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Exploring The Groundwater Possibilities In Wadi West Komombo-The Desert Fringes Of Aswan Governorate

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Abstract: *The West Komomboarea lies among Sahal El-Galaba which considers an important part of the Egyptian 1.5 million feddan national reclamation project. This area attracted the investors for reclamation and development of new settlements. The groundwater is the only water source for such integrated development. The main objectives of the present work are exploring and studying the groundwater aquifers in this area by some geophysical techniques.To achieve the aim of study, seven Vertical Electrical Sounding (VESes) carried out along one profile crossing the area and 18 electromagnetic stations (TEM) were done through a grid pattern across the study area.*

Interpretation of the field data revealed that the groundwater in the study area find in two water-bearing layers separated by a huge thickness of sandy clay layer. The first water-bearing layer has a low potentiality and small thickness (ranges from 10to 29m.) and its electricalresistivity ranges from 7 to 21 Ohm.m. The second water-bearing layer (main aquifer in this area) is found at depth varies from 150 to 300m and has a suitable thickness ranges from 100 to 130 m and a resistivity rangefrom 6.2 to 14 Ohm.m. This aquifer is capped with a thick layer of clay.

The first priority class is the most suitable sites to drill new productive water wells. It characterized by considerable resistivity values, large thickness and has low depths from the ground surface. It located at the southern part of the study area and it represented by stations P4V3 and P4V2. The total depths of the proposed wells must full penetrate the second waterbearing layer and reached to the clay layer.Drilling new water wells in the study area should be under control to avoid the aquifer deterioration due to the over pumping processes.

Key Words: *West Komombo, Desert Fringes, Aswan Governorate Groundwater Exploration, Geophysical Technique's.*

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I. Introduction:

The Egyptian 1.5 million feddan national reclamation project is one of the most important projects in last few years. Sahal El-Galaba area is a part of this project and the area of study lies among Sahal El-Galaba area West Komombo. The study area lies between Lat. 24° 22' 15" and 24° 30' 00"N,and between Long. 32° 42' 58"and32° 52' 06"E (Fig.1).It is characterized by an arid climate with desert-like conditions. Although rainfall is not significant throughout the year, some rare and irregular storms take place over scattered localities during the winter season.

Due to the scarcity of subsurface geological information in this area, the present study aims to get some information about the underground water potentialities and subsurface conditions from the interpretation of the vertical electrical sounding and Time-Domain electromagnetic sounding. Different surfacegeological studies of the areawere carriedout by many authors (e.gAttia, 1954; El-Ramly, 1973; El-Shazly et al, 1975; Khader, 1978; Klitzsch and Harms, 1979; Issawi, 1981; Said, 1981; Issawi and Jux, 1982).

Topography of the investigatedarea is generally irregular. A number of small, shallow and dry wadies run towards the Nile and are mainly controlled by the ENE-WSW and E-W Fractures and by rock texture (El-Shazly et al, 1975). Also several isolated hills are present. Geologically, the Nubia formation of Cretaceous age (Issawi, 1981) which covers all the examined area and overlies the basement rocks, is mainly composed of sand and sandstone with clay and shale intercalations of irregular thicknesses (Fig.2). The structure of the area, which represents a part of West Aswan area, is dominated by ENE-WSW trending open folds of regional and local scale, while the fractures and faults have several trends and partly extend across long distances, some are short and grouped together in parallel arrangement accompanying the major fractures (El-Shazly et al, 1975).

Meteorologically, the surveyed area is characterized by arid conditions,i.e. high temperature, no rainfall, low relative humidity and a relatively high rate of evaporation. In spite of this study, the hydrological setting of this area does not understand, therefore, groundwater potentiality remains largely unknown.Surface Electric Resistivity and Electromagnetictechniquesare still the most suitable and widely used for groundwater exploration as major advances are made in processing and handling of data.

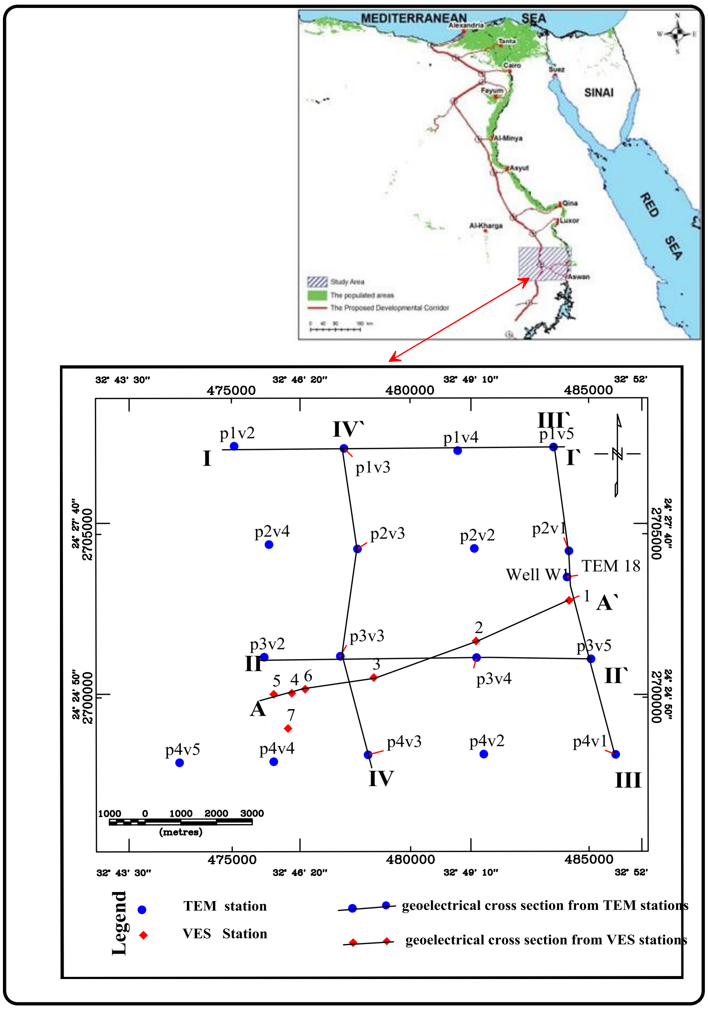

Fig. 1: location map of the study area and spatial distribution of the field measurements.

