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BEST LOCATIONS FOR GROUNDWATER MONITORING WELLS INSIDE HIGHRISK FACILITIES

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استخدام المسح الجيوكهربى لتحديد افضل المواقع لتصميم آبار المراقبة للمياة الجوفية داخل المنشأت عالية الخطورة

الخلاصـــة: تمثـل المنشـأت عاليـة الخطـورة مثـل محطـات تكريـر البتـرول مصـدراً مـن مصـادر الخطـورة علـى البيئـة المحيطـة ممـا تنتجـه مـن انبعاثـات غازيـة تنبعـث فـى الهـواء وملوثـات سـائلة تتسـرب الـى الميـاه السـطحية و الجوفيـة. ومـن هنـا توصـى التشـريعات المحليـة وانظمـة الادارة البيئيـة بنشـر شـبكة بيزومتريـة لمراقبـة محـددات تلـك الملوثـات ومـدى إذعـان تلـك المنشـآت للمتطلبـات التشـريعية. يهـدف العمـل الـى اسـتخدام المسـح الكهربـى لتحديـد الوحـدات الهيدروجيولوجيـة التـى تشـغل المنطقـة التحتسـطحية داخـل احـدى محطـات تكريـر البتـرول بالقـاهرة الكبـرى. وقـد تبـين مـن تفسـير قطاعـات المسـح الجيـوكهربى أن منطقـة الدراسـة تتكـون مـن طبقتـين وهمـا الطبقـة (ا) وهـى تمثـل الطبقـة السـطحية, والطبقـة (ب) وهـى تتكـون مـن ثـلاث طبقـات بهـا عديسـات مـن الطمـى, وهـى تمثـل الخـزان المـائى للمنطقـة. الطبقـة (ا) و(ب١) و(ب٢) تتبـع العصـر الحـديث والربـاعى بينمـا (ب٣) تتبـع عصـر الميوسـين. وبنـاءا عليـه تـم اختيـار سـتة مواقـع لانشـاء وتصـميم عـدة آبـار مراقبـة داخـل محطـة تكريـر البتـرول تراعى فيها المعايير الدولية.

ABSTRACT: *High risk facilities like oil refinery plant represent a source of hazard on the surrounding environment due to its production from gaseous pollutants that emit to air or liquid pollutants that release to surface water and groundwater. All local legislations and environmental management systems recommend that the surrounding environment of such facilities should be covered with a network of monitoring systems among them such as a system for monitoring groundwater to determine the compliance of the facility with legal requirements. In this work, six vertical electrical soundings were used to define the hydrogeological units of the subsurface in the area. The interpretation of VES's proved that the geo-electrical cross sections consist of two main geo-electrical layers. A-layer represents the surface layer. B- Layer consists of three main sub-layers and its characterized by the presence of clay lenses. This layer represents the water-bearing aquifer. The surface layer (A) and sub-layers B1 and B2 belong the Recent and Quaternary eras. While sub-layer B3 belong the Miocene. Based on this result, six well selected locations have been proposed for monitoring groundwater pollution inside the fence of the oil refinery plant.*

1. INTRODUCTION

The main objectives of such a survey are to explore the water-bearing formations in the area underneath the site project and its vicinity, define the lithological units constituting the shallow section and trace the direction of water flow. The resultant information represents a considerable base to select the best sites for monitoring wells. This study includes field and office activities. The results of both activities are given in this scientific study in the form of field observations and measurements, field sounding curves, interpreted sounding curves and geoelectrical cross sections.

To achieve this objective, the following activities have been conducted:

1- Collecting previous information about the geomorphology, geology and hydrogeology of the investigated area and its vicinities.
2- Carrying out a total of 6 Vertical Electrical Sounding (VES).
3- Performing land topographic survey to locate the Vertical Electrical Sounding on the topographic map and to determine their elevations with respect to the mean sea level.
4- Conducting qualitative and quantitative interpretations of the Vertical Electrical Sounding curves.
5- Using the interpreted data in constructing a number of geoelectrical cross sections in different directions reflecting the geological and hydrogeological setting in the area of concern.

2. THE LOCATION OF THE STUDY AREA

The investigated area is located in the southeast of Ismailia Canal, south of Cairo in Mustorid area, to the east of the Nile River. The area looks like a strip of land extending in NW–SE direction for about 850 m long and about 536m width covering an area (Fig. 1).

