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GEOELECTRICAL PROSPECTING FOR GROUND WATER AND SUBSURFACE GRAVEL OCCURRENCES IN THE SOUTHERN PART OF EL-SALHAIYA PLAIN, ISMAILIA GOVERNORATE

El-Arabi H. Shendi

Department of Geology, Faculty of Science, Suez Canal University, Ismailia .

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ABSTRACT :

The southern part of El-Salhaiya plain extends parallel to the Ismailia irrigation canal for a distance of about 40 km., covering an area of about 600 km^2 . It is one of the most important reclamation and agricultural projects in Egypt. The geologic and hydrogeologic history of this area concluded that the Quaternary ground water aquifer has an appreciable thickness, besides the presence of subsurface gravel bodies with reasonable thicknesses, depths and lateral extension. Twenty Schlumberger vertical electrical soundings (VES) were measured, covering an area in a grid pattern system in order to evaluate the ground water and gravel occurrences. This geoelectrical surveying has detected a fresh water horizon ranging in thickness from 8 to 38 meters where the recommended depths and sites for drilling water wells are given. On the other hand, the delineated thicknesses of the subsurface gravel deposits, with different grain sizes, vary from 10 to 45 meters occurring at depths of approximately 10 meters where an exploitation map is proposed .

INTRODUCTION :

The serious increment of population in Egypt requires directing our attention towards reclamation projects taking into account that these projects should depend, mainly, on the ground water and not on the Nile water. El-Salhaiya plain is one of these large projects. The present piece of work studies only the southern part of this plain which extends parallel to the Ismailia irrigation canal for a distance of about 40 km and goes northward for about 15 km, covering an area of about 600 km^2. This part of the plain comprises El-Qassasine city and the associated villages Fig.(1).

PURPOSE OF STUDY :

The purpose of the study has been directed to cover the following topics :

1- Prospecting for ground water, their conditions; depths; qualities and recommending sites for drilling productive wells.
2- Prospecting for subsurface gravel deposits, their depths; thicknesses; grain sizes; approximate volumes of each grain size and recommending sites for carrying out quarrying activities.

GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS :

The southern part of El-Salhaiya plain varies in altitude between 20 and 40 meters above sea level, surrounded by low lands from all sides Fig.(1). It is mainly composed of a clastic unit, varying in thickness from 200 to 250 meters of quartz sands and gravels, intercalated with clay lenses. These sediments are assigned to early Pleistocene age and they form the main ground water aquifer in the eastern Nile delta (El-Shazly et.al. 1975, Said 1981 and Zoetbrood 1984). It was also believed that this clastic unit might represent the final depositional phases of the Prenile when its water flow became minimum and its far tributaries suffered great deficiency in their water supply. The surface gravel associations represent the earliest channel-fills and vary in size from granules (2-4 mm) and pebbles (4-64 mm) to cobbles (> 64 mm) which are suitable for concrete manufacture, water wells casing and foundation purposes (El-Fawal & Shendi 1991). The coarse grain size characterizing the plain sediments can reflect good hydraulic properties and therefore good environment for ground water movements and accumulations (Geriesh 1989).

Structurally, the study area is a part of the traditional tectonic zone between the Gulf of Suez taphrogeosyncline and the unstable shelf of the northern part of Egypt (Said, 1981). NNW-SSE and NE-SW faulting are young and affected the quaternary sequence, whereas, the WNW-ESE faulting affected clearly the underlying Miocene rocks (El-Heiny 1981 and Said 1991). However, the ENE-WSW faults configurate a number of parallel morpho-tectonic basins with highs in-between. These basins controlled the depositional regime, thickness and configuration of the overlying quaternary sediments and can be considered as a good environment for ground water accumulation.

The clastic unit in the southern part of El-Salhaiya plain is classified as the main ground water aquifer which is of unconfined type and underlined by Miocene sequence of marine origin. Sometimes, clay lenses may exist forming confined conditions. The thickness of the sandy aquifer increases gradually from

