BACKGROUND ACTIVITY 8

Hydroville, USA

SOIL PERMEABILITY

(Adapted from: Soil Permeability. *Fuel Site Quandary.* Texas Learning Technology Group. 1995. Pages 66–70.)

Description:

Students will investigate how soil types differ in permeability.

Rationale:

During the Hydroville Pesticide Spill Scenario, the soil scientists will calculate the rate at which the pesticide is moving through the soil.

Purpose/Goals:

Students will be able to:

- determine how rapidly water flows though various types of soil
- relate permeability to soil type and particle size

Prerequisites:

Background Activity 7: *Soil Texture*
(Activities 7 and 8 can be combined and run together.)

Time Estimate:

Prep: 40 minutes

Activity time: One or two 50-minute periods (some soils take much longer than others for the water to permeate)

Materials:

- ☐ Two 250 mL beakers
- ☐ Marbles
- ☐ Sand
- ☐ 300 grams of powdered clay (Ball Clay Kentucky – OM4)
- ☐ Buckets for disposal of wastewater and soil

Each Student:

- ☐ Hydroville Science Journal

Each Group of Two or Three Students:

- ☐ One soil column
- ☐ Four basket-style coffee filters
- ☐ Masking tape or duct tape
- ☐ One 800 or 1,000 mL beaker
- ☐ One 250 mL graduated cylinder
- ☐ Stand with 4" ring
- ☐ 300 grams of coarse sand (Industrial Quartz – 20 mesh)
- ☐ 300 grams of "silt" (Industrial Quartz – 70 mesh)
- ☐ Balance
- ☐ Non-permanent marker
- ☐ Stopwatch or wall clock with a second hand

Pages to Photocopy:

One copy/group:

- Instructions: *Soil Permeability*

One copy/student:

- Worksheet: *Soil Permeability*

Teamwork Skill:

- Stay on task with your group.

Terminology:

Impermeable	Saturated
Permeability	Soil porosity
Pore space	Water-holding capacity

Background Information:

Soil Porosity

Soil texture affects many other properties such as structure, chemistry, and most notably, soil porosity, and soil permeability. *Soil porosity* refers to the amount of *pore space*, or volume of open space between soil particles. It is a measure of how much of the soil is made up of pore space (air) as opposed to solid materials. Some of this pore space may be filled with water, so the amount of water a soil can hold is partly determined by its porosity.

Pores are created by the contacts made between irregular-shaped soil particles. Fine-textured soil has more pore space than coarse-textured soils because more of the small particles can be packed into a unit volume. More particles in a unit volume allow more contacts between the irregular-shaped surfaces, and hence more pore space. As a result, fine-textured clay soils have a higher *water-holding capacity* than coarse-textured sandy soils.

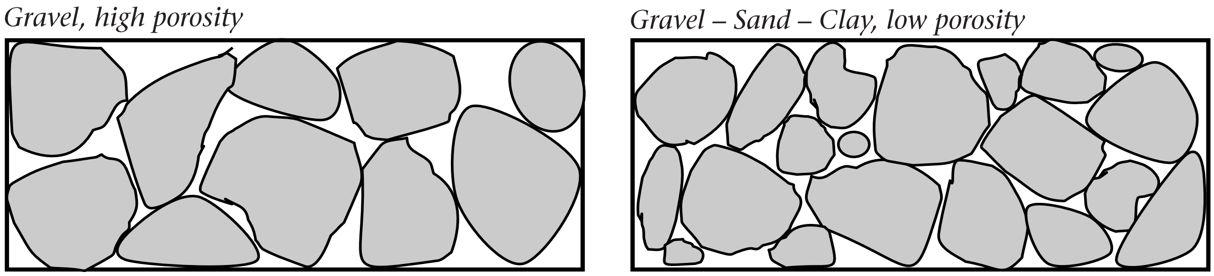


Figure 1. Different Rock Types Have Different Levels of Porosity

Soil Permeability

Soil permeability refers to the rate at which water and air move through subsoil (above 36 inches). Soil texture, density, particle size, and structure determine the permeability of a soil. Soils composed of large regular particles, such as gravel or sand, have large pore spaces between soil particles. Therefore, there is very little restriction of air and water movement resulting in a high permeability rate. A highly permeable soil is one in which water runs through it quite readily, and is not a desirable soil for agriculture but would be suitable for uses where adequate drainage is required.

Dense, heavy clay soils consist of small particles with very few visible pore spaces. These soils compact and form hard pans or clay skins, which are *impermeable* and do not allow water or air to move through it. This structure acts as a barrier to the passage of water, which means there is a very slow permeability. Water may stand on the surface or roots become waterlogged because of poor drainage. *Saturated* soils also have poor permeability since the pore spaces are full of water and cannot hold any more moisture.

Silt and loam have adequate pore space with moderate permeability. Water and air movement is good, and clay skins are absent. Plant roots are abundant and penetrate easily through the soil.

Ideal Soil Conditions

A good soil for growing plants contains about 50% solids (minerals, nutrients, organic matter) and 50% air space (for air and water retention and movement). The soil particles should be a mixture of sand, silt, and clay in a relative proportion: 40% sand, 40% silt, and 20% clay. This mixture of minerals is called loam and is preferred for agriculture. This combination of sand, silt, and clay gives the ideal pore space between particles, which provides the maximum water-hold capacity when mixed with organic matter.

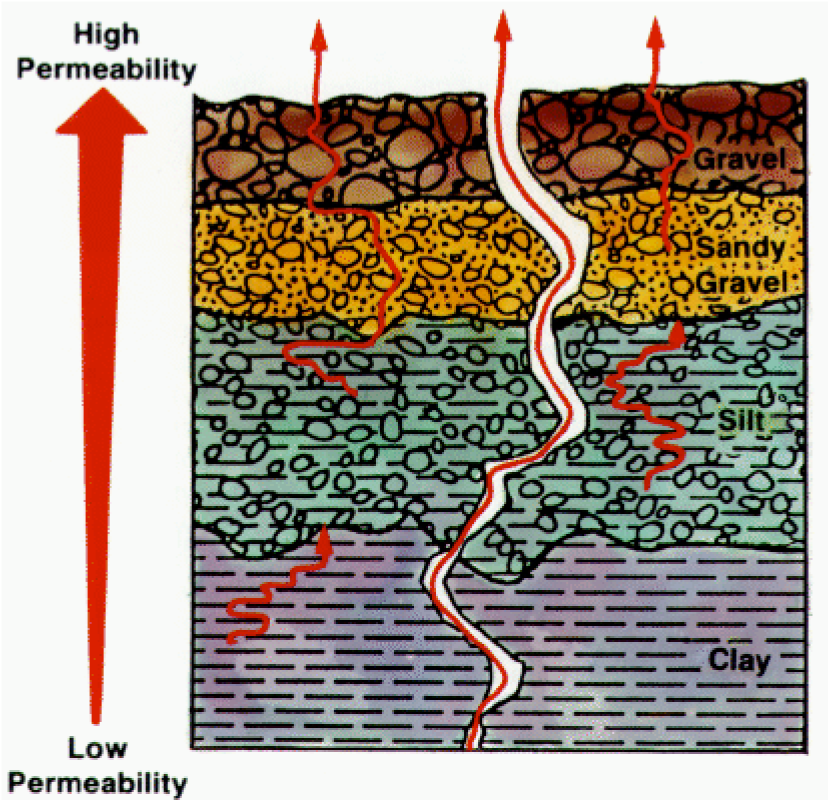


Figure 2. Soil Permeability of Various Soils

The amount of organic matter in soil also affects soil permeability. As organic matter fills in the pore space between coarse-textured soil particles, more water may be retained, thereby increasing the water-holding capacity of sandy soils. In fine-textured soils, the organic matter inhibits the small clay particles from compacting by getting in between the minute pore spaces. When this occurs, the soil permeability rate increases and the water-holding capacity of the soil decreases. Usually, the darker the color of the soil, the higher the organic content and the more water the soil is able to hold. Soil that has a high organic content is capable of absorbing materials such as oils, gasoline, and diesel fuel.

Some plants, such as rice or wetland vegetation, require more water than air in the soil spaces. Soils that are used for building roads or foundations need more air than water. Therefore, it is important for soil scientists to measure the rate of permeability to determine land use.

Suggested Lesson Plan:

Getting Started

1. Purchase 4" diameter, thin-walled PVC pipe from a building or plumbing supply store to make the soil columns used in the soil permeability test. If you buy a 6-foot length, you can cut it into 10 6-inch sections to make 10 soil columns. Plumbing contractors will often cut and donate sections of PVC pipe from their scrap materials.

2. Set up a soil column to test the soil permeability of clay as a class demonstration. (See student Instructions.) Pre-moisten (saturate) the clay the day before the actual test. Measure 300 grams of clay and place into the soil column. Pour 200 mL of water over the soil. Let stand overnight.

3. Display two glass beakers in the front of the class, labeled “Soil A” and “Soil B.” In the Soil A beaker, fill half the beaker with marbles. Fill the other beaker with the same amount of sand.

