Contamination in Orangetown: A Mock Trial and Site Investigation Exercise

Donald I. Siegel — Department of Earth Sciences, Syracuse University, Syracuse, NY 13244, disiegel@syr.edu

Jeffrey M. McKenzie — Department of Earth Sciences, Syracuse University, Syracuse, NY 13244, jmmckenz@syr.edu

ABSTRACT

This report discusses how we developed and implemented an interactive upper division/graduate level class project based on a fictional trichloroethylene contamination incident as part of our spring-2003 semester hydrogeology curriculum at Syracuse University. The "truth" of the contamination was based on a hypothetical Visual MODFLOW and MT3D computer simulation of groundwater flow and contaminant transport. The class was divided into three consulting groups. One provided expert services to people living in a town ("Orangetown") whose drinking water had been contaminated. The other two groups provided expert services to two fictitious manufacturing companies accused of responsibility for the contamination. The consulting groups prepared environmental assessment and contaminant characterization reports on different, fixed mock budgets. The culmination of the project was a daylong mock trial. Lawyers represented the three consulting groups (one real lawyer and two senior consulting hydrogeologists with extensive trial experience) and a jury of lay people decided the outcome. The overall exercise substantially increased the students' attention and interest in the material, as well as their examination performance in the course. Future iterations of the Orangetown Project may be integrated with courses in Maxwell School of Citizenship and Public Affairs, S.I. Newhouse School of Public Communications, and the Syacuse University College of Law.

INTRODUCTION

Instructors that teach university courses in contaminant hydrogeology usually spend the majority of time lecturing on the geochemistry of different classes of contamination, mathematics and modeling approaches used to characterize contaminant transport, field methods used in contaminated site investigation, and the different approaches used to clean up contamination. Typically students solve numerous homework problems to gain experience with the technical material in each subject area and take examinations testing their competence in the material.

In contrast to what is presented in textbooks, we find the quality and amount of chemical and hydrologic data in "real world" problems, such as investigations of leaky underground storage tanks or landfills, is often scant and of poor quality. The practice of contaminant hydrogeology is more often an exercise in clear critical thinking and "best professional judgment" than applying sophisticated mathematics and models to excellent academic-quality data sets. "Best judgments" are commonly tested through litigation, where attorneys examine hydrogeologists who serve as expert witnesses (e.g. Harr, 1995). Some of the most intensive and aggressive questioning hydrogeologists and other environmental scientists encounter is in the courtroom, not in the classroom or at professional meetings.

This paper presents the results of a semester-long class project designed to introduce graduate and upper division undergraduate students taking our contaminant hydrogeology course to the full process of contaminant site investigation through a mock trial experience.

METHODS

We designed the class project to address the overall educational objectives we have for the course, Contaminant Hydrogeology (GOL600/400; 3 credits), offered through the Department of Earth Sciences at Syracuse University (NY), in the spring 2003 semester. The constituency of the class is primarily graduate and upper level undergraduate students in the Department of Earth Sciences. In the course, students learn about major types of solute contamination: landfill leachate, gasoline and oil, pesticides, acids and bases, and dense non-aqueous solvents, and how they move in ground water. Students were assigned a standard textbook (Bedient et al. 1999), problems and periodic tests, as is the norm. The mock trial project took the place of individual class projects and was worth 40% of the student's final class grade. The grading for the mock trial project was based on written reports and evaluations of group performance and preparedness at the mock trial.

The semester-long class project was designed as a "real-world", contentious, groundwater contamination problem, including a mock trial and ruling made by a jury of lay people. The project was loosely patterned after the Woburn contamination scenario made famous in the book and subsequent movie, "A Civil Action" (Harr, 1995), but centered on a fictitious litigation in the "City of Orangetown." There, "Pure Water for Life" (a citizen group) was suing "Xenophobotech Corporation" (a military hardware manufacturer) and "HotSAX, Inc." (a woodwind instrument manufacturer), for contaminating an Orangetown water supply well with solvents. The class was divided into three groups to provide expert services to the three fictional litigants in the trial. Throughout the semester, the student groups acted as environmental consultants. Each group had to submit proposal describing its technical investigations, which were limited by a fictitious budget. Once the proposed plan was accepted, each group had to buy site data (provided by us, the course instructors), complete the site-investigation, write up the findings, prepare for the trial, and endure the mock trial itself.

