Groundwater Source Protection

Objectives:
The student will be able to:

- Define a Wellhead Protection Program
- List 25 common groundwater pollutants
- List 25 potential sources of groundwater pollution
- Identify problems involved in starting a Wellhead Protection in a develop area.

Suggested Grade Level:
9-12

Subjects:
Chemistry, Biology, Environmental Science, Social Studies, Ecology

Time:
1-2 Class Periods

Materials:
- Copies of student sheets

BACKGROUND INFORMATION

It is important to be aware of the source of your drinking water. If the water is pumped from a well, the source is groundwater from an aquifer. Just like rivers and lakes, aquifers need to be protected from contamination. Chemicals spilled on or applied to the ground can move down and eventually contaminate an aquifer, sometimes making groundwater unsafe to drink. It is especially important to protect areas immediately around wells from releases of harmful chemicals, because it is from within these sensitive areas that chemicals can most quickly and profoundly affect the quality of water pumped from a well. EPA's Source Water Protection (SWP) Program was established to help states and communities protect their drinking water supply sources. Wellhead Protection Programs may serve as Source Water Protection Programs for communities relying on groundwater as their source of drinking water. Wellhead protection is a 5-step process involving: (1) forming a community planning team; (2) delineating the area contributing groundwater to a water supply well; (3) identifying potential contaminant sources within the delineated area that pose threats to the well; (4) using a combination of management strategies to ensure that identified sources don't impact the well; and (5) developing a contingency plans in case there is a release of contaminants within the delineated area.

Wellhead protection management strategies incorporate broad concepts such as land use control and/or management, best management practices, and pollution prevention. Specific strategies may include the following: zoning controls, local ordinances governing pesticide/herbicide use, enforcement of septic tank regulations, and community education. Homeowners, businesses, farmers, and industries may also be encouraged to use pollution prevention and best management practices to prevent contamination in the delineated areas. For example, waste oil collection centers may be set up in convenient locations so that oil can be brought in for proper disposal or recycling (rather than citizens dumping it illegally onto the ground).
The illustration in Figure 4 shows a wellhead protection area with the zone of influence (Zone I), a 10- year time-of-travel (Zone II), and the rest of the recharge area for the well (Zone III). Potential pollutants and potential pollutant sources are listed in Student Sheets, Figures 2 and 3 respectively. Various activities in the recharge area are illustrated in Figure 4.

TERMS

Source Water Protection: process that involves delineating areas contributing water to a water well or surface water intake; identifying potential contaminant sources that may threaten the water supply; and using management strategies to protect the source water from contamination. Source water protection is applied to both surface water and groundwater supply sources.

time-of-travel: the time required for groundwater to move from a specific point beneath the surface to a well

Wellhead Protection Area: the surface and subsurface area surrounding a public water supply well through which contaminants are reasonably likely to move toward and reach such well

Wellhead Protection Program (WHPP): a groundwater-based source water protection program

zone of influence: area surrounding a pumping well within which the potentiometric surface has been changed due to groundwater withdrawal

zoning: to divide into areas determined by specific restrictions; any section or district in a city restricted by law for a particular use

ADVANCE PREPARATION

A. Copy Student Sheets for each group or individual.
B. Make overhead transparency of Student Sheets.

PROCEDURE

I. Setting the stage

A. Discuss the concept of Wellhead Protection and go over terms.

B. Put up overhead transparencies of Figure 1 and Figure 4.
1. Discuss land use zones and time-of-travel.
2. Discuss groundwater pollutants and potential sources. (Students may wish to read over Student Sheets - Figures 2 & 3.)

C. Break into study/discussion groups to complete activities.

II. Activity

A. Assume you are a mayor considering a WHPP. List the considerations (pros and cons) of establishing such a program.

B. If you are a farmer or businessperson in the same town, what concerns would you have if this program were instituted?

C. As a citizen drinking the water produced by the well, what concerns would you have? What form would you prefer the WHPP take? Why?

D. You are an employee of the state environmental agency and would like to see a WHPP put into place by all small towns. What position would you take relative to this town after learning the above positions?