4. **Journal Prompt:** “Look at the two beakers. Soil A is filled with marbles and Soil B contains sand. Both samples are dry. Answer the following questions based on your observations and background knowledge:”

   a. Which soil has larger particles? *Soil A*

   b. Which soil has larger pore spaces? *Soil A*

   c. If you put Soil A and Soil B into separate funnels and poured the same amount of water into each funnel, which one would have a better water-holding capacity (hold more water)? Explain your answer.
   Soil B, because the particles are smaller and there are more pore spaces, which allows the soil to hold more water.

   d. How could you improve the water-holding capacity of Soil A?
   Add Soil B or organic matter to Soil A to fill in the pore spaces so it would be able to improve its water-holding capacity.

Doing the Activity

1. **Soil Permeability Demonstration:** Start at the beginning of class.

   a. Ask a student to start timing as soon as you pour 200 mL of water into the saturated clay.

   b. Write the starting time on the board.

   c. Check the water level in the clay permeability test periodically throughout the class period.

   d. Stop timing when 100 mL of water is collected in the beaker.

   e. Record the ending time on the board. This is the clay permeability rate for the class. (If the water has not reached the 100 mL mark on the beaker by the time class is completed, record greater than (>) the elapsed time.)

   f. *There will be only one trial for clay unless you repeat the test in other classes.*

2. Students work in groups of two or three. Each group will test the permeability of sand, and then silt. The permeability testing for clay will be done as a class demonstration.

3. Review Instructions for *Soil Column Setup* and *Soil Permeability Testing* with students. Each group will conduct three trials and average the permeability rate of both sand and silt.

4. Tell students to smooth the surface of the soil after each trial, for more accurate results.

5. Remind students **not to throw the soil or filtered water down the sink.** Have students pour soil solutions into a bucket until it can be poured outside. They can dispose of filters and soil in normal trash can (or compost).

Classroom Hints:

- A 4-inch ring or larger will hold the soil column steady. If smaller rings are used, students may have to hold the soil column while the water is poured.
- Students can test soil permeability of other soils from around school, their homes, or from a garden supply store. You may want to test the soil before the lab to ensure the test is completed in the time allotted.
- Allow extra time (about 30 minutes) if testing fine-textured soils.
- Let some groups test the permeability rate of other liquids besides water to simulate an oil spill. Vegetable oil or an oil-water mixture can be used.

Wrap-up

1. Record each group's average permeability rate for sand and silt on the board. Students add this data to Table 3 on the Worksheet, and then calculate the class average for each soil. Sand should have the highest permeability rate and clay should have the lowest. As a class, discuss reasons for any variations in the results.
2. Soil permeability rates will vary based on the amount of soil used, if it is compacted, or the technique used to pour water onto the soil. This is an opportunity to discuss experimental error and reasons for multiple trials.
3. Assign Conclusion Questions for homework.
4. **Journal Prompt:** If a diesel truck overturned and spilled fuel onto the ground, explain what would happen to the fuel in the soil.
   Answer: Several things can happen to fuel that is spilled on soil. It may run off, soak in, or both. What happens depends upon the type of soil. The fuel that soaks in may move almost straight down through the soil very rapidly, or impermeable soils may block it so that it moves downward very slowly. Fuel that moves straight down through permeable soil may contaminate the groundwater and get into drinking water supplies. The organic content of soil can significantly alter its capacity to absorb spilled substances. Soil that is high in organic content may absorb most or all of the spilled fuel. Oil and fuel would pass most readily through coarse-grained soils with low organic content.

Assessment (Journal Prompt or Class Quiz):

1. "A fuel spill occurs on sandy soil with a shallow water table (that is, the level of the groundwater that is tapped for drinking water is not far below the surface). Should the public be concerned? Why or why not?"
   Since the soil is very permeable and has a low organic content, it will absorb little fuel. There is a great danger of the spill getting into the groundwater and from there into the drinking water.

2. "Under what conditions would a soil with lots of pore space still be impermeable? Draw a picture to illustrate your answer."
   It may be possible for a soil to have unconnected pore spaces similar to closed cell foam. This might occur if sand grains have been cemented together. Some limestone rock is very porous, but impermeable to water because the pores are not connected.

Extensions:

Science

Design and test a method for determining soil permeability in a natural environment.

Social Studies

1. Students can locate and research major flood events in the U.S. and around the world in the 20^{th} century. Students can then research the soil permeability of these flood areas and correlate the severity of the flooding to the soil type.

2. Students can also trace the growth of western agriculture as it relates to dam building (for example, the Colorado and Columbia rivers). Why was flood control a priority during the era of large dam building? How was agriculture made more viable in relation to the dam building? How have farmers adapted practices to their newfound stable water source?

Language Arts

Have students read "Atop the Mound" from *PrairyErth: A Deep Map* (1992) by William Least Heat-Moon (1939–). Introduce the reading by locating the area of this excerpt: Chase County in the Flint Hills of central Kansas. The following are various options for using this reading in a language arts activity. The questions can be answered as a class discussion or in a writing assignment.

1. Students should keep a list of new words encountered in the reading and then define these words.

2. Have you ever been drawn to a distant rock, mountain, or hill? Where were you? Describe the incident.

3. Can you recall a time when your hike seemed to draw on endlessly, the end appearing almost an illusion? The author describes his method of managing this experience with the distant mound. How have you plodded along during a long hike?
4. Least Heat-Moon describes the sensation of sitting and looking out to the world from the mound. Write a descriptive paragraph or two based on a time when you were perched on a hill or rise and surveyed the country and people below and beyond. Imitate the author's style of concrete images: "trucks inching out the turnpike miles, the turbulence of their passage silenced by distance…fence lines, transmission towers, and dug ponds." Include the unexpected detail as well, such as the author's "insects."
5. In the second-to-final paragraph, he describes the soil as dark and granular. What type of soil would exist on the vast prairies of Kansas? What would cause the soil to be dark and granular? In what ways are past tribes and early pioneers intimately connected to the land and the soil? What has changed in regard to our current sense of connection? What does the author want us to think about this "erosional ellipse"?
6. Do you know of a tribal sacred place in your county? Describe it. If not, is there a place that honors pioneers in your area? A park? A graveyard? Visit the site with your journal, spend an hour there, looking, listening, sensing, and writing about it. From your notes, write two to three paragraphs, describing and musing about the place.

Resources:

- Resources on soils and soil testing can be found on the GLOBE Program Web site.
- University Extension offices are excellent sources of information and many have groundwater models that teachers can borrow.
- Heat-Moon, William Least. *PrairyErth (A Deep Map): An Epic History of the Tallgrass Prairie Country,* Houghton Mifflin Co., 1991.
- See the Hydroville Web site for links to Web resources for this activity at http://www.hydroville.org/links/ps_resources.aspx.

Teacher Key

Worksheet

Note: The permeability rates for sand and silts in Tables 1 and 2 will vary for each group. Permeability rates will depend upon how well the students followed the instructions. The data in Table 3 are examples of relative permeability rates for each soil. Your class results may be significantly different from these.

Table 3. Soil Permeability Rate Test for Class

	Average Permeability Rate (seconds)		
Group Data	**Sand**	**Silt**	**Clay (demonstration)**
Group 1	*6*	*33*	*>600*
Group 2	*6*	*40*	
Group 3	*8*	*32*	
Group 4			
Group 5			
Group 6			
Group 7			
Group 8			
Group 9			
Group 10			
Class Average (seconds)	*6.7*	*35*	*>600*

Conclusion Questions

1. Which soil had the fastest permeability rate? Explain why this occurred by relating your answer to particle size and pore space.
   Sand has the fastest permeability rate because it has large particles and large pore spaces.
2. Which soil had the slowest permeability rate? Explain why this occurred by relating your answer to particle size and pore space.
   Clay has the slowest permeability rate because it has small particles and small pore space.
3. Using the *Soil Texture Triangle*, look at the composition of clay loam and silt loam. Which soil would have the faster permeability rate? Support your answer with data from your permeability test.
   Silt loam would have a faster permeability rate than clay loam because silt had an average permeability rate of 35 seconds and clay had a permeability rate of <360 seconds.
4. Which soil had the best water-holding capacity? What would you recommend this type of soil be used for (e.g., home building, farming, wetlands, landfills, etc.)?
   Clay has the best water-holding capacity, but clay soil would not be good for farming or home building because of its ability to retain water. It would be desirable for wetlands.

5. What combination of soil types would you recommend for agriculture? Include percentages of each soil type and reasons to support your answer.
A combination of 40% sand, 40% silt, and 20% clay (loam) would be good for agriculture. Sand breaks apart easily and does not clump. Clay and silt would fill in the pore space of the sand particles increasing the water-holding capacity.