Class Project Design - The contaminant problem was a hypothetical trichloroethylene spill that contaminated a confined (overpressured) sand aquifer, overlain by layers of silty and clayey soil through which water and contaminants would slowly move (Figure 1). The

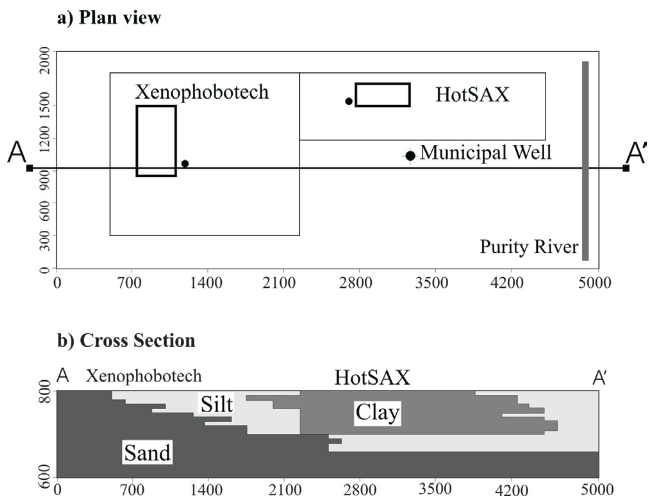

Figure 1. Geologic cross section and site map taken from the Visual MODFLOW computer interface. The plan view shows the companies involved in the litigation, their property boundaries and storage tanks (solid circles) and the contaminated municipal well. The cross section is through the Orangetown site and includes geology. The students were provided with the plan view (a) but not the geology (b).

Figure 2. Description of the class project, as given to the students at the beginning of the semester.

Description of Orangetown Groundwater Contamination Site

Concentrations of trichloroethylene (TCE) of ~70 ug/L along with smaller concentrations of dichloroethylene were measured in samples of water from Orangetown Municipal well field, New York, in February, 2000. Concentrations of both compounds exceed EPA guidelines and the well field was closed in March 2000. Orangetown built their well-field in April 1996 and they had no complaints from consumers until late 1999. Analyses were made when consumers complained about "off taste" in their water. Before then, only standard analyses for coliform bacteria and nutrients were made on the water. Since February 2000, the Town has had to purchase water and they are pursuing the possibility of a costly alternative of using water from the adjacent Purity River.

After contamination was discovered, the Department of Environmental Conservation funded an investigation in 2001 and discovered that underground storage tanks at Xenophobotech had leaked. Water draining into the excavation pit had a concentration of TCE of 29,500 ug/L. Xenophobotech is a firm that has been making military components for surface to air missiles since the early 1970s. Solvents also were discovered contaminating soils at the land surface at HotSAX Inc.'s tank farm, probably because of long term spillage. Here, water in a temporary well point had a TCE concentration of 9,899 ug/L. HotSAX Inc. is the world's largest manufacturer of woodwind instruments and also began operation in the early 1970's. Contaminated surface soils to a depth of 20 feet at the firms have been removed.

There is no information on the extent to which ground water under any of the properties is contaminated; nor how long the contamination might persist now that contaminated unsaturated soils have been removed. The Department of Environmental Protection will be installing an expensive remediation system (cost ~$5,000,000 extended over a long time) once the extent of contamination is known, and the Town is suing the companies for costs of cleanup. Citizens have formed an environmental advocacy group, *Pure Water for Life,* and are suing the companies for $10,000,000 for potential health problems caused by their drinking the solvent-tainted water. To date, no one has shown ill effects of drinking the water. Both Xenophobotech and HotSAX are soliciting proposals from environmental engineering and consulting firms to evaluate the problems on their properties and to provide expert support for future litigation. Pure Water for Life and Orangetown similarly are requesting proposals from scientists and engineers to provide expert support in their potential litigations.

