

# A Grave Mistake

## **B Grade Level:**

Middle School, High School

- **Subject Areas:**

Environmental Science, History, Earth Science

- **Duration:**

Preparation Time: 30 minutes

Activity Time: 50 minutes

- **Setting:**

Classroom

- **Skills:**

Organizing (plotting); Interpreting (drawing conclusions); Analyzing

- **Charting the Course**

In "Get the Ground Water Picture," students investigate the porosity and permeability of soil and learn about ground water systems. Students should participate in "The Pucker Effect" to understand how contaminants move underground and how testing is conducted. Students can learn how water spreads disease in "Poison Pump," "No Bellyachers," and "Super Sleuths."

- **Vocabulary:**

Ground water

---

*A few members of your community appear to have contracted a similar illness. The community is blaming a local factory for contaminating the ground water. Could the community be making a grave mistake?*

## **Summary**

Students analyze data to solve a mystery and identify a potential polluter.

## **Objectives**

Students will:

- Analyze data to trace the flow of contaminants in ground water.
- Conclude that past solutions, developed with the best of intentions, may create contemporary problems.

## **Materials**

- Glass baking dish or clear plastic lid from a salad container used by fast-food restaurants
- Sand
- Grape-flavored drink powder
- Spray bottle
- Sharp pencils
- Copies of the **Community Map**

## **Making Connections**

Too often, when trying to solve a problem quickly, people jump to the wrong conclusion. All data must be considered before making a decision about an issue. By investigating a mystery, students learn that the most obvious solution to a problem is not always the correct one.

## **Background**

Arsenic, a naturally occurring chemical element, is currently used primarily in the production of pesticides and wood preservatives. In some areas, levels of arsenic are increasing in ground water because of seepage from hazardous waste sites. In the past, arsenic compounds were used for the treatment of certain diseases. This practice has been discontinued because of an awareness of arsenic's negative effects and because of the development of safer drugs.

Throughout the world, arsenic in ground water often comes from natural sources such as bedrock. The highest natural concentrations of arsenic in the United States are found in the Southwest, the Northwest, Alaska, and other areas near geothermal activity. Arsenical pesticide runoff also produces elevated arsenic levels in ground water.

However, another potential source of ground water contamination by arsenic is cemeteries! From 1880 to about 1910, arsenic was widely used as an embalming fluid. During the American Civil War, a physician developed an embalming fluid that preserved the bodies of thousands of dead soldiers for their long journey home; arsenic was a major ingredient. Because the only alternative was to use ice, this fluid was considered a major advancement and was soon adopted throughout the country. Of course, people in the late 1800s did not recognize the significance of concentrating large amounts of arsenic in a particular area such as a cemetery.

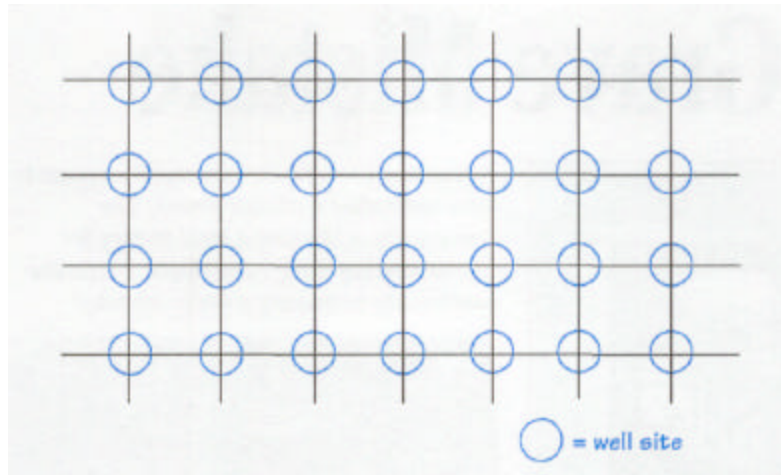
During this period, people were buried in wooden coffins or metal containers that degraded over time. Arsenic, a basic element, does not degrade. As water moves downward through the soils of cemeteries, it can carry arsenic through the ground water. Therefore, the potential exists for ground water contamination by arsenic in areas near cemeteries where burials were conducted from 1880 to 1910.

Arsenic poisoning may be either acute or chronic. Acute poisoning occurs when a person ingests a large quantity of arsenic at one time. This condition is characterized by vomiting and diarrhea, and may lead to shock, coma, and even death. Chronic poisoning occurs over a longer period of time.