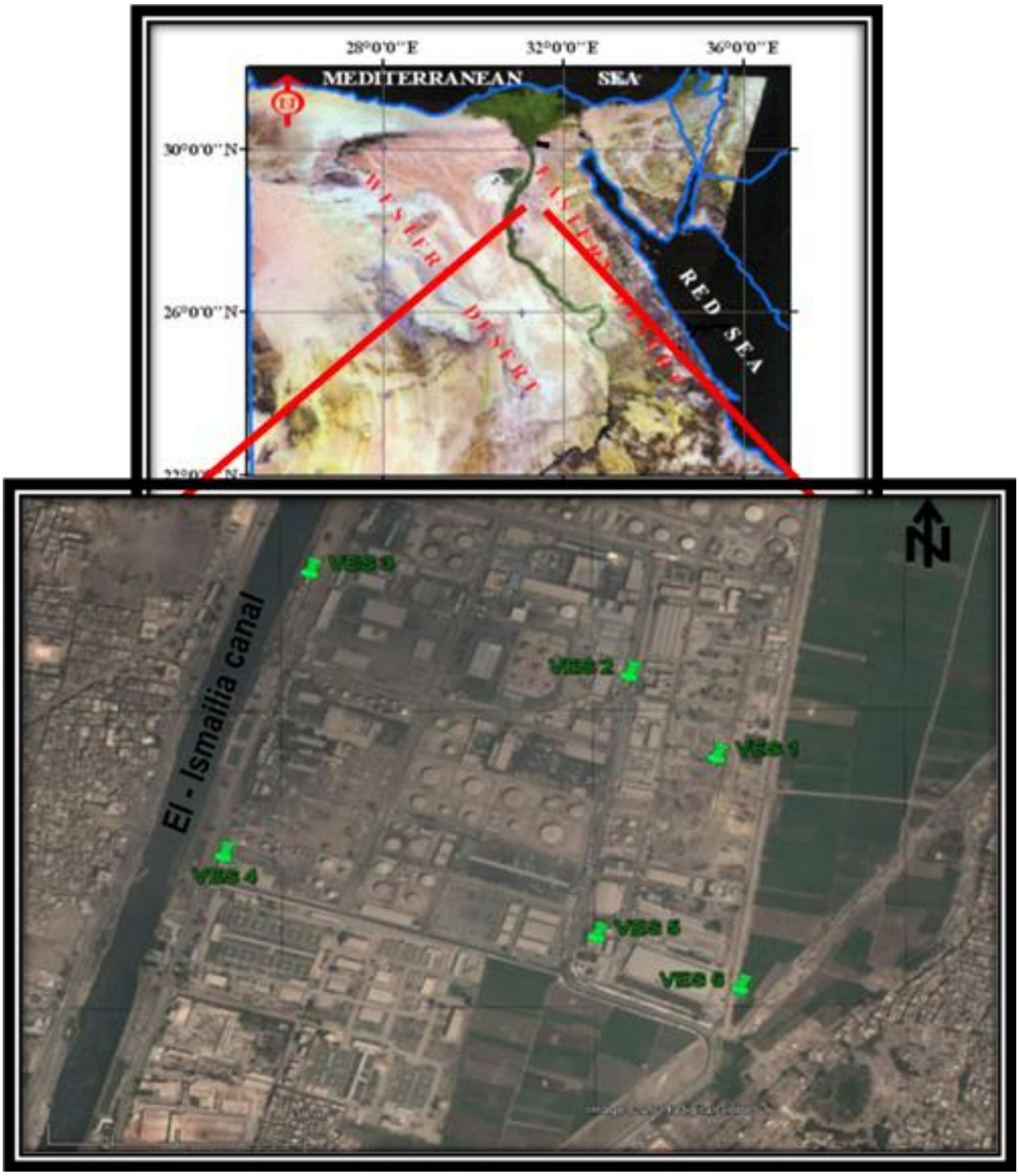

Fig. (1): Location map of the study area.