Outline for Consulting Proposal

Page 1 Title Page with "consulting firm" and project team – who you are.
Page 2 Introduction and Background
Why are you doing the project? What evidence is there for contamination, etc.
Page 2.5-5 Scope:
Task I. Characterization of hydrogeologic conditions
Provide some background information and literature and/or conceptual models of what might be happening.
Task II. Groundwater sampling and analysis
How you will sample wells and what parameters will be analyzed. Indicate if any field data will be taken and how the samples will be collected. For this class, you will sample the wells once or twice at most.
Task III. Compilation and evaluation of data
How you will treat data. Will you use statistics and if so, what statistics? Will you compare data to allowable levels? What will you do with the hydrologic data? Will you attempt solute transport modeling and if so, what and under what contingencies?
Task IV. Reporting
What product you will deliver to your client – a single report of no more than 5 pages with accompanying figures, tables of all data collected, calculations, maps, tables and cross sections will be made.
Task V. Meetings and coordination – Not applicable to this class
Page 6 Cost – Here you lay out what all of your proposed work will cost.
References

Figure 3. Consulting proposal guide and format used by consulting groups.

"truth" of the contamination for the class was a mathematical model of this scenario created by the authors using MODFLOW, a U.S. Geological Survey 3-dimensional numerical groundwater computer code (McDonald and Harbaugh, 1988), coupled to MT3D, an Environmental Protection Agency contaminant transport code (Zhang, 1990), together in a commercial package, Visual MODFLOW (Guiguer and Franz, 2001). The model consisted of 15 layers, divided into 800 blocks each. The computer calculated hydraulic head (the height to which water would rise in a groundwater monitoring well) and concentrations of contaminants, mostly trichloroethylene (TCE), at the center of each block. The MODFLOW and MT3D models were run under non-steady state conditions to simulate both the movement of solutes and the subsequent pumping by the municipal well within the model domain.

Although the model could be much more complicated, we chose a relatively simple design, given the difficulty the students would have in characterizing the problem within their limited budgets – a common issue in real-world studies. At the onset of the project, the students were only provided with an aerial map of the study area, including property boundaries and the location of the town well (Figure 1a), and a brief description of the problem (Figure 2).

Site Assessment and Characterization - Although the students knew of the site model, they were not shown the full model until after the mock trial. The three class groups assessed the local geology and extent of contamination for their respective clients by using standard hydrogeology investigative techniques, such as installing monitoring wells and sampling groundwater. Data for the investigations, including hydraulic head measurements and contaminant concentrations in water samples, were supplied by the instructor and derived from the model simulation.

The defendants were instructed that they had to be true to science and engineering, while trying to minimize liability. In contrast, the "Pure Water for Life" consultants were told to use science and engineering within the broad range of plausibility to convince a lay jury to award them the damages asked. All groups had to initially submit a consulting proposal, with a rigidly proscribed format (Figure 3). No group could obtain information outside their own property lines and each group had a fixed budget to buy hydrologic and geochemical data (Table 1): $200,000 for Xenophobotech's consultants, $100,000 for HotSAX's consultants, and only $20,000 for "Pure Water for Life's" consultants. Pure Water for Life's consultants also had the opportunity to be "creative," by asking the Town and "University" professors at Orangetown University (i.e. us) for *pro bono* or inexpensive specialized technical assistance. As an example of an investigation, Xenophobotech's consultants drilled 10 wells on Xenophobotech's property, obtained hydraulic conductivity values from slug tests (a standard engineering test) for 4 wells, and obtained analyses of water samples from all wells for concentrations of inorganic solutes and volatile organic compounds.

After about 7 weeks of data acquisition and interpretation, scientists for Xenophobotech and HotSAX produced interpretive reports distributed to all. Pure Water for Life Scientists had an additional 3 weeks to then do studies and produce their report, also distributed to all as pre-trial filed testimony (Figure 4).

Item	Price	Notes
Test hole and well	$50/ft	Includes well log (geology), water level, and supporting information.
Slug test for hydraulic conductivity	$300/test	The value plus error bar. Test must be done in existing monitoring well.
Inorganic analysis	$300/sample	pH, major and minor solutes. Analysis must be from existing monitoring well.
Volatile organics	$100/sample	Hydrocarbons and solvents. Analysis must be from existing monitoring well.
Report costs	$2500/well	Up to $20,000. Consulting reports often cost several tens of thousands of dollars to prepare in professional practice.

Table 1. Pricing for site investigation data. Each consulting group was given a fixed budget: Xenophobotech's consultants had $200,000, HotSAX's consultants had $100,000, and Pure Water for Life had $20,000.

The Consulting Report

No more than 10 pages of text, double spaced, 10 pitch, Times Roman or Ariel. Stapled. Clean. Neat.

