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Groundwater Rising as Environmental Problem, Causes and Solutions: Case Study from Qus City, Qena, Egypt

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ABSTRACT
A study of the groundwater rising in Qus city and its hazardous environmental impacts were studied. The study focused on understanding and describing the mechanism by which waste water enters the groundwater. The main environmental problems are architectural, social and healthy. Detailed geoelectrical, topographical and brief hydrogeological analyses had been carried out. Three subsurface geoelectrical layers are recognized and their lithological counterparts are identified. The daily seepage from latrines may represent the main contributor of groundwater rising in the shallow aquifer. Moreover, seepage from irrigation canals and the municipal water supply system leakages further raise the groundwater level. The depth of groundwater table attains 0.50 m in the low-lying southeastern areas and 5.50 m in western areas towards the Nile. The groundwater quality grades from fresh to brackish water where the total dissolved solids ranges from 289 mg/l to 2129 mg/l. The completion of the city sewerage network and a dewatering system in the southeastern parts may be suggested as a solution to overcome the problem.
Keywords: Drains, Environmental impact, Groundwater Level, geoelectrical Layer, Latrines, Seepage, Sewerage, Waste Water.

INTRODUCTION
In the last ten years, a huge environmental problem occurred due to the rising in the ground water in Qus city (Latitude: 25° 55' 0 N, Longitude: 32° 45' 0 E, Fig. 1). In some localities, the level reaches 0.5 m under the ground surface. Since seven years ago, the project of the sewer network started. The company that is responsible for the project pumped a huge amount of groundwater (Fig. 2A) to lower the groundwater level in the city. Due to the high pumping rate, most of the fine particles (Fig. 2B) were removed from the aquifer and accordingly, the porosity and permeability of the aquifer have been increased. The present study aims mainly to point to the probable causes and effects of the groundwater level rising in the Qus city and to find a suitable solution. The majority of the city is affected by the problem (Fig. 2C).

Domestic wastewater discharge
Qus city suffers the lack of sewer network. Therefore the wastewater is poured out either directly to the streets (Figs. 2C) or transported by vehicles to the nearby irrigation canals (Fig. 2D). In some poor houses, standing sewage is a constant problem, as residents cannot pay the fees demanded by 'evacuators. In some parts of the city, some new houses lack any latrines, because people assume that they will eventually get sewer. Thus, different environmental problem occurred such as dumping solid wastes and other pollutants into waterways. The surface water level in two irrigation canals (Qus and Gamalya) inside the city was defined to find their contribution to the problem.

Due to the concerns about possible adverse impacts on human health, a decision was taken to establish the public sewerage network and to provide the population with better services. Based on the ongoing operation in the sewerage network project, it is expected to solve the problem of sewage disposal.

MATERIALS AND METHODS
Several techniques were used including topographic analysis, geoelectric profiling and groundwater level measurement as follows:

Topographical Survey
The purpose of the topographical survey is to define the highly effected areas in the city such as Al Ewdate and Shareen. A topographic map of the city was produced and helped in assessing the flow direction of groundwater. Several profiles have been surveyed to study the topography of the Qus city and its surroundings. The profiles were chosen according to the variation in elevation, the highly affected areas and areas close to irrigation canals and Nile River. The majority of the city was surveyed and elevations 79.59 and 70.48 m (above sea level) represent the highest and lowest points respectively. There is an irregular variation in the ground surface level, and the ground surface in some houses is lower than that of the neighboring streets. The vast variation in ground surface elevation between the old and new districts exaggerated the damage particularly in the southeastern parts. The low topographic parts in the city create groundwater basins that drained the surrounding areas as shown in Figures (3A and 3B).

Geoelectrical Studies
Geolectrical studies are mainly conducted to explore the subsurface geology, specially the lithological variations that cause the problem. The area was covered by a total number of 33 Vertical Electrical Sounding (VES) profiles (Fig. 4). The direct measurements of the groundwater level from some available wells within the city (Fig. 4) were used to verify the interpretation of the geoelectrical data and to mark the groundwater flow direction. The Schlumberger configuration was

