

STRATEGIC NECESSITY OF AL-UHUDIA STREAM FOR GROUNDWATER FLOW REGIME OF AL-HILLAH CITY⁺

الاهمية الاستراتيجية لجدول اليهودية على نظام جريان المياه الجوفية لمدينة الحلة

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Abstract:

Hydrogeologic study of Hillah City which is located in the western side of Babil Province is made. The study is focused to the strategic effects of Al Uhudia Stream on the groundwater system of Al Hillah City. It flows from the north toward the south of the city with length of 11km and difference in levels of 3m between the (intake and tail) U.S and D.S of the stream. The existence of the stream causes at least approximately a reduction in water table levels of 0.5m overall the study area with continuous dewatering process as well. In summary, the role of the stream serves as a dewatering system of underlying layer and as irrigation stream to irrigate the fields at the tail. The existence of the stream with its shoulders will provides a pleasant view to the city, if a good touristic planning is developed.

المستخلص:

انجزت هذه الدراسة الهيدروجيولوجية لمدينة الحلة والتي تقع في الجانب الشرقي لمقاطعة بابل. تركزت الدراسة على التأثيرات الاستراتيجية لجدول اليهودية على نظام حركة المياه الجوفية لمدينة الحلة. ان الجدول يجري من الشمال الى جنوب المدينة بطول 11 كم وبفرق ارتفاع 3م في مستوى الماء بين اعالي واسفل النهر. ان وجود الجدول يسبب نقصان في مستويات المياه الجوفية على الاقل مقداره $\frac{1}{2}$ م لكل منطقة الدراسة تقريبا. ان الجدول يخدم هدفين اساسيين هما بزل لطبقة الحشرج المفتوح التحتية وري الاراضي الزراعية اسفل النهر. ان الجدول مع اكتافه (محرماته) يكون منظرا جميلا للمدينة بادارة ذات تخطيط سياحي جيد.

Introduction

[1] performed a wide study for subsurface water Resources. The study includes hydro chemical characteristics of the groundwater at the study area. [2] Studied Iraqi soils and described different types of soils at Euphrates Banks adjacent to the considered area and indicated that these soils are partially transferred and usually consist of silty Loam. [3] tested field specimens extracted from the area. He found that soils of rivers and irrigation canals consist of silty loam whereas river plain deposits made of silty clay. [4] studied drainage system and soil salinity in a Euphrates Basin. He presented that an excess salinity of soils may be attributed to the rise of groundwater levels and water logging. He recommended accomplishing a good drainage system to solve this problem. [5] presented that groundwater quality characterized with moderate to high turbidity. [6] indicated that the rise of

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groundwater levels in Al Hillah City is attributed to the access rise of Al Hillah River water levels and the absence of water drainage system. [7] undertook drainage water quality of Al Hillal-Kifl Drains. She found that drainage water is not good for human and agricultural purposes. [8] studied groundwater quality and pollution with main pollutants of Al Hillah City. It is indicated that the wells water is of a meteoric origin.[9] indicated general digital computer program listings prepared for one, two, and three-dimensional nonsteady flow of groundwater in heterogeneous aquifers under nonleaky, and leaky artesian conditions based on a finite difference approach as it is used to formulate the equation of groundwater flow. The programs are written in FORTRAN IV language. [10] used a computer program for aquifer simulation using the finite difference approach to examine aquifer response to various schemes of well field operations to treat two field problems at north Shropshire catchment's area was simulated to estimate the potential discharge and aquifer response and a groundwater pollution control scheme near an industrial area was adopted through simulation by a mathematical model. [11] published a report of three-dimensional groundwater flow model (MODFLOW) for analyzing groundwater flow under various hydrologic conditions. [11] presented the most widely used analytical solution of Theis. The technique described can be generally applied to well test analysis and representations of radial flow. His report included twenty examples covering Theis solution, Anisotropy, Artesian-water table conversion, steady state application to a hazardous waste problem, etc.

Stream History :

Since the beginning of nineteenth century, Al Hillah represents a small city is surrounded by a bailey of four sides to protect the city against strangers. Outside the bailey, it is surrounded by an agricultural lands and groves of palms. Al Uhudia Stream is a natural (Uncontrolled) small stream with a length of 11 km, located west of the city; it was carrying in the past water (about 1.5 m³/s) from Al Hillah River at the intake point with U.S water level of 26m a.s.l at latitude of 32° 31' 1.32" and longitude of 44° 25' 22.22" and flowing toward the south to be ended at the tail point north *Al-Imam Bakir* with D.S Level of 23.066m a.s.l. at latitude of 32° 24' 43.30" and longitude of 44° 24' 17.50". The main role of the stream in the past is to irrigate the agricultural lands it passes over.

In the end of the nineteenth century, after the development and widening of Hillah City and the recession of the agricultural lands backward to the west, the importance of Al-Uhudia Stream is reduced gradually for irrigation purposes because it is substituted by a new canal called Al Hillah Main Canal to serve political purposes; this occurred at the eightieths of nineteenth century. Subsequently, in the following decades, the government buried the stream to overcome the undesirable healthy effects of the dead stream.

Case Study and Social Problems:

In recent decades, after the development and widening of Al Hillah City the location of Al-Uhudia Stream becomes inside the populated areas. After the cancellation of the stream for irrigation, it has been buried gradually; consequently the water table levels begin to rise step by step with time especially at the area adjacent to the flow of the stream. Many areas in the center of the new parts of the city were covered with swamps and left unpopulated.

The undesirable effects of the ancient stream cancelation become nowadays a true problem for the population of Al Hillah City; moreover the rise of water table levels causes many structural damages for existing buildings. On visiting the populated neighboring area of the stream, one concludes how the people suffer the rising of the water table levels. Some of the people left whereas others sold their houses.

In Summary, this study is focused to conceptualize the true reason of this gradual rise of water table levels.

Purposes of the Study:

The purposes of this study can be summarized in the following main targets:

- 1- Defining the main roles and features of the stream.
- 2- Conceptualizing reasons and adopting an optimum solution for water table rise.

Location of Al-Hillah City:

Al-Hillah City located at the western part of Babil Province. As shown in the location map of Fig. (1).