Page 1 Title Page – names and "consulting firm"
Page 2 Executive Summary
A page of single line "bullets" of your major conclusions. **Bold** face.
Page 3 Introduction and Background
Why you did the project. What evidence is/was for contamination, etc.?
Page 4 Methods
Briefly describe what you did, citing references as to methods. If you choose to do a model of some kind for prediction, you need to reference the method used and put in the appropriate math. Remember, lawyers have to read the report and understand it.
Pages 5-7 Results – data and statistics
If you want to use them; brief discussion of concentrations found, water levels, etc. but without any interpretation. Refer the reader to tables for raw data; Include examples of calculations done.
Pages 8-10 Interpretation – figures, calculations, etc.
Remember, lawyers have to read the report and understand it.
Page 11 Summary and conclusions
These can be "bullets" which will go with minimal revision into the Executive summary at the top.
Page 12 References
Figures – absolute minimum:
- Site map with locations of monitoring wells
- Plume(s) extent, extrapolated as needed, contoured broadly if you are smart
- Geologic cross-section along major flow path through site and extrapolated as necessary or desired.
- Watertable map showing directions of groundwater flow, contoured clearly, extrapolated as deemed necessary

Tables – absolute minimum:
- List of monitoring wells/ piezometers, porous media sampled, screened interval, location of wells (can be referenced to figure).
- Chemical analyses, referenced to well
- Water level measurements, reference to well
- Hydraulic conductivity measurements, referenced to well

When you prepare the figures, do them in Microsoft PowerPoint. Why? You will have to prepare ~5 figures for trial where you will present your ideas and results to a lay jury which does not know science. So you must think all the time how to present and explain your results.

Figure 4. Consulting report outline and format used by the student groups for their Site Assessment Reports.

Issue	Information
Purpose of a Trial	To resolve disputes, not to determine the truth
Direct testimony	Poise leads to dignity
Cross examination	1.Defend known items 2. Show a balance between commitment and detachment 3. KISS – "Keep it simple, stupid!"
Re-direct	Return to known items

Table 2. Trial facts and hints for expert witnesses.

Figure 5. The Lampe Courtroom, Syracuse University. Plaintiffs at front table, jury to the left, witness box is left of the white screen and author, Siegel, is talking to the class prior to proceedings.

Mock Trial - When all of the pre-filed reports were produced, volunteer attorneys were assigned to each group: a senior partner of a major law firm in Syracuse and two senior hydrogeologists in major consulting firms who have extensive experience giving expert testimony. The judge for the trial was the environmental science advisor to a U.S. Senator from New York, and a real court reporter donated his time to record the trial. Six members of the community volunteered to serve as jurors in the mock trial: an editor of a local paper, a physician, a computer systems analyst, a librarian, a speech pathologist, an antiquities dealer, and two special education teachers. The educational level of the jurors is higher than most "real juries"; nevertheless, they served the purpose of the project. The Syracuse University College of Law provided a mock courtroom for the day-long trial.

The trial consisted of brief opening remarks by the judge, and then segments of 15 minutes of direct testimony, 30 minutes of cross examination, and 10 minutes of redirect testimony for each litigant group. One student in each group provided live testimony on the stand, presenting the group's visualization of the contamination problem.

RESULTS

As expected, each consulting group developed a different hydrogeologic conceptual model of the Orangetown site that was true to science while serving the needs of the client. Xenophotobech's scientists determined that contamination from Xenophobotech bypassed the Orangetown water supply well completely, partly because they neglected to consider that pumping of the town well diverted contamination toward the well. Scientists for HotSAX found that contamination from their company had to be minimal because their factory is underlain by thick clayey soils that do not pass water easily. Pure Water for Life scientists argued that the companies share equal blame for the contamination. Their arguments in court were buttressed by clever use of isotopic "fingerprinting" analyses for chlorine in the dissolved solvent.

True to form (based on the senior author's professional experience), the technically most organized and professional work was done by the consulting firms for the defendants, Xenophobotech and HotSAX. These groups had more resources (money) to obtain scientific information to buttress their cases. In contrast, despite equal technical skills, the consulting group for the plaintiffs, Pure Water for Life, was disorganized and had a hard time reaching consensus on what to do. They had to do much more critical thinking, which led to divisive debate to evaluate the problem, rather than letting the data 'speak for itself'.