II. Methodology:

2-1- Vertical Electrical Soundings (VESes)

Vertical Electrical Sounding technique was carried out to determine the subsurface sequences, their aerial distribution, waterbearing layers and to select the proper sites to drill new productive wells. The conventional 4-electrode Schlumberger array was used to acquire the apparent resistivity data at seven stations. The maximum current electrodes separation (AB) was 2000 m. These seven VESes were distributed along one profile in the middle part of the study area (Fig.1). Field measurements were achieved by using the direct current resistivity meter "Terrameter SAS 1000". One ofthe sounding stations was performed besidean existing wellto be a parametric measurement and hence control the interpretation of the field data.

The acquired field data were interpreted to obtain the true resistivity and thickness of each geoelectric layer.Using RESIST program (Van Der Velpen, 1988) for the non-automatic iteration method. In this program, the field data are compared with the data calculated for an assumed earth layer model(Fig.3). The assumed model is based on all the available information obtained primarily from the existing well (lithology and depth to water), geological and hydrogeological settings of the study area.

2-2- Time-Domain Electromagnetic soundings (TEM)

Time-Domain Electromagnetic sounding technique was used for mapping the water-bearing layers, where the conductivity of the water- bearing layer is more than that of the dry layers. This method is used to determine the changes in resistivity with depth due to their better vertical resolution and their lower sensitivity to geologic noises. In this method, the current pulses are sent through the transmitter loop laid on the ground surface, after cutting-off the current, the rapid decay of the current at the end of each pulse generates a magnetic field diffuses into the stratified earth. Eddy currents induced by the time-varying magnetic field generate, in turn, secondary magnetic field in the electrically conductive stratified earth. The amplitude and rate of decay of these secondary fields are measured on the receiver loop and analyzed in terms of variations in the electrical resistivity with depth (Kontar and Ozorovich, 2006; Massoud et al., 2010 and Shaaban et al., 2016). Eighteen TEM soundings (Fig.1) were acquired with TEM-FAST 48HPC instrument with the usage of ungrounded horizontal magnetic antennas in single loop configuration (square loop with 200m side length),one loop combines the functions of transmitter and receiver. At the same sounding site, the measurements were repeated more than once to obtain the best field curve (enhanced signal to noise ratio) suitable for processing and interpretation. One sounding was measured adjacent to the existing well and VES station to aid in the correlation and to decrease the ambiguity during the interpretation of the acquired data (Fig.3). Based on Occam's inversion principle (Constable et al., 1987), the acquired TEM data in the form of apparent resistivities versus time were processed and inversed, using 1X1D software (Interpex 2008).

III. Results And Discussions:

3-1- Vertical Electrical Soundings

The quantitative interpretation of each VES station measurements was represented in terms of true resistivity and thickness. This type of interpretation illustrates the variations in the resistivities and thicknesses of each geoelectric layer and determines the depths to the water-bearing layers and their extension across the study area. The interpreted data revealed that, the geoelectric succession in the study area consists mainly of fourgeoelectric layers summarized in table 1. The following is a brief description of these layers from top downwards:

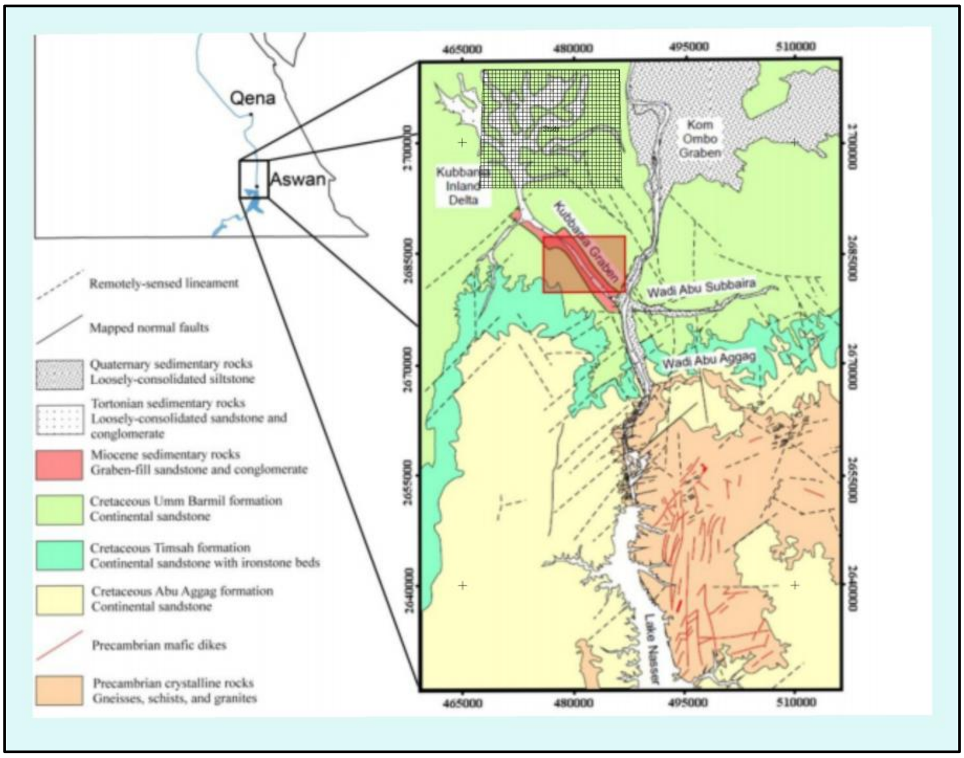

Fig. 2: Geologic map of the area around Aswan and Komombo.
(modified from Lansbery (2010).

<u>Geoelectriclayer "A":</u>

This layer represents the surface cover which is composed of gravel, sand, conglomerates, boulders and clay.It attains a range of resistivity varying from 1172 to 4282 Ohm.m, and a thicknessranges from 5 to 20m. The wide range of resistivity is due to different composition of the surface geoelectric layer.

<u>Geoelectric layer "B":</u>

This layer is poorly sorted and is composed of gravels, sand, conglomerates, boulders and clay.It attains a wide range of resistivity varying from 54 to 570 Ohm.m. The thickness of this layer ranges from 40 to 60m. The wide range of resistivity is due to different composition.

<u>Geoelectriclayer “C”:</u>

This layer represents the first water-bearing layer in the study area. It has resistivity values varying from 40 to 88 Ohm.m and a thickness ranges between 20 and25 m. This layer is composed of sandstone with some clay intercalations.

<u>Geoelectric layer “D”:</u>

It represents the base of the first water-bearing layer in the study area. It has resistivity values varying from 8 to 14 Ohm.m. The base of this geoelectric layer did not reach through this technique. This layer is composed of sandy clay with low potentiality.

3-2- Time-Domain Electromagneticsoundings

The initial model used for interpreting the TEM soundings is based on the results obtained from the VES soundings and the existing wells. The constructed model is best fit with the smoothed data. The obtained results from these TEM soundings reveled that, the vertical resistivity stratification in the study area is composed of six layers (table 2). The following is a description of these layers from top downwards.