Student Pages for

SOIL PERMEABILITY

Follow this Page

Soil Permeability

Introduction:

In this activity, you will measure the rate of soil permeability for sand, silt, and clay. *Soil permeability* refers to the rate at which water and air move through the soil. After the experiment, you will be able to answer questions like, "What soil type allows water to pass through the soil?" and "Which soil has a good water-holding capacity?" It is important for soil scientists to know the rate of permeability for soil to determine how the land can be best used: agriculture, buildings, landfills, wetlands, septic tank and drainage fields, etc.

Each group will test sand and silt that has been *saturated* (pre-moistened). The permeability testing for clay will be done as a class demonstration. Each group will conduct three trials and then average the permeability rate.

Materials:

Each Student:

- ☐ Hydroville Science Journal

Each Group of Two or Three Students:

- ☐ One soil column (4" diameter PVC pipe)
- ☐ Four basket-style coffee filters
- ☐ Masking tape or duct tape
- ☐ One 800 or 1,000 mL beaker
- ☐ One 250 mL graduated cylinder
- ☐ Stopwatch or a wall clock with a second hand
- ☐ Stand with 4" ring
- ☐ 300 grams of sand
- ☐ 300 grams of silt
- ☐ Balance
- ☐ Non-permanent marker

Part 1. Soil Column Setup

Procedure

1. Cover one end of a PVC pipe (soil column) with two basket-style coffee filters. Hold the filters in place. Tape over the edge of the coffee filters so they are securely fastened. *Be careful not to tear the filters.*
2. Measure 300 grams sand and add to the soil column. Flatten the surface of the soil.
3. Set the soil column onto the top of a ring stand. Place an 800 or 1,000 mL beaker on the base of the stand. Make sure it is directly underneath the soil column.

Instructions, Page 2

4. Measure 150 mL of water into a graduated cylinder and pour over the soil to pre-moisten (saturate) it.
5. Wait until all of the water has drained through the soil (when the water is no longer visible on the top of the soil and when the water has stopped dripping).
6. Remove the beaker and pour the water into a waste container designated by your teacher. Wipe of the beaker so it is clean and dry.

Part 2. Soil Permeability Testing

1. Measure 100 mL of water into a graduated cylinder and pour into the beaker. Mark the 100 mL level with a non-permanent marker on the beaker. *Do not use the graduations on your beaker.* Place the marked beaker under the soil column.
2. Measure 200 mL of water into a graduated cylinder.
3. When your lab partner begins timing, pour the water into the center of the soil in the column. *The permeability rate of sand may be very fast, so watch carefully.*
4. Stop timing when the water reaches the 100 mL mark on the beaker. Record starting and ending times in Table 1 on the worksheet.
5. Empty the beaker into the designated waste container when the rest of the water has permeated through the soil. *Do not pour water with soil into sinks.*
6. Record the permeability rate (in seconds) in Table 1.
7. Repeat steps 1–6 in Part 2 two more times, using the same soil. *Rinse and dry beaker and smooth out the surface of the soil before starting another trial.*
8. Calculate the average permeability rate for your soil based on three trials. Record in Table 1.
9. Discard soil and filter into designated waste container.
10. Repeat soil column setup and permeability test for silt. Record data in Table 2.

Part 3. Permeability Test for Clay (Demonstration)

1. Check the water level in the clay permeability test.
2. Record clay permeability rate in Table 3. If the water has not reached the 100 mL mark on the beaker by the time class is completed, record greater than (>) the elapsed time.
3. Write down the soil permeability averages for all of the groups in Table 3.
4. Answer Conclusion Questions on the student worksheet.

Worksheet

Name ______________________________

Date _________________ Period ______

Soil Permeability

Instructions:

Record the rate of permeability for the sand in Table 1 and for silt in Table 2. Share your average permeability rates with the class. Calculate the class average for each soil in Table 3.

Table 1. Soil Permeability Rate Test for Sand

Permeability Test	Starting Time	Ending Time	Permeability Rate (seconds)
Trial 1			
Trial 2			
Trial 3			
		Average Permeability Rate	

Table 2. Soil Permeability Rate Test for Silt

Permeability Test	Starting Time	Ending Time	Permeability Rate (seconds)
Trial 1			
Trial 2			
Trial 3			
		Average Permeability Rate	

Worksheet, Page 2

Name______________________________

Date__________________ Period______

Table 3. Soil Permeability Rate Test for Class

	Average Permeability Rate (seconds)		
Group Data	**Sand**	**Silt**	**Clay (demonstration)**
Group 1			
Group 2			
Group 3			
Group 4			
Group 5			
Group 6			
Group 7			
Group 8			
Group 9			
Group 10			
Class Average (seconds)			

Conclusion Questions:

1. Which soil had the fastest permeability rate? Explain why this occurred by relating your answer to particle size and pore space.

2. Which soil had the slowest permeability rate? Explain why this occurred by relating your answer to particle size and pore space.

Name_______________________________

Date__________________ Period_______

3. Using the *Soil Texture Triangle*, look at the composition of clay loam and silt loam. Which soil would have the faster permeability rate? Support your answer with data from your permeability test.

4. Which soil had the best water-holding capacity? What would you recommend this type of soil be used for (e.g., home building, farming, wetlands, landfills, etc.)?

5. What combination of soil types would you recommend for agriculture? Include percentages of each soil type and reasons to support your answer.

BACKGROUND ACTIVITY 9

Hydroville, USA

DECISION ANALYSIS

(Adapted from: V. Campbell, J. Lofstrom, and B. Jerome. *Decisions – Based on Science*. National Science Teachers Association. 1997. Pages 41–45.)

Description:

Students will develop a decision chart to analyze various elements of a decision.

Rationale:

In the Hydroville Pesticide Spill Scenario, the Southerville Enviro-Clean teams will use decision charts to prioritize a list of actions to clean up the pesticide spill site.

Purpose/Goals:

Students will be able to:

- develop a list of solutions or actions for a particular problem
- develop a list of stakeholders and their differing goals or criteria for evaluating the solutions
- use a decision chart to evaluate solutions or actions in light of stakeholders' specific goals
- see how decisions involve balancing costs, benefits, and personal values or preferences

Prerequisites:

None

Time Estimate:

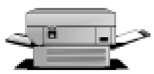
Prep: 20 minutes

Activity time: One 50-minute period

Materials:

- ☐ Hydroville Science Journal
- ☐ Overhead with list of actions for the spill generated by the class in “Welcome to Hydroville”
- ☐ Pesticide Spill Scenario Video

Pages to Photocopy:



- Two transparencies of *Decision Chart*

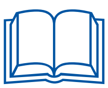
One copy/student of:

- Worksheet 1: *Decision Chart*
- Reading: *Cost/Benefit Analysis and Ethical Considerations* (optional)
- Worksheet 2: *What's the Big Idea?* (optional)

Teamwork Skill:

- Criticize ideas without criticizing people.

Terminology:



Cost/benefit analysis
Subjective vs objective
Risk assessment stakeholders

Background Information:

Decision Charts

Often decisions can have many solutions or actions based on different criteria or goals. Individuals involved in decision analysis use many tools to help make a well-thought-out choice. One of those tools is a *Decision Chart* (see Transparency).

A decision chart is used to resolve a problem or a question called a Problem Statement. A problem statement is written in the form of a question to describe the decision that needs to be made and generally starts with “what” or “how.” Problem statements should be constructed so that they require more than just a "yes" or "no" answer.

Across the top of the chart are listed all the possible goals, criteria, or standards for the decision. In order to generate all of the goals for a decision, you should first identify all of the possible stakeholders in the decision. Stakeholders are individuals or groups who have an interest in the decision and often have different criteria or standards that they want applied.

Down the left side of the chart are listed all of the solutions or actions that could be taken in the decision.

In the boxes formed by the intersection of the goal with the solution, ratings are placed for each solution of the goal stated. Often these ratings are based on statistical analysis, cost/benefit analysis, or risk assessment, but they can also be based on value judgments.

In this activity, students will not use a numerical rating system, but a three-part system based on "+" or "-":

a. "+" indicates that the action or solution meets the specific goal or criteria;

b. "n/a" indicates that the action or solution is not applicable and does not affect the goal or criteria;

c. "-" indicates that the action or solution does not meet the goal or criteria.

Suggested Lesson Plan:

Getting Started

Journal Prompt: "How do you make choices? When faced with the choice of going to a movie with your friends or doing your term project, how do you go about making that decision? How do you decide whether something is worth doing or not?"