Mock Trial - At trial, the mood was somber, given the austere setting of the Lampe Courtroom, a courtroom used for instruction at the Syracuse University College of Law (Figure 5). The judge ruled with an iron hand (supported by a geologist's pick struck on a piece of granite, as is appropriate for the course). Defendants, plaintiffs and their attorneys sat at separate tables facing the judge, jury box, and witness box (Figure 5). The students emotionally were immersed in the mock trial, party due to the semester long buildup to it. One student commented in the course evaluation that:

> Even though the trial was a "mock" presentation, I had butterflies as if my work was actually being tested in a court of law. I feel it was an accurate representation of how "real-world" trials occur and believe that everyone involved benefited from the experience.

The lawyers had prepared their witnesses to some extent before the trial, and we also gave students a list of critical elements for expert witnesses to know (Table 2). All students did very well under intense cross-examination. The judge leaned over and asked the senior author if the witnesses had any previous courtroom experience. When he said that they did not, she commented that she had seen real expert witnesses do far worse.

The student expert witnesses clearly were keyed up for their role-playing, as shown in the following exchange by one of the expert witnesses during cross-examination – obviously the student had not visited the Orangetown sites, but acted as if he had:

> Q: Did you personally visit the HotSAX site?
> A. Yes.
> Q. And have you personally visited the Xenophobotech site?
> A. Yes
> Q. And have you been on the Orangetown Well site as well?
> A. Yes.

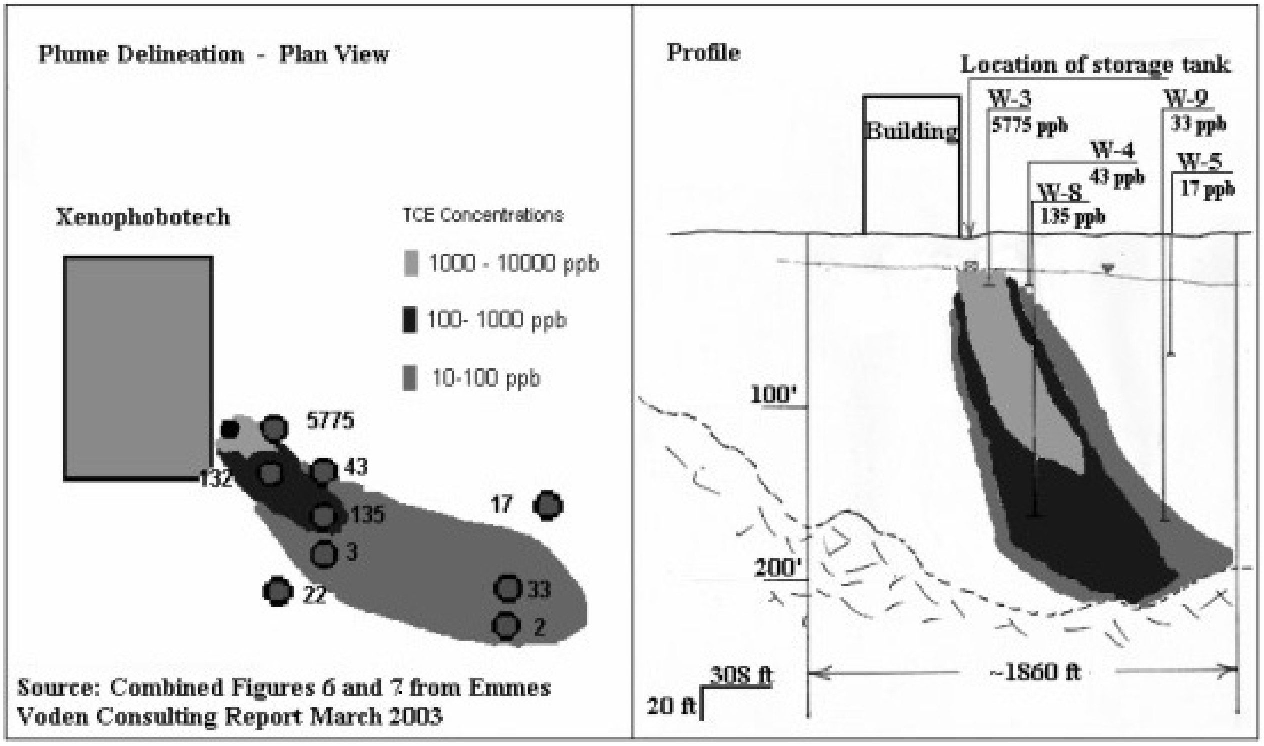

Figure 6. Diagram, produced by Xenophobotech's consultants, shown in court illustrating the TCE plume.