Symptoms of chronic poisoning include skin lesions that are noncancerous and tingling, and numbness of the soles and palms that develops into a painful condition called neuritis. With neuritis, reflexes in the extremities may be impaired and even lost. Upon identification and treatment of the condition, the patient generally recovers within months—although recovery is not always complete.

By sampling well water, we can assess changes in ground water quality or quantity. This is accomplished either by drilling wells specifically to secure water quality data or by sampling existing wells (e.g., city wells, individual domestic wells, irrigation wells, and stock wells). Hydrologists need ample sampling sites (wells) when investigating an area's ground water to ensure accurate results.

The exact number of wells needed to obtain reliable coverage and data is determined on a case-by-case basis. A grid pattern of wells produces excellent results. With a grid pattern, not only can cross sections be created, but also a more thorough (three-dimensional) picture of ground water systems (aquifers) can be mapped. The grid below shows the ideal situation, but, in reality, the expense of well drilling usually prohibits a perfect grid.



Monitoring a well over time allows hydrologists to observe changes in water quality and quantity. Water managers make use of the record of these changes when managing ground water systems.

## Procedure

### Warm Up

Draw a diagram similar to the one below on the board.

Ask students: If family members living in this house find nitrates in their drinking water (which comes from a well), where should they look for the source of the contaminant? (Animal wastes are a common source of nitrates.)



To illustrate how a contaminant moves with ground water you can demonstrate a plume. (A plume is a continuous emission from a point source of contamination that has a starting point and a noticeable pathway. Contamination plumes can

spread thousands of feet from a source and may persist for many years even after the contaminant is removed.)

Fill a glass baking dish with sand about 1 inch (2.5 cm) deep. Bury grape-flavored drinking powder at one end of the dish. Elevate that end of the pan 1 ½ inches (3.75 cm). Using the spray bottle, thoroughly wet the sand. (This may require up to five minutes of misting.) Hold the container so that students can see the bottom. Ask them what conditions might have promoted this particular plume formation.

### **The Activity**

1. Present students with the scenario below:

You are a physician in a small community (about 1,000 residents). Yours is an old family in this area; your great-great-grandfather settled here in the 1800s and was a famous officer in the Civil War. Several members of your family are buried in the local cemetery.

Over the past couple of years a few members of the community have described to you their puzzling physical symptoms. Recently, a patient presented you with similar but more-serious complaints: weakness, tingling and numbness in his hands and feet, and dark warts on the palms of his hands and the soles of his feet.

You listen carefully as your patient responds to questions related to his medical history. He works in the small, local factory (Private Well #6, on the *Community Map*) that produces wood preservatives. He has lived in the area for about ten years. He and his wife of ten months have a private well at their home. His wife has not exhibited similar symptoms. He quit smoking three years ago and does not drink alcoholic beverages. He takes no medications, only vitamins.

You meet with members of the town council and express your suspicions - that the symptoms you have documented over the last few years are related to chronic arsenic poisoning from contaminated drinking water. You advise them that the accepted level of arsenic in drinking water is 50 parts per billion (ppb). The town council votes to budget money for ground water testing that will initially be limited to wells already in existence.

2. Distribute copies of the *Community Map* with contamination level data (*Data Set 1*). Identify the top right-hand corner of the map as the point of highest elevation and the low spot as the bottom left-hand corner.
3. Have students indicate the direction ground water will move. Explain that the contamination data were collected via tests conducted at existing wells – abandoned, private, and city wells.
4. Instruct students to begin on the southern border of the map (the bottom) and plot contamination levels from the bottom of the map to the top. As soon as they believe they know the source of the arsenic, they should stop

plotting data and alert the teacher. (Tell students that this is a race against time; they are competing to be the first to identify the polluter.)

