is Phase I, the present developed portion of the GKC, seen to the northeast of the red-dotted grid of the 4km^2 areal extent; the Minna-Kateregi-Bida Road is seen as the linear slope to the far east of the grid.)

The VES survey completed for this study was based on the Schlumberger array of the electrical resistivity method defined at 100m station-spacing. In the earth resistivity method, a direct commutated or low-frequency alternating current is introduced into the ground by means of two electrodes (metal stakes or suitably laid out bare wire) connected to the terminal of a portable source of electromotive force (e.m.f.). The resulting potential distribution of the ground, mapped by means of two probes (metal stakes or, preferably, non-polarizable electrodes), is capable of

yielding information about the distribution of electric resistivity below the surface. The resistivity method is used in the study of horizontal and vertical discontinuities in the electrical properties of the ground, and also in the detection of three-dimensional bodies of anomalies electrical conductivity. It is routinely used in engineering and hydrogeological investigations to investigate the shallow subsurface geology. Other than the search for water-bearing formations, the method has been used mainly in stratigraphic correlations in oil fields and in prospecting for conductive ore bodies. Earth resistivity method is also applied to archaeological problems (Parasnis, 1986; Kearey and Brooks, 1984; Giffiths and King, 1981; Keller and Frischnecht, 1966; Telford et al., 1976).

According to the site survey report completed by the firm of Adesoye and Partners (Adesoye, 1986), the Gidan Kwano Campus constitutes a tiny southern tip of the Nigerian Basement Complex (NBC) occurring in northcentral Nigeria. The major rock types mapped in the area consist of schists (i.e. quartz mica schist and quartz-bearing phyllitic schist), granite gneiss, biotite-hornblende granite, muscovite-biotite granite, pegmatite, and vein quartz. About 50-60% of the entire land area of the central parts is underlain by granitic bodies of hornblende-biotite granite and biotite-muscovite granite. These are ringed to the south by the granite gneisses which also occur to the north. A subordinate amount of mica schists is located at the northeast and this may be a southward extension of a layer of body of schist.

Methodology

Of the 441 (21x21) total VES points that would result from a 2km x 2km grid at 100m-spacing (see Fig.2), only a total of *circa* 309 points were surveyed owing to constraints of raw sewage pollution and built-up land areas encountered during the course of the survey. The field resistivity values were initially subjected to the log-log plot routine of the Windows-compatible WinResist® software whence corresponding field curves for all the stations occupied were produced (Jonah and Olasehinde, 2016). Each of the WinResist® log-log plot provides information on the numbers of layers, the average resistivity values of these layers, and their approximate thicknesses. Also, in order to show variation of resistivity on a constant plane across the two-dimensional 4km^2 area of study for the VES survey, resistivity maps at constant depths (i.e. iso-resistivity maps) were generated at the 1m, 10m, 20m, 30m, 40m, 50m, 60m, 70m, 80m, 90m, and 100m depth points

(Jonah and Olasehinde, 2016). Now, in order to show variation of overburden thickness (that is, depth-to-basement) on a constant plane across the two-dimensional 4km^2 area of study for the VES survey, an isopach map with its equivalent digital elevation model (DEM) map were produced for the 4km^2 area of study under consideration and these are shown as Figures 3 and 4.