Fig.(1) Location Map of Al-Hillah City showing Longitudes and Latitudes Coordinates (Areal photographic view, Based on Google earth 2007)

Geography and Hydrologic Infrastructures:

Al Hillah is a small city which cover an area of 44.34 km² located on both sides of Al Hillah River (usually is called shatt Al Hillah). The river divides the city into two unequal parts. The study area represents the larger western part with an average elevation of 28m a.s.l. In general, at the beginning of the century twenty one, the interested area becomes famous with the density of population and is surrounded by the orchards of palms. Al-Hillah River represents the

eastern boundary of the area whereas Al Asmack Canal (or Al Hillah Main Canal) represents a western boundary. Al-Uhudia Stream flows approximately through the middle of the study area. However, the direction of flow in the three preceding hydraulic boundaries follows the topography of the area which descends toward the south. Fig.(2) and Table (1) contain the existing hydraulic boundaries with their coordinates of inlet and outlet of each on the bases of longitude and latitude abscissas.

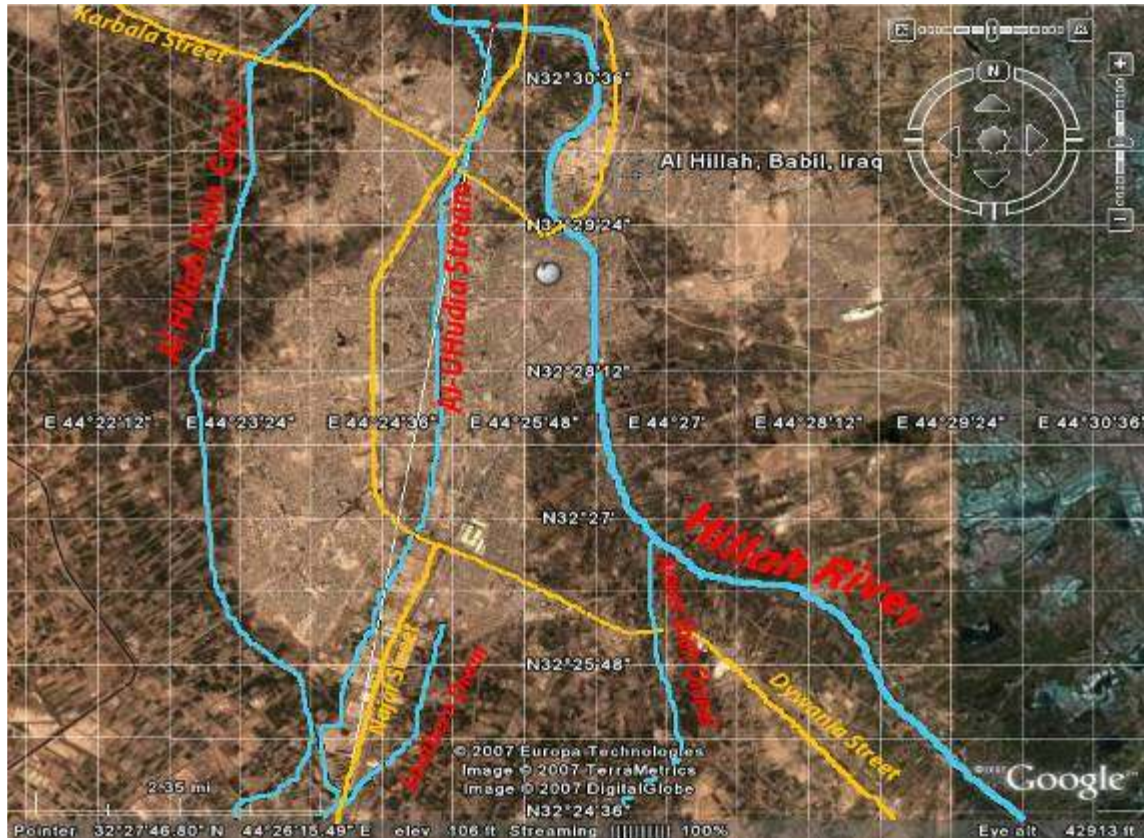


Fig.(2) Geographic Map Contains Most Essential Features of the Study Area (Based on Europe Technology, Image 2007)

Table (1) Elevations, Inlets and Outlets of the Existing Hydraulic Boundaries

	Latitude	Longitude	Elev.,m a. s. l.
Al Uhudia Stream			
inlet	32° 31' 1.32"	44° 25' 22.2"	26
outlet	32° 24' 43.3"	44° 24' 17.5"	23
Hillah River			
U.S	32° 31' 02.7"	44° 25' 22.5"	26
D.S	32° 26' 46.0"	44° 26' 55.5"	24.6
Al Hillah Main Canal (Al Smack Canal)			
U.S	32° 31' 2.63"	44° 23' 52.3"	26.5
D.S	32° 25' 16.1"	44° 24' 1.05"	23
Ameer Shah Channel			
Inlet	32° 26' 46.0"	44° 26' 55.5"	24.6
D.S	32° 24' 43.7"	44° 26' 54.7"	23

Based on field measurements by the author, 2007

Topography of Al-Hillah City:

Al Hillah City constitutes a flat land with an elevations range between 27.8-25.6m a.s.l. The highest levels have been found at the north of Al Hillah City and along the flow of Al Hillah River. From the flow location of the river, the land begins to lower toward the southern-west to reach level of 25.6m a.s.l. In this way, the study area has two gradients constitutes a synchronized lowering of the land toward the south and west directions. Therefore the flow direction of surface water toward the south is expected. In general topographic features are represented in the contour map of Fig. (3). A contour map is prepared depending on the Topographic map of Iraq and field measurements using the level instrument and GBS Device.