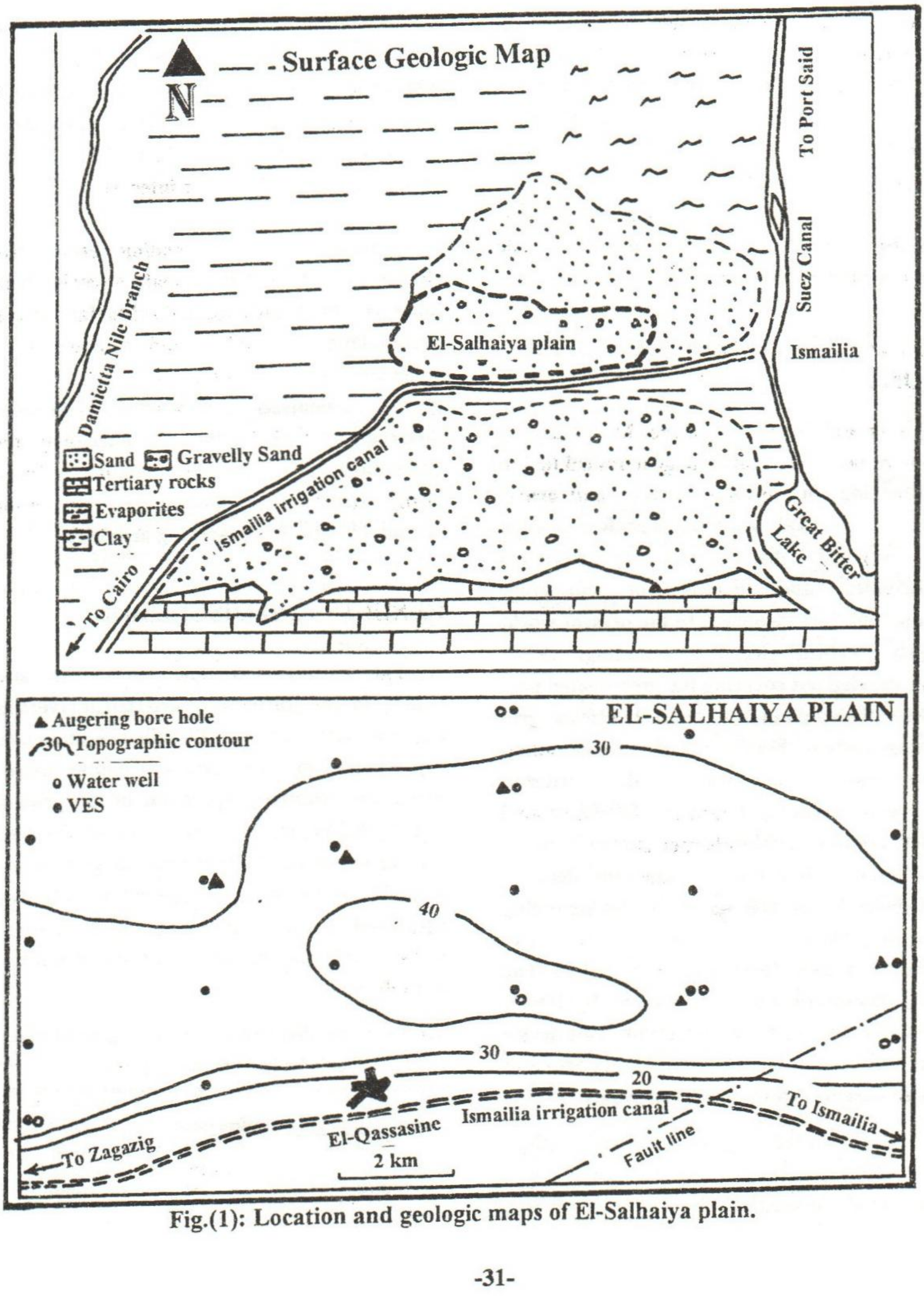

Fig.(1): Location and geologic maps of El-Salhaiya plain.

south to north due to the general tilting of the underlying Miocene rocks . The aquifer recharge from rain water doesn't exist due to the rare rainfall. However, Wadi El-Tumilate branch might have played a significant role in forming and recharging the ground water in the area because it has acted during its evolution history as a distributary for the Nile delta branches (Gereish 1994).

FIELD AND LABORATORY OPERATIONS :

It is well known that the D.C. resistivity method provides a valuable geophysical tool in prospecting for ground water and gravel deposits. Vertical sounding is preferred when the vertical distributions of electrical resistivities and depths of subsurface formations are required. In the present work, twenty vertical electrical soundings (VES) were carried out covering the investigated part of El-Salhaiya plain in a relatively regular grid pattern system Fig.(1). Six of these soundings were measured near water wells in order to deduce a resistivity spectrum for the ground water aquifer. Schlumberger electrode layout was used with a current electrode distance (AB-distance) of 600 meters. This spreading was long enough to penetrate the water bearing horizon for a few tens of meters. The field measurements were taken by RSP-6 resistivity and self potential unit. This device was designed to measure direct current resistivities and spontaneous potentials.

The calculated apparent resistivity values were then plotted on log-log papers and interpreted manually by curve matching technique through using two and three layer master curves of Mundry & Homilius (1979). Thereafter, the obtained true resistivities and depths were used as an initial input for a computer software of Velpen (1988) to get more accurate and reliable interpretation.

Depending on the sounding results, five sites were anticipated to make augering bore holes reaching the expected subsurface gravel accumulations (Fig.1) and samples were collected. These samples were subjected to grain size analysis using a system of sieves of different meshes trying to determine the percentage and approximate volume of each grain size as an initial step to decide reasonable sites for quarrying activities.

RESULTS AND DISCUSSION :

The interpreted true resistivities and depths to the different geoelectrical layers in the southern part of El-Salhaiya plain are represented in the form of contour maps. First. the resistivity spectrum of the ground water aquifer in the area could be deduced relying on the results of the soundings near the available water wells in compatible with the measured water salinity values from these wells. The expected spectrum values are listed in table (1).

Table (1): Resistivity spectrum of the ground water aquifer in El-Salhaiya plain.

Average water salinity (ppm)	True resistivity range (Ωm)	Assumed water quality
2500	50 - 100	salt
1300	100 - 200	brackish
1000	200 - 300	fresh

The geoelectrical results with respect to ground water occurrences and subsurface gravel deposits will be discussed as follows: the concerned clastic unit in the studied part of El-Salhaiya plain could be divided into three main geoelectrical layers which are :

1- *The top layer* varies in thickness from 1.5 to 6 meters and has a true resistivity ranging between 60 and 400 Ωm (Figs. 2&3). The great variation in resistivity values could be attributed to lithologic changes (i.e. variations in sand/clay ratio) and water content due to irrigation processes. The high resistivity values represent high percentage of gravel and pebble content. These deposits can be exploited by open quarrying operations. Accordingly, two sites are recommended (i.e. sites A & B, Fig.3) to exploit these deposits where, their true resistivity reaches as high as 500 Ωm. However, the removal of such deposits will improve the physical properties of the land for agricultural purposes.