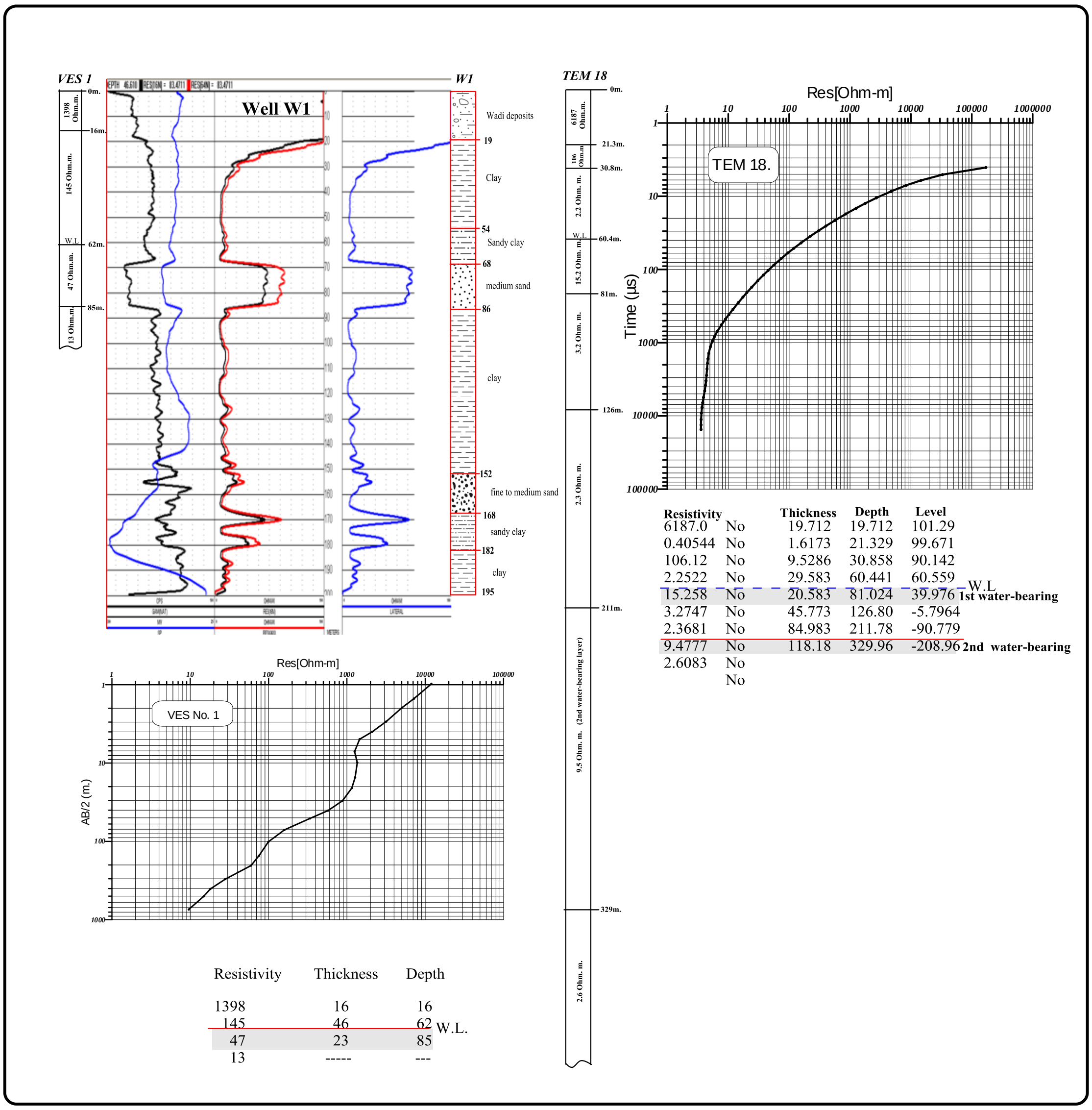

Fig.3: Parametric measurements of TEM station No. well, beside well W1

Table (1): A summary of the geoelectric layers in the study area from VESes interpretation.

GeoelectricLayer	Thickness (m)	Resistivity (Ohm-m)	Lithological composition
Layer "A"	5 - 20	1172- 4282	**Gravels, sand boulders and clay (Dry layer)**
Layer "B"	40 -60	54- 570	**Sand intercalated with clay (Dry layer)**
layer "C"	20 - 25	40 -88	**Sandintercalated with clay (Water bearing)**
layer "D"	----	8-14	**Sandy Clay**

Table (2): A summary of the geoelectric layers in the study area from TDEM soundings interpretation

Layer	Thickness (m)	Resistivity (Ohm-m)	Lithological description
Layer "1"	34-50	4825-10750	**Gravels, sand, boulders and clay intercalation (surface cover)**
Layer "2"	10-24	85-249	**sandstone intercalated with clay (Dry layer)**
Layer "3"	17.8-38	1.2- 6.3	**Sandy Clay**
Layer "4"	10-29	7.2- 21	**Sandstone with clayintercalations.(First water-bearing)**
Layer "5"	131-154	1.8- 3.9	**Sandy Clay**
Layer"6"	100-129	6.2-14	**Sandstone with clay intercalations (Second water-bearing)**
Layer "7"	----	1-3.9	**Clay**

Layer "1":

The first layer is correlated with the geoelectric layer A andthe upper part of layer B that obtained from the VESes interpretation; these two layers are grouped together assurface layer. It has resistivity values range from 4825 to10750Ohm.m. Its thickness varies from 34 to 50m. It is composed of Gravels, sand, boulders and clay interbeds.

Layer "2":

The second layer is correlated with the lower part of geoelectric layer B; it represents the lower part of the dry zone. Its resistivity values range from 85to 249Ohm.mand its thickness varies from 10 to 24 m. This layer is composed of sand with clay intercalations.

Layer "3":

This layer represents the upper clay layer that capping the first water-bearing layer; its resistivity values range from 1.2 m to 6.3Ohm.m.The thickness of this layer varies from 17.8 to38 m. This layer is composed of clay andsandy clay.

Layer "4":

The fourth layer is correlated with the geoelectric layer C; it represents the first water-bearing layer in the study area and is composed ofSandstone with clay intercalations**.** Its resistivity values range from 7.2 to 21Ohm.m. Its thickness varies from 10 to 29m. Due to its small thickness this layer has low water potentiality.