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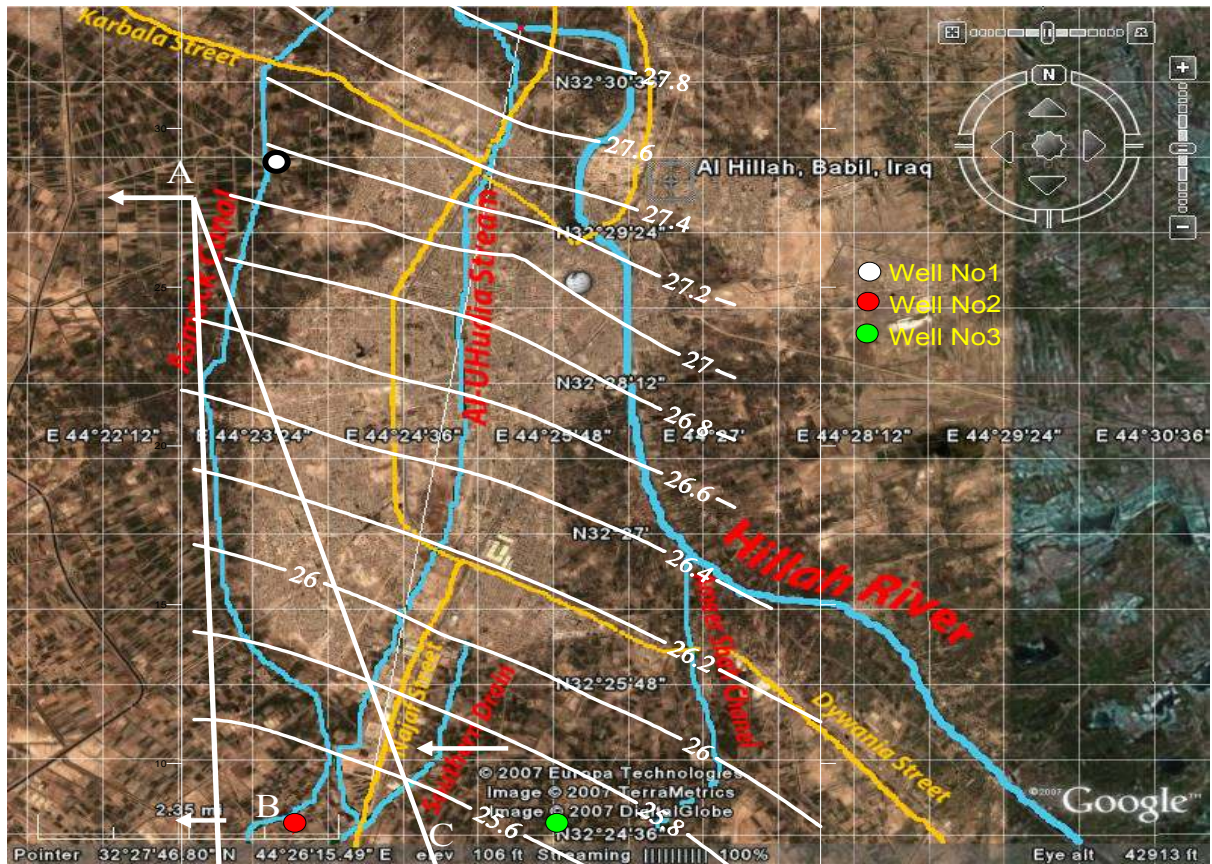


Fig.(3) Topographic Contour Map of Al Hillah City (m.a.s.l) Showing Most Important Hydrologic features,(Based on Field Measurements, Topographic Map of Iraq, GBS Device, and Google Earth,2007)

Geology:

The study area consists of quaternary deposits and upper Miocene. Quaternary deposits are flood plain deposits of Euphrates River; a depression fill deposits are also found in the area which may be accumulated by floods. It consists of, in general from fine sand, silt, and silty clay which may be found everywhere [1]. Dry Marsh and Aeolian Deposits are also found especially at the eastern parts of the area. [12] mentioned that Sabkha Soil (flat salty plane) is of widely spread in Al Hillah Area.

Deposits are usually accumulated by human activities to form geomorphologic features of earth crust of ancient Babylon City.

Injana Formation exposes at NW of Al Hillah City which in turn belongs to Upper Miocene, [13].

The surface layer of the area is composed of alluvial deposits; therefore it is rich of fresh water and constituted of relatively a thick layer of sand which may reach 8-10m thickness. In general, sections AB and AC are selected in Fig.(3) within the area to indicate geologic formations in vertical plane and the extensions of the unconfined aquifer; they are shown in Figs.(4a & 4b).

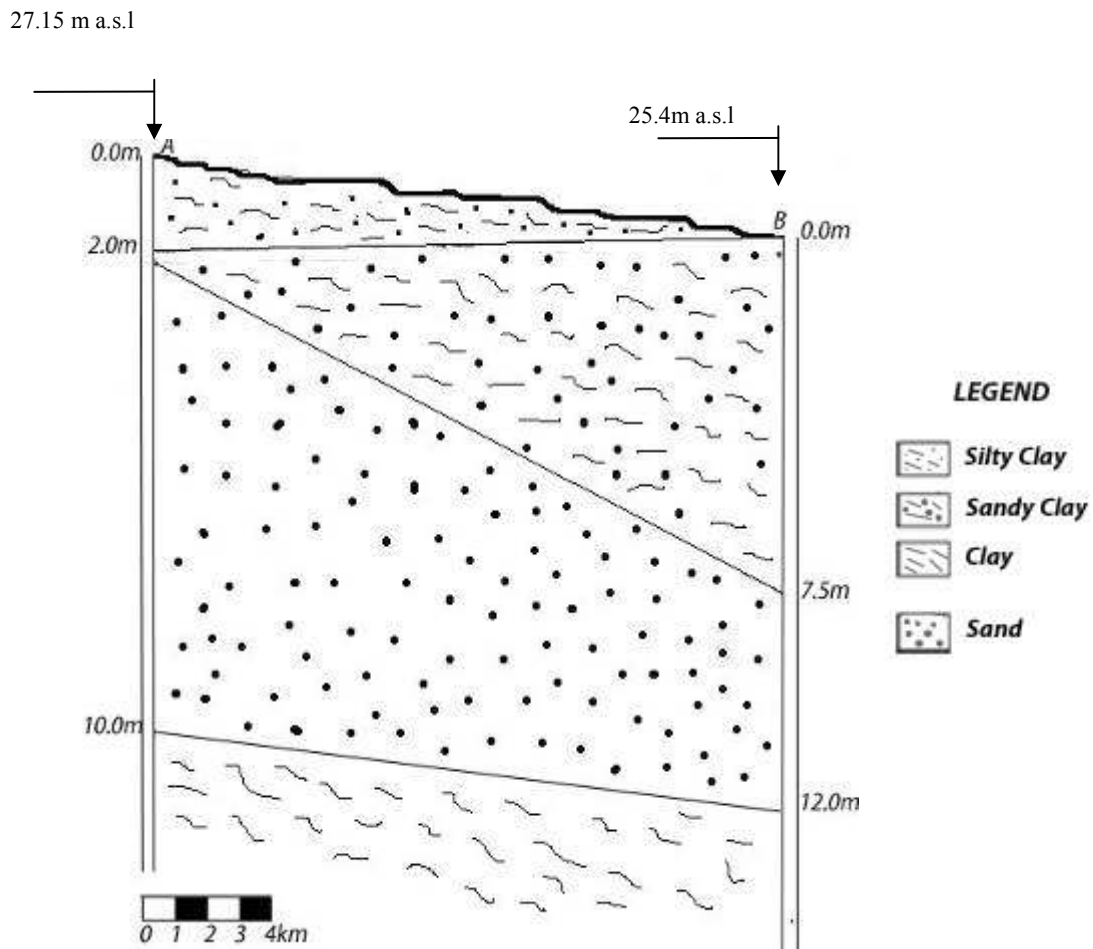


Fig.(4a) Section AB, Showing a Vertical Profile of the Region and Wells Lithology