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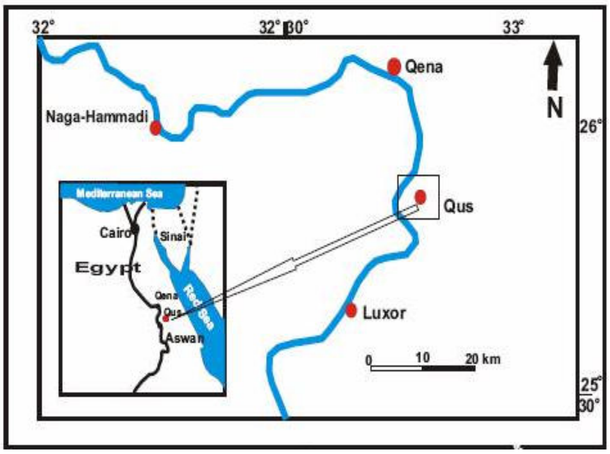

Figure (1): Location map of the study area.

applied with a distance ranging from300 m to 600 m between the current electrodes. The Terrameter SAS 300 C was used to carry out the resistivity measurements. The VES`s data were interpreted by using the software of Zohdy and Bisdorf (1989). Figure (5) shows an example of the interpreted curves of the study area.

Geology

The study area is occupied by sedimentary deposits that belong to Quaternary. According to said (1990) the Holocene deposits are composed of clay, silty-clay and clayey silt while the Pleistocene deposits consist of graded sand and gravel intercalated with clayey lenses.

Figure (11) shows a Lithological cross section in the Nile Valley at Luxor south of the study area (after Said, 1981).

Hydrogeological setting

The surface water system in the study area is represented by the River Nile and two irrigation canals. The southern canal is Qus canal while the western one is Gamalya canal. The groundwater in the study area belongs to Quaternary, which is effected by different geological and environmental conditions specially the variation in thickness and composition of the layers as well as the water chemistry.

According to the lithologic composition, Holocene acts as an unconfined aquitard while the underlying Pleistocene sediment represents the main semiconfiend aquifer.

The Holocene aquitard which receives the surface water seepage, includes the phereatic groundwater that constitutes the base of the cultivated lands with thickness varies from 12.5 m northeast of Luxor (southern part of the study area) to 26 m in the western bank of the River Nile (Kamel, 2004). The permeability ranges from 0.40 m/day to 1.00 m/day while the hydraulic conductivity is low and increases with depth (Abd El-Monim, 1986). The sewage discharge, seepage from irrigation canals (Qus and Gamalya), the agricultural drains from the nearby lands and upward leakage from the deep aquifers principally represent the main components of recharge to the Quaternary aquifer

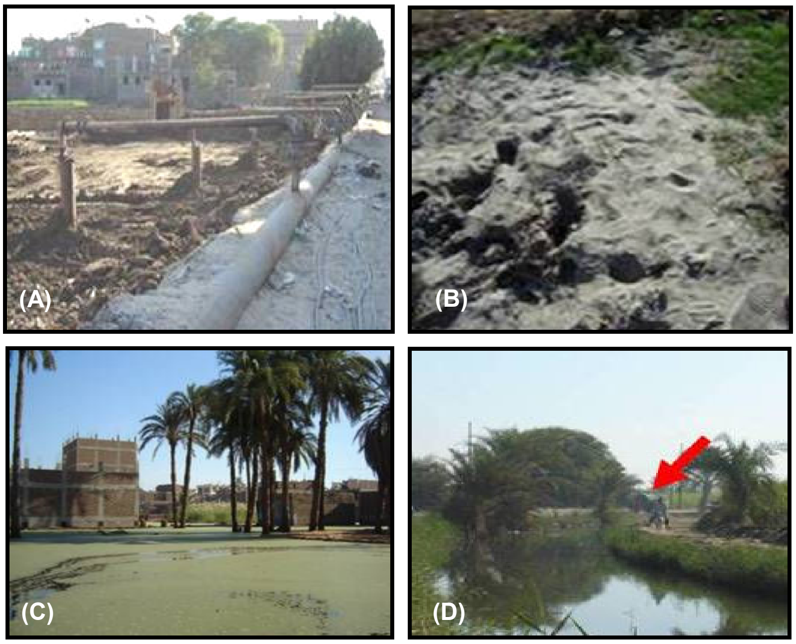

Figure (2): Field photographs showing: **(A)** water pumping during sewers net instillation, **(B)**: fine particles removed from the aquifer, **(C)** raw sewage overflows into streets (green color refers to algae cover), and **(D)** discharge of raw sewage into Qus irrigation canal.