2- *The second geoelctrical layer* has a true resistivity ranging between 140 and 1500 Ωm (Fig.4) and its thickness varies from 5 to 45 meters (Fig.5). This layer is treated as the main source of the subsurface gravel occurrences. The great variation in its true resistivity is mainly due to a change in gravel/sand ratio where the resistivity values increase towards the increment of this ratio. Accordingly, three sites are recommended for quarrying of gravel deposits (i.e. sites A,B & C, Fig.6). Site (A) is located to the east of El-Qassasine city and is easily accessible from El-Qassasine - Ismailia asphaltic road. The other two sites are located to the north of El-Qassasine city and they lie directly at the asphaltic road of El-Qassasine - El-Qantara (Fig.6). These three sites are anticipated according to the following reasons:

a- Their high values of true resistivities which could be attributed to the presence of considerable percentage of gravels accumulations.
b- Their great thicknesses which reach as high as 45 meters (Fig.5).
c- Relatively deep water table which leaves these sediments in dry conditions, reasonable for quarrying operations.

3- *The third geoelectrical layer* represents the ground water aquifer in El-Salhaiya plain. Depending on the vertical variation in its true resistivity, this layer could be divided into two zones which are:

a- Upper fresh water zone which has true resistivities varying from 100 to 500 Ωm (Fig.7) and thicknesses between 6 and 38 meters (Fig.8). It is noticed that the resistivity values decrease toward the Ismailia irrigation canal in opposite to what is expected. This means that the Ismailia canal has no direct recharging effect on this shallow water aquifer. However, the depth to this water zone increases northward (Fig.9); reflecting variations in ground topography. It is recommended that, drilling of wells should be directed towards the sites where there is a great thickness of this water zone (Fig.8). According to the resistivity spectrum of the ground water aquifer in the area, this zone is classified as fresh water aquifer which may have water with low salinity (1000 ppm, table 1).

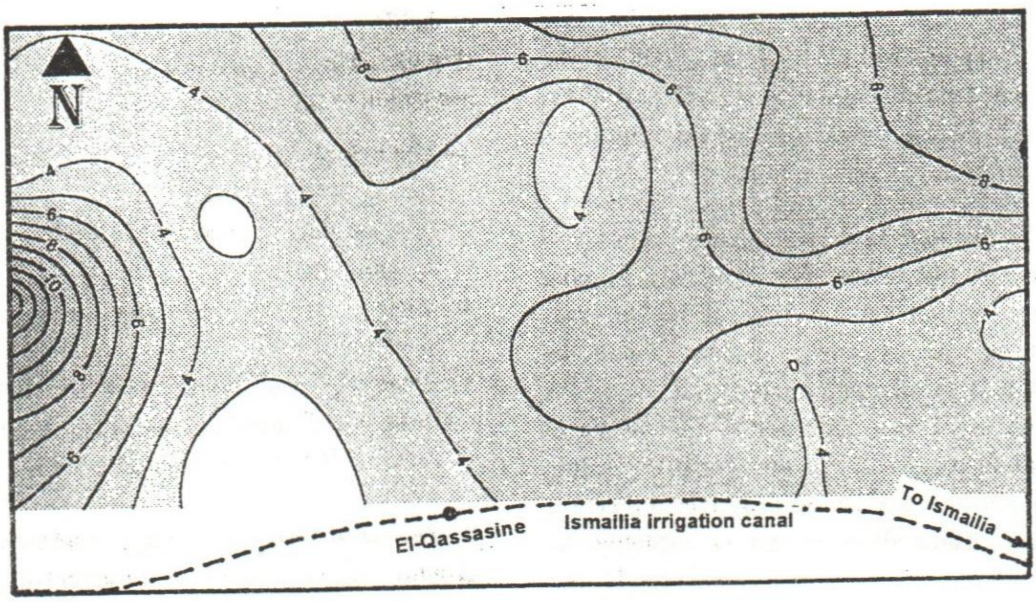

Fig.(2): Thicknesses of the surface geoelectrical layer (in meters) (Depths to the subsurface gravel deposits)