Q. And were you there to personally observe the drilling of the various wells and the placement of the piezometers?
A. I believe our scientists and some of our technicians were there. No, I was not present during the installation of the wells.
Q. Do you feel it's important to go out and observe the well drilling to make sure that the well drillers are following the appropriate procedure?
A. No, because they follow appropriate procedures because they have to, and we have other staff that monitors that activity.

Each student witness presented the results of each group's scientific interpretation using Microsoft PowerPoint illustrations, one of which is shown as Figure 6. In this figure, Xenophobotech shows the zone, or plume, of contamination as a fairly restricted area under their facility. In contrast, Figure 7 shows the "truth" – contamination migrated from the Xenophobotech property to the municipal well.

The major issues that the students had to address under cross-examination were different. In the case of Xenophobotech, opposing attorneys questioned why the consultants did not better sample vertically to determine exactly where the plume of contamination might have gone, as well as why the expert did not think a pumping well would induce any contamination to it. Attorneys questioned the HotSAX expert on the extent to which fractures and cracks in the clayey soil might have allowed contamination to move downward farther than he postulated. The experst had some problem explaining the data they obtained from the drilling, which included observations of fractures. For example (from the court transcript):

Q. I have in front of me a drill report for p-1 that began at 800 feet. And it indicates that the soil from 800 to about 670 is silty clay, brown, upper 15 feet, fractures. Soil gray below minor peaty layers. Does that indicate that just the upper 15 feet of the core was fractured?
A. The way we interpreted it, yes.
Q. But it could be interpreted that that entire unit, it did not segregate a separate fractured layer in the upper 15 feet, did it?
A. I believe it did. The upper 15 feet, I think that was very unequivocally reported in the well logs.
Q. But it is possible that the rest of that section was fractured also?
A. I can't say that.
Q. If that section was fractured would TCE or other contaminants have been able to penetrate through that unit?
A. TCE would penetrate to the extent that there were fractures.
Q. So that's a yes.
A. Yes.

The Pure Water for Life expert demonstrated, with water and food coloring, how mixtures of contamination could occur, and then discussed how isotopes (a form of an element with more neutrons than the most common kind) of chlorine in TCE can be used to fingerprint contamination sources. Following is a sample of this testimony (from the court transcript):

Q. Do you have an illustration for us?
A. Yes, I do. One can imagine that the blue dye is the TCE from HotSAX. And the red dye is the TCE from Xenophobotech. Now, if one were to merely dilute these we can clearly see that by diluting you still have the same color, it's just more dilute. It doesn't mean that the chemical fingerprints have changed. However, if we mix the two together we can very definitely see that

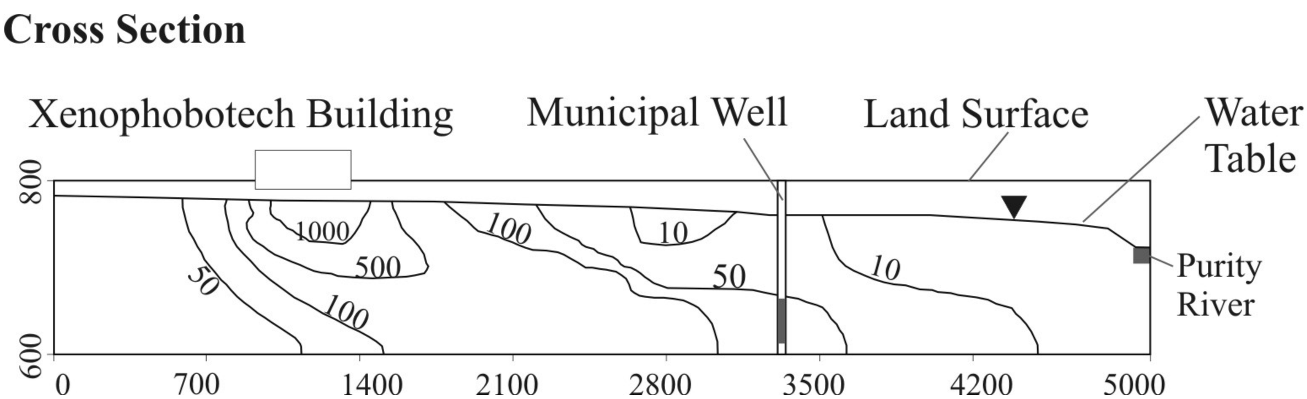

Figure 7. Diagram showing "true" extent of contamination as created by the authors. Distance units are in feet. Contours lines represent concentration of TCE in ug/L.

