Judge's Commentary: The Ground Pollution Papers

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Teams tended to expend more effort on Problem One, and these comments concern that problem. The top papers handled both problems well.

The papers that I saw broke Problem One into several subproblems; assumptions beyond the problem description were needed to attack these, and the best papers made these very explicit with as much justification as possible. The subproblems included:

1. list of "pollutant" species,
2. mathematical model of pollutant transport,
3. detection of time and number of spills, and
4. location of spill sources (using 1–3).

The answers varied greatly, even among the best papers, depending on the assumptions and on the interpretation of the spreadsheet data. The winners

- showed evidence of careful search and interpretation of relevant literature;
- posed the subproblems well, and found mathematical models capable of producing usable answers;
- presented their results in clear, convincing ways; and
- avoided major errors (these seemed often to be due to poor communication among team members!).

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The problem statement might well have given at the Web site some description of the site (dump? storage?), description of soil/aquifer types, and other qualitative information that a professional in this field would be given.

The spreadsheet columns are labeled according to assayed chemical species and contain their concentrations in the form of separate time series from several wells and depths. There was little agreement among the contestants as to which species were "pollutants": concentrations for most species (e.g., organochlorides) were negligible, others were non-increasing with time or likely to occur naturally (in rainfall or in soil), and some columns seem to use more than one unit of measurement.

The Outstanding entries are good examples of how different the models could be. The entry from Zhejiang University fits the data to solutions of a simple partial differential equation. Note that the "diffusion" mentioned here is mostly of dynamic origin (percolation, although I did not see that term in any paper I read). Some contestants seem to have considered thermal (Brownian) diffusion important, but it is far too small to be observable in most fluids. The team from Earlham College neglected diffusion but assumed that different species might travel at different rates; this team used time-series graphs to good effect in selecting species to look at and to estimate times.

Other papers had trouble in finding the direction of flow, in putting together diffusion and advection, or in finding a rationale for data selection. Some teams did not find relevant scientific literature that would help in modeling.

About the Author

David L. Elliott is Professor Emeritus of Mathematical Systems at Washington University in St. Louis, and since 1992 has been Visiting Senior Research Scientist at the Institute for Systems Research of the University of Maryland, College Park.

He took his B.A. (Pomona College, 1953) and M.A. (USC, 1959) in Mathematics, and his Ph.D. (UCLA, 1969) in Engineering. After working in control systems and oceanic acoustics at the U.S. Naval Ocean Systems Center, Prof. Elliott taught at UCLA, at Washington University, and as a visitor at Brown University and once more at UCLA. He also served as Program Director for System Theory at the National Science Foundation, 1987–1989. His research has been in nonlinear control theory and applied mathematics (including the kinetics of blood coagulation—he has hemophilia).

He is an IEEE Fellow and member of SIAM, AMS, MAA, and Sigma Xi. He was associate editor for several mathematical journals and edited *Neural Systems for Control* (Academic Press, 1997). His previous association with MCM was as faculty advisor in 1985 and 1986 for Outstanding MCM teams from Washington University.