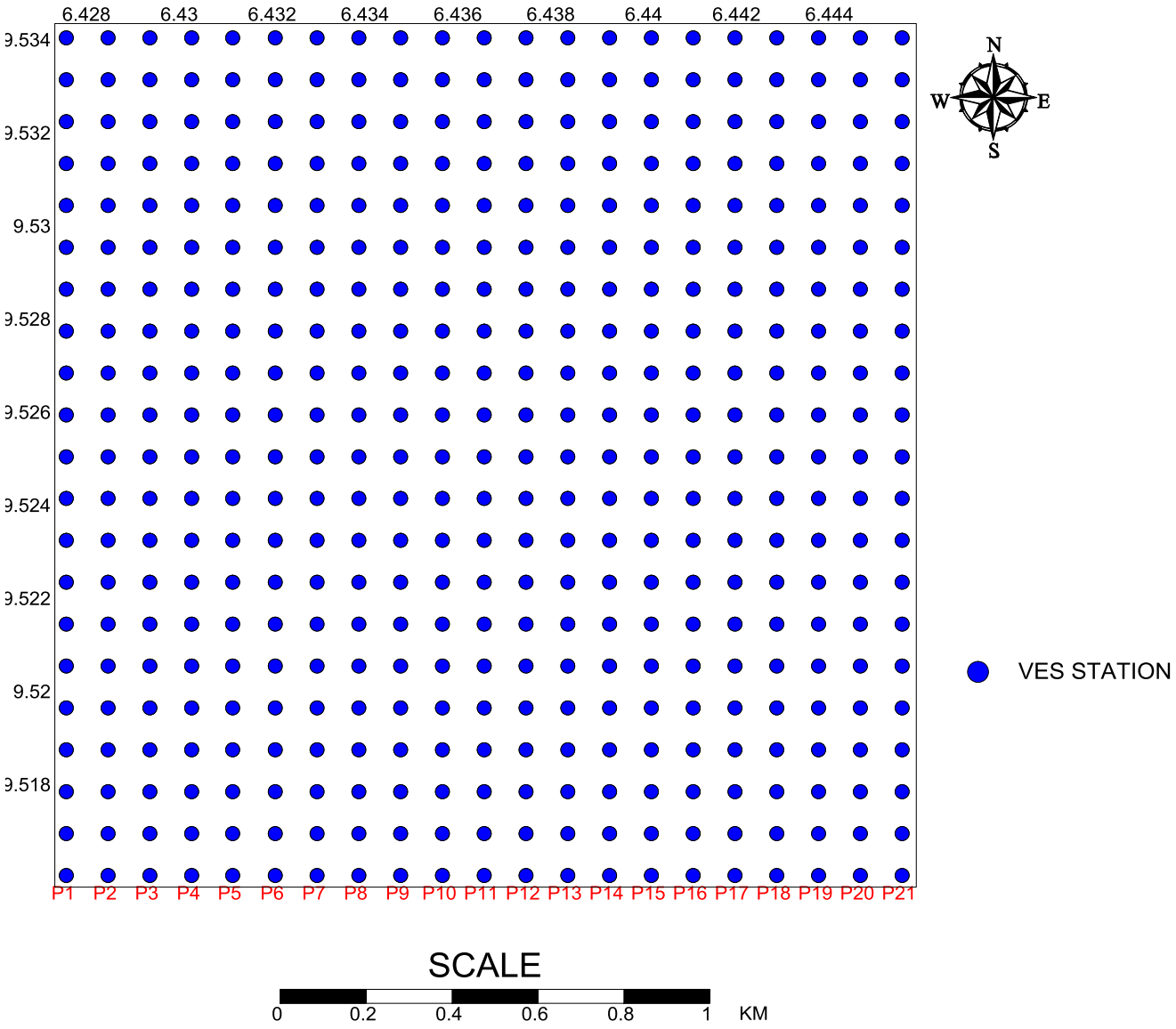

Figure 2. Conventional grid matrix format of the layout of Fig.1

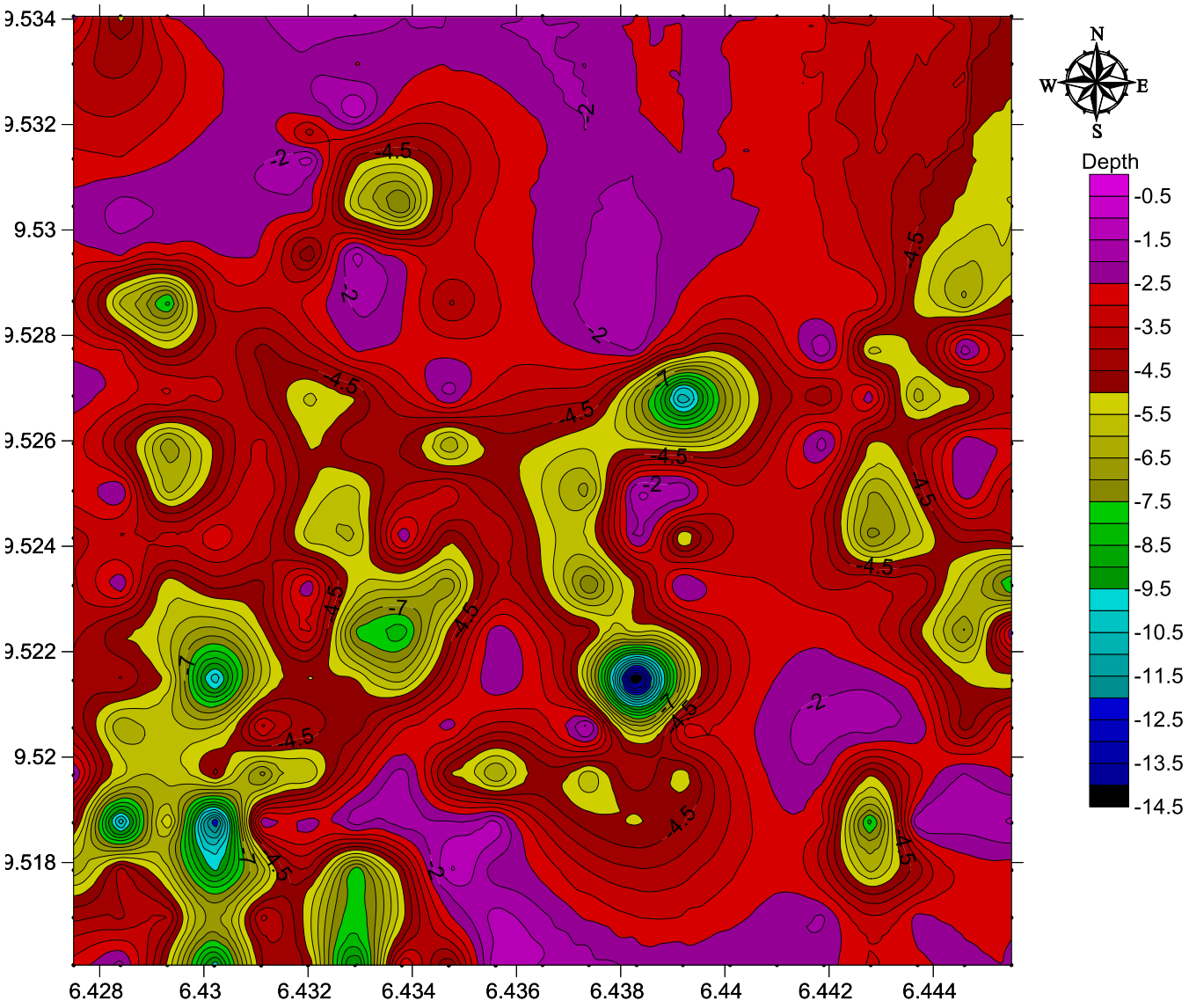

Figure 3. Isopach map of 4km^2 the area of study

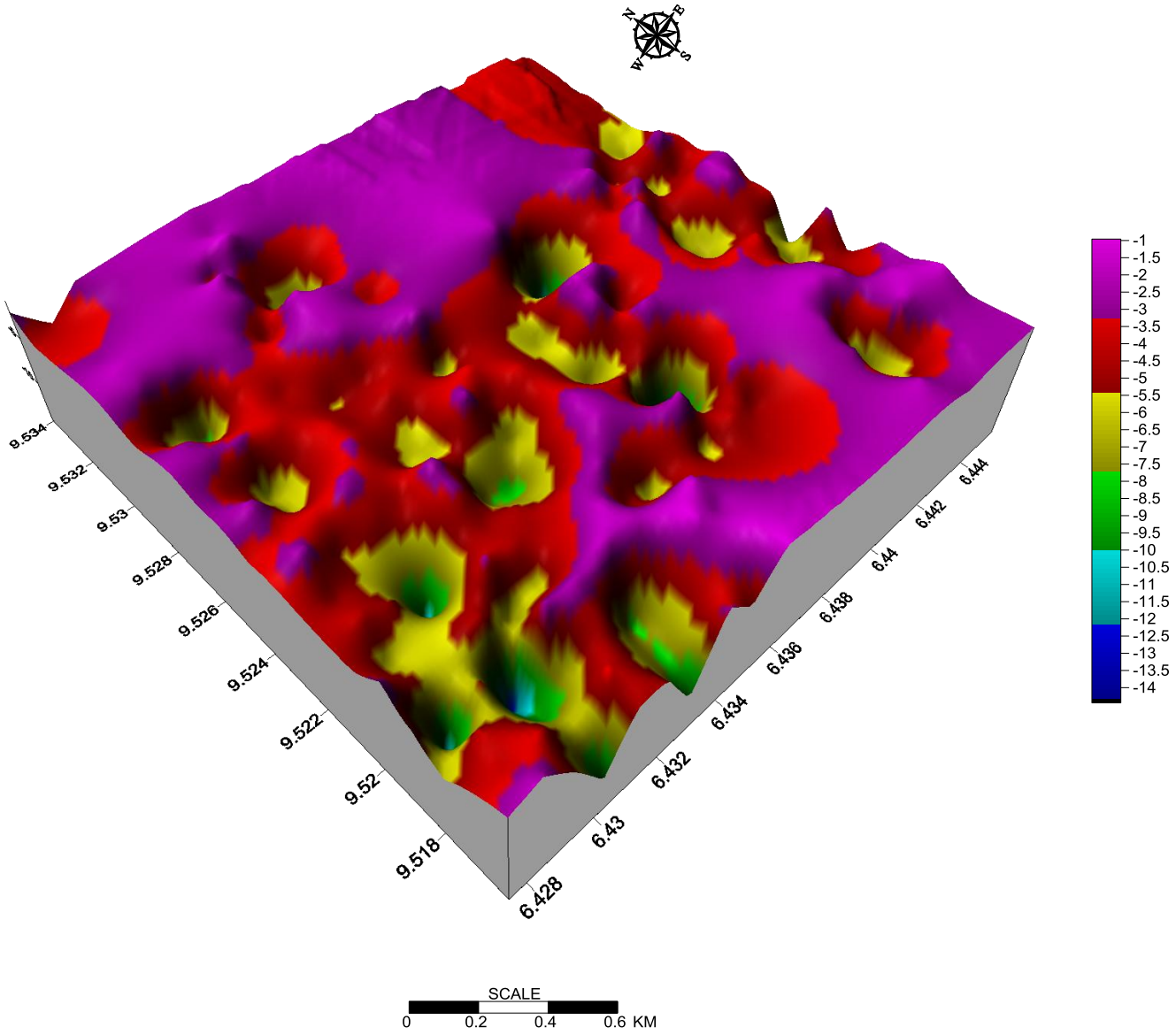

Fig.4. Equivalent digital elevation model (DEM) of the isopach map

Discussion

Result for groundwater prospect at the Phase II Development is as presented in Figure 5. Conclusion drawn from the interpretation route for groundwater potentials at the 4km^2 area of study indicates that there is discerned a sense of "geological fault-sources" at the right of the central mid-plane much close to the southeast and also a sense of "geological fault-sinks" at some points on the first transverse traverse line much close to the southwest. These "geological fault-sinks"