the color that we get when mixed in equal proportions is green. That is 50 percent TCE from Xenophobotech, 50 percent TCE from HotSAX. Clearly, not literally, but figuratively.
Q. Is the same signature found in the carbon isotopic data?
A. The same signature is found.

Subsequently, the expert stated that the isotopic 'fingerprint' data showed a 50:50 mixture of TCE from HotSAX and Xenophobotech reaching the city well. However, under intense cross-examination, the expert had to admit that not enough TCE was in the water to do such an analysis; a water-table map made by his firm for the site was substantially wrong, and that data were not plotted correctly on materials presented to the court. It was a difficult time for the expert, who nonetheless kept his cool (from the court transcripts):

Q. Have you checked your measurements to see that they were accurately to scale or are they just approximations?
A. In this case an approximation.
Q. If they were an approximation then why did you put a scale on the map? Isn't it important to be accurate in terms of these things?
A. It is important to be accurate.
Q. And I think distance is probably very critical here considering the media we're going through, the clays and things like that, the slow travel times that occur in clays, is that correct?
A. That is correct.
Q. And so that in terms of this diagram it doesn't fully and accurately portray what is in fact on the ground, is that correct?
A. This is merely a planned view. When calculations are made they were made accurately.
Q. Well, the calculations were made accurately, but then when they were put on this Exhibit they were put on inaccurately. Is that correct?
A. That would be correct.

The jury was allowed 30 minutes to come to a decision for two questions: first, whether HotSAX and/or Xenophobotech were responsible for contamination of the city well, and second, if both companies were guilty, what were the proportions of blame. The verdict was guilty for both companies, with Xenophobotech responsible for 75-80 percent of the contamination and HotSAX for the rest. The truth was, in fact, about a 50:50 mix as suggested by the isotopes analyzed by Pure Water for Life.

The jury commented that Pure Water for Life's isotopic data seemed to implicate both HotSAX and Xenophobotech as guilty, despite the fact that they did not understand all of the isotopic diagrams shown to them, or that concentrations of the solvent were too small to get good data. The jury also commented on the quality of the diagrams presented in court. Xenophobotech's diagrams were hard to read and made it difficult for the jury to fully understand the testimony. The jury felt that witness "performance" on the stand, in addition to technical content, influenced their decision – something well known in the courtroom (Wyche, 1995).

After the jury made its decision, the true extent of the contamination, as simulated by the computer model, was presented and comments were solicited from all present. The attorney and mock-attorneys also commented publicly on how well the student witnesses held up under cross-examination. One of the hydrogeologists who acted as an attorney said that he almost had a "sadistic pleasure" being on the other side of the witness box to grill the expert.

Student Course Evaluations - At the end of the semester, the students were asked to anonymously write a few paragraphs to evaluate the course and the course project. The overall class evaluations for the course were very positive, and the students particularly enjoyed the class project and the mock trial. Both from our observations and the students' class reviews, the class project was very stimulating. From the class evaluations:

> I think that this trial was the best educational experience I have had here at Syracuse University so far.
>
> [The mock trial] was the most interesting and invaluable 3 hours I have spent in any academic setting. What I learned during those three hours was just amazing.
>
> Splitting the class up into groups was good and gave a "competitive edge" to the project that can really bring the best out in people.

Based on the student reviews, we feel our original goal when we designed the course project was met – to teach contaminant hydrogeology from a practical, "real-world" standpoint. Many students stated that the class project gave them tangible experiences that directly prepared them for jobs in environmental geology. From class reviews:

> I feel confident that I could now begin to conduct a competent site assessment, analyze geochemical data with an informed eye and constrain plume morphology and migration.

> It is not often that in the classes I have taken here at SU [Syracuse University] where I leave with a sense of confidence in the work I can perform and/or exhibit outside a classroom.