E. Is a WHPP a good groundwater protection approach? Why or why not?

III. Follow-up

A. Each group should have a spokesperson report its conclusions to the class. Allow some discussion and debate over the "best" policies.

B. Give quiz over groundwater pollutants and potential sources of pollution to groundwater.

C. Have students write a short essay about what they think they could do to protect groundwater in the area.

IV. Extensions

A. Students should find out if their state or city has a WHPP and what is or is not being done in its implementation.

B. Locate a city well and visit it. Have students identify pollutants and potential pollution sources in the wellhead protection area.

C. Learn about Environmental Ethics. Read "Jay's Situation" and "Ethics". Respond to the questions. Students should look for ethical, win-win compromise solutions.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Case Studies in Wellhead Protection, EPA Office of Water, EPA 440-6-90-004, April 1990.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Cunningham, William P. and Barbara Woodworth Saigo, Environmental Science: A Global Concern, Wm. C. Brown Publishers, Dubuque, IA, 1997.

Enger, Eldon D. and Bradley F. Smith, Environmental Science: A Study of Interrelationships, 5th Edition, Wm. C. Brown Publishers, Dubuque, IA, 1983.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Thank you to the Environmental Protection Agency *Water Sourcebook* for this activity!

http://water.epa.gov/learn/kids/drinkingwater/wsb_index.cfm

FIGURE 1

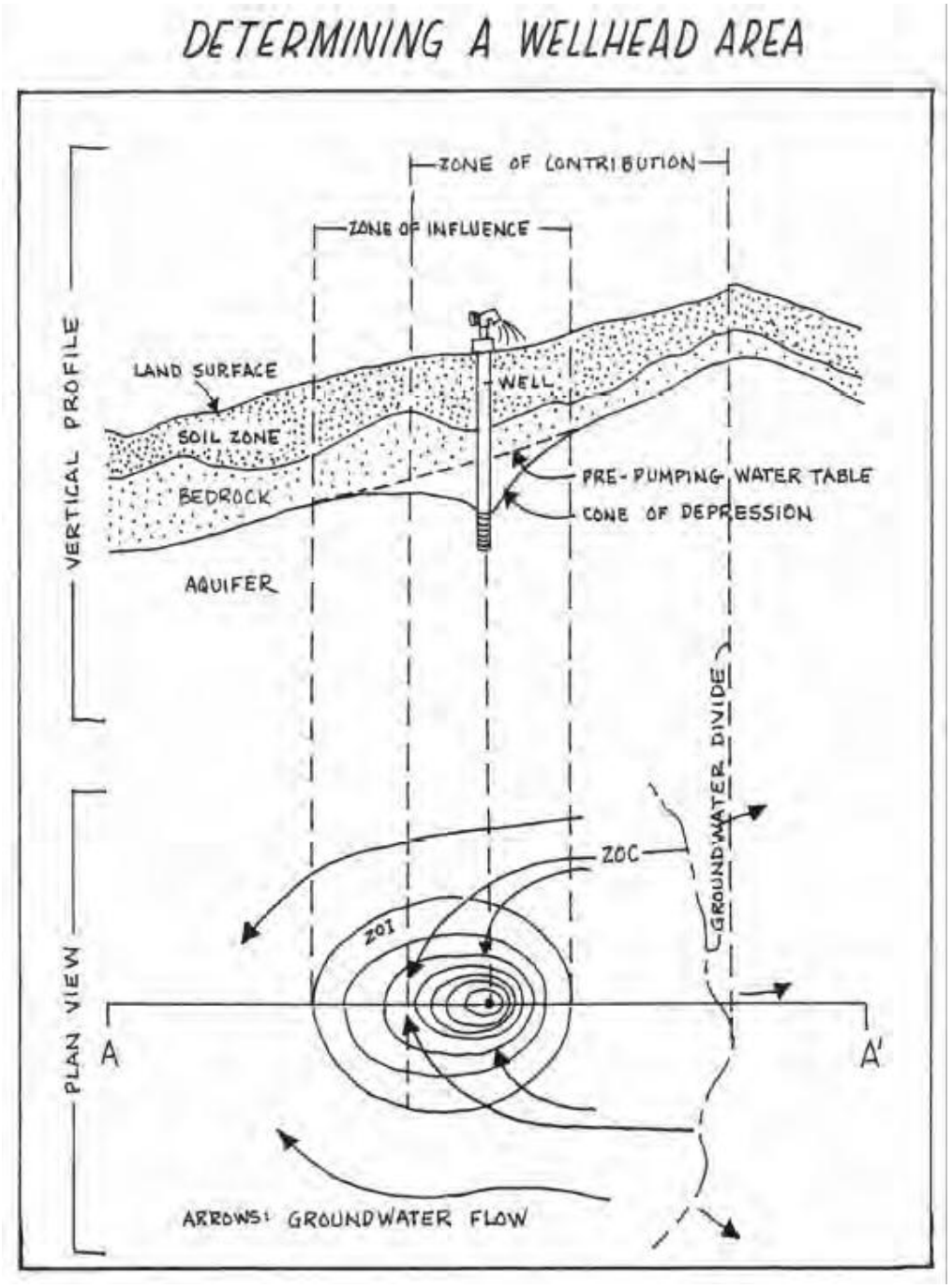

DETERMINING A WELLHEAD AREA
ZONE OF CONTRIBUTION
ZONE OF INFLUENCE
VERTICAL PROFILE
LAND SURFACE
WELL
SOIL ZONE
BEDROCK
PRE-PUMPING WATER TABLE
CONE OF DEPRESSION
AQUIFER
GROUNDWATER DIVIDE
ZOC
ZOI
PLAN VIEW
A
A'
ARROWS: GROUNDWATER FLOW