Layer "5":

The fifth layer represents the base layer under the first water-bearing layer; its resistivity values range from 1.8 to 3.9Ohm.m.The thickness of this layer is huge andvaries from 131 to154 m. This layer is composed of clay and sandy clay.

Layer "6":

This layer represents the second water-bearing (main water-bearing) layer in the study area. Its resistivity values range from 6.2 to 14Ohm.m.Its low resistivity values are contributed to the increase in its argillaceous materials or to the increase in its water salinity. The thickness of this layer varies from 100 to 129m.

layer "7":

This is the last layer in the penetrated succession.It is composed of clay with low resistivity values that varies from 1 to 3.9 Ohm.m. The thickness of this layer didn't determine.

IV. Groundwater Occurrence

The interpreted data of both VESes and TEM soundings were used to construct five geoelectric cross sections. These cross sections traverse the study area in two directions; the first ones run in W-E direction (A-A`, I-I` and II-II`) while the others run in S-N direction (III-III` and IV-IV`). They aim to illustrate the vertical and horizontal variations in the stratification of their sites. Also, they aim to determine the distribution of water-bearing layers in the study area (Figures 4 to 8).

From the previous discussion, it is obvious that, the saturated zone in the study area is represented by the geoelectric layer (C) as obtained from the VESes or layers 4 and 6, as obtained from the TEM soundings. The upper layer of the saturated zone (geoelectric layer C and layer 4) is composed of sand and clay intercalations. It is characterized by resistivity values range from 40 to 88Ohm.m(from VESes) and from 7.2Ohm.m at TEM P3v3 to 21Ohm.m at TEM P4V5 (from TEM); where they decrease in the middle part of the study area (Fig. 9). Its thickness ranges from 10m at TEM P3V5 to 29m at TEM P4V5; while it decreases towards the SE direction (Fig. 10). The secondwater-bearing layer that considers the main aquifer in the study area (geoelectric layer 6) is composed of argillaceous sand. It has resistivity values vary from 6.2 Ohm.mat TEM P1V5 to 14Ohm.m at TEM P4V3; they decrease toward NE direction (Fig. 11). The uppersurface of this layer is located at depth 150m at TEM P4V2and 300 at TEM P1V2; they increase towards the NW direction (Fig. 12). Its thickness ranges from 100m at TEM P1V5 to 130m at TEM P4V3 (Fig. 13). The first water-bearing layer is not enough for sustainable development of this area since it has a small saturated thickness. The second water-bearing layer is suitable for exploitation since it is composed of sand and silt and has appropriate thickness.

To select suitable sites for drilling new productive water wells in the study area, three factors must be taken account. These factors are; the resistivity values of the first and second water-bearing layers, the thicknesses of both water-bearing layers and the depths to the upper surface of the two water-bearing layers from the ground surface. The first priority class is the most suitable sites to drill new productive wells is characterized by high resistivity values, large thickness and has low depths from the ground surface. It located at the southern part of the study area and it represented by stations P4V3 and P4V2.

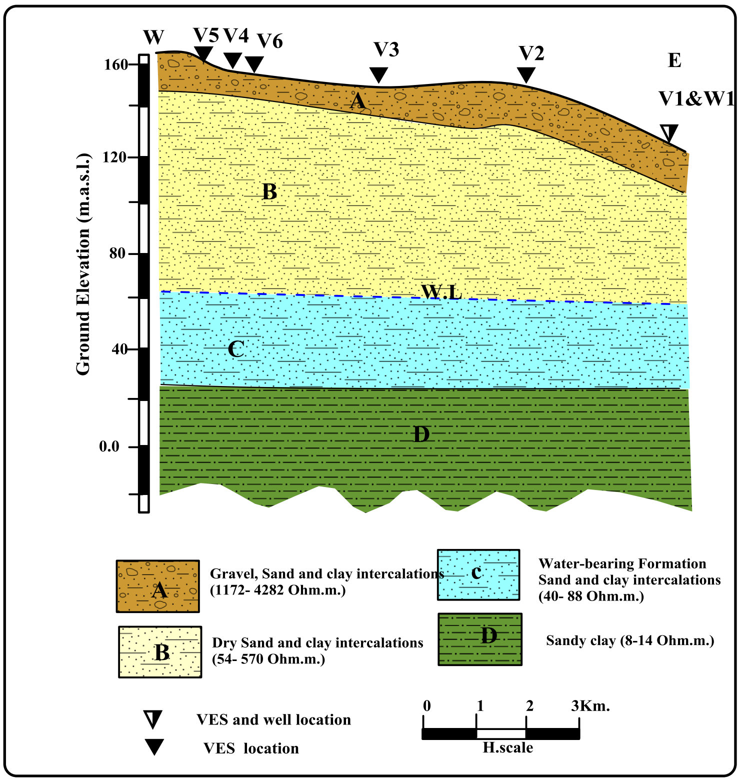

Fig.4: Geoelectric cross section A-A` (From VES results).

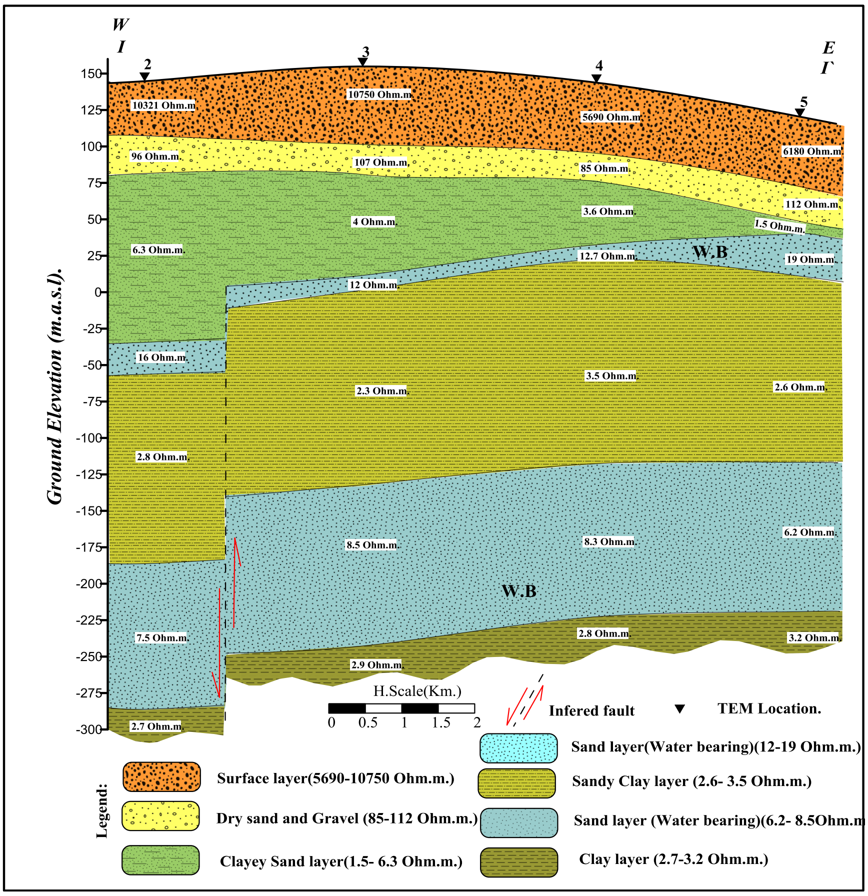

Fig.5: Geoelectric cross section I-I`.