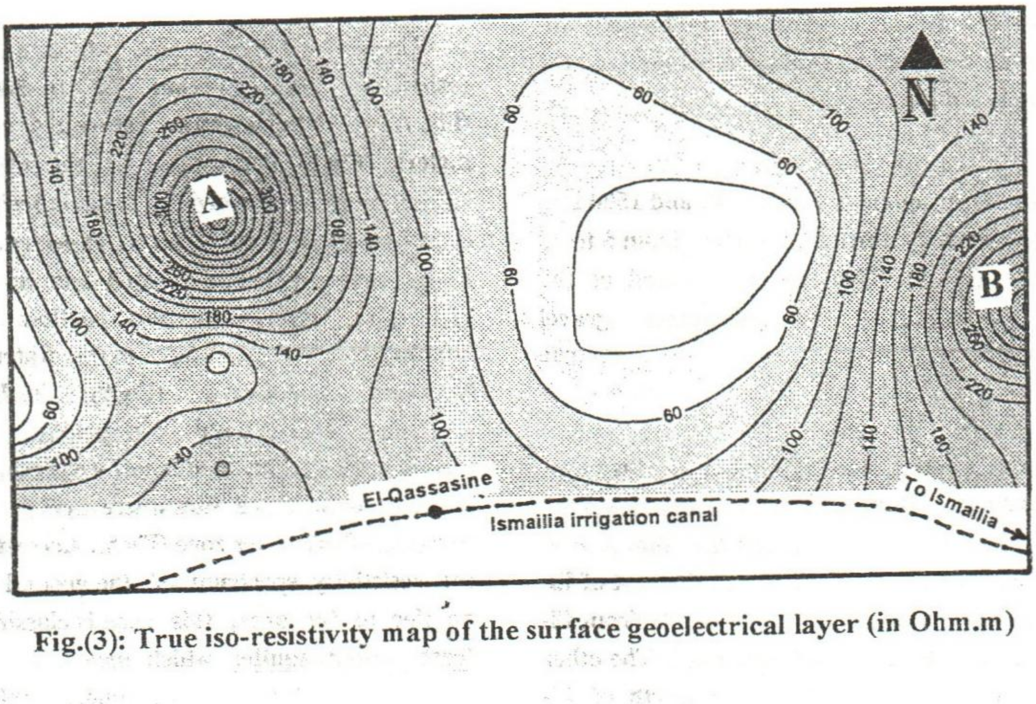

Fig.(3): True iso-resistivity map of the surface geoelectrical layer (in Ohm.m)

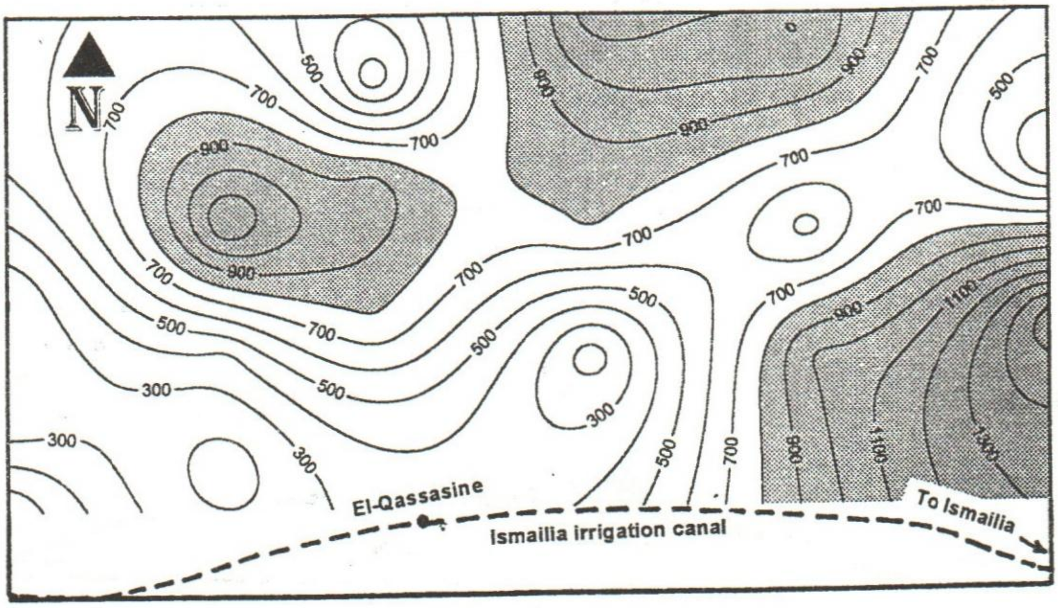

Fig.(4): True isoresistivity map of the subsurface gravel deposits (in Ohm.m)

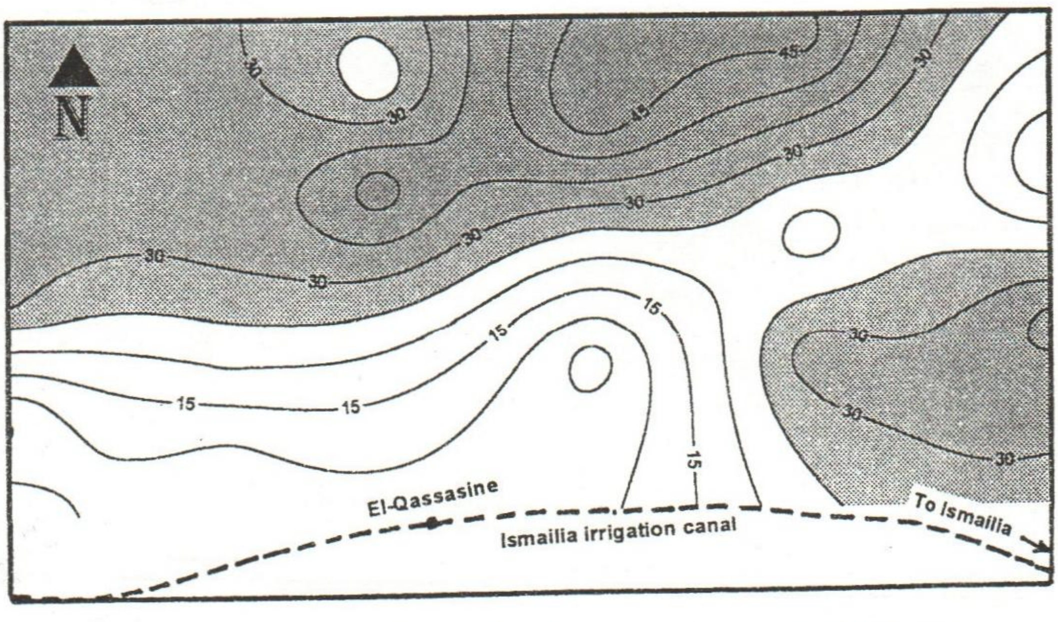

Fig.(5): Thicknesses of the subsurface gravel deposits (in meters)