FIGURE 2

COMMON GROUNDWATER POLLUTANTS

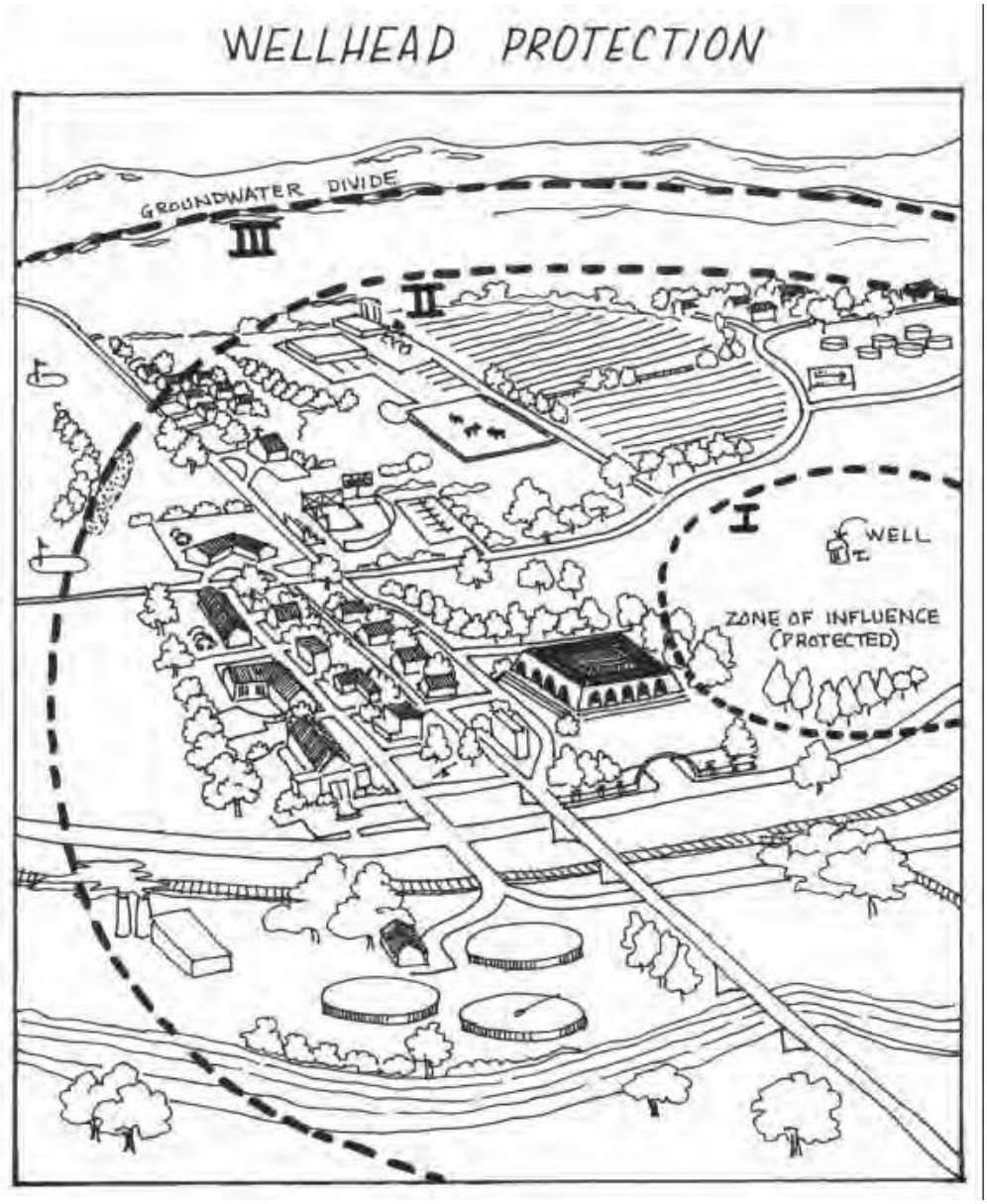
1. Antifreeze (for gasoline coolant system)
2. Automatic transmission fluid
3. Engine and radiator flushes
4. Hydraulic fluid (including brake fluid)
5. Motor oils/waste fuels/grease lubricants
6. Gasoline, jet fuel
7. Diesel fuel, kerosene, #2 heating oil
8. Degreasers for driveways and garages
9. Battery acid (electrolyte)
10. Rust proofers
11. Car wash detergents, waxes, and polishes
12. Asphalt and roofing tar
13. Paints, lacquer thinners, and brush cleaners
14. Floor and furniture strippers
15. Metal polishes
16. Laundry soil and stain removers (including bleach)
17. Spot removers, cleaning solvents
18. Disinfectants
19. Household cleaners (oven, drain, toilet)
20. Cesspool cleaners
21. Refrigerants
22. Pesticides (insecticides, herbicides, rodenticides)
23. Photochemicals/ Printing ink
24. Wood preservative (creosote)
25. Swimming pool chlorine or bromine compounds
26. Lye or caustic soda
27. Jewelry cleaners
28. Leather dyes
29. Road salt (Halite)
29. Fertilizers (if stored outdoors)
30. PCBs
31. Other chlorinated hydrocarbons, including carbon tetrachloride)
32. Any other product with “Poison” labels (including chloroform, formaldehyde, hydrochloric acid, (including bleach) and other acids)
33. Other products not listed that you feel may be toxic or hazardous (please list):