Doing the Activity

1. Work through an example problem on a decision chart using the Transparency. You may have to use more than one transparency master if the class brainstorms many goals/criteria or actions/solutions. Use the following problem or have the class brainstorm a problem statement of their own:

    a. Problem Statement: "If your family were to go out for dinner tonight, where should they go out for dinner?"

    b. Discuss "Who are the stakeholders in this decision?" *Parents, children, friends, etc.*

    c. Goals/Criteria: Brainstorm possible goals or criteria for each stakeholder and list them across the top of the chart.
    (a) Children: *tastes good, fast, foods they like, etc.*

       (b) Parents: *low cost, healthy, filling, atmosphere, etc.*

    d. Solutions/Actions: Brainstorm multiple possibilities and write possible solutions in the rows down the left side of the chart. *These will be a list of local restaurants or other possibilities.*

    e. In each cell under "Goals/Criteria," have students agree on whether the action meets the goal (+), doesn't affect the goal (n/a), or doesn't meet the goal (-). Emphasize that these rankings are subjective but should be based on the best factual information available.

f. Look at the overall ratings on the decision chart for each solution/action and decide the best overall solution(s) or action(s) to the problem statement. (For example: In the Pesticide Spill Scenario, students will need to rank the actions they are likely to take to clean up the spill site and to protect human health, and then choose the best possible set of actions or solutions based on cost and risk management.)

2. Hand out a blank decision chart to each student.

   Show the list of actions generated by the class when they first viewed the Pesticide Spill Video. Have students write these actions down the left side of their Decision Chart. (If there are more actions than space provided on the chart, students can use a second chart or draw one on notebook paper or graph paper to have more space for actions or goals.)

3. What is the problem statement? *What actions should be taken to clean up the pesticide spill in Hydroville?*

4. Show the Pesticide Spill video again. Have students take notes on who the stakeholders are in this problem and what their goals or criteria might be.

5. Generate a class list of stakeholders and their goals or criteria for the cleanup. Students prioritize and write this list across the top of their chart. Some examples are:

   - *Insurance Company – cost, client relations, protecting humans and environment*
   - *Regulatory Agencies (DEQ, EPA, Department of Fish and Wildlife, City, Police, Department of Transportation) – follow state and federal rules, observe NOEL (No Observable Effects Level)*
   - *Property Owners – safe homes, clean water for irrigation, compensation for crop or animal loss, lost days of work, etc.*
   - *City of Hydroville – safe drinking water, fast cleanup, cost of follow-up testing of the water*
   - *General Public – reassurance that it is safe, open communication about spill and cleanup; fishing, boating, and swimming in Beaver Creek deemed safe*
   - *Soil Scientists – containing the pesticide at the spill site, ensuring removal of all of the pesticide from the spill site, etc.*
   - *Environmental Toxicologists – protecting human and environmental health, etc.*
   - *Mechanical Engineers – ensuring safety of cleanup crew, fast response and cleanup, etc.*
   - *Analytical Chemists – confirming that no pesticide is detected in Beaver Creek in the short or long term, etc.*

6. Working in pairs, assign students different roles and have them rank the actions with the goals from the perspective of this individual.

   Possible roles:

   - Hydroville high school senior
   - Retired community member who loves to fish
   - Hydroville City Council member
   - Farmer who lives near the spill site
   - Hydroville parent at home with two small children
   - Person working on the site cleanup
   - Add others that you might think of

7. Have groups of four compare their rankings to see if they differ or are the same. Have students explain to each other their choices of ranking.

8. **Students save these Decision Charts in their journals for reference when their teams begin the Data Synthesis section.**

Wrap-up

Journal Prompt: Why do you think ratings differ from one individual or stakeholder to another? When you made your rankings from the point of view of another person, were you making your decision based on fact or perception?

Assessment:

Have students develop Decision Charts, list stakeholders and their goals, and actions to be taken, and determine optimum solutions for one of the following problem statements:

- Which diet should I go on to lose weight? I want to lose 10 pounds by the prom in 2 weeks.
- Should students be allowed to go off campus during lunch or free periods?
- Topic of their choice from class-brainstormed list.

Extensions:

Language Arts/Social Studies/Science - Cost/Benefit Analysis and Ethical Considerations

1. Assign the article, *Cost/Benefit Analysis and Ethical Considerations,* to be read as homework. Students should underline or highlight important words and/or phrases.
2. In class, students to work with a partner to compare their initial understanding of the ideas in the writing.
3. Reconvene the class. Call on particular pairs of students to share their initial understanding of what they read, as well as share the words and/or phrases they underlined. Ask them to explain why they underlined certain words and/or phrases.
4. Have students work either with the same partner or with a new partner to write down what they think is the "big idea" of this essay. Use student worksheet, *What's the Big Idea?*
5. Once they have determined the "big idea," ask the students to narrow down their understanding of what they think is the most important point of this writing.
6. Then ask the student pairs the following question: "How do you know that's the most important idea?" Ask them to write down three examples or comments that support their assertion that this is the most important idea.
7. Call on various pairs of students to present and explain their answers, and their evidence for those answers, to the class.
8. Essay assignment: Write a reaction paper to the statement "How much is a human life worth?"

Language Arts/Social Studies/Science

Have students examine a local environmental or political issue and interview key people involved on various sides of the issue. Also, interview local citizens.

1. Have students develop a decision chart based on the views of one of the stakeholders they interviewed.
2. Have students work with a partner to co-author a front-page news article on this issue. Include several quotes from various people (300 words). Refer to your local newspaper for models of organization and style.

Resources:

- Project Learning Tree. *Exploring Environmental Issues: Focus on Risk*. American Forest Foundation. 1998.
- V. Campbell, J. Lofstrom, and B. Jerome. *Decisions Based on Science*. National Science Teachers Association. 1997.
- Environmental Response Television.
- See the Hydroville Web site for links to Web resources for this activity at http://www.hydroville.org/links/ps_resources.aspx.

Transparency

Decision Chart

Problem Statement:

Goals/Criteria

Solutions/Actions

Student Pages for

DECISION ANALYSIS

Follow this Page

Worksheet 1

Name________________________________

Date____________________ Period_______

Decision Chart

Problem Statement:

Goals/Criteria

Solutions/Actions								

Cost/Benefit Analysis and Ethical Considerations

Cost/benefit analysis is being used increasingly to help make decisions about reducing environmental risks. Some examples include decisions about removing asbestos from school buildings, cleaning up toxic waste sites, and chlorinating drinking water.

On first encounter, cost/benefit analysis appears to be a relatively simple, straight-forward, "matter-of-fact" aid to help people decide what to do about reducing environmental risks. By definition, a cost/benefit analysis entails calculating the costs (in monetary terms) associated with a particular action, projecting the expected benefits (in monetary terms) of that action, and comparing the two figures. On the one hand, if the benefits outweigh the costs, then that course of action is economically justified. On the other hand, if the costs outweigh the benefits, that course of action is not economically justified. The decision maker might look for an alternative course of action, might still choose to proceed with that option, or might decide not to take action at all.

For example, a few years ago, it was determined that too many people were getting head injuries as a result of falling off their bicycles. A cost/benefit analysis revealed that low-cost helmets could be made available that could help to prevent head injuries and could save millions of dollars in medical costs. Helmets could even help to save lives. Consequently, many communities across the nation decided to require people to wear helmets while riding bicycles. In this case, the decision to require helmets was rather obvious: The low costs of helmets (cost) were outweighed by the savings of millions of dollars in medical costs and by the prevention of injuries and deaths (benefits). Similar analyses were conducted regarding the costs and benefits of using air bags and seat belts in automobiles.

While cost/benefit analysis can be a very useful tool in the decision-making process, not all cases are as low-cost or as straightforward as requiring citizens to wear a helmet while bicycling. To be able to make valid cost/benefit judgments, a person must compare the costs and benefits while using the same measurement scale. In cost/benefit analysis, the measuring scale is usually in dollars. For example, if taking an action to save lives is going to cost $1 million, how many lives would have to be saved to be worth that investment? Or put very simply, how many lives are equivalent to $1 million? This question raises an important issue: How much is a human life worth? When the costs are low, as in the case of bicycle helmets and seat belts, the decision is easy. Most people would probably argue that if seat belts saved only a few lives a year (maybe only one life), the investment would still be worth it. But, when the costs start to get very high, tough questions are asked. Let's look at some of these more difficult types of problems.

Superfund Cleanup

The Superfund is a pool of money budgeted by the U.S. Environmental Protection Agency (U.S. EPA) to clean up toxic waste sites across the nation. Just about everyone agrees that toxic waste sites are dangerous to human health and the environment and that they should be cleaned up. On average, the U.S. EPA has been spending $6.1 billion a year on toxic waste cleanup. It has been estimated that approximately 500 cancer deaths a year are prevented because of this investment. Thus, if we use cost/benefit analysis, we find it has cost an average of $12.2 million for each life saved. Given the high cost of cleanup, the question frequently asked is how much should each site be cleaned up? Should every molecule of a toxic substance be cleaned up from a particular location? If it's not necessary to clean up every molecule of a toxic substance, then how much should be cleaned up, or how much is safe enough? To answer these questions, we must first ask questions that no one really wants to answer: How much is a human life worth? How much should we spend to save 500 people from dying of cancer as a result of being exposed to toxic wastes? Could the money spent on cleaning up toxic wastes be better spent elsewhere?