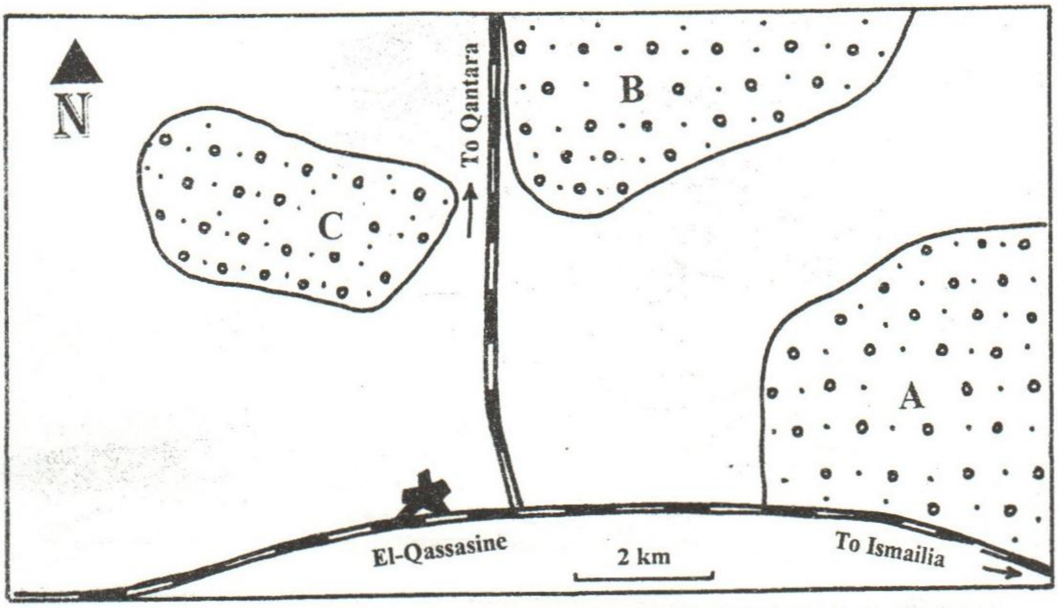

Fig.(6): Expected subsurface gravel bodies in El-Salhaiya plain

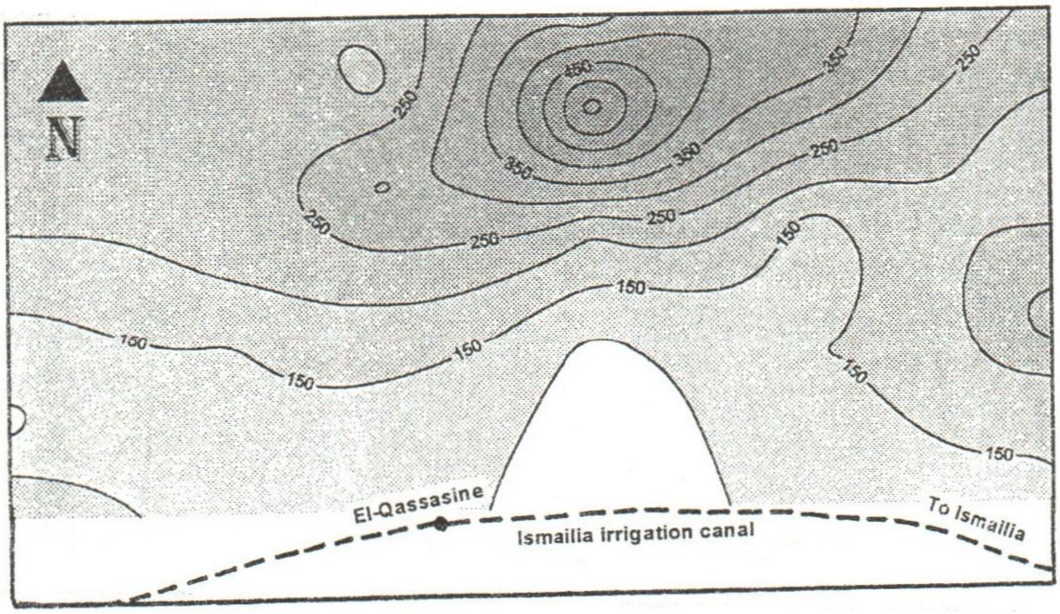

Fig.(7): True iso-resistivity map of the shallow fresh water aquifer (in Ohm.m)