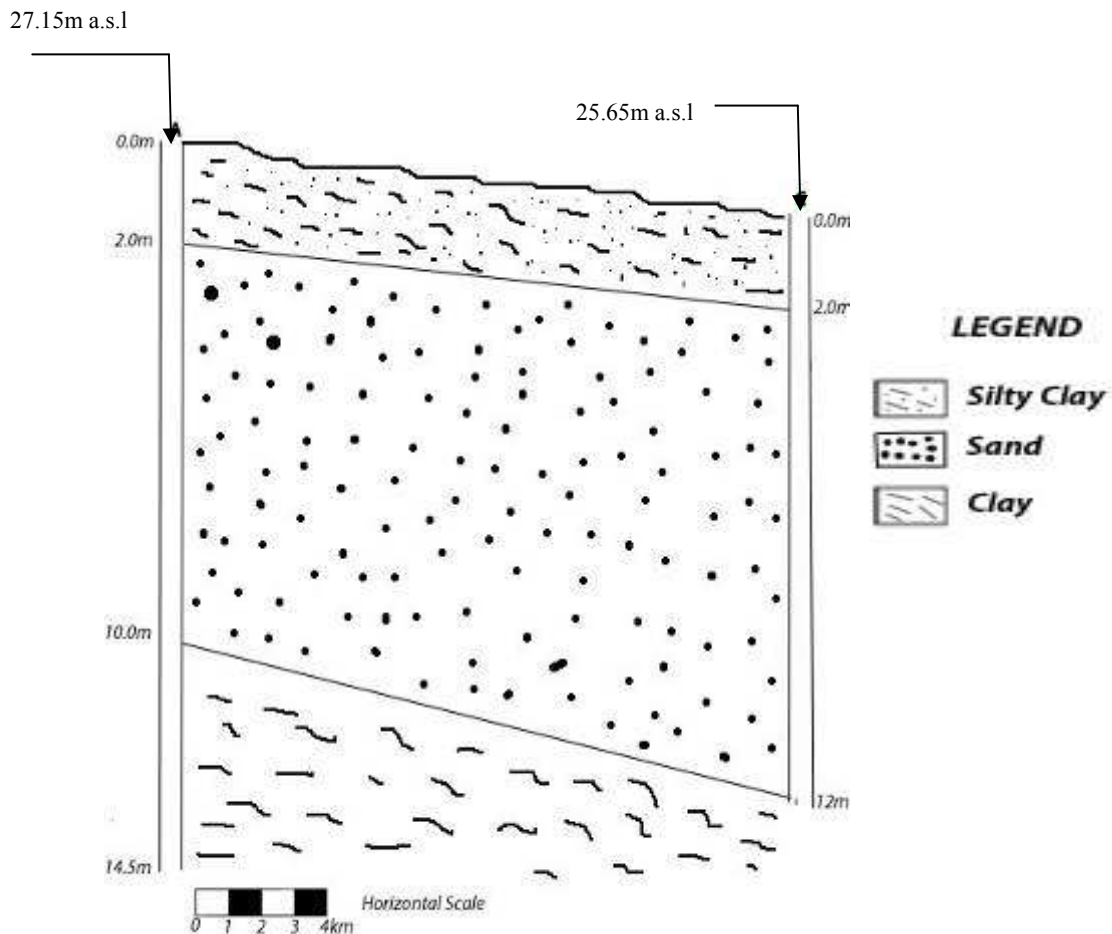


Fig.(4b) Section AC, Showing a Vertical Profile of the Area and Wells Lithology

Natural Aquifer Properties:

In groundwater hydrology, the geologist or engineer is constantly facing the question of finding reliable and representative values of aquifer hydraulic properties. Pumping tests have proved to be the most suitable means of achieving this purpose. [14] presented the most important methods nowadays available for the evaluation of pumping test data. Three pumping tests were performed in the unconfined aquifer using three scattered wells in the region as shown in Fig (3). These tests have been conducted without observation wells. Thus the storage coefficient cannot be obtained. The data obtained from these tests were analyzed using Jacob method, [14]. Transmissibility values are interpolated over all the area and given in the contour map of Fig.(5).

A value of specific yield for unconfined conditions is assumed to be 0.2 for aquifers of similar geologic formations [15].

Bottom Depths of the Unconfined Aquifer:

Field investigations were carried out by the General Directorate of Water Well Drilling, 2003. The contour map Fig.(6) is prepared depending on the lithology of Wells A, B and C of Figs (4a, and 4b). A lithology of the existing wells reveals that the aquifer is characterized with shallow depths