FIGURE 3

POTENTIAL SOURCES OF GROUNDWATER POLLUTION

1. Truck terminals and service stations
2. Petroleum pipelines, stores, and tank farms
3. Auto repair, body shop, and auto supplies
4. Rust proofers
5. Pesticide, herbicide wholesalers
6. Dry cleaner
7. Painters, finishers, furniture strippers
8. Printers, photo processor
9. Auto washes, laundromats
10. Beauty salons
11. Medical, dental, and vet offices
12. Food processors, meat packers, and slaughter houses
13. Concrete, asphalt, tar, and coal companies
14. On-site sewage disposal
15. Railroad yards, industrial sites
16. Storm water impoundment
17. Cemeteries
18. Airport maintenance, fueling
19. Machine shops
20. Metal platers
21. Heat treaters, smelters, annealers, descalers
22. Wood preservers
23. Chemical reclamation
24. Industrial waste disposal
25. Municipal and private waste retailers wastewater treatment plants, lagoons
26. Landfills, dumps, and transfer stations
27. Junk, salvage yards, recycle centers
28. Subdivisions, ,individual residences
29. Heating oil storage (consumptive use)
30. Golf courses, parks, nurseries
31. Sand, gravel, other mining
32. Abandoned wells, existing wells, sinkholes
33. Feed lots, manure piles
34. Agricultural chemical storage, handling, spreading, spraying
35. Construction sites
36. Transportation corridors
37. Fertilized fields, agricultural area

FIGURE 4


WELLHEAD PROTECTION
GROUNDWATER DIVIDE
III
II
I
WELL
ZONE OF INFLUENCE
(PROTECTED)

JAY'S SITUATION

Jay Barlow is sitting with his elbows on his desk. His face is pressed into his hands. He feels a small hand pull his hand away from his face. "Daddy?" Jay looks down into his daughter's sparkling brown eyes. He is still her hero, and that trusting smile just increases the pressure he already felt. Last week Jay was on top of the world. He was hired onto an environmental project as a consultant. The state of Florida had finally passed a regulation that would require a zone of protection around wellheads. The state's minimum requirement is a 500-ft. radius around the well. The suburb he lives in has adopted more stringent measures. He was given a map showing several public wells from which drinking water is pumped. His task is to recommend a viable zone of protection and report any potential contamination hazards. Interestingly, the very area in which he lives is included on the map. He is familiar with a large land development that has been in construction for two years. His neighbor has told him many details as he is the construction foreman. The massive construction effort has provided 200 jobs. Jay decides to meet with a company representative. They discuss the scope of the project. To his dismay, he discovers that the final two years of the company's project involve developing land directly over the aquifer within the state's minimum protection zone from the well. The land developers purchased the land at high cost before the state laws were passed. The company has invested millions in pre-development and will not respond positively to any attempt to block the contract. They have plenty of resources to fight a legal battle against the state. Jay's uncle calls him for advice on a leaking UST (underground storage tank). He thought to call Jay because Jay knows about environmental issues. His uncle cannot afford to have the tank dug up and replaced; it would bankrupt his small business. Jay has no idea what to tell his uncle except that the leaking gasoline is a serious threat to groundwater. Jay's uncle laments that he has owned the station for 30 years and would have no income without it. As if Jay didn't have enough to think about, he realizes that his uncle's gas station is also located above the aquifer.

1. What do you think is Jay's primary responsibility as an environmental professional?

2. Does Jay have a responsibility to his uncle?

3. Are the construction workers Jay's problem?

4. Should he be worrying about the drinking water in his own region?

5. Should the above concerns affect Jay's recommendations to the state about the wellhead protection for that particular aquifer? If so, in what way?

ETHICS

As part of this lesson, the instructor may wish to include a brief discussion on ethics. The environmental industry is dependent on ethical decision making. For an intensive treatment of this issue, Michael Josephson's *Making Ethical Decisions* (1993) is perfect. In *Making Ethical Decisions*, Josephson describes "The Six Pillars of Character: (1) Trustworthiness, (2) Respect, (3) Responsibility, (4) Justice and Fairness, (5) Caring, (6) Civic Virtue and Citizenship."[1] Most students of this age will be surprised to learn that acting with "Caring" (being sensitive to human suffering such as job loss and family distress) is an integral part of the decision-making process at the professional level. The teacher will most likely find that the majority of the class will choose extreme action in one direction or the other. The middle road seems a taboo place to choose; yet, in reality, it is often the only reasonable one. With the added responsibility of ethics, students will find achieving that "balance" between the economy and environment a less bitter pill to swallow. It may be most effective for the ethics treatment to follow the exercise. Since the "balance" method gives them a standard to shoot for, students should then have the opportunity to reconsider their answers.