III. GEOLOGIC, GEOORPHOLOGICAND YDROGEOLOGIC SETTIG OF THE STUDY AREA

The geomorphologic and geological settings of the investigated area can descried as follows:

3.1 Geomorphologial Setting:

Geomorphologic landform stability is the sensitivity of any landscape to be eroded or modified by eolian processes (wind), river processes, and over land flow. USA federal regulations in 10 CFR part 61.50 require that upstream drainage area be minimized to decrease the amount of runoff which could erode or inundate units. The investigated area lies on low elevated land. The average of the ground elevation ranges from +15 to + 18m above the mean sea level. Generally, the eastern part of the Nile Delta including the investigated area is characterized by a semiarid to arid climate with hot summer and mild rainy winter. The different geomorphologic units identified the investigated area can be segmented into the following categories (El Shazly, 1963);

i- Marginal plan part which borders the Ismailia Canal and is bounded from the east by the relatively high land which form "Foot hill topographic area" which can be considered as the eastern limit of the Nile Delta, with an average width of about 15 km. The surface of this part consists largely of sand and gravels.

ii- Foot hill part which constitutes the eastern boundaries of the area. There are several valleys which originate from the neighboring higher table land part. The encountered rocks (sand, sandstone and marly limestone) belong to the Oligocene. The surface is affected by various structures.

iii- Table Land Area; which bounded to the west by the "Foot hill area" and extends toward the Suez city. This plateau rises to the east where its surface is dissected by a number of erosional and structural valleys. Drainage runs towards the Nile basin. However, the directions of drained networks change in places to the northeast-direction and follow lines of faulting.

3.2. Geologic Setting:

According to the regional surface geological map (El-Shazly, et.al, 1975), a thin layer of Nile sediments (5m) covers the surface of the investigated area. The comprise sand, clay and gravels. Three kilometers to the east of Ismailia Canal, exposures of Miocene sediments cropping out, which consist mainly of greenish clay and limestone (Fig 2). A fault trace could be drawn at the foot hill of the Miocene exposures. The schematically compiled stratigraphic section in the investigated is shown in (Fig. 3) According to (Said, (1961); ElFayoumy, (1968); Soliman and Korrany, (1972); El-shazly et.al. (1975); Hilmy et.al., (1986); Kotb, (1987); Mousa, (1988); Mousa, (1990); Zaghloul et.al., (1990); Ezz El-Deen, (1993); Sallouma and Gomaa, (1997); Helmy, (2002).The geologic succession from bottom to top is described as the following:

Age		Rock unit	Lithic description
Quaternary	Holocene		Sand and clay
	Pleistocene		Sandy clay Clayey sand
Tertiary	Miocene		Sand, gravels and clay

Fig. (2): Regional surface geological map of the study area and its vicinities, After El-Shazly et al. (1975).

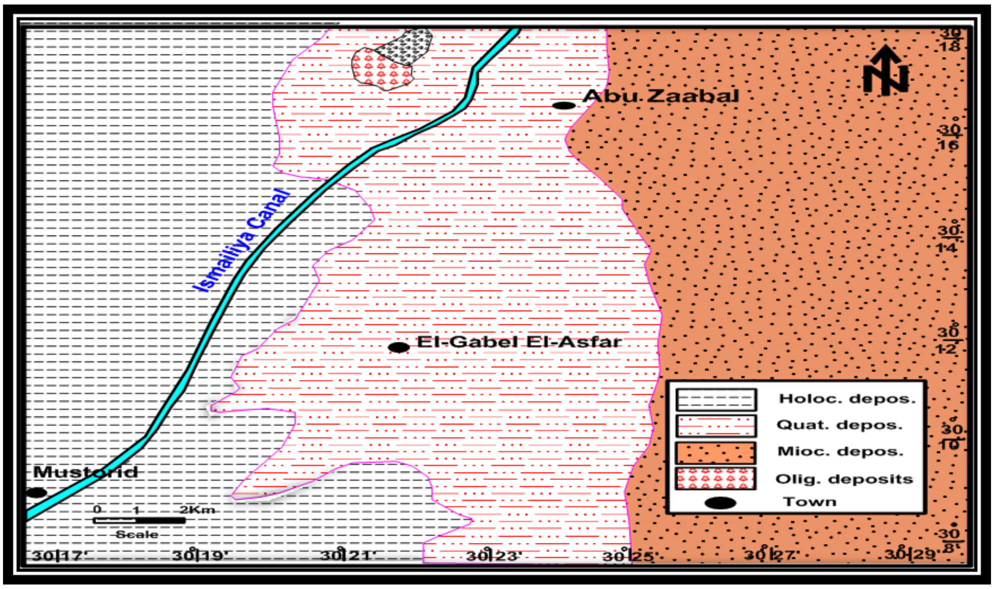

Fig. (3): Compiled stratigraphic columnar section in the study area (After El-Fayoumy, 1968, El-Shazly, et al., 1975 and Mousa, 1990).

