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ABSTRACT

This project is the design and implementation of a program to construct and execute a steady-state groundwater flow model for a confined or unconfined, isotropic, homogeneous aquifer. The program allows the user to either select an applicable mathematical equation, specify the boundary limits of the model, and enter required data for the computation, or load an input file containing a previously defined model and its parameters for update or revision. Prior to execution of the modeling process, the program saves the aquifer model parameters and input data, in a separate user specified file specially formatted for future use by the modeling program. At the end of execution, options are provided to save the modeling results to a file formatted for use by other graphics applications or formatted to represent the modeling grid.
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INTRODUCTION

Groundwater flow is the movement of water through an aquifer and its resulting behavior when affected by external stresses such as pumping or water injection. An aquifer can be generally categorized as confined or unconfined and is defined as a unit of porous, permeable material (such as sandstone) capable of storing or transmitting water to wells. An unconfined aquifer has a water table as its upper boundary; a confined aquifer is overlaid by an upper boundary known as a confining bed which consists of material such as clay that retards vertical water movement. Aquifer composition directly affects water flow. Water movement through a homogeneous, isotropic aquifer (an aquifer composed of uniform material with equal hydraulic properties in all directions) is markedly different than through a heterogeneous, anisotropic aquifer (an aquifer composed of differing materials in various locations with hydraulic properties varying according to direction of flow).

In order to predict groundwater flow, a model is constructed as a means to represent an approximation of a field situation. The reasons for modeling can be specific or general. Examples of cases where modeling is useful to predict the consequences of a proposed or ongoing action are: pumping water from a well, attempting to acquire an insight into the controlling parameters in a specific setting such as groundwater usage by a town and surrounding farms, or studying the hydrologic processes in a geologic setting over
a large area. Physical models, such as a laboratory sand tank, directly simulate groundwater flow. Mathematical models indirectly simulate flow by using mathematical equations that represent the processes that occur, in addition to other equations which describe the parameters along the model boundaries. Additionally, mathematical models are solved analytically or numerically through the use of a computer. An analytical model is based on a known equation that calculates the total quantitative water flow through an aquifer. A numerical model based on standard geophysical techniques and formulas is used to derive a set of algebraic equations to calculate the two or three dimensional flow through a discrete element such as a cube of the aquifer. This model type is used when the values of the parameters vary within the model area. The equations used are in matrix form, are solved through iterative techniques, and like the answers obtained, are numerical approximations.

One form of numerical modeling, the finite-difference model, is based on a rectangular grid that defines the model boundaries and the nodes within each grid cell where the model will be solved. In constructing a two dimensional finite-difference model, spreadsheet software provides an equivalent grid matrix. Each entry in the spreadsheet is a finite-difference cell containing an equation.

Currently in order to prepare and execute a spreadsheet-based groundwater flow model on a microcomputer, the time required to construct, test for accuracy and execute the
model is prohibitive for all but instructional purposes. While I was attending a graduate course on applied groundwater modeling taught by Dr. Berkebile, this modeling technique was addressed. A class participant was assigned the task of preparing a presentation on this subject. Three spreadsheet models, representing three simplistic flow models and utilizing non-complex formulas in the iterative computations, were presented. Discussion centered on model construction, accuracy, model size limitations, factors affecting execution time, and exportation to graphics based mapping software to produce a plotted representation of the groundwater flow. Without considering unresolved problems in the execution of one of the models, a considerable time investment was required to produce a single groundwater flow map.

This project provides a program that acts as a user interface, reducing the modeling process for the user to a series of menu choices and entries. The user defines the model size and type, the equation set, and performs data entry of the model parameters (boundary head values). Alternatively the user selects a file containing a previously defined aquifer model and its parameters for revision or as a mask for a new model. At the close of a modeling session, the program has automatically created a re-useable file of the modeling parameters and input data and by user choice, an exportable file of the model results which is accepted as input by mapping software. This program reduces the time
investment incurred by the user and provides a potential for instructional or commercial applications.