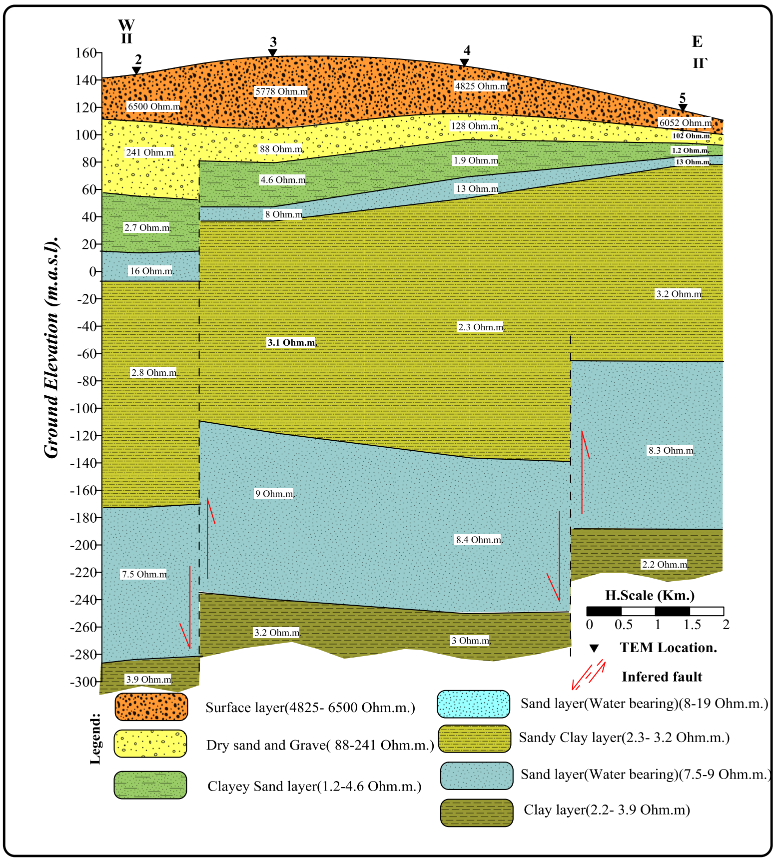

Fig.6: Geoelectric cross section II-II`.

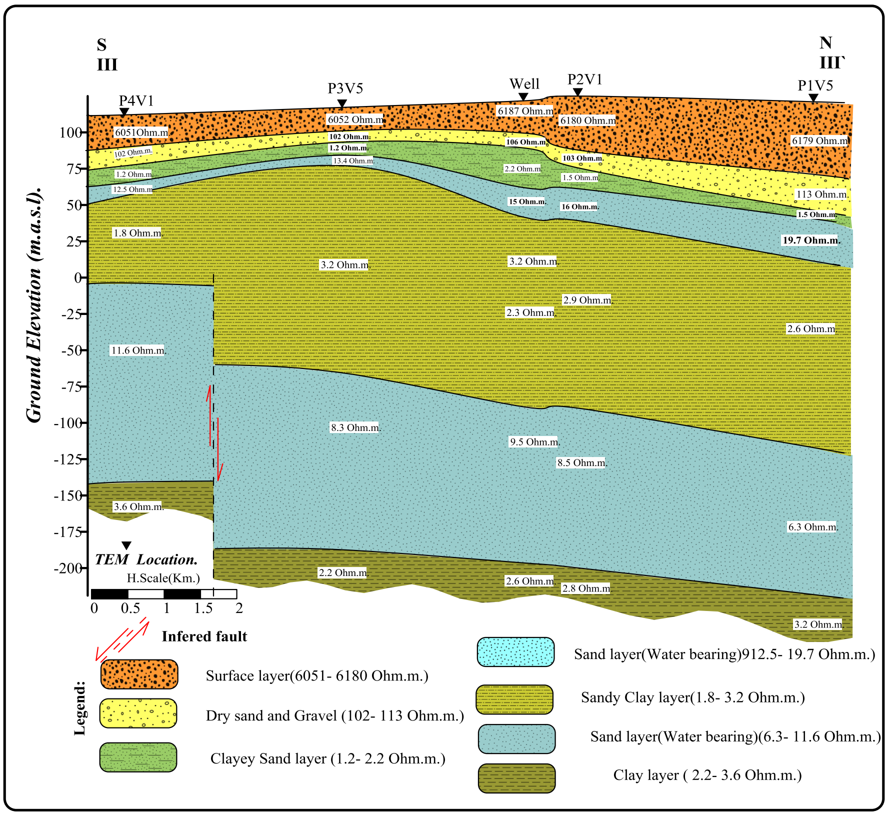

Fig.7: Geoelectric cross section III-III`.