5. Once consensus is reached (they will probably think Factory B is to blame), divide students into groups and ask them to discuss and write summary responses to the following questions:
  - What should you town do with this information?
  - What options should the factory be given?
  - This factory is a major employer of people in your community. Will this situation affect your discussions with factory owners?
6. Have groups share their answers with the rest of the class.
7. Announce to the class that the factory owner was contacted by the mayor, and she has proven that her operation is not responsible for the arsenic contamination. All arsenic coming into and leaving the factory has been accounted for.
8. Ask students what should be done. Students may conclude that they had insufficient data. Inform students that the city has budgeted additional funds and has commissioned a water quality testing agency to locate the source. This agency drilled test wells to confirm whether or not the factory was the source. Since the factory has accounted for all of its arsenic, other sites need to be tested.
9. Tell students that each group represents a water quality testing agency. The goal is to see which group can locate the source of the arsenic first.
10. Refer students to the borders of the map, explaining how magnitudes (letters and numbers) can be used to plot coordinates on the map. Tell them that at each coordinate a test well is drilled.
11. Tell them you will supply the data (*Data Set 2*) for each coordinate they select on the map (e.g., B10, E8, I12). They should send one representative to you with a chosen coordinate. If the coordinate is not available, have students request a different one. After the student receives the information, he or she returns to the group and helps plot the data. After each reading, students should determine whether or not they need more data. They can request readings for more wells, but only one at a time. The groups work independently of each other, keeping their results secret until they think they have identified the source.
12. Students will identify high arsenic concentrations north of the factory. They should find the highest levels of contamination just south of the cemetery. Discuss other possible sources of the arsenic plume. Ask students if the cemetery could be the cause. Share with students information about embalming techniques between 1880 and 1910.

## **Wrap Up**

Discuss what community members should do now that the source of contamination has been identified. Have students consider special problems associated with issues surrounding cemeteries (e.g., disturbing grave sites).

Ask students how the following comment applies to this situation: "Past solutions sometimes become present problems." Can they think of any other examples?

## **Assessment**

Have students:

- plot data to determine a source of arsenic contamination (steps 4 and 11).
- determine that insufficient data can lead to invalid conclusions (step 8).
- cite current examples that illustrate the idea: "Past solutions — present problems" (Wrap Up).

## **Extensions**

Again, share the medical history of the patient with students. Have students speculate on answers to the following questions:

Why didn't the patient's wife exhibit similar symptoms? (He had been drinking the water for 10 years; she had only been consuming it for 10 months.)

The physician maintained that he had seen a few similar cases. Why wasn't arsenic poisoning immediately identified as the cause? (Many physicians would be unaware of the association of these symptoms with arsenic poisoning. Also, several people might live in the same household and be drinking the same water, but they might not all develop symptoms at the same time. People's bodies react differently to toxins, and their habits vary. Perhaps the patient drank eight glasses of water every day, while his wife usually drank milk and fruit juice.)

Students who have experience drawing isolines can use them to organize the data. How do students think these isolines would correspond with contour lines?

Have students investigate the condition of ground water in their own community. Who is responsible for testing to ensure that drinking water is safe? Do students feel that sites or activities within their own community might be polluting ground water?

Students can visit a community cemetery and estimate the number of burials from 1880 to about 1910. Could this cemetery be a possible source of arsenic poisoning?

## **Resources**

Ingram, Colin. 1991. *The Drinking Water Book*. Berkeley, Calif.: Ten Speed Press.

Parfit, Michael. 1993. "Troubled Waters Run Deep." *National Geographic Special Edition* (November): 78-89. Photograph of ground water test wells on pp. 80-81.

Rail, Chester D. 1989. *Groundwater Contamination*. Lancaster, Pa.: Technomic Publishing Company, Inc.