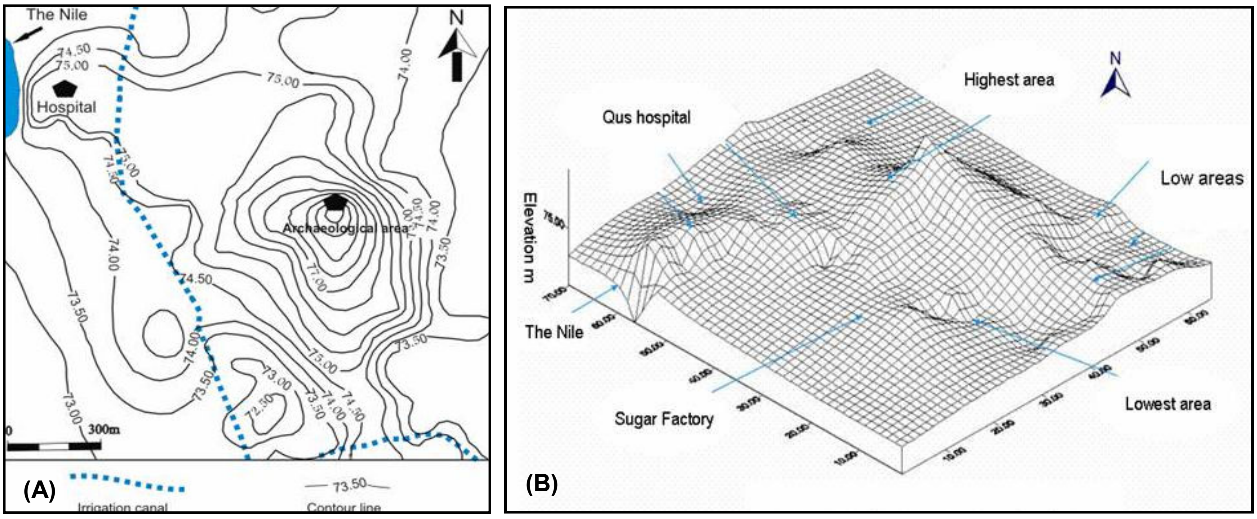

Figure (3): **(A)** Topographic contour map of the study area, (**B)** three-dimensional elevation model of the study area.

in the City of Qus. The most effective factor for the recharge is the sewage discharge. As a result of the construction of the High Dam in 1964, the water level in the Nile (68.40 m December 2006 at Qus city) shows relative steady state and is lower than the groundwater table in the surrounding Quaternary aquifer. Accordingly, the Nile may become a large drain of the groundwater. The depth of the shallow groundwater in the Quaternary aquifers beneath the City as measured from the available wells (Fig. 4) ranges from 0.50 m in the low-lying areas (southeastern parts of the city) to 5.5 m in other areas (western parts near the Nile). Based on the groundwater level in these wells, the groundwater heads decrease gradually towards the Nile and the general flow direction is directed to the Nile. Due to the presence of clay intercalation, some local flow directions may exist.

Results

The aim of the quantitative interpretation of the VESes, is to determine the thickness and the true resistivity values of the subsurface layers as well as the geological situation of the subsurface section. The interpretation of the VESes was used in construction of five geoelectrical cross sections covering the whole area (Figs. 6B-6F). The constructed geoelectrical cross-sections showed that three geoelectrical units are dominant and a fourth unit has a localized existence. The units are composed mainly of earthfill, clay and sand deposits. The inferred lithological units were correlated with those obtained from the available hand dug wells in the study area.

The first geoelectrical unit varies laterally in thickness from 1m to about 8m and has a very low resistivity between 1Ω-m and 5Ω-m. It comprises the