THE GEOLOGIC SUCCESSION

A-The Tertiary sediment can be discriminated into the Eocene, Oligocene, Miocene and Pliocene:1- Eocene (Upper sediments: can be discriminated into the following: Anqabia Formation, it is composed of sandstone, sand and clay. Maadi Formation, hard dolomitic sandstone. 2- Oligocene sediment can be discriminated into the following Unit 8- It is represents by basalt sheet. Unit 9: it is composed mainly of friable sand with quartztic sandstone. 3- Miocene sediments: the subsurface Miocene sediments in the investigated area can be classified into the following units from top to bottom as: Unit 1- It is consists mainly of sandstone and sandy clay. Unit 2- It is composed of two distinctive beds, fine friable sandstone at base and sandstone at top. Unit 3- It is composed of alternative beds of clay and calcareous sandstone. Unit 4- It is made up of fine to medium grained friable sands with intercalation of clay. Unit 5- It is composed mainly of inter beds of calcareous sand and clay. Unit 6- It is mainly friable sands intercalated with calcareous sandstone Unit 7-: It formed basal part of the Miocene sequence in the investigated area. It is composed of sandstone and clay interbeds.

B-Quaternary Sediments are classified into eight units. These units do not show any indication of displacement along the subsurface fault plane or in the overlying Quaternary sequence. The Quaternary sequence (from bottom to top) is as follow: 1- Coarse channel lag deposits, which consists of coarse sand, cemented with flinty pebbles and gravel. 2- Lenticular sand bodies, exhibit a crossbeded structure to the west with rare plant roots. 3- Nile silt (very fine clean silt), showing cross bedding. Nile silt, laterally westward, comes below and inter finger with the Nile mud. 4- Nile mud (brownish gray, fatty touch, small carbonate concretions) with vertical joints filled with fine sand. 5- Alluvian deposits (medium to coarse grained). 6- Alluvial coarse sand (with flinty gravel lag forming broad channels), slightly consolidated. 7- Sand (dark yellow with brownish flint), fine to medium grained. 8-Eolian sand (very fine to medium).

3.3. The Hydrogeological Aspects:

Two main aquifers are existed in the investigated area, the Quaternary aquifer which represents the water table aquifer and the Miocene aquifer which is confined of semi-confined aquifer type:

1- Quaternary Aquifer; this aquifer is represented mainly by Plio-plistocene sediment sand is composed of false bedded feldspar bearing coarse sand. The thickness of the Quaternary increases eastward. This aquifer is recharged mainly from the direct seepage and infiltration water.

2- Miocene Aquifer; this aquifer is represented by non-marine. It is composed of sands intercalated with few clay. Two criteria are used to consider the aquifer as confined, these are: A) the frequent occurrence of clay with thicknesses that may reach to 10m in some location. B) the barometric efficiency of the aquifer, where water level rises 36m in some locations. The depth to water in the western part (the Quaternary aquifer) ranges between 6.0 to 13.60m below the groundwater level, whereas the depth to the static water level in the eastern part (the Miocene aquifer), ranges between 18.50 and 38.93m below ground surface (Al-Gamal, 1995).

4. FIELD WORK AND DATA ACQUISITION

Geoelectrical and topographic surveys have been carried out in the study area. Each of the two types is separately discussed as follows: A total of 6 Vertical Electrical Soundings (VES) have been carried out in the study area. The location of VES stations was chosen according to field conditions. The distribution of the sounding stations and the trend of geoelectrical cross sections are shown in Figure (4).

Topographic survey was carried out to determine the locations (latitudes and longitudes) and the elevation of the sounding stations using the GPS apparatus (E Trex type) (Table 1).

Table (1) Ground elevation, latitudes and longitudes of sounding stations.