We also were pleasantly surprised to find that the class project helped students think about problems in a non-traditional "textbook" approach. From class reviews:

> The ability to think things out and solve a problem is one of the most important skills anyone could ever need to develop. Rather than being told what was right and what was wrong, we were left finding out for ourselves, with a bit of guidance, when we "slipped."

SUMMARY AND CONCLUSIONS

Reviews of the course project were overwhelmingly positive. Many participants suggested that students in the College of Law be involved in the process, perhaps guided by experienced lawyers. The project could easily have been expanded to 6 hours of testimony by adding re-cross examination and summation arguments by the lawyers. Funding and the patience of the volunteers needed for the project precluded an extension of the trial.

As instructors, we found the trial focused the students on learning the complexities of contaminant transport and fate in a timely manner, if for no other reason than not to embarrass themselves in public. We are concerned about the different ways that environmental science is practiced in academia, the political arena, and in the courts (Siegel, 2001). What society arguably would like to see is the overlap of the best of each, but what often happens is the converse: sound law lags behind sound policy which in turn lags behind current sound science. We think classroom projects such as "Contamination in Orangetown" provide students with an important benchmark educational experience to which they can compare future environmental work that involves the lay public with scientific issues. The performance of the students on standard examinations in the course, including the comprehensive final examination, was measurably better this year than in past years. We think the students were very focused on the technical material because of the trial scenario.

We are exploring the idea of expanding the course to include the Syracuse University College of Law, Syracuse University Maxwell School of Citizenship (public policy), the S.I. Newhouse School of Communication and perhaps even the College of Visual and Performing Arts.

Our science students would be the scientific experts that "do" the science. Policy students might be involved "representing" the EPA or NYDEP and testify whether the science met regulatory constraints. Policy students could also be involved in the court proceedings that could include financial claims and/or medical liability issues. Law students could serve as the lawyers. Media students could report on the proceedings (written or video) and assist with the development of visual materials for trial. Acting students could even play the roles of aggrieved citizens or material witnesses to the contamination and testify in court. As background, the professors for the science, policy, and law courses would each give a lecture to the entire assembly explaining the basics of important aspects related to the problem.

We could choose, for our numerical simulation, a local urban setting that could be visited, although the contamination would not be real. Alternatively, we could choose a real (unknown to the students) EPA Superfund site. There are many alternatives, and it will take some time to decide what to do, pending on interest outside the Department of Earth Sciences.

ACKNOWLEDGMENTS

We thank the College of Arts and Sciences, Syracuse University, for their generous funding of this pilot project, and the Syracuse University College of Law for providing the Lampe Courtroom on a weekend day.

This project simply would not have been possible without the gracious volunteering (and role playing, in italics) of: Dr. Rhea Jezer (Environmental Advisor to Sen. Hillary Clinton, *Judge*), Dean Heberlig, Esq. (Senior Partner; Bond, Schoeneck & King; *Lawyer for Xenophobotech*), Edward Hinchey (Office Principle, ERM, *Lawyer for Pure Water for Life*), Guy Swenson (Senior Hydrogeologist, O'Brien and Gere Engineers, *Lawyer for HotSAX*), John Drury, CSR, RPR (*Court Reporter*), and the jurors; Bette Siegel, Robin Illowsky, Jerry Illowsky, Randy Marshall, Jane McKenzie, Stephanie Bergman, and Jef Sneider.

REFERENCES

Bedient, P.B., Rifai, H.S., and Newell, C.J., 1999, Groundwater Contamination: Transport and Remediation, Prentice Hall PTR, Upper Saddle River, N.J., 604 p.

Guiguer, N.B. and Franz, T., 2001, User's Manual for Visual MODFLOW, Waterloo Hydrogeologic, Waterloo, Ontario, 316 p.

Harr, J. 1995, A Civil Action, Random House, New York, 500p.

McDonald, M.C., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 6, Chapter A1, 586 p.

Siegel, D.I., 2001 "Truth or Consequences" for the Practicing Hydrologist: On Scientific Certainty and Ethics, Hydrologic Processes, v. 15, p. 521-523

Wyche, B.W., 1995, The hydrogeologist in litigation: top ten tips on how to be an effective expert witness, Groundwater Monitoring and Remediation, Spring - 1995, p. 94-96.

Zhang, Z., 1990, MT3D: a modular three-dimensional transport model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems, Report to the U.S. Environmental Protection Agency, Ada, Oklahoma, 170 p.