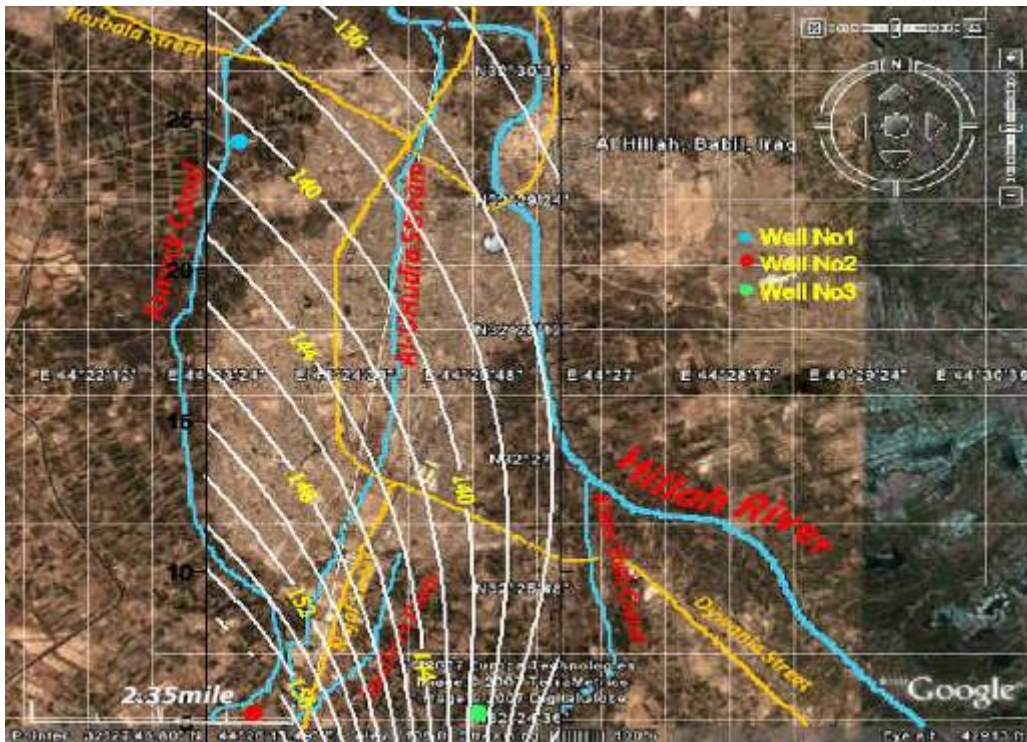


Fig.(5) Transmissibility Contour Map(in m^2/s) Showing Existing Wells Locations

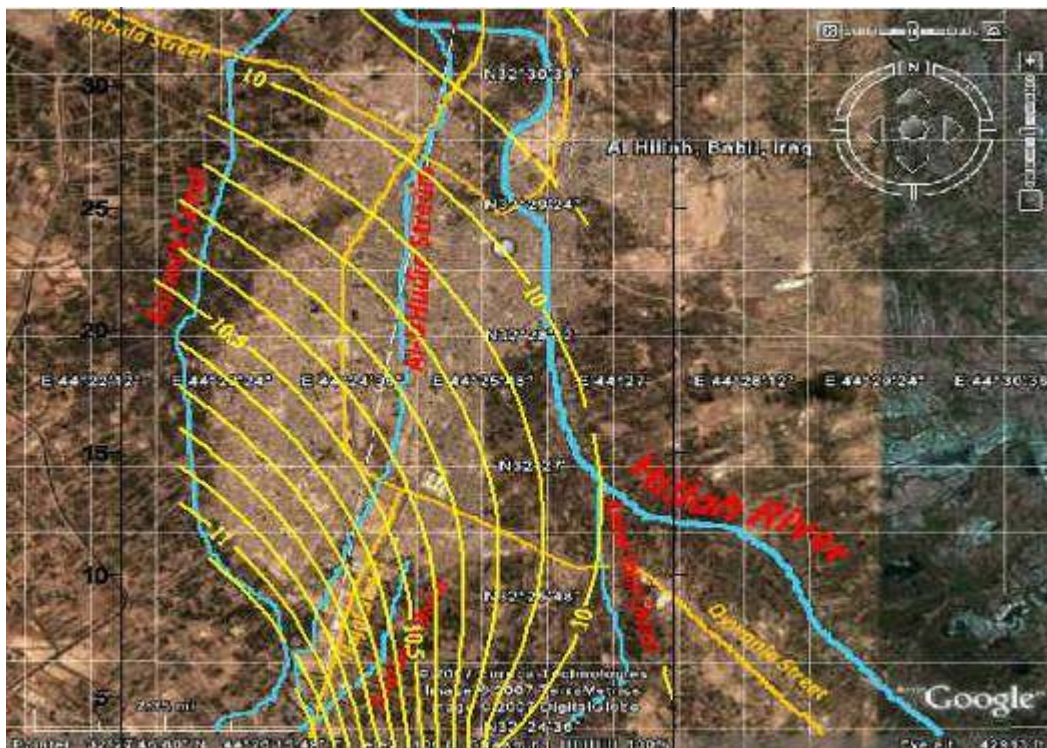


Fig.(6) Bottom depths of the Unconfined Aquifer Contour Map of Al Hillah City, m.a.s.

Natural Groundwater Regime:

In general, the groundwater in the study area flows from the north toward the south. Al Asmak Canal represents the main feeding boundary in the area as shown in Fig.(7). The figure shows how are the canal feeds the groundwater system with the extraordinary recharge from

the north-east direction. The groundwater levels of Fig.(7) are based on field measurements at the study area, knowing that these measurements obtained by assuming that Al-Uhudia Stream is not exist (this assumption is right because the stream nowadays is out of work and buried).

A deep inspection of the flow net of Fig.(7), one concludes that the canal traces through one of the flow lines. This conclusion assures the good choice of the existing stream position. In general, a surveying study of a groundwater system indicates that a highest W.T.L. of 26m.a.s.l occurred at the north and 23m a.s.l at the south.

If Al-Uhudia Stream is reactivated without any release from Al Hillah River (in this case, the stream used as a drain), the natural groundwater regime is changed completely as shown in Fig.(8). The system shows that the shape of the flow net is changed completely where the flow lines are directed toward Al-Uhudia Stream flow from both sides, moreover the groundwater levels are lowered about 0.5m overall the whole system. Some places such as Al Thowra Area (with high density of population) which located on both sides of the upstream of Al Uhudia between equipotential lines (25.6-26) endures a hazardous conditions with the absence of Al Uhudia Stream.