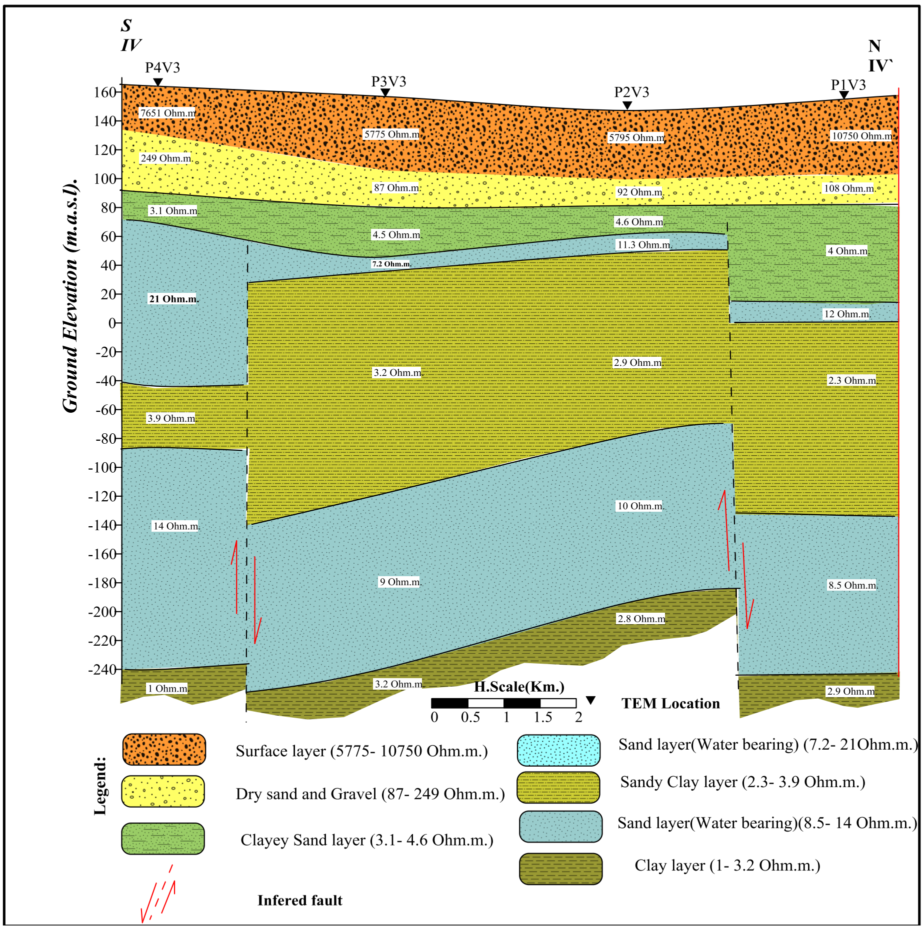

Fig.8: Geoelectric cross section IV-IV`.

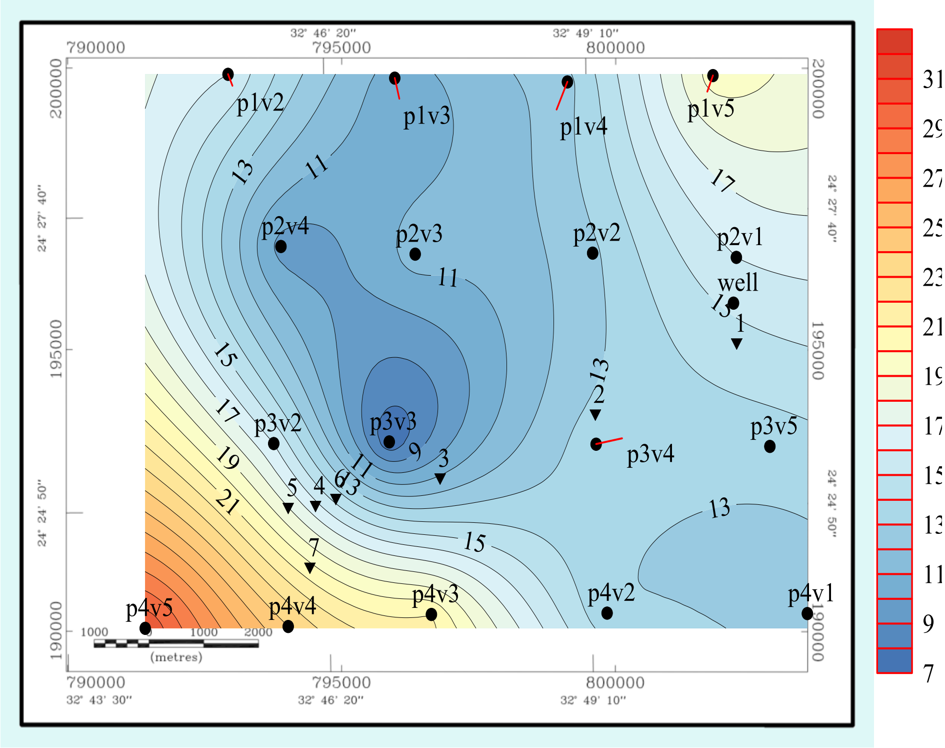

Fig.9: **I**so-resistivity contour map of the 1st water-bearing layer.

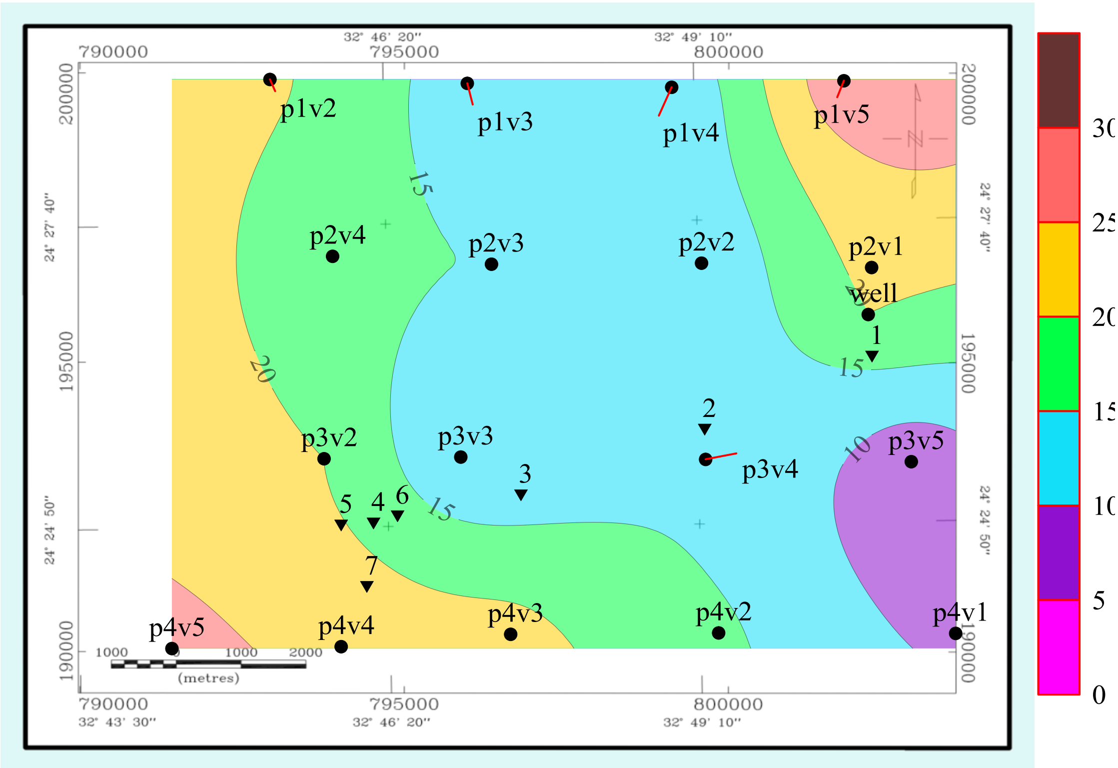

Fig.10: The thickness contour map of the 1st water-bearing layer.