VES No.	Lat.	Long.	Gr. Elevation (m)
1	30° 8′ 23.5″	31° 18′ 7.7″	+18
2	30° 8′ 29″	31° 18′ 2.2″	+18
3	30° 8′ 36″	31° 17′ 42″	+15
4	30° 8′ 17.1″	31° 17′ 36.4″	+15
5	30° 8′ 11.6″	31° 18′ 00″	+17
6	30° 8′ 8.1″	31° 18′ 9.1″	+17

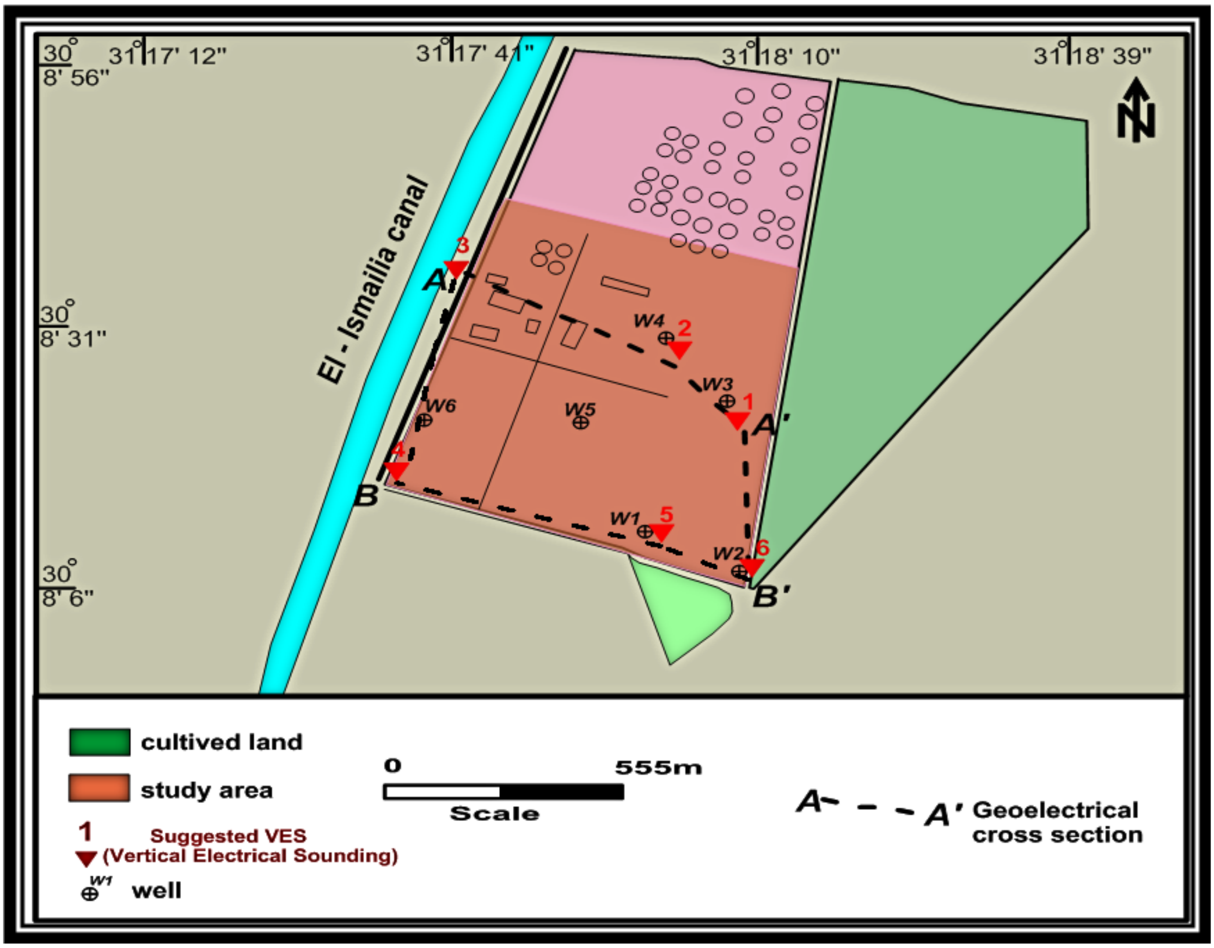

Fig. (4): Location map of Vertical Electrical Sounding (VES) stations, and directions of geoelectrical cross sections in the study area.

5. DATA ACQUISISTION

The symmetrical 4-electrodes Schlumberger arrangement has been used to carry out the field measurements with current electrodes separation (AB) ranging from 1 to 300m.

The “Syscal” resistivity meter has been used for measuring the apparent resistivity with high accuracy at different electrode spacing. For each of six sounding stations, the calculated apparent resistivity has been plotted against the corresponding half the electrodes separation (AB/2) on a bio-logarithmic paper).