Reduced Environmental Risks

Other issues further complicate cost/benefit decisions when related to reducing environmental risk. There appears to be increasing evidence that sometimes when risks are reduced in one area, they increase in another area. Take, for example, the environmental goal of reducing air pollution by increasing the gas mileage in automobiles. To accomplish this goal, automobile makers would have to produce vehicles that are smaller and lighter. However, if cars are made smaller and lighter, they may be less safe. One could make a strong argument that smaller, lighter, and less-safe cars could result in more people being killed in automobile accidents. In fact, these less-safe cars might even eliminate all of the safety gains that have been achieved from the use of seat belts and air bags in cars. Thus, one might ask the question: Is reduced air pollution from cars worth more fatal accidents?

The answers to these questions are generally not found by examining the economics of the issue, but are instead related to ethical considerations of values, tradeoffs, and an equal distribution of the costs and benefits of the risk reduction action.

From: Project Learning Tree. Exploring Environmental Issues: Focus on Risk. American Forest Foundation. 1998. pp 86-87.

Worksheet 2

Name____________________________

Date________________ Period______

What's the Big Idea?

What's the Big Idea?

Narrow it down: What's the most important point?

How do you know that's the most important idea? Write three examples or comments that support your assertion that this is the most important idea. If they are quotes, include the page number so you can refer to it later when writing about or discussing this idea.

1. ____
____
2. ____
____
3. ____
____

BACKGROUND ACTIVITY 10

Hydroville, USA

SITING YORETOWN'S LANDFILL

(Adapted from: "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.)

Description:

Students will use a decision chart and siting criteria to rank four potential sites for a city landfill.

Rationale:

During the Hydroville Pesticide Spill Scenario, students will need to use a decision chart to analyze the various actions they could use to clean up the pesticide spill site.

Purpose/Goals:

Students will be able to:

- develop criteria for siting a city landfill
- use a decision chart to analyze the cost and benefit of each site in relationship to the siting criteria
- rank the four sites based on their decision chart analysis

Prerequisites:

Background Activity 7: *Soil Texture*
Background Activity 8: *Soil Permeability*
Background Activity 9: *Decision Analysis*

Time Estimate:

Prep: 20 minutes

Activity: Two 50-minute periods

Materials:

- ☐ Hydroville Science Journal
- ☐ Rulers

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Pages to Photocopy:

One copy/student:

- Instructions: *Siting Yoretown's Landfill*

One copy/group of three to four students:

- Map of Yoretown and Buckeye County
- Transparency of *Topography of Terrain*
- Worksheet 1: *Site Evaluation Sheets for Sites A, B, C, and D*
- Worksheet 2: *Landfill Site Comparison*
- Worksheet 3: *Decision Chart*

Teamwork Skills:

- Ask for justification for team member's conclusion or answer.
- Integrate a number of different ideas into a single position.

Terminology:

Topography	Groundwater	Bedrock
Leachate	Landfill	Terrain
Aquifer	Landfill liner	Public service announcement (PSA)

Background Information:

Read *Siting Yoretown's Landfill Information Sheet* along with the students.

Suggested Lesson Plan:

Getting Started

1. **Journal Prompt:** "What information would you need to approve the siting of a landfill in your town?"
2. **Classroom Hints:**
   - Make overheads of the topographic map for each team. Have teams build a 3D model of the contours.
   - Organize background discussion and activities on reading topographic maps, covering slope and scale.
   - Hold an initial discussion about what a city must consider before building a public facility such as a landfill.
   - Brainstorm about siting something in the local area such as a skate park, mall, dance club. What interests and regulations would have to be considered?

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

- Work through site A as a class and then have the teams do the rest of the sites on their own.

Doing the Activity

1. Students should be organized into groups of four. Each team should have a copy of the *Map of Yoretown and Buckeye County* and a transparency of *Topography of Terrain* (so that they can place it over the Yoretown map). Hand out the Instructions, copies of each of the four site evaluation sheets, Worksheet 1, and Worksheet 2.
2. As a class, review the *Criteria for Evaluation* on the Instructions before starting.
3. Group members divide up Worksheet 1 so that each member evaluates a different site. A group recorder writes the evaluations onto Worksheet 2: *Landfill Site Comparison*.
4. The group then uses Worksheet 2 to rank the four sites on the decision chart on Worksheet 3.

Wrap-up

1. Have each group place their rankings on the board or overhead under the letters for the site. Do all of the groups agree? If not, have groups defend their order. See if the class can reach consensus on the order. There are pros and cons to all four sites, although two are preferable over the others. Assessment of team responses should be based on the persuasiveness of the student presentations, which should be based upon the facts that they have collected about each site.
2. Hold a mock town meeting. Have teams who have chosen different sites as their first choice present their findings to the town council (the rest of the class) and have the class vote.

Assessment:

As a member of the technical advisory council, you will need to write a public service announcement (PSA) to advertise the council's site selection to the citizens of Yoretown.

Extensions:

Social Studies/Language Arts

1. Have students visit the local landfill. Using the criteria in this scenario, how would they assess the location of the landfill?
2. In teams of three or four, write a 5- to 10-minute skit and then perform it for the class.

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

3. Based on the Yoretown's Landfill scenario, write a script about a city council meeting where irate local citizens, who have just learned that their neighborhood has been chosen for the new landfill site, testify. Based on typical NIMBY (Not In My Back Yard) arguments, script these folks with their frustrations, concerns, and anger. How can you, the members of the city council, persuade them that their neighborhood is the best alternative for Yoretown?

Resources:

- *Investigating Solid Waste Issues*, produced by the Ohio Department of Natural Resources, is available through the Ohio Department of Natural Resources.
- How Landfills Work.
- Landfills: Hazardous to the Environment.
- See the Hydroville Web site for links to Web resources for this activity at http://www.hydroville.org/links/ps_resources.aspx.

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Teacher Key

Worksheet 2. Landfill Site Comparison

Goals/Criteria	Location A	B	C	D
Total cost (in millions of dollars)	*$30.9*	*$23.1*	*$34.2*	*$28.2*
Size (in acres)	*100*	*80*	*110*	*90*
Road access (good, poor)	*good*	*good*	*good*	*good*
Zoning (residential, rural, industrial, farm)	*rural*	*farm*	*industrial*	*rural*
Slope (slight, moderate, steep)	*slight*	*slight*	*moderate*	*moderate slope to river*
Soil depth (feet)	*4 ft*	*6 ft*	*3 ft*	*1 ft*
Soil type	*silty clay*	*clay*	*sandy loam*	*sand*
Soil permeability (slow, moderate, rapid)	slow	*very slow*	*moderate*	*rapid*
Bedrock (non-porous, porous)	*non-porous*	*porous*	*porous*	*porous*
Aquifer depth (feet)	*65 ft*	*85 ft*	*45 ft*	*35 ft*
Danger to groundwater (low, moderate, high)	*moderate*	*low*	*low*	*high*
Odors to town (winter, summer, none)	*in winter*	*none*	*none*	*in summer*
Is the site near **public** buildings?	*no*	*yes, high school*	*no*	*no*
Is the site > 1,000 ft from homes?	*no*	*no*	*no*	*yes*
Is the site > 5,000 ft from airport?	yes	no	yes	yes
Is the site > 200 ft from river?	*yes*	*yes*	*yes*	*no*
Is the site > 1,000 ft from nature preserve?	*yes*	*yes*	*yes*	*no*
Distance of wells or mines from site; type?	*1,000 ft well field*	*1,500 ft gas wells*	*1,500 ft oil well*	*500 ft abandoned mine*

Worksheet 3. Decision Chart

Answers will vary but conclusion should be supported by data.

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Student Pages for

SITING YORETOWN'S LANDFILL

Follow this Page

Instructions

Siting Yoretown's Landfill

Yoretown has a solid waste disposal problem. The landfill used for the disposal of its solid waste is near maximum capacity. Since Yoretown is so far from other disposal sites, it would not be cost effective to have the community's waste hauled elsewhere, although this remains an option.

The city council has discussed this problem with the Buckeye Solid Waste Management District Policy Committee. The city council and the solid waste district committee have identified four possible landfill sites for a new county landfill. These are on the outskirts of town. The committee now seeks technical advice on which is the best site. Therefore, the district has established a technical advisory council to investigate these potential sites.

Materials:

- ☐ Rulers
- ☐ Soil Texture Triangle from Background Activity 8

One Copy per Group:

- ☐ Map of Yoretown and Buckeye County
- ☐ Transparency: Topography of Terrain
- ☐ Evaluation Sheets for Sites A, B, C, and D
- ☐ Landfill Site Comparison
- ☐ Decision Chart

Technical Advisory Team Instructions:

1. Your group represents the technical advisory council.
2. Unless otherwise directed by your instructor, your group must evaluate the information on each site. Use the *Criteria for Evaluation* to determine the suitability of the site.
3. After completing the site evaluation sheets for the four sites, fill in the *Landfill Site Comparison* worksheet.
4. Now as a group, decide how to rank the sites. The best site will meet the most criteria and have the least environmental impact. The number one recommendation must be defended with reasons why the site was selected over the others.

