Name ____________________ GEOL 715

FINAL PROJECT--- SIGNIFICANCE OF BUNDARY CONDITIONS

Introduction

One of the most important decisions made in the construction of a site-specific ground-water flow model is the type and location of boundary conditions. In most problems the modeler will be forced to make a decision whether to use the natural boundaries of the flow system (ground-water divides, rivers etc.), which can be remote from the area of interest of the model and, therefore, require extensive enlargement of the model grid, or whether to use artificial (mathematical) boundaries to try to represent the behavior of the flow system at some location inside the natural boundaries. These decisions can be critical to the success or failure to the model. Often, one type of boundary condition can be appropriate for a certain type of applied stress, hut may be inappropriate for a different type of applied stress. As a result, the model may be adequately calibrated using the first set of boundary conditions, but may not make realistic predictive simulations under a different stress because a second set of boundary conditions was more appropriate.

The purpose of this exercise is to evaluate the significance of using different boundary conditions on a simple flow system and to see how each set of boundary conditions affects the simulated heads and fluxes in the model. The assignment consists of performing a series of three numerical experiments, A, B, and C using the groundwater model provided in Homework #3 (pltest.for). Series A is the reference set to which the others are compared. Each series consists of three simulations, which for the sake of simplicity will be referred to as Al, A2, A3, B1, etc. In each series of experiments the boundary conditions for simulation 1, 2, and 3 are different but the geometry of the flow system is the same, In the 1 series (base case) simulations a simple two-dimensional, steady-state flow system is constructed but is constrained by three different sets of boundary conditions. In the 2 series experiments the hydraulic conductivity of the flow system is doubled. In the 3 series experiments a pumping well is added to represent an internal stress on the flow system.

The results of the experiments are based on contouring the simulated water levels using SURFER or other contouring software and computing a water budget of the flow system (you are required to modify the code to do this). Comparisons are then made to determine which set of boundary conditions is most appropriate.

Problem Statement

The flow system is 22 meters long in the x direction and 10 meters wide in the y direction. Prepare an input data file to set up a one-layer model having 22 columns and 10 rows. Assume the aquifer has a thickness of’ 1 meter and is isotropic and homogeneous. Assign all nodes a hydraulic conductivity of 2 meters/day for 1 and 3 series and 4 meters/day for 2 series.

The boundary conditions refer to the four lateral boundaries of the rectangular flow system. In each case the upper and lower borders of the flow system are stream surfaces (no-flow boundaries), the lateral boundary conditions applied to the left and right faces vary for each of the three simulations in each series. In the Al, B1, and C1, the lateral boundaries are constant heads, whereas the upper and lower boundaries are specified heads. In A2, B2, and C2 the lateral boundaries are constant head, whereas the upper and lower boundaries are no flow. In A3, B3, and C3 the lateral boundaries are one constant head and one constant flux, whereas the upper and lower boundaries are no flow.

This scheme orders the flow systems with respect to decreasing dominance of constant head and specified head boundaries. Thus, the boundary conditions used in Al, B1, and C1 are all either constant head or specified head, whereas the boundary conditions used in A3, B3, and C3 there is only one boundary with a constant or specified head, The significance of changing the dominance of one type of boundary condition becomes evident as the simulations are run and the results displayed as potentiometric contours and tabulated as water budgets.

Boundary Conditions for Simulations A1, B1, and C1

In simulations A1, B1, and C1 assign the nodes in column 1 along the left boundary a constant head of 100 meters. Assign the nodes in column 22 along the right boundary a constant head of 0 meters. Assign the values of specified head to the nodes along columns 1 and 22 (the left and right boundaries) using the following formula

$$h = h_1 - \frac{(h_1 - h_2)}{(x_2 - x_1)} x$$

where h_1 is 100 meters, h_2 is 0 meters, and x = 0 is the distance from the left boundary of the flow system.

Boundary Conditions for Simulations A2, B2, and C2

In simulations A2, B2, and C2 assign no-flow boundary conditions to the nodes in rows 1 and 10 along the upper and lower boundaries of the flow system. Assign the nodes in column 1 along the left boundary a constant head of 100 meters. Assign the nodes along column 22 a constant head of 0 meters.

Boundary Conditions for Simulations A3, B3, and C3

In simulations A3, B3, and C3 assign no-flow boundary conditions to the nodes in rows 1 and 10 along the upper and lower boundaries of the flow system. In the input data file (or modify the computer code), assign the nodes in column 1 along the left boundary a constant flux of 10 cubic meters/day. Assign the nodes in column 22 along the right boundary a constant head of 0 meters. Place a pumping well at node (5, 11) and assign it a discharge rate of 100 cubic meters/day.

<u>Interpretation of</u> <u>Results</u>

To interpret the results, contour the simulated head values for each run. In addition, using the water budget at the end of each simulation, summarize in a table the volumetric inflow across the left boundary and the outflow across the right boundary.

Questions - A Series Simulations

(1). What is the difference in the simulated heads among the three sets of boundary conditions?

(2). What is the difference in the simulated fluxes among the three runs?

(3). What does this indicate about the ability of the various boundary conditions to represent a simple linear flow system? Is this troublesome?

Questions - B Series Experiments

(1). What is the difference in the simulated heads among the three sets of boundary conditions?

(2). What is the difference in the simulated heads relative to the same runs in the A Series simulations?

(3). What is the difference between the simulated fluxes among the three runs?

(4). What is the difference between the simulated fluxes relative to the same runs in the A Series simulations?

(5). What does this indicate about the need for site-specific values of hydraulic conductivity to constrain a model that is only calibrated against water-level data?

Questions - C Series Experiments

(1). What is the difference in the shape of the cone of depression among the three sets of boundary conditions?

(2). What is the difference in the flux across the left boundary among the three sets of boundary conditions?

(3). What is the difference in the head at the pumping well among the three sets of boundary conditions?

Final Question

In a concise manner citing the potentiometric surfaces and water budgets computed previously made, summarize the results of the numerical experiments and describe the ramifications to constructing a calibrated ground-water flow model.

Report of the Final Project

The final report should include a brief abstract, an introduction section, the numerical method for the two dimensional flow domain (Yu, 1997), the model setup, results, summary, and at least five references.