6. INTERPRETATION AND DISCUSSION OF THE GEOELECTRICAL DATA

The measured field curves have been quantitatively interpreted to determine the true resistivities and thicknesses of the different geoelectrical layers. It involves the determination of the number of the geoelectrical layers as well as the true depth, thickness and resistivity of each layer. The computer programs "RESIST" (Van Der Velpen, 1988) and RESIX-PLUS, ver.2.39 (Interpex, 1996), have been used for the quantitative interpretation of the Vertical Electrical Sounding (VES) curves. The available information about the regional and local geologic setting of the area was taken into consideration in assigning the lithology to the resulting resistivities. The interpreted data of each curve represent the geoelectrical layers with their corresponding thicknesses and resistivities. The variations of the geoelectrical parameters of an individual layer along its extension are considered. The resistivities are related to lithology according to the geologic information of nearby wells. The geologic setting and relevant information are visualized and described in view of a number of generated geoelectrical cross sections crossing the concerned sites in different directions. The detailed interpretation results of the geoelectrical resistivity sounding measurements in the study area are discussed as followed.

The quantitative interpretation of the field curves revealed that the geoelectrical succession is formed of a number of layers, which are grouped together in two main layers. The first layer is dry surface layer “A” and the second is water bearing layer “B”. Four geoelectrical cross-sections were constructed to illustrate the subsurface conditions within the study area (Figs. 5, 6, 7 & 8). The detailed description of the geoelectrical layers from top to bottom can be described as follows:

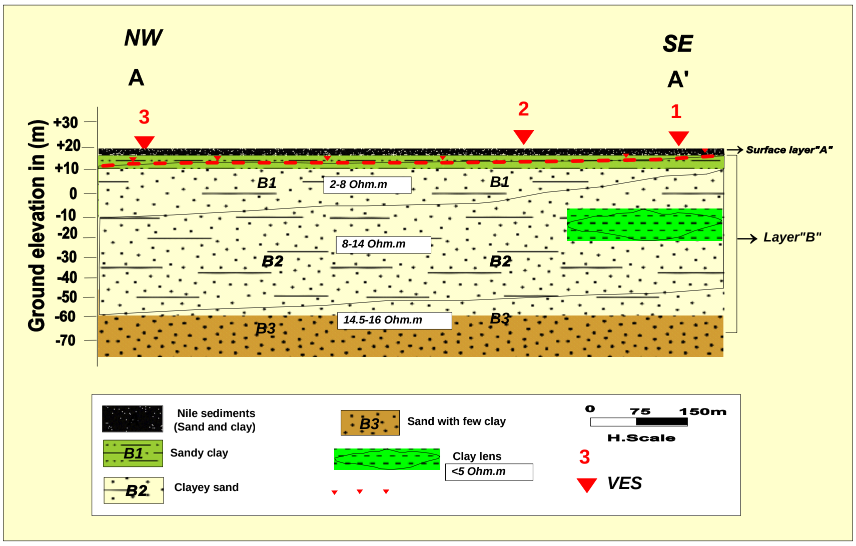

Fig. 5: Geoelectrical cross section A-A' in the study area.

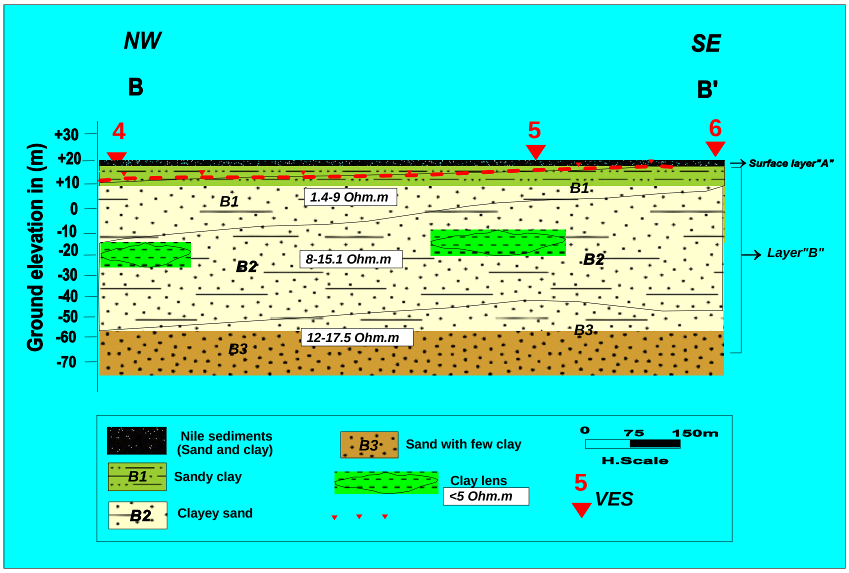

Fig. 6: Geoelectrical cross section B-B' in the study area.

