GROUND WATER

Software Spotlight

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Introduction

In this installment, we once again turn the "Spotlight" on MicroFEM, an interactive finite-element ground water modeling package for Windows, version 3.5. You may recall that we last reviewed MicroFEM in its DOS incarnation back in 1997. Although we liked the product, we pleaded for a Windows version. Normally, we do not do columns on upgrades, but this release is a major revision of the code, and merits fuller description.

MicroFEM can simulate steady-state or transient three-dimensional flow of a constant-density fluid in confined, unconfined, and leaky aquifers. Material properties are assigned to elemental nodes. Aquifers and aquitards can be heterogeneous, and aquifers can have spatially varying anisotropy. Up to 20 aquifer layers are supported, with up to 25,000 nodes per layer. In a graphical environment, MicroFEM includes functionality for mesh generation, interactive mesh editing, data import, and pre- and post-processing.

MicroFEM sells for U.S. $1950 ($975 for universities). FemInvs, an inverse parameter estimation module, is available as a $600 option. A single purchase includes a license for all personal computers in the purchaser's office. MicroFEM 3.5 LT is a freeware version of the Windows package available for download from the MicroFEM Web site. It is limited to two aquifer layers and 2500 nodes per layer, but otherwise includes all functionality of the parent product.

How We Tested

MicroFEM runs on Windows 95, Windows 98, and Windows NT platforms. It requires approximately 2.5 MB hard drive space. We tested MicroFEM on two laptops and a workstation. The workstation was a Dell Dimension XPS T600 with a 600 Mhz Pentium III and 256 MB of RAM running Windows NT. The laptops were a Toshiba Tecra 8000 with a 250 Mhz Pentium II and 128 MB of RAM and an IBM ThinkPad 390 with a 266 Mhz Pentium II and 128 MB of RAM running Windows NT. During the course of the review, a minor upgrade from version 3.4 to version 3.5 was shipped. Two of three reviewers implemented the upgrade patch without difficulty. The other reviewer declined to implement the upgrade. Also during the course of the review, one laptop was upgraded to Windows 2000. No difficulties were encountered with brief test runs under Windows 2000. One reviewer had extensive prior experience with MicroFEM, one had limited experience, and one had none.

What We Found

Modeling in MicroFEM entails grid generation, model editing and parameterization, calculation of model results, and display or post-processing of results. Each of these tasks are accomplished in different modes, in the parlance of the MicroFEM paradigm. Modes are selected through the menu bar "View" item.

The finite-element approach allows for accurate and efficient spatial representation of distinct hydrogeologic units. For computational efficiency, finite-difference equations are used for the vertical solution. The program supports a wide range of boundary conditions for the top layer. These include precipitation, rivers, drains, wadis, and evapotranspiration.

Unconfined aquifers can be simulated in the top layer.

MicroFEM includes two mesh generators—one for rather evenly spaced nodes and the other for grids with a large contrast in spacings. The user specifies a series of fixed nodes and then the generator fills in the rest according to a general spacing guide that you specify. Any of the nodes can then be modified on the fly to make it fit your boundaries precisely. All parameters are assigned on a node basis. This is different from some other popular models that assign properties like hydraulic conductivity on an element basis. When assigning the properties to the regions, you can choose sections with a marker or a line tool.

The finite-element solution used by MicroFEM allows anisotropy to be specified in any direction (as compared to finite-difference models, where anisotropy axes must be aligned with grid directions). This allows the user to better describe natural hydrogeologic systems. For example, permeability ellipses can be aligned with the trend of deposition of meandering river valleys or buried glacial geomorphic features.

MicroFEM has an intelligent standard data structure paradigm that allows for easy and flexible import of ASCII data files of parameters. These can be either as one-dimensional vectors of values or as XYZ specifications that are interpolated to nearest nodes. MicroFEM can import as well as export a variety of ASCII file formats, including AutoCAD DXF (drawing exchange file). Input to and output from EXCEL is readily accommodated through the CSV (comma separated variable) format. HPGL file export is also included.

Model solution execution was straightforward and fast. A 3500 node problem with two layers required about 20 seconds on the workstation.

MicroFEM can produce graphical output in the form of areal maps of water levels (or any other parameter). In addition, MicroFEM can produce cross sections showing aquifer layers with ground water levels. Flowlines created by MicroFEM can also be shown on these cross sections. MicroFEM can produce hydrographs of water levels from transient simulations.