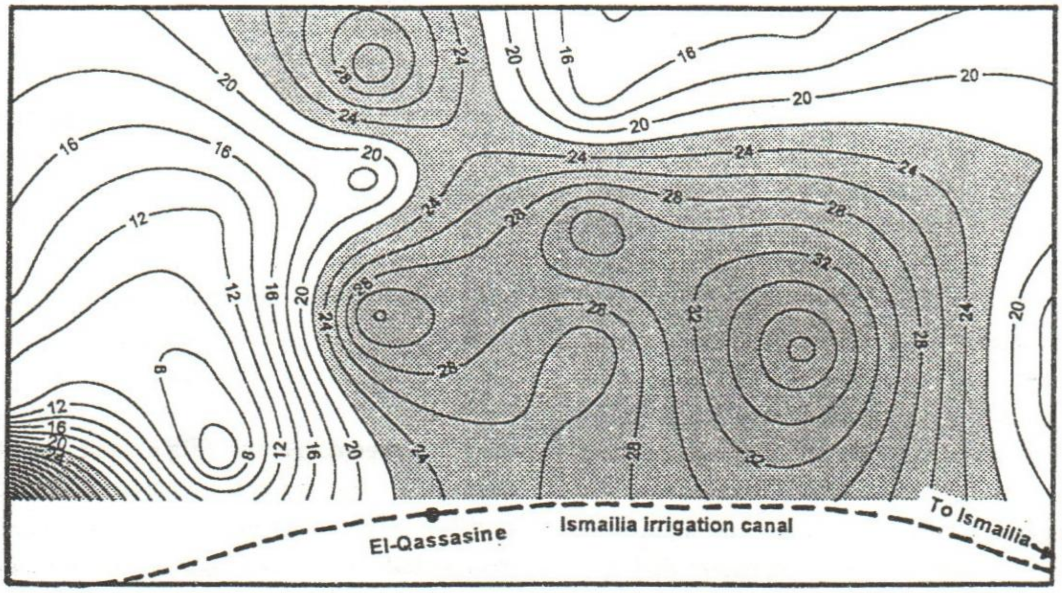

Fig.(8): Thicknesses of the shallow fresh water aquifer (in meter).

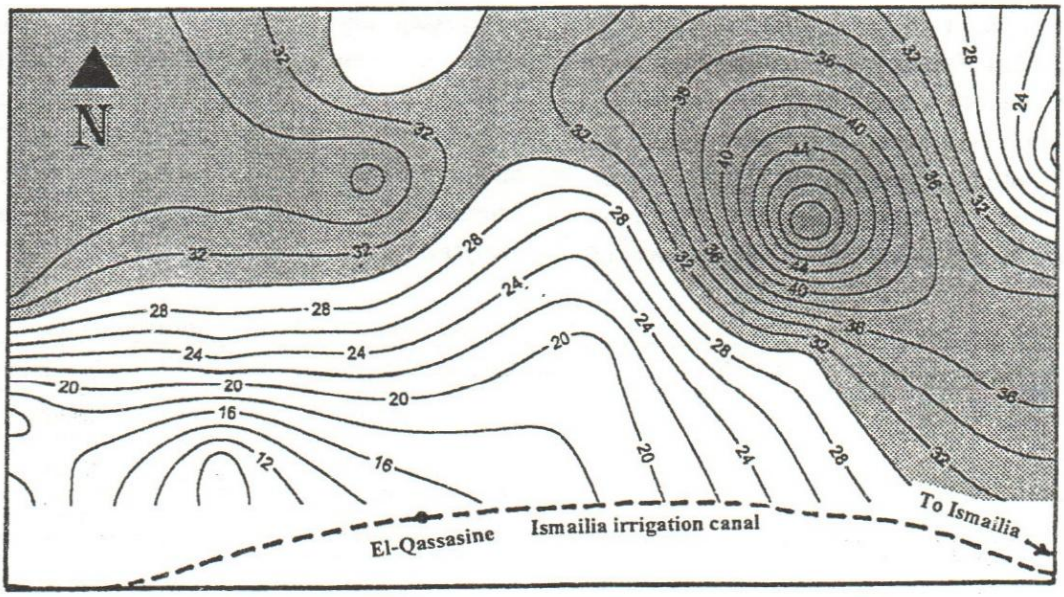

Fig.(9): depths to the shallow fresh water aquifer b.g.l.(in meter)

b- Deep brackish to salt water zone which has true resistivity ranging between 10 and 45 Ωm Fig.(10) and depths starting from 25 meter to 80 meter below ground surface (Fig.11). The ground water salinity in this zone reaches about 2500 ppm as measured from the water wells and it could be classified as brackish to salt water aquifer. Depths of water in this aquifer should control drilling water wells. It is also noticed that the true resistivity of this zone decreases in the part of El-Salhaiya plain to the west of El-Qassasine city but increases in the eastern part (Fig.10). This observation may explain the effect of the Ismailia canal in recharging the deep ground water aquifer in the eastern part of the plain rather than the western part due to the following reasons:

a- The increase of clay/sand ratio in the western part of the plain which may prevent the intrusion of canal water into the land.

b- The opposite occurs in the eastern part of the plain where there is an increase in the gravel+sand/clay ratio besides the presence of major fault near the village of El-Mahsama Fig.(1) which may facilitate the movement of fresh water from the canal towards the concerned ground water aquifer.

APPROXIMATE VOLUME ESTIMATION OF THE SUBSURFACE GRAVEL SEDIMENTS :

According to the interpreted true resistivities of the second geoelectrical layers, three subsurface gravel bodies are expected (i.e. A,B &C, Fig.6). Thereafter, five augering boreholes were done in these zones, reaching the interpreted depths (Fig.6) and samples were taken for grain size analyses. From the results of this analyses, only three fractions were considered, namely gravels, granules and pebbles (2-64 mm in diameter), very coarse sand (1-2 mm) and coarse sand (0.5-1 mm) according to Wentworth scale 1922. The interpreted thicknesses and the approximate areas of these gravel bodies were used to estimate the approximate total volume as well as the volume of each grain size (table 2) taking into account the percentage of each fraction as deduced from the grain size analyses.

Table (2): Approximate volume of each grain size in the expected subsurface gravel bodies.