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Criteria for Evaluation

Geology

1. **Slope and terrain** – These conditions can be important because they determine how much earth must be moved to prepare the site and which direction the surface water will flow off the site.
2. **Soil depth** – Shallow soils might not provide enough soil for daily cover of the landfill. (Alternative covers, such as foam or canvas blanket, can be used to cover the landfill day by day when soil is difficult to obtain, but at an additional cost.)
3. **Soil type and permeability** – Soil type will influence the permeability at the landfill site. As a rule of thumb, clay soils will have lower permeability than sandy soils (Table 1). The more permeable the soil, the more chance that rainwater can collect in the landfill and become a carrier for leachate (chemicals from the trash). The more impermeable the soil layer at the bottom of the landfill, the less likely leachate can seep through to the groundwater. Use the Soil Texture Triangle to help analyze composition of the soil.
4. **Bedrock** – Bedrock can have pores or fractures that allow the water to flow through. Bedrock of a less porous nature and without fractures lowers the chance for liquids to drain out of the landfill.

Table 1.

Soil Particle Type	Particle Size Diameter (mm)	Permeability
Clay	Below 0.002	Very slow
Silt	0.05–0.002	Slow
Very fine sand	0.10–0.05	Moderately slow
Fine sand	0.25–0.10	Moderate
Medium sand	0.5–0.25	Moderately rapid
Coarse sand	1.0–0.5	Rapid
Very coarse sand	2.0–1.0	Very rapid

Groundwater

Depth of uppermost aquifer system – Many farms and cities rely on groundwater for their drinking water. Sites close to an existing water well or well field should be carefully evaluated. There should be at least 15 feet between the bottom of the landfill (landfill liner) and the uppermost aquifer.

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Instructions, Page 3

Gas Migration

Potential explosive gas migration – Over a period of time as waste decomposes, explosive gases such as methane can develop. Potential pathways for this gas to migrate beyond the landfill include underground utility structures such as sewers, water lines or electric cables, pipelines, oil wells, and gas wells. These should not be within 1,000 feet of the landfill.

Wells, Mines, and Quarries

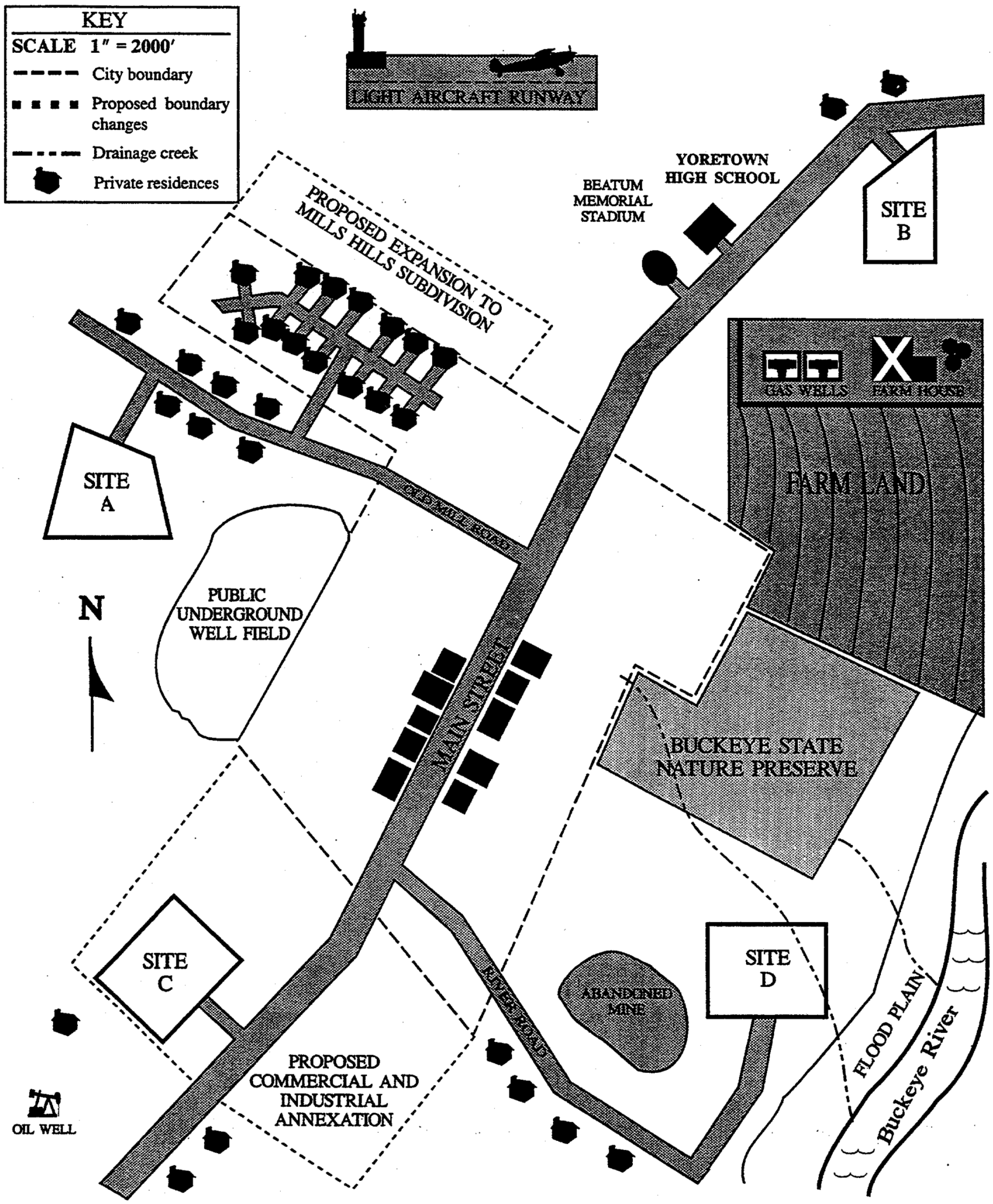
Wells, mines, and quarries can be sources of potential subsidence (sinking of the ground), especially if within 2,000 feet of the buried solid waste. Subsidence can cause rupturing of the liner systems, which are designed to contain hazardous liquids that collect at the bottom of landfills.

Other Issues

1. **Access** – Can trucks get to it? Can traffic be managed?
2. **Zoning and land use** – What is the land currently used for? Is the land more valuable for those uses? How will a landfill affect growth and development in general, and in particular, at this specific site?
3. **Location** – Would the presence of a landfill cause any detriment to an already established cultural feature?
4. **Residence** – No solid waste placement can be within 1,000 feet of a home whose owner has not consented to construction of the landfill.
5. **Natural features** – Generally, it is unacceptable to locate solid waste landfill within 200 feet of a stream, lake, or natural wetland unless proof of satisfactory diversion of the stream or protection of the lake is offered.
6. **Airports** – If solid waste is placed within 10,000 feet of an airport serving turbine-powered aircraft or within 5,000 feet of an airport serving piston-type aircraft, the permit application must demonstrate that the facility will not pose a bird hazard to aircraft.
7. **Nature preserves** – A landfill cannot be located within 1,000 feet of nature preserves.