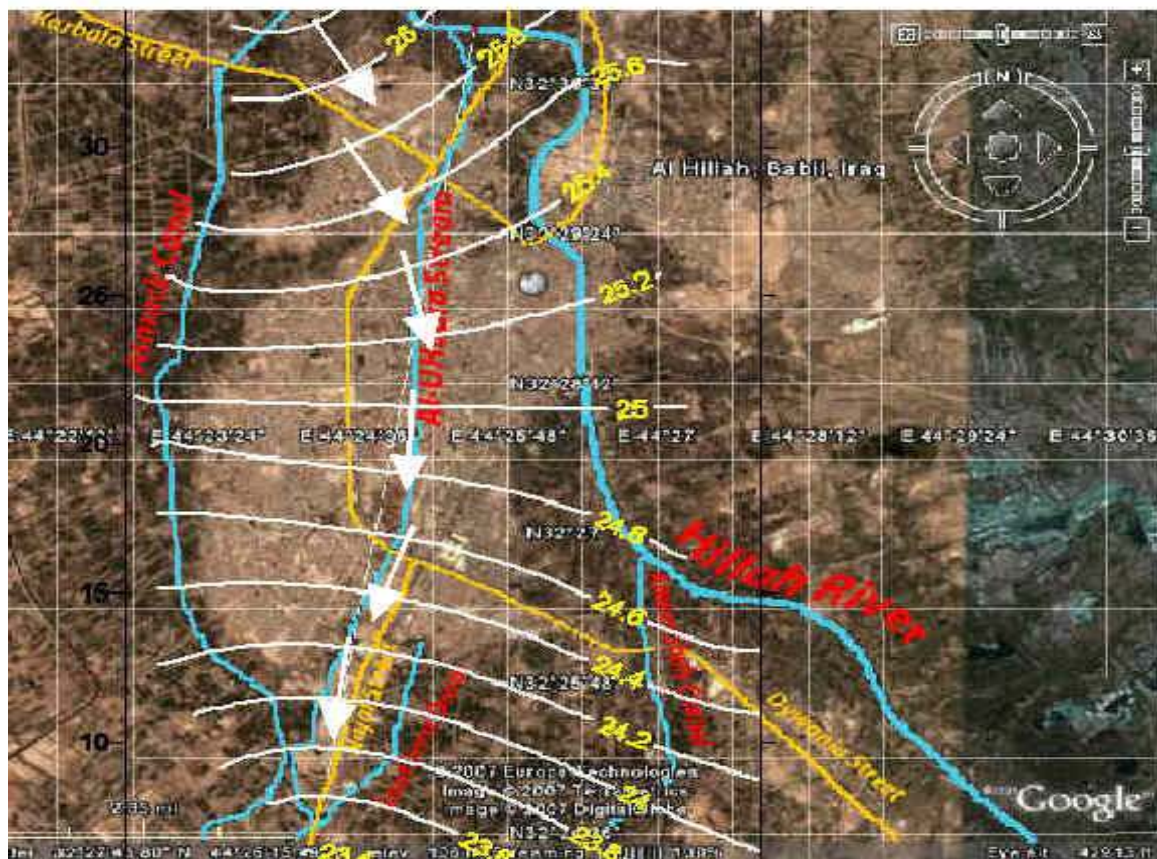


Fig.(7) Natural W.T.L of the Unconfined Aquifer,m.a.s.l Excluding Al-Uhudia Stream Effect (based on field measurements by the author using a GBS Device and Level instrument, 2007)

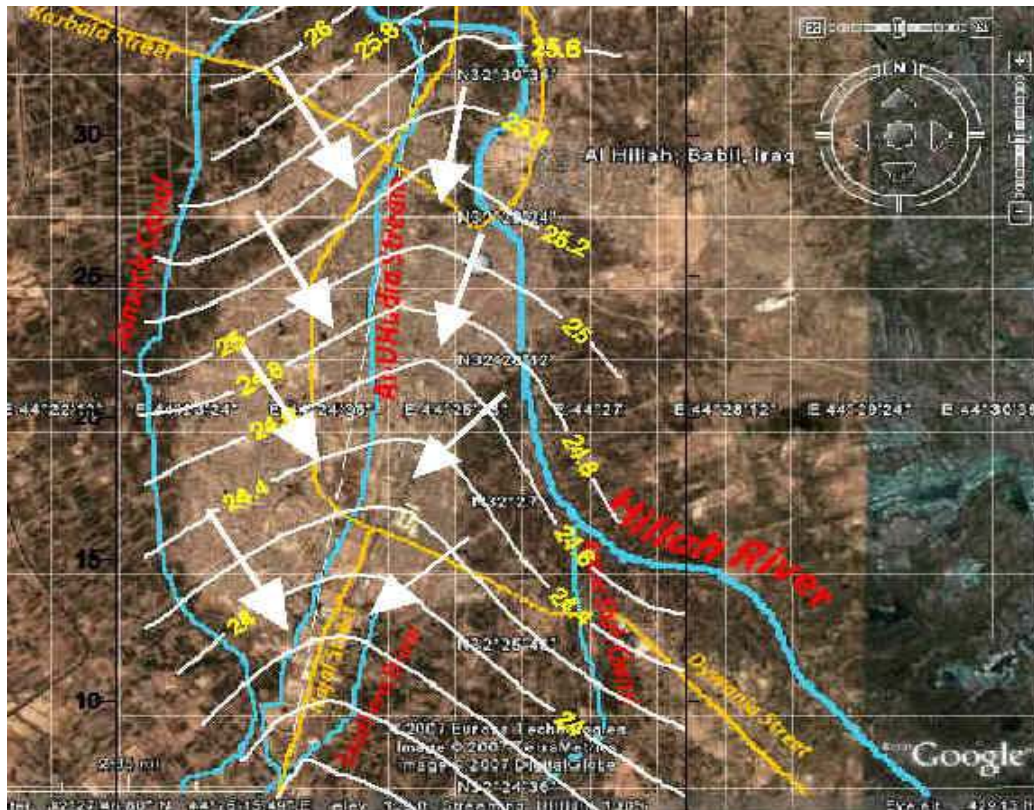


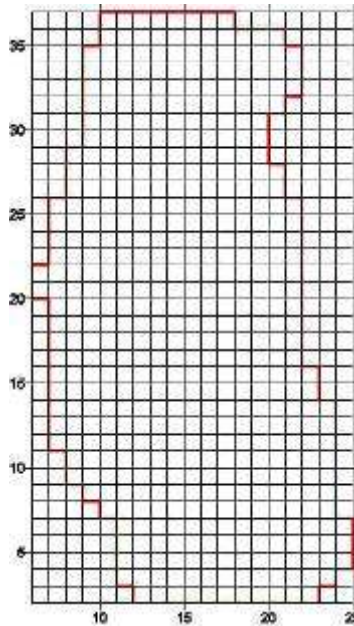
Fig.(8) Natural W.T.L of the Unconfined Aquifer,m.a.s.l Including Al-Uhudia Stream Effect (based on field measurements by the author using a GBS Device and Level instrument, 2007)

Simulation of Groundwater Regime:

The current study deals with the problem of groundwater in the unconfining layer, therefore a modeling process will be restricted to the unconfined aquifer accordingly.