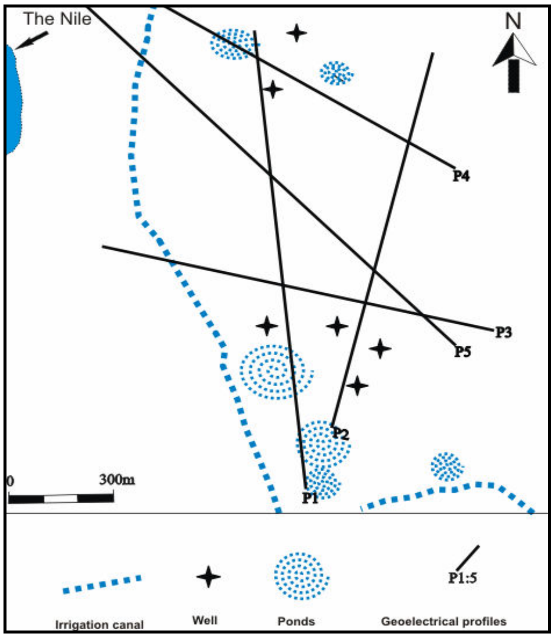

Figure (4): Location map of the Vertical Electrical Sounding (VES) profiles.

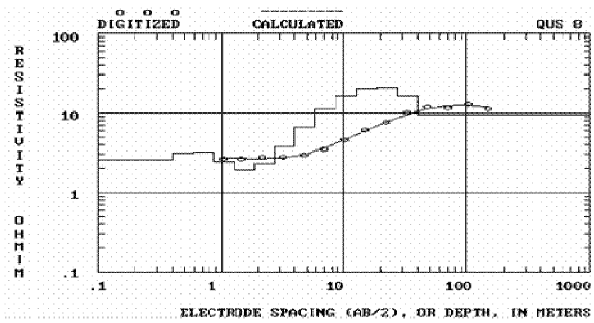

Figure (5): Example of an interpreted VES curve for VES No. 8 according to Zohdy and Bisdorf method (1989).

