Node 1 has T_1, and T (0 to 1) is just $(T_0 + T_1)/2$ (surprise again!). Using a transmissivity map next to the model makes it easy to see (and change) T in any node; otherwise you must change T in four node equations every time you want to try out another idea.

Be careful trying out the rest of the examples. There is also a mistake in the last equation on page 385: the first term should be $\frac{1}{2}(\phi_1^2 + . . + \phi_4^2)$. If you take it slowly and build all unfamiliar equations using the basic head equation or its variations, you will avoid a lot of the mistakes I made. Again, don't put in fancy terms for flows and leakance until you're sure the node equations are okay. Good luck on Figure 10.

A few other random observations:

1. Keep notes on where you stick wells.

2. The Lotus 1-2-3 spreadsheet supports its own graphs. These help a lot in visualizing flow nets and are instantly available as you work.

3. Contouring packages such as the one from Golden Software can be used to contour the data from a run. Just save an ASCII print file in the format used by the contouring program.

Extra credit problem: (1) Add in a term for elasticity and compute subsidence due to pumpage for a three-layer aquifer. (2) Make an overlay map using the rate of flow and salinity [see Bear (1979), *Hydraulics of Ground Water*, p. 453] and predict water-quality trends.

Summary

A spreadsheet is a natural extension of a pocket scientific calculator. If you ever wished for a way to make a ground-water model that is as available and usable as your calculator, wish no more. This article tells just about everything you need to know to grab your models back from the programmers and PhD's and do them yourself. In the future, practically all small to medium problems will be done this way.

REPLY TO the preceding Discussion by Alice M. Campbell of "The Power of the Electronic Worksheet: Modeling Without Special Programs"

by T. N. Olsthoorn

I welcome very much Alice Campbell's eye-opener to people that I may have scared with the equations in my paper. While she gives a fast introduction course, the paper itself shows a variety of problems the method can deal with, as well as the equations needed.

Campbell points directly to some sensitive points regarding who is going to use the method and in what cases, as well as who must beware. Clearly, large institutions, including where I work, don't appreciate this democratization of modeling. (This is why the paper has been a personal initiative in the first place.) On the other hand, the outer world has been very enthusiastic. I received many (mostly US) requests for reprints including a direct call from the USA from a friendly person practicing with his Apple Macintosh. (I answered them all except two from Bavaria, Germany, which got lost.)

In the meantime, I know a number of individuals from local water authorities, waterworks, and consulting firms who have started to use the method intensively and successfully. Also, visitors to our institute, mainly from developing countries, are enthusiastic. Instead of large or medium-sized computers, a micro is the most they have. And while most big computer users hardly ever heard of a spreadsheet, people in the middle of China, with only an IBM-PC, have been using a worksheet daily; they told me to start spreadsheet-modeling right away!

Alas, there were some minor slips of the pen in the paper. In addition to the two that Campbell noted, the second and fifth formulae in Figure 10 lack the coefficient before ksi, namely 3/2 and 4, respectively. This should be obvious since the coefficients in the numerator must always balance those in the denominator (consider this a practical hint while deriving or checking formulae.)

Block-centered or mesh-centered transmissivities may be a matter of taste, but I consider block-centered transmissivities somewhat cleaner and more like the finite-element method. Either method is not substantially easier than the other. Mesh-centered transmissivities, for instance, do not lead to $(T_0 + T_1)/2$, as Campbell points out, but to $2T_0T_1/(T_0 + T_1)$ instead. Moreover, in order to include the transmissivity jump in Figure 3 of my paper, you must change the formula in two adjacent lines of nodes instead of one, if you use mesh-centered transmissivities.

Campbell's suggestions to include flows, salinity, and settlement are good, but do it carefully. Among the things I did was a simultaneous surface/ground-water model in a single spreadsheet. There are, of course, many more possibilities. The experienced user may eventually appreciate such advanced spreadsheet features as the macros of Lotus 1-2-3, giving you even more control over the sheet to do some real fancy things with it.

DISCUSSION OF "A Program to Calculate Aquifer Transmissivity from Specific-Capacity Data for Programmable Calculators," by J. B. Czarnecki and R. W. Craig, September-October 1985 issue, v. 23, no. 5, pp. 667-672

by Jack E. Kelly, Anderson & Kelly, 6700 Emerald St., Boise, Idaho 83704

The method is quite useful for the majority of well test data, although the HP-41C version does not display T= (answer) unless steps 95 and 104 are deleted or other modification is made. In addition, a "GTO SPECCAP" after step 108 facilitates restarting the program.

However, my primary reason for writing is to reinforce the authors' caution concerning well losses. My frustration with well-documented low specific-capacity values that contradicted other data that indicated higher transmissivity values (from wells that are uncased in a limestone aquifer) led to an investigation of the apparent high "well losses" at high discharge values. It was concluded that most of the losses occurred in the aquifer itself because of turbulent flow conditions there. The specific capacity at maximum discharge rates of some flowing wells was more than an order of magnitude less than that at low discharge rates! A brief description of our findings was presented in a Field Report in the May-June 1980 issue of *Ground Water*, titled "The 'Cheat Sheet': A New Tool for the Field Evaluation of Wells by Step-Testing."