Body number	A.T. (m)	A.T.S.A. (m^2)	A.T.V. (m^3)	% & V.G.	% & V.V.C.S.	% & V.C.S.
A	29	16000	464,000	49%	19%	28%
				22 7,360	88,160	129,920
B	31	13000	44,000	14%	26%	53%
				6160	11,440	23,320
C	33	11000	363,000	32%	9%	25%
				116,160	32,670	90,750

A.T. = Average thickness in meter.
A.T.S.A. = Average total surface area in km^2.
A.T.V. = Average total volume in m^3.
% & V.G. = Percentage and volume of gravels in m^3.
% & V.V.C.S. = Percentage and volume of very coarse sand in m^3.
% & V.C.S. = Percentage and volume of coarse sand in m^3.

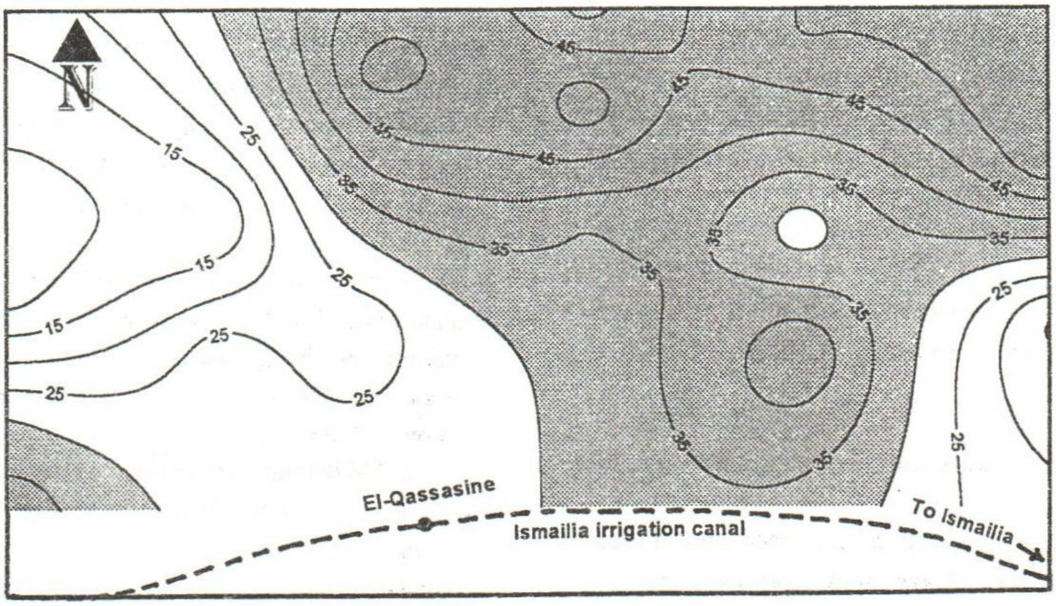

Fig.(10): True iso-resistivity map of the deep salt water aquifer (in Ohm.m)

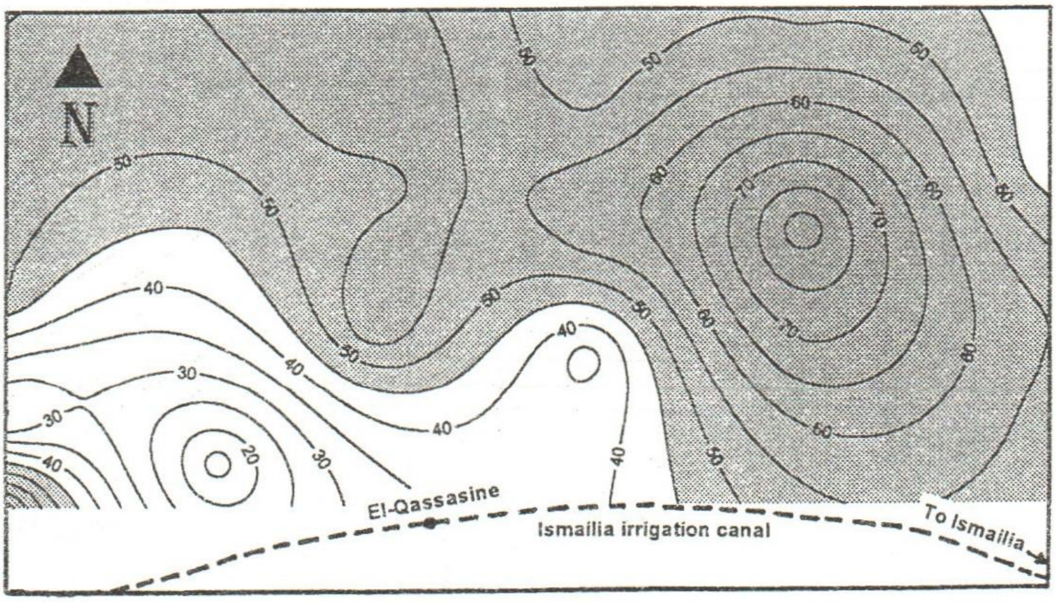

Fig.(11): Depths to the deep salt water aquifer b.g.l. (in meters)

The numbers in the above table indicate that the three subsurface gravel bodies give approximately a total volume of about 350,000 m^3 of gravels, about 132,000 m^3 of very coarse sand and about 244,000 m^3 of coarse sand. These bodies can be arranged according to their importance as follows: A, C and B. Their locations are easily accessible through El-Qassasine - Ismailia asphaltic road and El-Qassasine - El-Qantara asphaltic road (Fig.6).