Mesh Design:

Usually a simulated area is discretized into a suitable number of meshes depending on the size of the considered area. In this case each mesh is taken as (1mesh = 0.31855 km). In such a manner a maximum number of meshes in the X direction is (NC=25) beginning with NC=6 whereas a maximum number of meshes in the Y direction is (NR = 37) beginning with NR =1. Fig.(9) shows the discretization of the area and mesh design.



Design

Fig.(9) Mesh

Mathematical Background of Simulation Program:

Several programs have been written for aquifer simulation by a mathematical model, using a finite difference approach. The program written by [9] is preferred to be used instead of writing a new one. It is chosen because of its flexibility for modification. The program depends on the derivation of finite difference equation which in turn is based on the mass conservation principle and Darcy's Law. A detailed derivation of the finite differences equations and convergence test for errors study are found in [9].

Input Data Files:

A file for each hydrogeologic parameters is prepared that contains the value of that parameter at each nodal point within the model domain. These parameters include hydraulic conductivity of water table conditions, storativity or specific yield for water table aquifer; pumping rate with infiltration; bottom level of impervious beds, wherever they occur; hydraulic heads, or elevations of the surface water body wherever it occurs, dimensions of the meshes net; initial water table levels..

Calibration of the Model:

Once the input-output information are specified, the program is run by a computer for a time long enough to perform a state of dynamic equilibrium in which the inflow-outflow relations become steady. This step is made in order to simulate the natural conditions in the field [10]. If the computed hydraulic heads show large differences from the measured (field) groundwater levels, then inflow-outflow parameters or aquifer coefficients should be reconsidered and checked until best match is achieved. An exact match between the computed and field data is rarely possible, because of the lack of detailed and accurate input data. In general, the more accurate input data the better match is obtained.

Thus, the ideal approach of simulation of an area is to run the program without any artificial stresses for assumed uniform hydraulic heads until a steady state condition is reached. Then the

model prediction is used as an input initial head to compute the change in hydraulic heads as a result of any other artificial stresses.

Recharge of the Unconfined Aquifer:

A recharge value of 10.3 cm/year, [16] which is equal to the total annual rainfall, is used for the infiltration rate. This value was specified for each nodal point within the modeled area. Several attempts have been conducted for the calibration of the recharge values through the calibration of the model.

Simulation of groundwater System:

After the program has been run for long period (4762days), the predicted static water level is obtained and show a relatively acceptable similarity with the measured water levels which are shown in Fig (10).

Discussion of the Results:

A comparison between the natural water levels and the modeled water levels show an acceptable similarity ($\pm 10\%$ differential error between natural and simulated W.T.L, [10]) as shown in Fig.(10).

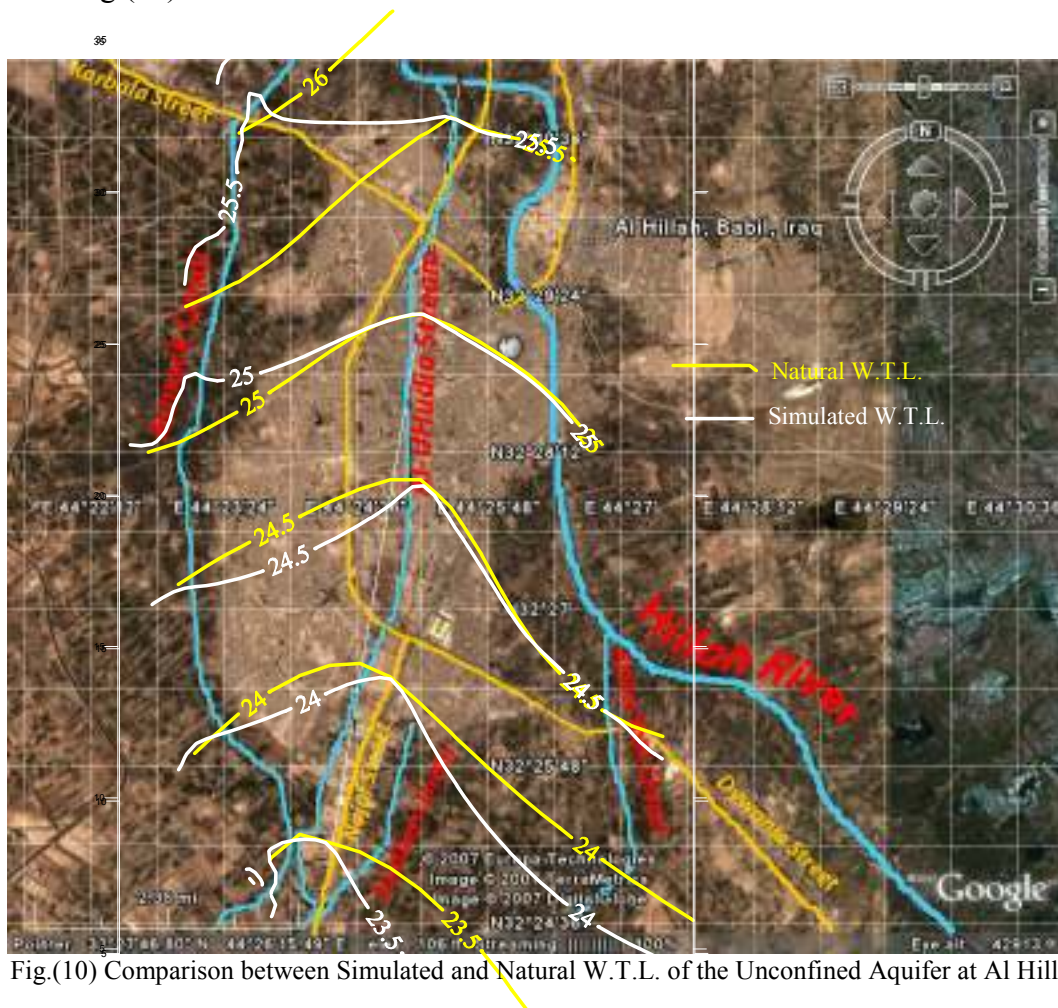


Fig.(10) Comparison between Simulated and Natural W.T.L. of the Unconfined Aquifer at Al Hillah City

Environmental Applications:

One of most current prevailing widespread usage of the stream is as a dewatering system. In this strategy, it is suggested to lower the *tail water level* of the stream with a suitable amount say 2m and with a release of $0.2\text{m}^3/\text{s}$ from Al Hillah River. This lowering of the tail water level of the stream causes relatively a certain change in the hydraulic gradient of the stream. This change is formulated in the mathematical model and run for the same 4762days. The results are compared with the natural W.T.L and represented in Fig.(11).