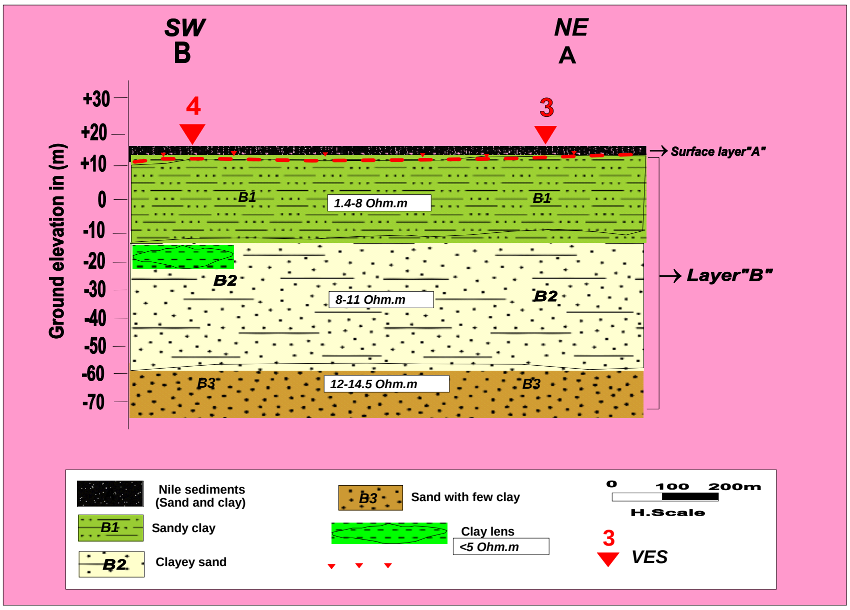

Fig. 7: Geoelectrical cross section B-A in the study area.

Surface layer "A":

This layer represents the surface cover, which is composed of dry deposits (sand and clay) and exhibits a wide range of resistivity varying from 5 to 562Ohm.m. The wide range of resistivity is due to the different compositions of this layer. The thickness of this layer ranges from 2.4 to 3.9m.

Layer "B":

This layer represents the water bearing formation in the study area. It can be divided into three sub layers, the upper one "B1" has resistivity values varying from 1.4 to 9Ohm.m and its thickness ranges from 9.6 to 29.6m. This layer is composed of sandy clay deposits. The second one "B2" shows resistivity values ranging from 8 to 15.1Ohm.m and its thickness ranges from 39 to 53m. This layer composed of sandy clay, clayey sand and sand deposits. This layer is characterized by the presence of clay lenses, while the last one "B3" is composed of sand deposits and has resistivity values ranging from 12 to 17.5Ohm.mandits lower surface was not determined.

Geoelectrical cross sections:

Four geoelectrical cross sections have been constructed from the interpreted data to establish the geological and hydrogeological situations of the area of concern and give an ideal picture about the continuity or discontinuity of the lithologic units. The cross-sections A-A' and B-B' traverse the area in NW-SE directions (Fig.6 & 7), while cross-sections B-A and B'-A' are constructed in SW-NE and SE-NW directions respectively (Fig. 7 &8).

These geoelectrical cross sections would complete the hydro-geophysical picture and determine the thickness and extension of the water bearing formations. The data of the geoelectrical cross sections such as thickness and resistivities of each layer along these cross sections are summarized in Table (2).