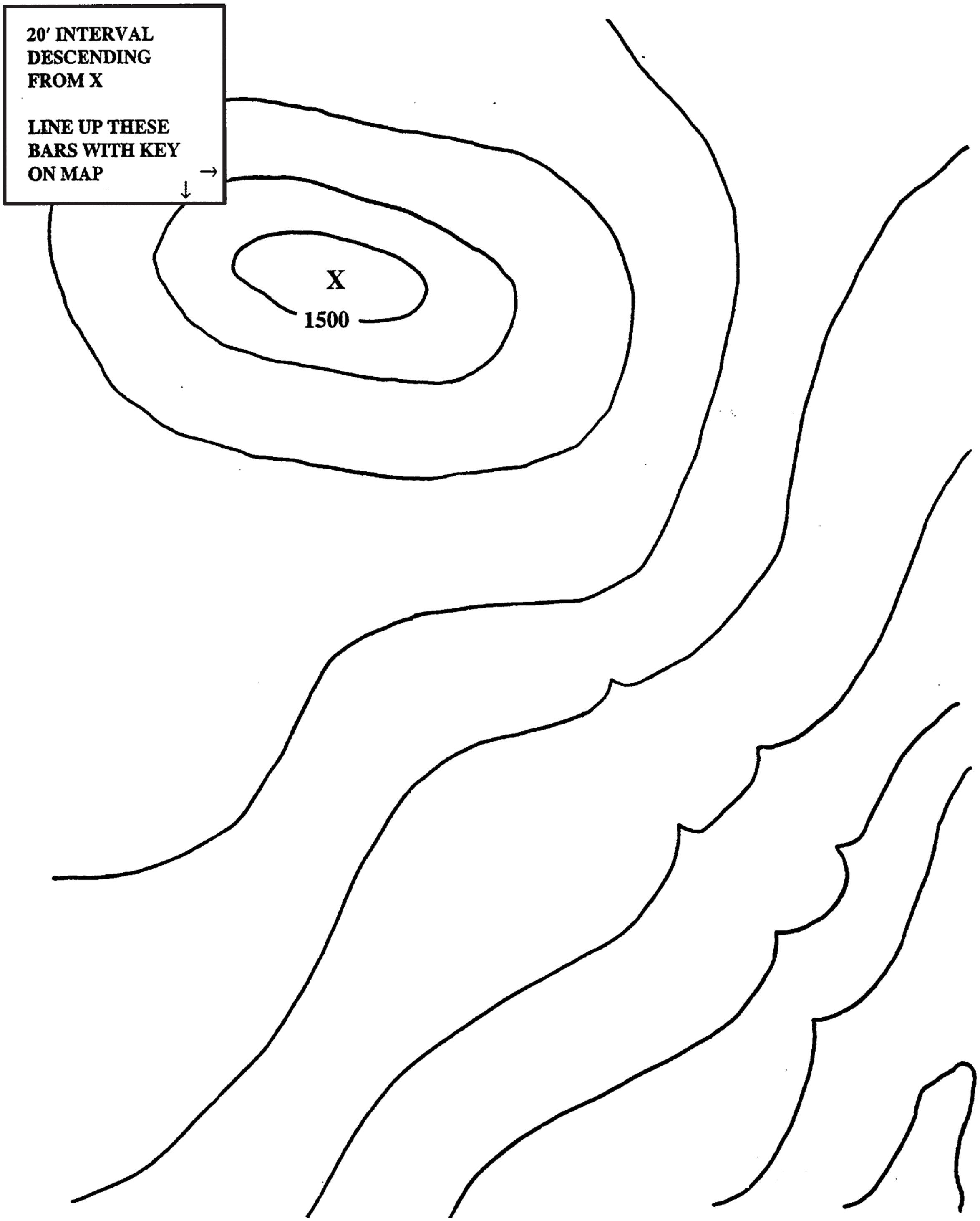
Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Map of Yoretown and Buckeye County



Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Topography of Terrain



Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Worksheet 1

Name ______________________________

Date __________________ Period ______

Site A Evaluation

Location:
☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW of Town
Prevailing wind direction: from NW in winter and SE in summer.
Description of site: Zoning and land use (residential, farming, industrial, rural), location relative to other features (buildings, parks, etc.):

____

____

Number of acres: 100
Cost appraisal of property: $900,000
Landfill development costs: $300,000/acre

Soil depth: 4 ft.
Soil type: Silty clay
Bedrock: Shale
Uppermost aquifer: 65 ft.

Total cost: ____

Road access: ____

Slope and terrain: ____

Soil characteristics: ____

Soil permeability: ____

Danger to groundwater: ____

Odors to town? Direction and time of odors: __________________________

Suitability of the site:

Pros: ____

____

____

____

Cons: ____

____

____

____

Conclusion: ____

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Worksheet 1, Page 2

Name ______________________________

Date ________________ Period ______

Site B Evaluation

Location:
☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW of Town

Prevailing wind direction: from NW in winter and SE in summer.

Description of site: Zoning and land use (residential, farming, industrial, rural), location relative to other features (buildings, parks, etc.):

____

____

Number of acres: 80
Cost appraisal of property: $700,000
Landfill development costs: $280,000/acre

Soil depth: 6 ft.
Soil type: Clay
Bedrock: Fractured limestone
Uppermost aquifer: 85 ft.

Total cost: ____

Road access: ____

Slope and terrain: ____

Soil characteristics: ____

Soil permeability: ____

Danger to groundwater: ____

Odors to town? Direction and time of odors: ________________________

Suitability of the site:

Pros: ____

____

____

____

Cons: ____

____

____

____

Conclusion: ____

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Worksheet 1, Page 3

Name ________________________________

Date ____________________ Period _______

Site C Evaluation

Location:
☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW of Town

Prevailing wind direction: from NW in winter and SE in summer.

Description of site: Zoning and land use (residential, farming, industrial, rural), location relative to other features (buildings, parks, etc.):

____

____

Number of acres: 110
Cost appraisal of property: $1,200,000
Landfill development costs: $300,000/acre

Soil depth: 3 ft.
Soil type: Sandy loam
Bedrock: Fractured basalt
Uppermost aquifer: 45 ft.

Total cost: ____

Road access: ____

Slope and terrain: ____

Soil characteristics: ____

Soil permeability: ____

Danger to groundwater: ____

Odors to town? Direction and time of odors: _________________________________

Suitability of the site:

Pros: ____

____

____

____

Cons: ____

____

____

____

Conclusion: ____

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Worksheet 1, Page 4

Name ______________________________

Date ________________ Period ______

Site D Evaluation

Location:
☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW of Town

Prevailing wind direction: from NW in winter and SE in summer.

Description of site: Zoning and land use (residential, farming, industrial, rural), location relative to other features (buildings, parks, etc.):

____

____

Number of acres: 90
Cost appraisal of property: $300,000
Landfill development costs: $310,000/acre

Soil depth: 1 ft.
Soil type: Sand
Bedrock: Fractured limestone
Uppermost aquifer: 35 ft.

Total cost: ____

Road access: ____

Slope and terrain: ____

Soil characteristics: ____

Soil permeability: ____

Danger to groundwater: ____

Odors to town? Direction and time of odors: ___________________________

Suitability of the site:

Pros: ____

____

____

____

Cons: ____

____

____

____

Conclusion: ____

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Worksheet 2

Name________________________________

Date____________________ Period_______

Landfill Site Comparison

Goals/Criteria	A	B	C	D
Cost (in millions of dollars)				
Size (in acres)				
Road access (good, poor)				
Zoning (residential, rural, industrial, farming)				
Slope (slight, moderate, steep)				
Soil depth (feet)				
Soil type				
Soil permeability (slow, moderate, rapid)				
Bedrock (non-porous, porous)				
Aquifer depth (feet)				
Danger to groundwater (low, moderate, high)				
Odors to town (winter, summer, none)				
Is the site near **public** buildings?				
Is the site > 1,000 ft from homes?				
Is the site > 5,000 ft from airport?				
Is the site > 200 ft from river?				
Is the site > 1,000 ft from nature preserve?				
Distance of wells or mines from site; type?				

Adapted from "Finding the Best Site," Investigating Solid Waste Issues, Ohio Department of Natural Resources, 1994.

Worksheet 3

Name________________________________

Date__________________ Period______

Decision Chart for Landfill Site

Rank the potential site locations using the criteria for site selection using the following:

(+) = meets the goal or criteria

(n/a) = is not applicable or does not affect the goal or criteria

(-) = does not meet the goal or criteria

GOALS/ CRITERIA	Cost	Road access	Zoning	Slope	Soil depth	Soil type	Soil permeability	Bedrock	Aquifer depth	Danger to groundwater	Odors to town	Near public buildings	Distance from homes	Distance from airport	Distance from river	Distance from nature preserve	Sufficient distance from wells or mines?
Site A																	
Site B																	
Site C																	
Site D																	

What location do you believe best meets the goals and criteria set out by city council and the waste site management committee?

Why did your team recommend this site to the council?

DATA COLLECTION

DATA COLLECTION

Description:

Students learn about topographic maps and build a 3-D model of the spill site. They view the video again to refresh their memories and begin collecting information about the physical location of the spill site. Students research and share the backgrounds and careers of the experts whose knowledge will be essential to the Southerville EnviroClean team.

Purpose/Goals:

Students will be able to:

- understand how to read contour lines on a map
- build a 3-D model of the spill site from a topographic map and add key features
- develop an understanding of specific expert careers
- collect more data about Hydroville and the spill site

Prerequisites:

Background Activities 1–10

Time Estimate:

Prep: 60 minutes

Activity: Three to five 50-minute periods

- Days 1–2: Topographical Maps (optional, but highly recommended)

  Building a 3-D model of the spill site
- Day 3: Hydroville update
- Days 4–5: Career Information – 50 minutes to research or assigned for homework (optional), allow 20 minutes for team sharing

Materials:

Each Student:

- ☐ Hydroville Science Journal
- ☐ *Map of Hydroville*

Classroom:

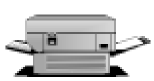
- ☐ Class "Know and Want to Know" posters from Welcome to Hydroville
- ☐ Pesticide Spill Video
- ☐ Computers with Internet connections
- ☐ Emergency Response Guidebook (Published by the Department of Transportation – Ordering information and on-line version reference is available at Hydroville Web site: http://www.hydroville.org/links/ps_resources.aspx)
- ☐ Paper cutter

Building a 3-D Model of the Spill Site

(Materials for one model; one model per team):

- ☐ Three pieces of 20" x 30" foam core or cardboard
- ☐ Thirteen copies of *Topographic Map of Spill Site* (enlarged)
- ☐ Cardboard for cutting surface
- ☐ Highlighters (one/team)
- ☐ Scissors
- ☐ Utility or Exacto® knives (two/team)
- ☐ Multi-purpose glue
- ☐ Ruler
- ☐ Colored markers or pencils