located on the slope of the landform of the area of study are the most important aquifer locations because they are situated on the low-slopes of subsurface fault lines; the generally shallow nature of the water-bearing fractures concentrated on the high-slope at the right of the central mid-plane much close to the southeast is the perfect "aquifer source" for the generally deeply-incised nature of the water-bearing fractures concentrated on the low-slope at the southwest. The isopach map of the area of study under consideration here indicates that, across the $4km^2$ areal extent, overburden thickness of the sub-5m depth range predominates except at a scattering of isolated locations mostly in the southern half and favouring the southwest where overburden thicknesses of between 5m and 12m can be discerned. It is observed from the field survey that the southwest portion of the area of study is criss-crossed by seasonal streams and is generally characterized by valley morphology. However, an isolated depth designation of between 12m and 14.5m exists at the southern central portion that can be correlated with Station Number 5 of Profile 13, that is, P13-7 ($N9^0 31'17.24''$; $E6^0 26'17.88''$).

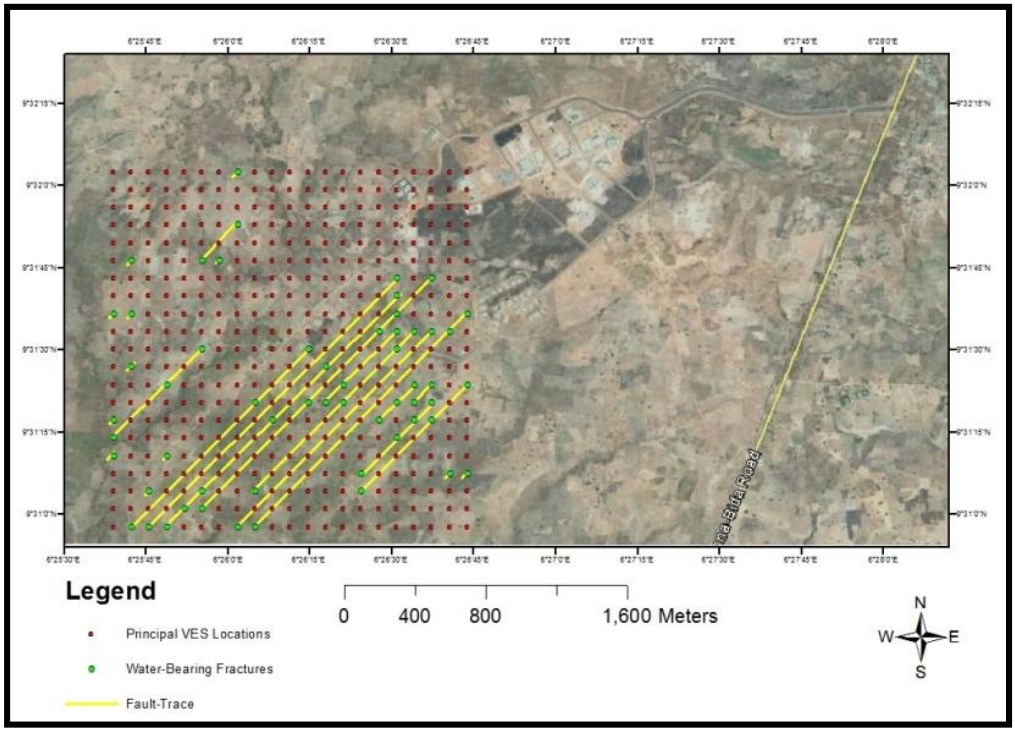

Figure 5. Result for groundwater prospect at the Phase II Development showing fault-trace of fracture signatures inferred from a combination of the geoelectric cross-sections and the induced polarisation tables on the satellite imagery map of the area of study with the developed Phase I in the background

Also, examination of the slope of the landform of the wider 8km^2 Phase II Development (Figure 6) would indicate that overburden thicknesses should increase toward the southwest because the resultant north-south east-west tilt of the landform suggest groundwater prospects at the southwestern portion, which is actually the case here; thus it not surprising that at the southwestern corner overburden thickness of greater that 5m should be discerned.