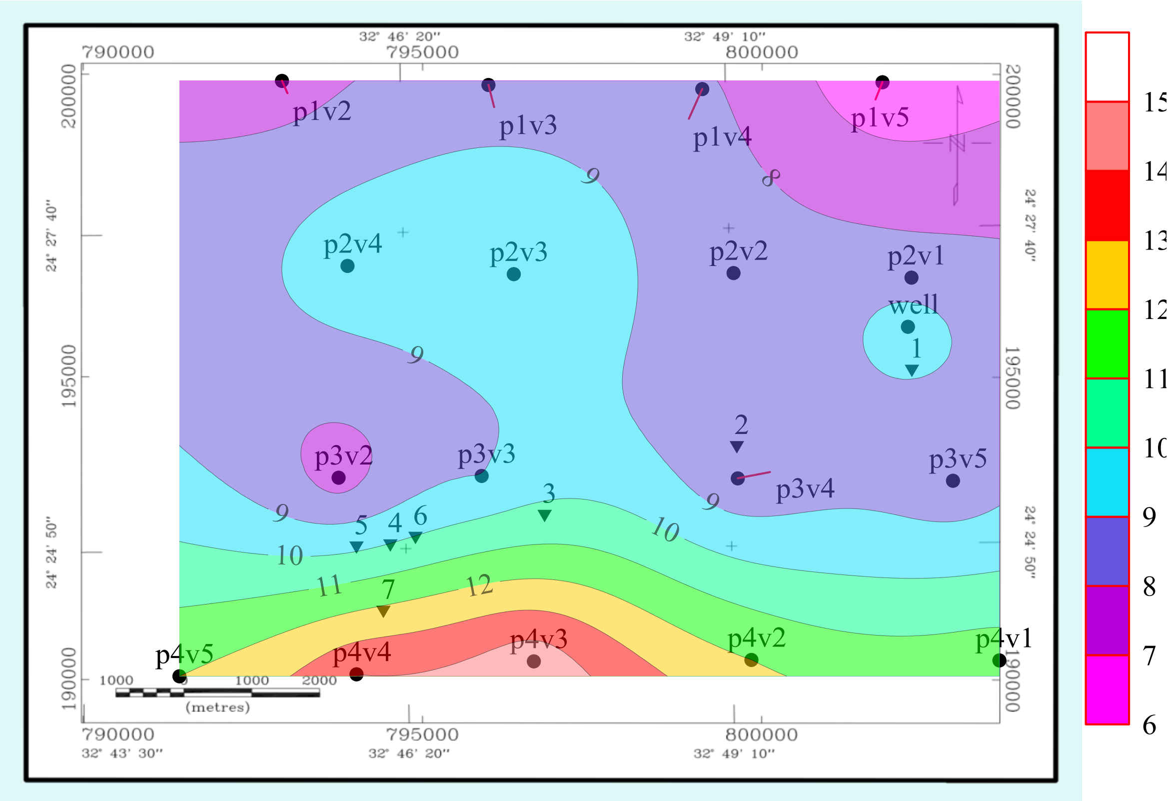

Fig.11: Iso-resistivity contour map of the 2nd water-bearing layer.

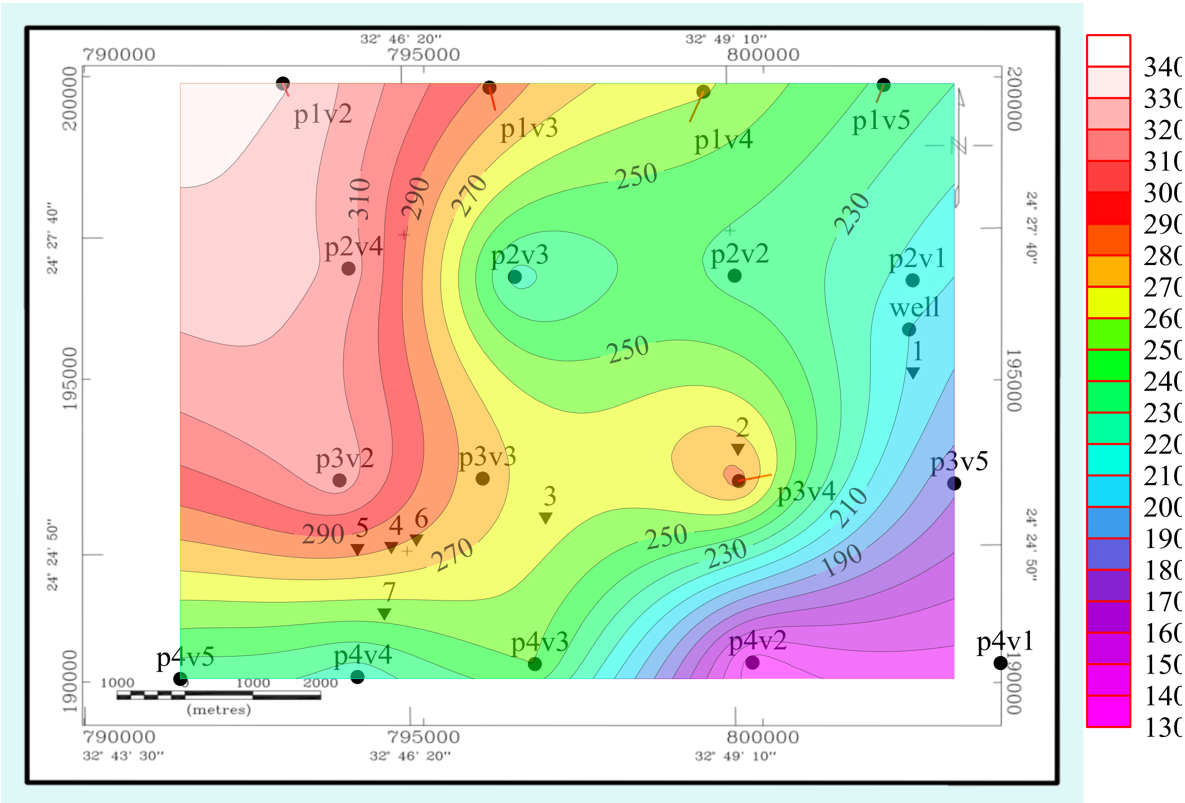

Fig. 12: Iso-pach contour map of the upper surface of 2nd water-bearing layer.