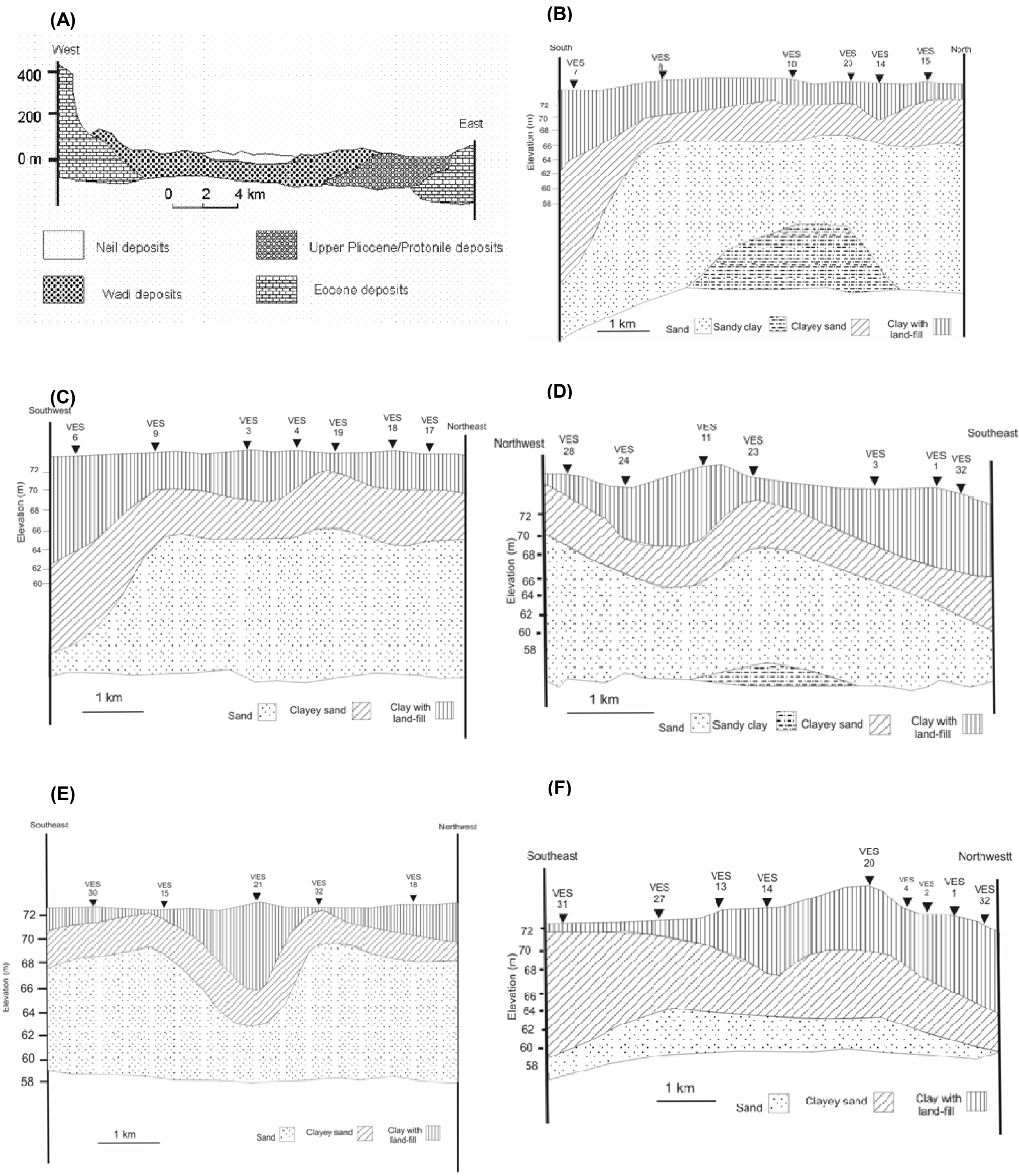

Figure (6): **(A)** Lithological cross section in the Nile Valley at Luxor (modified after Said, 1981). **(B, C, D, E, and F)** Geoelectrical cross sections P1, P2, P3, P4, and P5.

surface layer of clay with some earthfill materials. It acts as an aquitard and receives the surface water seepage from different sources especially sewage disposal. The second geoelectrical unit in the area is characterized by low resistivity 6Ω-m to 9Ω-m with lateral variations in thickness from about 3 m to 10 m. This unit constitutes the clayey sand deposits that are saturated with water, and it may be considered as a Holocene aquitard. The third geoelectrical unit has a moderate resistivity values ranging from 15Ω-m to 45Ω-m with a lateral variations in thickness allover the investigated area, where the maximum thickness of 16m was recorded at the site of VES No. 10. This unit is composed of saturated sand and considered as the main Pleistocene shallow aquifer in the study area. The fourth and deep unit has a very low resistivity value (5Ω-m). It represents the deep sandy clay layer in the stratigraphic section of the area (Figs.6B and 6D).

The presence of clay accumulations in the study area may complicate the hydrogeological conditions, particularly the groundwater flow regime. Moreover it may create a perched condition in the topographic depressions within the city by ceases the downward infiltration of the waste water to the main aquifer.

Environmental impact of the groundwater rising level

Qus city is underlain by landfill, clay and sand deposits, it is believed that the raw sewage infiltrates to the underlying shallow aquifer. Therefore, the groundwater in the city is very vulnerable to contamination by surface land use especially raw sewage disposal. Sewage disposal process has been widely recognized as a major source of groundwater contamination. Sewage water contains many different pollutants especially bacteria, viruses, nutrients, suspended loads, oxygen demanding substances, and many other contaminants each with different environmental effects. These components may cause ground water contamination through leaching of waste water, pollution of surface water resources, nuisance insects creation, noxious odors production, and contribute to the spread of many diseases. Accordingly, the problem may have a bad impact upon soil, surface- and groundwater, air, local residences, animals, plants and house foundations (Figs. 7A, and 7B).

Suggestions and Recommendations

Based on the results, some suggestions and recommendations can be proposed to stop the fast rising rate of water level in the city as follows:

1. Prevention of further sewage disposal into streets by completing the sewage network and application of the best available wastewater treatment technologies.
2. Installing a dewatering system to the superficial aquifer (Quaternary aquifer) which is responsible for the problem. The extracted water may be used for agricultural purposes after required treatment. This system should be constructed along the southeastern corner of the city to decline the raised water level (Fig. 8). The system can be used to monitor level and quality of the groundwater. The water extracted from these wells requires some treatment before use.
3. Water level in the irrigation canals should be lowered, it is strongly recommended to reduce the rate of groundwater recharge.
4. The maintenance of the agricultural drains around the city should prevent water comes from the surrounding irrigated lands.
5. Preparation of a consolidated plan to control and monitor the groundwater level by regular measuring of water level in the city.
6. Regular examination of the quality of surface and groundwater by carrying out chemical and microbiological analyses in order to trace the source of recharge water as well as pollutants.

Figure (7): **(A)** Impacts upon pupils health, and **(B)** impacts upon foundations.