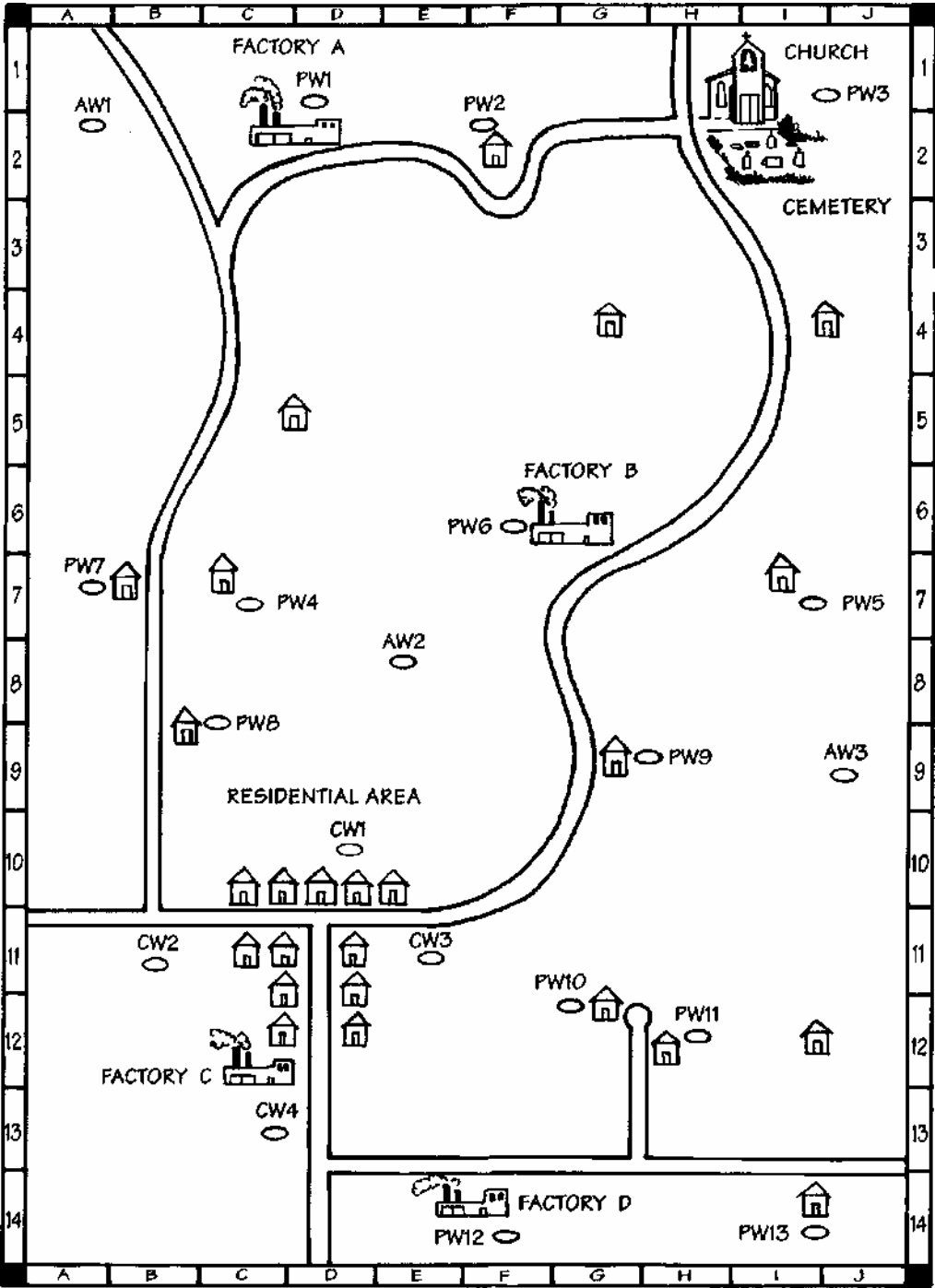
Stewart, John Gary. 1990. *Drinking Water Hazards*. Hiram, Ohio: Envirographics.

Williams, Melissa Johnson, and John L. Konefes. 1992. "Environmental Concerns of Older Burial Sites: The Use of Arsenic in Nineteenth Century Embalming Preparations." *American Cemetery* (February).

DATA SET II

B12	=	0
E12	=	0
G12	=	0
I12	=	0
B10	=	13
E10	=	20
G10	=	20
I10	=	18
B8	=	18
E8	=	38
G8	=	33
B6	=	15
E6	=	42
G6	=	61
I6	=	48
B4	=	6
E4	=	32
G4	=	65
I4	=	70
B2	=	0
E2	=	0
G2	=	0
I2	=	78

# Community Map





KEY:


AW# = ABANDONED WELL

PW# = PRIVATE WELL

CW# = CITY WELL

 = PRIVATE HOUSE

 = SITE OF WELL

 =FACTORY

Concentration of  
Contaminant  
(PPb)

DATA SET I

AW1 = 0

AW2 = 39

AW3 = 9

PW1=0

PW2=0

PW3=0

PW4 = 24

PW5 = 35

PW6 = 54

PW7=12

PW8 = 21

PW9 = 30

PW10 = 12

PW11 = 3

PW12 = 0

PW13 = 0

CW1 = 22.5

CW2 = 6

CW3 = 15

CW4=0

DATA SET II  
(provided by  
teacher)