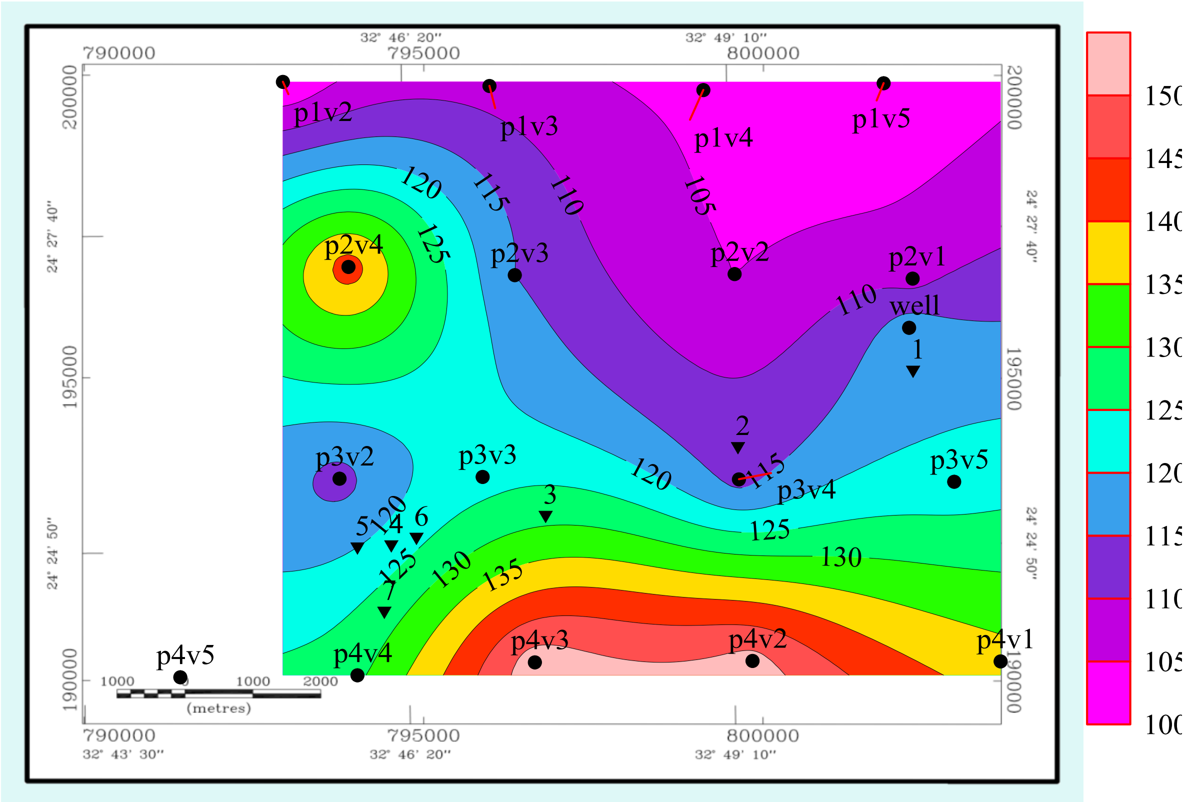

Fig.13: The thickness contour map of the 2nd water-bearing layer.

V. Summary And Conclusion

New land reclamation projects in the desert fringes of West Komomboare depending mainly on groundwater.This area is a part of the Egyptian 1.5 million feddan national reclamation project. The integration between the Vertical Electrical Soundingsand the Time-Domain Electromagnetic Soundings has a benefit to clarify the factors affecting the groundwater occurrences and to locate the best sites to drill new water productive wells.

Field work in the investigated area includes carrying out sevenVESes along one profile, using 4-electrode Schlumberger configuration with maximum AB/2 spacing 1000 m; and carrying out eighteen TEM soundings, using single loop configuration with square side length 200m. Interpretation of the acquired VESes indicates that, the geoelectric succession in the study area consists of fourgeoelectric layers (A, B, C and D). Layers A and B are the surface and dry layers, these layers consist of gravels, sand, boulders and clay intercalations. The saturated zone is represented by the geoelectric layer (C) which consists of sand and clay intercalations. The last geoelectric layer (D) consists of sandy clay. The obtained interpreted models of the TEM soundings consist of seven geoelectric layers; the first and second layers represents surface and dry layers. They consist of gravels, sand, boulders and clay intercalations. The third layer is sandy clay layer capping the first water-bearing layer. While the fourthgeoelectric layer in the study area represents the first water-bearing layer and it is equivalent to the geoelectric layer (C) and composed of sand and clay intercalations.This layer is underlined by a thick sandy clay layer (fifth layer). The sixth layer in the geoelectric succession is the second water-bearing layer (the main aquifer) in the study area and composed of sand and clay intercalations. The last geoelectric layer is sandy clay layer, which represents the base of the second water-bearing layer in the study area.

The obtained results from both the VESes and TEM soundings were used to construct five geoelectric cross sections traverse the study area in the W-E and N-S directions. These cross sections clarify the changes in the vertical and horizontal variations in the resistivity and thickness of each layer, and hence to highlight the water-bearing layers. Accordingly, the first water-bearing layer in the study area has electricalresistivity values vary from 7.2 to 21 Ohm.m; its decreases towards the middle part of the study area. The thickness of this layer ranges from 10 to 29m and it decreases towards the SE direction. This layer is not suitable for sustainable developments, where it has a small thickness and low groundwater potentialities. The second water-bearing layer has resistivity values vary from 6.2 to 14Ohm.m; it decreases towards the northern part of the study area. Its upper surface is located at depth vary from 150 to 300 m; the depth increases towards the NW direction. It is composed of sand and silt intercalations with a considerable thickness varying from 100 to 130 m. The low resistivity values of this layer can be attributed to the presence of argillaceous sand and/or increasing in the water salinity.

The first priority class is the most suitable sites to drill newproductive water wells. It characterized by acceptable resistivity values, large thickness and has low depths from the ground surface. It located at the southern part of the study area and it represented by stations P4V3 and P4V2.

Based on the obtained results, the following are recommended:

1- The first sites to drill new productive wells are these at the locations of stations P4V3 and P4V2.
2- The total depths of the proposed water wells must full penetrate the second water-bearing layer and reached to the clay layer.
3- Drilling new wells in the study area should be under control, to avoid the aquifer deterioration, due to the over pumping processes.

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