Rapid and comprehensive support for MicroFEM is available by e-mailing the author. Despite the author's location in Amsterdam, his responses are fast and comprehensive.

What We Liked

MicroFEM includes extensive capabilities in an accessible environment. The learning curve for MicroFEM is acceptable. A new user with extensive prior modeling experience required only a couple of hours to learn how to use the mesh-generation modules, and a couple of hours more to figure out how to set up the parameters and plot the results. An experienced user finds MicroFEM so easy to use that he uses it to solve essentially all of the flow problems that he encounters.

We liked the post-processing options for doing flowline and travel-time calculations. This makes it easy to determine the zone of contribution to wells in a wellfield or the forward or backward travel time from a recharge area to a discharge well.

What We Didn't Like

There are no example problems to work through or look at. This is an ongoing criticism we have of many packages submitted to Software Spotlight. We strongly urge all software publishers to provide example tutorial exercises. The tutorial exercises should include simple and common tasks that users are likely to be buying software to accomplish. For example, it would be worthwhile to include tutorials for a Dirichlet problem, a problem with a Cauchy boundary, a problem with heterogeneity, and a problem with one or more wells.

In the absence of the help manual, many of the buttons are not intuitive. This may simply be a result of the inherent complexity of the many different capabilities of MicroFEM. Also, one reviewer found interactive editing of the aquifer properties to be somewhat onerous. He noted that a lot of keystrokes were required to make sure that the values entered are saved. That reviewer did not explore the alternative parameter specification capabilities of MicroFEM.

It is not a criticism, but a suggestion—what reviewers really want next is solute transport simulation capability.

Overall

From our brief overview it should be clear that we find MicroFEM to be an intelligently designed, simple, powerful, and useful modeling package. We continue to be impressed by the capabilities of the software, and—particularly in this age of software bloat—by the spartan computer hardware resources requirements. The particular advantages that the finite-element method offers are desirable in many cases.

MicroFEM's moderate learning curve is coupled with a high payoff of utility for proficient users. The process of development of a ground water flow model forces users to be specific about their conceptual model, including parameter values and boundary conditions. In that sense, the ease of assembling a model in MicroFEM makes it a great tool not only for making deterministic predictions but also for evaluating conceptual models and identifying significant areas of uncertainty.

MicroFEM is simple enough to use for small-budget modeling investigations, yet robust and powerful enough to use in basin-wide water resources studies. The bottom line is that MicroFEM is a modeling tool that all of the reviewers indicated they would use now and in the future.

Ratings

The reviewers were asked to assign a numerical ranking from 1 (worst) to 5 (best) to the software in the following categories. The reported ranking is the arithmetic mean of the reviewers' rankings.

Capability	4
Reliability	5
Ease-of-Use	4
Technical Support	4

The Vendor

MicroFEM is available from Dr. C.J. Hemker, Geohydroloog, Elandsgracht 83, 1016 TR Amsterdam, The Netherlands; 31-20-6234624 (fax); microfem@xs4all.nl; http://www.xs4all.nl/~microfem/

The Reviewers

The author would like to extend his thanks and appreciation to the individuals who assisted in reviewing this software. They are: Fritz Carlson, CH2M Hill, 2525 Airpark Dr., Redding, CA 96001, fcarlson@ch2m.com; and Ward Sanford, U.S. Geological Survey, 12201 Sunrise Valley Dr., Reston, VA 20192.

Freeware Alert

It won't happen until you are under some serious time pressure, but when you go back to the office late at night to finish up a critical task and your machine won't even complete the boot sequence to bring up the operating system, then you will know that you are in deep trouble. But you won't panic if you have planned for the situation by going to http:// www.bootdisk.com/ and downloading the files necessary to make an emergency boot disk. With your emergency boot disk in hand, you'll be able to bring your system back up and do what you need to do to get out of trouble. The site even includes a freeware utility that enables you to boot and get read access to NTFS-formatted hard drives.

Coming Next Issue

SEVIEW, Integrated Contaminant Transport and Fate Modeling System, version 5.0, by Environmental Software Consultants Inc.

Our Mission

The goal of **Software Spotlight** is to help you to identify well-written, intuitive software while avoiding poorly written, crash- or error-prone software. Independent reviewers from government, industry, and academia "test drive" full working versions of software packages and provide you with a concise summary of their experiences and opinions regarding the capability, stability, and ease-of-use of these packages. We hope that you find it to be of use to you, and we welcome your comments, feedback, and suggestions for future columns. The best way to give us your input is by e-mail to spotlite@ngwa.org.

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