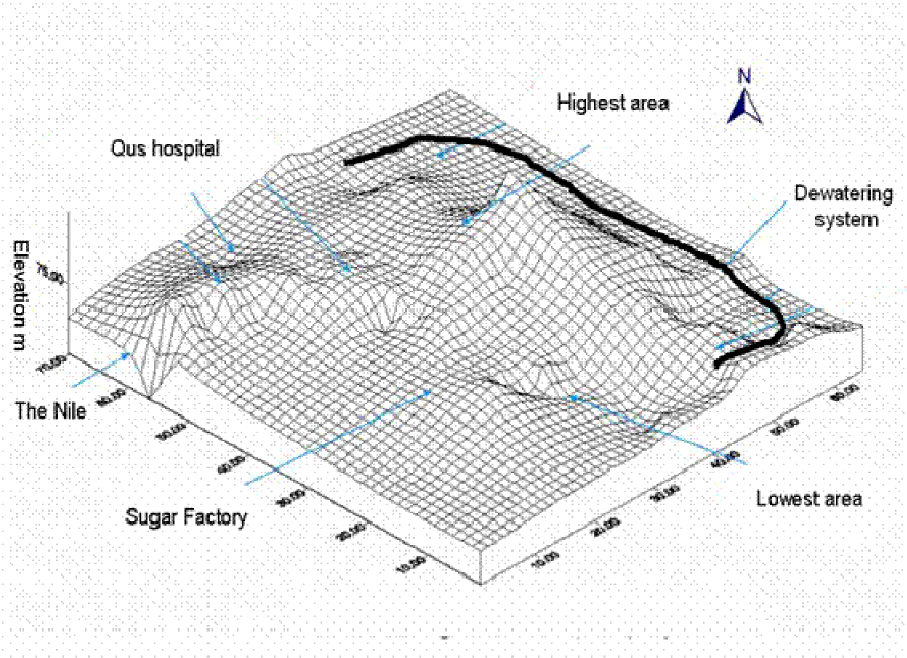

Figure (8): Location of the proposed dewatering system.

DISSCUSION

The potential impacts of the of the waste disposal activities on groundwater level as well as its environmental impacts on public health and houses foundation are poorly understood and should be subject of further investigation. The study of topographical and local surface water bodies in the Qus city showed that the highly effected areas are Al Ewdate and Shareen areas (southeastern parts of the city). According to the geoelectrical survey, the study area comprises three main geoelectrical layers. The third geoelectrical layer represents a shallow Pleistocene aquifer. The study suggests that the main cause of the upraised groundwater beneath the city is the direct discharge of raw sewage and waste water into the ground. The highly effective method to control the groundwater level is the construction of a dewatering system to decline the water level. Further studies are encouraged to get a complete picture about the environmental impacts of the groundwater rising level in the city.

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إرتفاع منسوب المياه الجوفية كمشكلة بيئية
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الملخص العربـــى

واكب النمو السكاني لمدينة قوص وغياب شبكة الصرف الصحى بها ارتفاع كبير في منسوب المياه الجوفية بالمدينة، وقد وصل هذا المنسوب في بعض المناطق وخاصة الاجزاءِ الجنوبية الشرقيةِ إلى مستوى له آثار شديدة الخطورة ، على البيئة والصحة العامة بالإضافة إلى الأضرار الهندسية بالمنشآت، والمرافق. وقد تم إجراء دراسة مستفيضة عن الظواهر والاسباب التي تقف وراء ظهور وتفاقم المشكلة، وكذلك مصادر التغذية المختلفة. وقد اظهرت الدراسة وجود طبقة سطحية من الطين والردم ذات نفاذية منخفضة تعوق انتقال المياه من الطبقات العليا إلى الطبقات السفلى والعميقة، مما أدى إلى ارتفاع منسوب المياه، وظهورها على سطح الأرض في بعض مناطق المدينة، ويشمتل البرنامج العلاجي المقترح للمشكلة ثلاثة اتجاهات تبدا بتشغيل شبكة الصرف الصحى بالمدينة ثم البدء في خفض منسوب المياه الجوفية إلى مستوى آمن عن طريق شبكة من الآبار في الأجزاءِ الجنوبية الشرقيةِ بالإضافة إلى التحكم في مصادر التغذية والوصول بمعدلاتها إلى اقل قيمة ممكنة.