Discussion of the Results:

By this scenario, the groundwater levels are lowered approximately by 0.5m overall the area under consideration. This amount of lowering in W.T.L. has very effective environmental dimensions in Al Hillah City.

A release of $0.2\text{m}^3/\text{s}$ represents 13.3% of the original design discharge of the stream which is only enough for the irrigation of the fields located at the tail of the stream but it leads to good results in contaminant transport and enhancement of the groundwater quality. This means in summary, that the stream has a *conjunctive use*; they are irrigation and dewatering processes instantaneously.

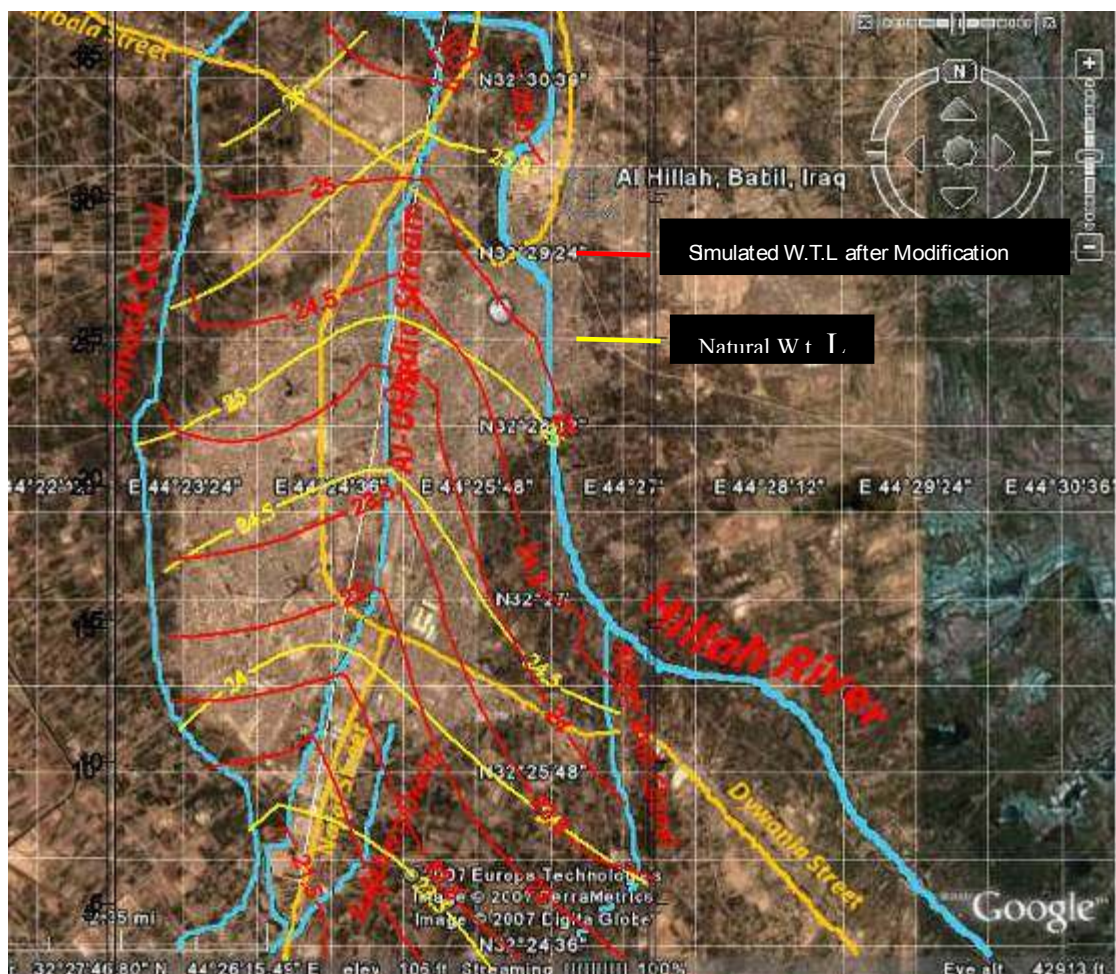


Fig.(11) Comparison between Natural and Simulated W.T.L after Lowering the Stream by 2m

Conclusions:

The following conclusions may be obtained from the current study:

- 1- Al Uhudia Stream plays important roles whether for irrigation of orchard fields on both sides of the stream and dewatering the unconfined aquifer stratum and lowers the water table levels by 0.5m.
- 2- The existence of the stream means a continuous natural purification of groundwater contamination. A small release of about ($0.2\text{m}^3/\text{s}$) will reactivate the process of contaminant purification.
- 3- Al Uhudia Stream with a suitable release from Al Hillah River serves as a good local touristic project with pleasant view sights for the population of the city. This in turn represents fantastic short touristic visits for the population under the current circumstances.
- 4- The new canal of Al Asmak (Al Hillah Main Canal) has harmful effects since a large amount of groundwater is induced permanently to the unconfining stratum of the study area.

Recommendations:

The following headings are recommended:

- 1- The stream should be reactivated again by allocating about $0.2\text{ m}^3/\text{s}$ of water from Al Hillah River for irrigation the tail fields and contaminant transportation purposes since it represents one of the major infrastructures of the city.
- 2- Specifying a permanent maintenance for the stream.
- 3- It is strongly recommended that Al Uhudia Stream should be undertaken as major structure of any future design for waste water drainage systems.
- 4- A good governmental agency should be prepared to protect the stream.
- 5- The employment of Al Hillah Main Canal should be reconsidered again in the future through the aquatic policy of Al Hillah City.
- 6- Extending of this study to assess the contaminant transport efficiency of the stream.

Symbols:

W.T.L: Water Table Level
NC : Number of Columns
NR : Number of Rows
U.S : Up Stream
D.S : Down Stream

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