Author's Commentary: The Outstanding Ground Pollution Papers

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Late on a November night, in the brew pub of an old logging and mining town somewhere in the Wild West, I happened to be sitting near a hydrogeologist. Besides the usual gossip typically heard in such a pub—about the taste of the local brew, the lack of fish in the river, cougars stalking deer in your back yard, and a bear trashing your garbage can in the front yard—the conversation turned to a discussion of a private or public agency that also monitors the geographic area from which the data come.

The data consist of a real, original, unaltered electronic spreadsheet listing measurements of pollutants in wells drilled through the aquifer in an area used by a private or public firm. The data are not only real, they are also significant, which means that someone could suffer or benefit from their analysis and interpretation.

After some discussion, the hydrogeologist granted permission to use the data in the MCM, provided no statement be made containing information that would identify the parties involved.

The two Outstanding teams used two fundamentally different approaches, but each demonstrated an effective understanding of the situation and a strong command of mathematical concepts. Both teams' understanding of the situation enabled them

- not to be overwhelmed by the size of the data file;
- not to be stopped by some of the data file's blank fields or repeated fields;
- not to be hampered by names of unfamiliar chemicals;

The UMAP Journal 20 (3) (1999) 371–372.

- to recognize naturally occurring from potentially polluting chemicals;
- to sort out chemicals with concentrations that seemed nearly constant, nearly random, or potentially revealing of a trend; and
- to locate and use references from the literature and the World Wide Web.

Beyond such an understanding of the problem, the two teams adopted very different mathematical methods of solution.

The team from Zhejiang University used the method of least squares (minimum variance) to fit the parameters of a partial differential equation modeling the physics of advection, dispersion, and retardation: dispersion coefficients, ground water velocity, ground porosity, and the time and location of potential sources of pollution. Their result suggests four spills, near the points with coordinates $(7077, 6538)$ and $(6931, 5823)$ in 1991, and $(7750, 6040)$ and $(6423, 7461)$ near the end of 1993.

The team from Earlham College used Delaunay triangulations and Voronoi polytopes to interpolate concentration gradients and ultimately to detect sudden increases in pollutant concentrations and trace them back to a putative source. Their result suggests two spills, first about 1992 and again about 1996, near the point with coordinates $(8000, 4500)$.

Though the two results differ from each other, they suggest an increase in pollution in the area corresponding to the upper right hand corner of the map $[0, 10000] \times [0, 7000]$. The two teams' papers also contain presentations of their assumptions, models, methods, and results that are quite impressive for a weekend's work.

About the Author

Yves Nievergelt graduated in mathematics from the École Polytechnique Fédérale de Lausanne (Switzerland) in 1976, with concentrations in functional and numerical analysis of PDEs. He obtained a Ph.D. from the University of Washington in 1984, with a dissertation in several complex variables under the guidance of James R. King. He now teaches complex and numerical analysis at Eastern Washington University.

Prof. Nievergelt is an associate editor of *The UMAP Journal*. He is the author of several UMAP Modules, a bibliography of case studies of applications of lower-division mathematics (*The UMAP Journal* 6 (2) (1985): 37–56), and *Mathematics in Business Administration* (Irwin, 1989). His new book is *Wavelets Made Easy* (Birkhäuser, 1999).