Ain Shams University
Faculty of Engineering
Irrigation and Hydraulics department

FACTORS AFFECTING GROUNDWATER FLOW IN WADIES ADJACENT TO NILE DELTA AQUIFER

By

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Approval sheet

This is to approve that the thesis presented by **`Eng.Samah Hassan Mahmoud`** to the Irrigation and Hydraulics department– Faculty of Engineering- Ain Shams university – entitled ` **FACTORS AFFECTING GROUNDWATER FLOW IN WADIES ADJACENT TO NILE DELTA AQUIFER** ` , for the Master of science (M.SC.) in Civil Engineering Irrigation and Hydraulics has been approved by the examining committee.

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Statement

This dissertation is submitted to the Faculty of Engineering-Ain Shams University for the degree of Master of Science (M.Sc.) in Civil Engineering (Irrigation and Hydraulics).

The work included in this thesis was carried out by the author in the department of Irrigation and Hydraulics, Faculty of Engineering-Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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To my mother soul

To my husband and my daughters

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ABSTRACT

Groundwater studies have become of great concern because the water supply of which system relies heavily on groundwater as a main source. In Egypt there are many aquifer systems of which the Nile Delta aquifer is considered as one of the most important aquifers.

In this work, an attempt has been done to describe the criteria and methodologies to understand and evaluate the factors that affect on the groundwater flow in the eastern Nile Delta aquifer, and to study all effects which have been caused by the ancient water Nile branches. Environmental problems such as salinitization, pollution water, logging and mounding of groundwater levels affect the development in eastern Nile Delta region.

In the eastern Nile Delta region there are many new development areas which have been planned based on surface and groundwater sources. According to the rapid and continuous development some problems appeared such as: water logging, water mounding and, water quality deterioration this problem appeared in El-Obour City that lies about 37km from Cairo in Heliopolis basin. A continues affects severely on the foundations and even the first living floors of villas , buildings, and factories in the industrial zones .

In order to analyze the problem and propose a solution, many studies were conducted. These studies include Topographic survey, Geophysical survey and Resistivity soundings, geotechnical analysis of soil samples taken from eighteen 18 pore hole, water levels in nineteen 19 piezometer.

These studies were done to analyze the hydrogeological conditions in the study area and to identify soil characteristics.

The data obtained from 106 vertical electrical sounding which have been done using schlumberger system. These aids to find the type and extant of the aquifer layers.

Hydrological and geological studies were conducted and GIS packages were used as an interface to derive a set of vector and raster maps that show the different characteristics of the study area.

A literature survey was done to review the previous studies and research works related to the study topic. Also, the mathematic approach was prepared including theories and laws governing the flow in porous media. The governing equations and boundary equations are presented. In order to simulate the existing conditions and study the effect of the proposed solutions, a numerical model was constructed using the Visual MODFLOW Package. The constructed numerical model was calibrated using the field observed data. The calibrated model was used to predict the response of the aquifers to the proposed solution.

The main conclusions and recommendations for future studies are presented.

List of Symbols

A	Compressibility of water	$[LT^2M^{-1}]$
A_{ij}	Conductance matrix	$[L^2T^{-1}]$
A_e	Elemental area	$[L^2]$
a_T	Transversal dispersivity	[L]
a_L	Longitudinal dispersivity	[L]
a_V	Vertical dispersivity	[L]
B_{ij}	Storage matrix	$[L^2]$
B	Compressibility of the aquifer	$[LT^2M^{-1}]$
b\`	Thickness of the layer that represents the stream bottom	[L]
C	Concentration of the solute	$[ML^{-3}]$
C_n	Courant number	
C\`\`	Ratio between the mass held on the solid surface and the mass of the solids in solution	
C_{in}	Concentration of the inflowing water in the case of infiltration or the average concentration in the aquifer in the case of abstraction of water	$[ML^{-3}]$
d\`	Effective grain diameter	[L]
d_i	Thickness of the aquitard	[L]
$D\`_{ij}$	Hydrodynamic dispersion-diffusion coefficient	$[L^2T^{-1}]$
D_{md}	Molecular diffusion coefficient	$[L^2T^{-1}]$
D_0	Diffusion coefficient in a free water system	$[L^2T^{-1}]$
Δt	Time step size	[T]
Δ	Elemental cross-sectional of area of cubic element perpendicular to the pore-water velocity	$[L^2]$
e	Element number	
e_l	(x) complementary error function=1-erf(x);	
G_l	Apacitance matrix	$[L^2]$
g	Gravity Acceleration	$[LT^{-2}]$
h	Hydraulic head	[L]

k	Permeability	[L^2]
K_l	Hydraulic conductivity tensor	[LT^{-1}]
K_v	Vertical hydraulic conductivity of the aquitard	[LT^{-1}]
K_d	Distribution coefficient	[L^3M^{-1}]
K`	Hydraulic conductivity of the layer that represents the stream bottom	[LT^{-1}]
J_i	Dispersive flux	[LT^{-1}]
l_i	Aquitard resistance i	[T^{-1}]
λ	Decay constant	[T^{-1}]
m	Aquifer thickness	[L]
N_e	Total number of element	
μ	Viscosity	[$ML^{-1}T^{-1}$]
n_e	Effective porosity	
N_p	Total number of the nodal points	
$N_{(x,y)}$	(y) shape function	
ν	Kinematic viscosity	[L^2T^{-1}]
$\partial h/\partial_{x_j}$	Hydraulic gradient in the J-direction	
$\partial c/\partial_{x_i}$	Concentration gradient in the direction i	[ML^{-4}]
P_n	Peclent number	
P_{ij}	Solute tran. Conductance matrix	[L^2T^{-1}]
$\pm Q_i$	Sink or source flow rate at the node i	[L^3T^{-1}]
Q_G	Concentration of the solute of a source or sink of a strength which is assumed to be known	[$ML^{-3}T^{-1}$]
q_i	Average discharge in the direction i	[$L^3T^{-1}L^{-2}$]
$\acute{\Gamma}_{liquid}$	Water filled area perpendicular to the direction of Darcy`s velocity	[L^2]
R_e	Reynold`s number	
ρ	Density of water	[ML^{-3}]
R	Retardtion factor	
r	Distance from the pumped well	[L]
ρ_b	Bulk density of the porous media	[ML^{-3}]

ρ_{dry}	Dry matrix material	$[ML^{-3}]$
S	Storativity of the aquifer	
S_0	Specific storativity	$[L^{-1}]$
T	Transmissivity of the aquifer	$[L^2T^{-1}]$
t	Time	[T]
$t_{.5}$	Half-life of the isotop	[T]
V	Velocity resultant	$[LT^{-1}]$
V_b	Elemental balk volume	$[L^3]$
V_e	Is the volume of the element	$[L^3]$
W(u,r,B)	Hantush well function	
▼	Vertical-delta $(\frac{\partial}{\partial x}+\frac{\partial}{\partial y}+\frac{\partial}{\partial z})$	$[L^{-1}]$
!	The factorial	
Ѓ	Time factor	

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