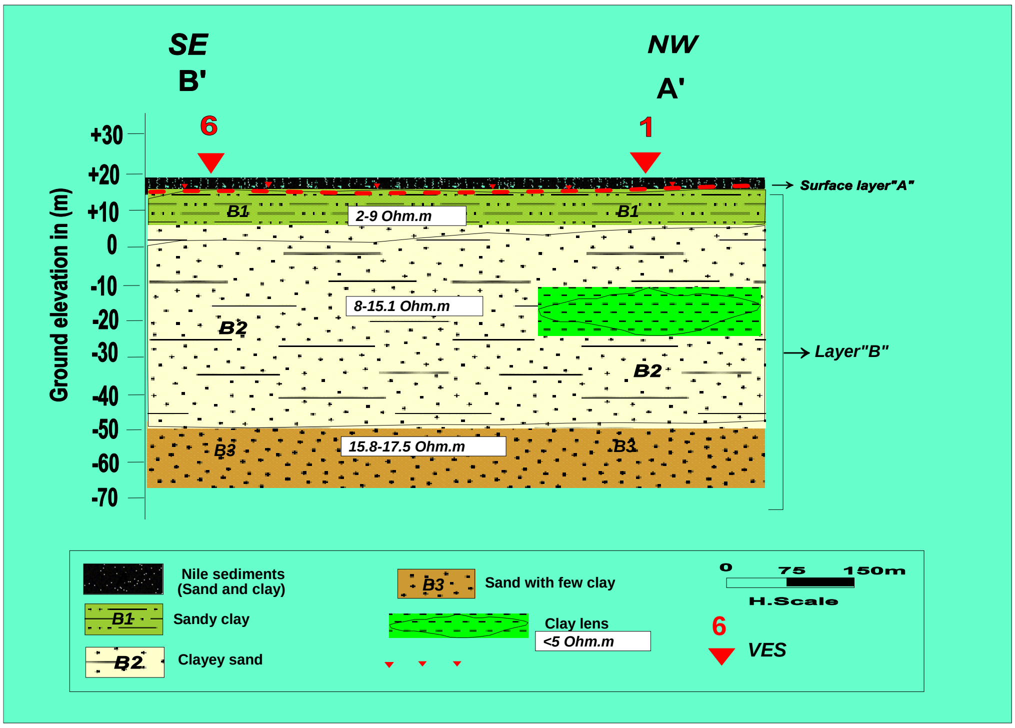

Fig. 8: Geoelectrical cross section B'-A' in the study area.

Table (2): Interpreted geoelectrical data in the study area.

Section	Trend and Length	VES'es No	Geoelectrical layers, Resistivity and thickness			
			Layer "A" Dry surface layer	Layer "B" Water bearing formation		
				Layer "B1"	Layer "B2"	Layer "B3"
A-A'	NW - SE 800 m	1, 2&3	5-652Ω.m 2-2.8 m	2-8 Ω.m 9.6-23 m	8-14Ω.m 46-53 m	14.5-16Ω.m -------------
B-B'	NW - SE 915 m	4, 5&6	7-291Ω.m 2.4-3.9 m	1.4-9Ω.m 12.1-29.6 m	8-15.1Ω.m 39-49 m	12-17.5Ω.m ------------
B-A	SW-NE 599 m	3&4	18-652Ω.m 2-2.4 m	1.4-8Ω.m 23-29.6 m	8-11Ω.m 39-46 m	12-14.5Ω.m ------------
B-A'	SE-NE 473 m	1&6	5-42.9Ω.m 2.4-3.9 m	2-9Ω.m 9.6-12.1 m	8-15.1Ω.m 49-53 m	15.8-17.5Ω.m -----------

The main observations and conclusions obtained from these cross sections can be summarized as follows:-

1- The geoelectrical cross sections consist of two main geoelectrical layers, A-layer which represents the surface layer and B-layer which consists of three sub layers and is characterized by the presence of clay lenses. This layer represents the water-bearing aquifer.
2- It is clear that the surface layer and sub layers B1 and B2 belong to recent and Quaternary in its age while sub-layer B3 belongs to Miocene, according to the nature of facies in the area
3- Generally, the dipping of the geoelectrical layers especially the layer B increases towards NW direction, toward the Ismailia Canal.
4- The resistivity values of the geoelectrical layers, especially the layers (B) increase downward reflects coarse sand, while the resistivity values decreases in NW direction toward the Ismailia Canal reflects fine sand with clay and clay intercalated.
5- There is a lenses or comparatively thin layer of clay (<5m) inside zones B.
6- Generally, the resistivity of the water bearing formations (layers B1, B2 & B3) increases downwards which can be attributed to the decrease in clay content as well as the decrease in water salinity and increase in sand content.
7- Generally, the groundwater potentiality in the area is connected to the presence of sand sediments in the subsurface.

CONCLUSION

Based on the information derived from the geoelectrical survey, the locations of six monitoring wells have been selected inside the fence of concerned site. The six locations are characterized by their accessibility, high probability of successfully penetrating water-bearing aquifer sand easily excavation in the subsurface sediments.

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