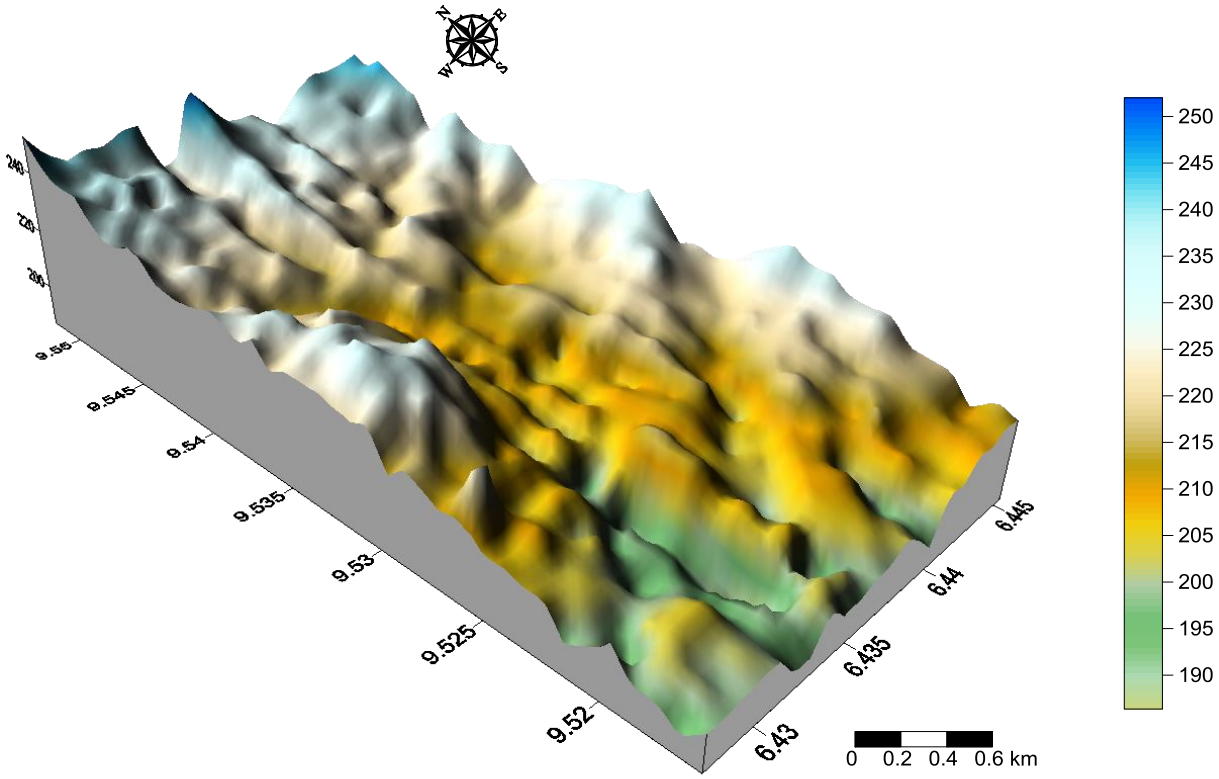

Figure 6. Site-specific geomorphic feature map of the wider 8km^2 Phase II Development

Conclusion

The "sub-5m depth range" designations are the ideal locations for facilities expansion because the comparatively shallow nature of the overburden materials means that structural foundations could be conveniently and cost-effectively sunk deep into the local solid bedrock. Information gleaned from the isopach map of Figure 2 and its equivalent DEM of Fig.3 would favour especially the northwestern and northeastern segments of the 4km^2 area of study as the portions most suited for

structural development facilities since the southwestern and southeastern segments are characterized by subsurface fractures linked to groundwater accumulation.

Recommendation

The northwestern and northeastern segments of the 4km^2 area of study under consideration here are the areas of this half-portion GKC Phase II Development that is strongly recommended for facilities expansion; the northeastern segment actually subsumes the whole of the present hostel facilities, and expansion due west of these students' hostels (that is, to the northwest) would minimise risks to the mapped groundwater sources in the southwestern and southeastern segments in the near-term.

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