Hydrologic Contaminant Transport Modeling: A Novel Analytical and Computational Approach

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ABSTRACT

We have developed a method for modeling contaminant transport in aquifers with rectangular boundaries utilizing an analytical solution to the porous medium flow equation and a finite difference solution to the advection-dispersion equation. Any number of wells may be placed within the aquifer, as well as any number of non-interacting contaminants. Constant head boundaries that simulate rivers may be included by means of a source term. With realistic parameters we are able to successfully model and predict contamination transport in an on-campus well site used for both undergraduate pedagogy and research.

I. BACKGROUND AND MOTIVATION

The University of Northern Iowa has a cluster of water monitoring wells which is near a river. A team of earth science students is estimating the effects of contamination within the aquifer spreading to the river. To assist them in their efforts we have developed a model which allows prediction of the spread of contaminants within the aquifer and into the river. The method presented here is chosen in favor of commercially developed packages such as MODFLOW because it is a wedding of computational and analytical work, it affords students the opportunity to explore the various facets of mathematical modeling firsthand, and it encourages faculty-faculty and student-student collaboration across departments. The purpose of this work is twofold: to outline the mathematical model we have developed and to also use that model to attempt a better understanding of a real system.

II. THEORY

There are a wide variety of approaches to modeling groundwater flow, both analytical [1,2] and numerical, involving discretization of space and using finite-element approaches [3,4]. Strictly speaking, we seek to describe contaminant flow in a confined aquifer with an impermeable rectangular boundary. However with the option of inserting a constant-head river within the aquifer the model at hand can be thought of as that of a semi-confined aquifer.