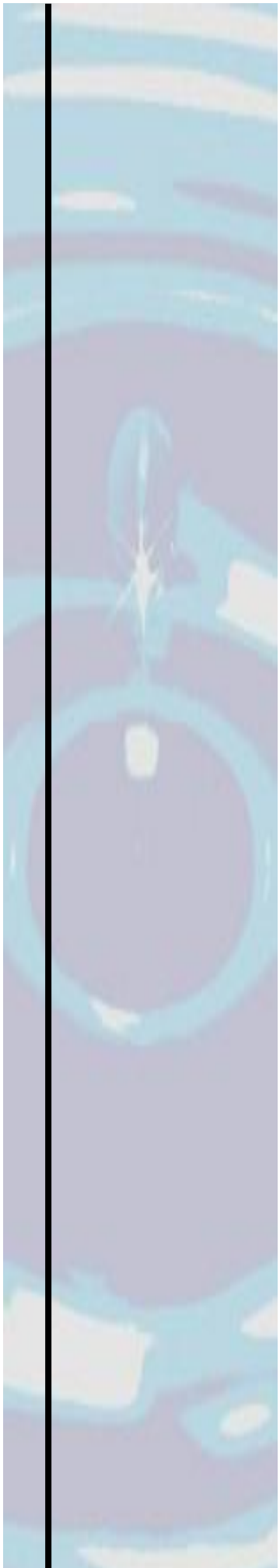
Here is a closure to share with students after they have completed the activity:

Reality will be frustrating for the generation who has grown up learning to accept environmental responsibility. The following recount is simplified, but factual, and is a real life example of the middle road. It should not be discouraging but enlightening. Sometimes when it is impossible to kill the dragon, be satisfied with knocking a chink out of its armor.... progress is progress is progress!

[1] Josephson, Michael, *"Making Ethical Decisions in Environmental Practice*," Environmental Manager, Vol. 1, July 1993.

CONCLUSION

There are many different options that Jay might choose. He always has the option of consulting with other professionals if he has run into an ethical snag. Generally, they will be objective and a good source for ideas. In dealing with land development, companies have to comply with many regulations today and often have a representative or department that handles that aspect. Jay may opt to call a meeting with this individual or group of individuals and call attention to the aquifer's vulnerability. Accomplished in a non-accusing diplomatic way, he may be able to convince the developers to choose double-walled, lined, or anodized septic tanks in order to head off future liability. While the threat to the aquifer is still apparent, it can be greatly reduced. The state may even be able to buy back a portion of the land. However, it is doubtful that the company would relent their construction. In fact, Jay may have to recommend a compromise or advise the department that they will probably be sued. Jay's uncle may have some help in dealing with his gasoline leaks. If he is in compliance with other state and federal regulations for underground storage tanks, he may be eligible to receive assistance from



Florida's leaking UST trust fund. Available in most states, these funds allow small business owners of USTs to receive assistance in cleaning up leaks. The money for these funds usually comes from a tax on gasoline. The sites chosen to receive cleanup funds are based upon how large the risk is to human health or the environment. Since Jay's uncle's tank is located in an area above a drinking water aquifer, there is a good chance that his cleanup will be funded.
In Florida, as previously discussed, there is a tremendous need for wellhead protection. In 1980, the Florida Department of Environmental Protection (FDEP) began fighting for wellhead protection. FDEP was promptly sued by large industrial corporations that had almost unlimited legal resources. The suit was in court for almost 15 years. FDEP was forced to accept compromise, a middle-of-the-road decision, by the judge. They achieved the stipulation of a circular buffer zone 500 feet in diameter.
Of course, this circular zone has no basis either geologically or hydrologically. Most aquifers are oddly shaped and miles in length or width. FDEP officials wanted to model individual aquifers and tailor the needed buffer zones. What good does it do to have a 500-foot circle of protective zone and a five-mile long cigar-shaped aquifer? It seems nonsensical, but the FDEP rejoiced. They now have buffer zones. Before May 1994, they had none. Perhaps they should have agreed to a compromise years earlier and started gathering data for the next fight.