CONCLUSION AND RECOMMENDATIONS :

Interpretation of the geoelectrical soundings which have been carried out in the southern part of El-Salhaiya plain could guide us to the following conclusion:

1. **Except the southwestern corner of the studied area, El-Salhaiya plain is recommended for drilling water wells ranging in depth from 30 to 80 meters below ground level (Fig.12).**
2. **Three sites were recommended for gravel quarrying Fig.(6). The total approximate volume of the gravels in the three sites is about 350,000 m^3 , the very coarse sand is about 132,000 m^3 and the coarse sand is about 244,000 m^3. These types of sediments are mostly used for concrete constructions, casing water wells and other foundation purposes.**

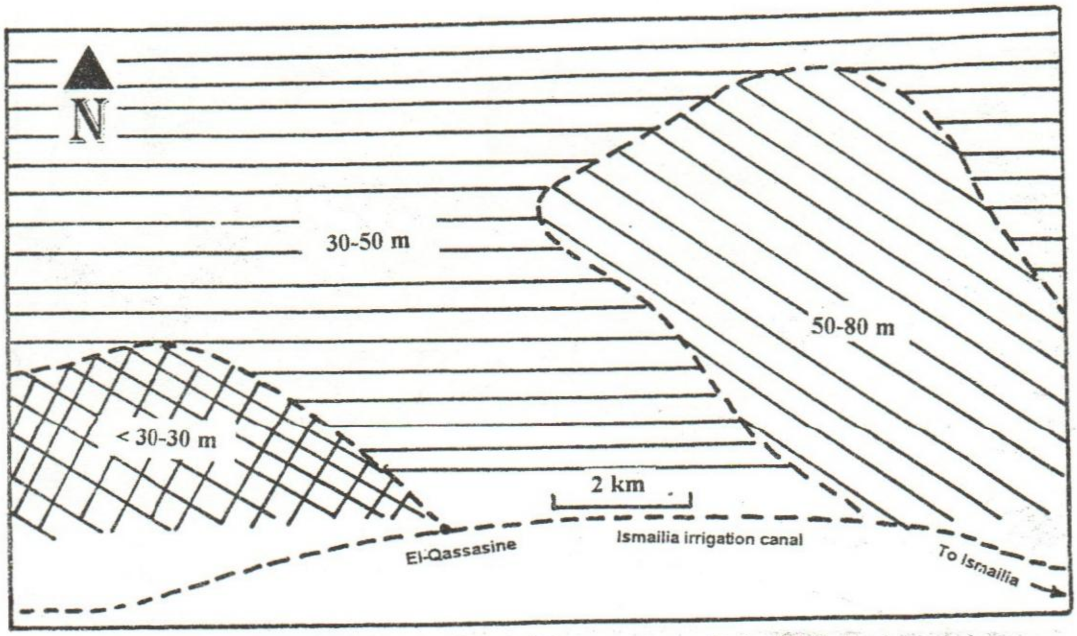

Fig.(12): Recommended depths for drilling water wells in El-Salhaiya plain

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تنقيب جيو كهربى عن المياه الجوفية وتواجدات الحصى التحت سطحية فى الجزء الجنوبى من سهل الصالحية – محافظة الإسماعيلية

العربى هندى شندى

قسم الجيولوجيا - كلية العلوم - جامعة قناة السويس - الإسماعيلية

يمتد الجزء الجنوبى من سهل الصالحية لمسافة أربعين كيلو متراً موازياً لترعة الإسماعيلية ومغطياً مساحة قدرها حوالى ستمائة كيلو متر مربع ، ويقع غرب مدينة الإسماعيلية . تعتبر هذه المنطقة أحد أكبر مشروعات استصلاح واستزراع الأراضى فى مصر . ومن الناحية الجيولوجية فإن المنطقة مغطاه بطبقة سطحية من الرمال والحصى مختلطة ببعض ترسيبات الطين فى شكل عدسى ، ويتراوح سمك هذه الطبقة من الرمال والحصى ٢٠٠ إلى ٢٥٠ متر وتتبع عصر البليستوسين ، وتعتبر خزان المياه الجوفية الرئيسى فى شرق دلتا نهر النيل . وقد تم إجراء دراسات جيوفيزيائية حقلية بطريقة الجس الكهربى الرأسى على منطقة الدراسة من خلال تنفيذ عدد عشرين جسة عميقة بتوزيع شلمبرجير بحيث تغطى المنطقة فى نظام شبكى بغرض :

١- استكشاف تواجدات المياه الجوفية وحساب أعماقها وسمك الطبقة الحاملة لها ومن ثم تحديد أماكن لحفر آبار إنتاجية فى استصلاح واستزراع المنطقة .

٢- استكشاف تجمعات الحصى التحت سطحية وحساب أعماقها ، وكذلك أحجامها ومن ثم تحديد أماكن لاستغلال تلك الرواسب .

وقد توصلت هذه الدراسة إلى أن المنطقة الجنوبية من سهل الصالحية تحتوى على مياه جوفية عذبة تتجمع فى النطاق الرسوبى المحصور بين عمقى ٣٠ إلى ٨٠ متراً ، وبالتالى لا ينصح بحفر آبار مياه يتعدى عمقها ٨٠ متراً حتى نتجنب تداخل المياه المالحة من الخزان الجوفى العميق . كما حددت الدراسة ثلاثة مواقع لاستغلال الحصى عن طريق عمليات التحجير حيث يبلغ الحجم الكلى لترسيبات الحصى فى تلك المواقع حوالى ٧٢٦٠٠٠ متر مكعب تصلح لعمليات الخرسانة وتبطين آبار المياه ورصف الطرق وغيرها من عمليات التشيد والبناء .