Pages to Photocopy:



Days 1–2:

One copy/student:

- Reading 1: *Topographic Maps*
- Worksheet 1: *Reading for Understanding Questions*
- Instructions: *Building a 3-D Model of the Spill Site*
- *Topographic Map of Spill Site* (on 8 1/2" x 11" paper)
- Worksheet 2: *Conclusion Questions*

Copies for one model:

- Topographic Map of Spill Site (13 copies/model – enlarge map 150% on 11" x 17" paper)

Day 3:

- Transparency: *Map of Hydroville*

One copy/team:

- Copy of Truck Manifest and Hazard Placard
- *HTV Newsflash*
- *Hydroville Times* article, *Toxic Pesticide Spill Near Hydroville*

Days 4–5:

One copy/student:

- Reading 2: *Getting Factual and Accurate Information from the Web*
- Reading 3: *Protocol for Conducting Interviews* (optional)
- Worksheet 3: *Career Information*, or students can record the information in their Hydroville Science Journal

Terminology:

Analytical chemist
Contour interval
Contour line
Environmental toxicologist
Mechanical engineer
Soil scientist
Topographic (topo) map

Background Information:

Hydroville Scenario

It is now time for your students to begin the Hydroville scenario. It is important that your students understand why they are involved with Hydroville and what is expected of them: what is the desired and successful outcome of all this study and work. Emphasize that this is a model or simulation based on a real spill that happened in Dunsmuir, California. Students get a chance to see how scientific experts would approach the problem and to use their knowledge and skills to develop a remediation plan.

Timing

Schedule a minimum of 2 1/2 weeks of class time to complete all of the sections in the scenario. Three weeks would be more realistic to allow students to do a more complete job. It is critical that the students have several periods to share and synthesize all of the information collected in the expert groups.

Suggested Lesson Plan:

Getting Started

1. If accessing topographic Web sites, reserve a computer lab with Internet access.
2. Prepare the materials for Day 1: Building a 3-D Model of the Spill Site. Get enough cardboard or foam board for each team to build one model.
   - Foam core is more expensive than cardboard, but easier to cut. You may be able to get free foam core from framing stores or sign-making companies.
   - Sources of cardboard include appliances, cardboard recycling centers, or pizza boxes.
   - Inexpensive utility knives can be purchased from your local dollar store.
3. Enlarge *Topographic Map of Spill Site* by 150% and print on 11" x 17" paper. Make 13 copies for each model. Cut maps into approximately 10" x 10" pieces.

   Classroom Hint: To save class time, construct two or three of the models yourself or with the help of a student aide. The models can be shared by teams for their final presentation.
4. To introduce topographic maps and 3-dimenional (3-D) images, access *Gallery of Virtual Topography* on the Web. Select a few of the simple features and download programs for students to use. Or obtain topographic maps of your town or other popular areas from the U.S. Geological Survey Library. See the Hydroville Web site for the links to these references: www.hydroville.org/links/ps_resources.aspx.
5. For homework, assign students Reading 1: *Topographic Maps* and Worksheet 1: *Reading for Understanding Questions*.
6. **Journal Prompt**:
   a. What is a topographic map?
   A topographic map shows the relief of the terrain or the landscape, represented by contour lines. These maps represent the horizontal and vertical dimensions of the features represented.

   b. How might having a topographic map of the spill site help the Southerville EnviroClean team?
   Topography maps show land formations, elevations, and key features, such as roads, wells, water sources, etc. The Southerville EnviroClean team may find these maps useful in determining the movement and location of the pesticide that spilled from the tanker truck and the area that may be affected.

Doing the Activity

Days 1–2. Topographical Maps and Building a 3-D Model of the Spill Site

1. Create the Southerville EnviroClean Teams: Divide your class into teams before beginning the Data Collection activity. Carefully select team members based on your observations of student participation during the Background Activities.
   - Each team should have students who have shown good teamwork skills and those who have leadership potential. Teams should be balanced in students' academic competence as well.
   - Each team of students will have at least one representative of each of the four expert groups. Students with the following skills do well in these expert areas:
     - Environmental toxicologist – good reading and artistic skills
     - Mechanical engineers – construction/model building skills
     - Analytical chemists – math and graphing skills
     - Soil scientists – math skills
   - Teams of four work well except when students are absent, so doubling up on the expert areas with teams often makes sense. The difficulty of having a team of eight is team management. We have had success with teams of six. Then each team has a couple of extra experts. To include everyone, team roles can be divided as long as there is planned time for the teams to get back together and to share what they have done or learned. If you are using teams of four and one person is absent during the expert research, two teams can share one expert.
2. Introduce students to topographic maps and 3-D images. Access Gallery of Virtual Topography Web site or discuss topographic maps of local areas.
3. Discuss the reading: *Topographic Maps* and the worksheet: *Reading for Understanding Questions*.
4. Make an overhead of the second page of the worksheet to walk students through the process of connecting equal elevations (benchmarks) to create contour lines using Map #1 and Map #2.
5. Each Southerville EnviroClean team will build a model of the spill site that can be used in the expert groups and in their final presentation.
6. Review the instructions and distribute materials.

Safety Issue: Students need to be cautious when using utility knives. Remind them to use a piece of cardboard as a cutting surface before cutting.

Wrap-up

1. When the models are completed, display them in the front of the room.
2. Check to see if key features are accurate and the model is complete.

Day 3. Hydroville Update

Getting Started

1. Read the *Pesticide Spill Scenario Fact Sheet* for an overview of all the facts revealed in the video and in the *HTV Newsflash* that was released at 10:00 a.m. on the morning of the spill.

   Classroom Hint: The Fact Sheet is useful to share with volunteer experts who are helping with the problem scenario. This fact sheet should NOT be shared with students.

2. Obtain copies of the Department of Transportation *Emergency Response Handbook* or print the pages for metam sodium from the online version of the handbook.
3. Make a transparency of the Hydroville Map

Doing the Activity

1. Display the poster or overhead from Welcome to Hydroville that has information collected from the first viewing of the video. Review that information.
2. Tell the class that each student team will take on the role of experts on the Southerville EnviroClean team. This company has been hired by the truck insurance company to clean up the spill site and develop a remediation plan (define remediation for the class). The cleanup team arrives at the spill site at 8:00 a.m. on the morning of the spill. Add this information to the fact side of the poster.
3. Show the Pesticide Spill video again. Have students take notes on sticky pads of additional information that they obtain. They can also add additional questions that need to be answered.
4. Hand out copies of the Truck Manifest, *HTV Newsflash*, and the *Hydroville Times* article, "Toxic Pesticide Spill Near Hydroville," to each team.
5. Explain that every truck on the highway that is carrying chemicals is required to post a diamond-shaped placard on the side and back that lists an ID number for the chemical it is carrying. If there is an accident, the emergency crews look up this ID number in the *Emergency Response Guidebook*. The *Guidebook* tells the police and fire department what precautions to take when approaching and working on the spill cleanup.

6. One team member should read these articles to the entire team. Team members should take notes or highlight important information to see if the articles provide answers to the questions they developed.
7. Add that information to the class poster.
8. Use the map transparency to review general information that the Hydroville Map gives about the town and the geography of the area.

Days 4–5. Career Information

Getting Started

1. Reserve computer lab with Internet access.
2. Check with school counseling office for recommended career Web sites and/or professional contacts for students to interview.

Classroom Hints: To save time, hand out a set of completed *Career Information Sheets* (from the teacher keys) to each team so students can familiarize themselves with the experts without doing the activity.

Doing the Activity

1. Each student on a team researches one of the careers represented on the Southerville EnviroClean Team. The expert areas to be researched are:
   - Environmental Toxicologist
   - Mechanical Engineer
   - Analytical Chemist
   - Soil Scientist
2. Career information can be researched from school career centers, on the Web, or through personal or phone interviews.
3. If you want students to do personal or phone interviews to obtain career information, review *Protocol for Conducting Interviews*.
4. Hand out a *Career Information Sheet* to each student.

Classroom Hints:

- Teams of four have one student for each expert group. Teams of four or more students can double up on any of the expert groups.
- You can assign students to expert roles or have them choose the expert they prefer.
- In the Data Analysis section, team members jigsaw into one of the assigned four expert areas to collect additional data.

Wrap-up

1. The teams reassemble and share their completed *Career Information Sheet* with the rest of their group. Each student's career information should be different, depending upon sources of information used.
2. As each person shares her or his career information, others in the group can take notes in their Hydroville Science Journals or fill out a *Career Information Sheet* of their own.
3. Within their teams, they answer the following question for each expert: "How would this expert contribute to your team's investigation of assessing and cleaning up the spill site?"
4. **Journal Prompt**: Write a paragraph explaining which expert you want to represent on your team: Analytical Chemist, Environmental Toxicologist, Mechanical Engineer, or Soil Scientist.
   Answers will vary, but student responses should help when assigning students to expert groups.

Resources:

Topographic Maps

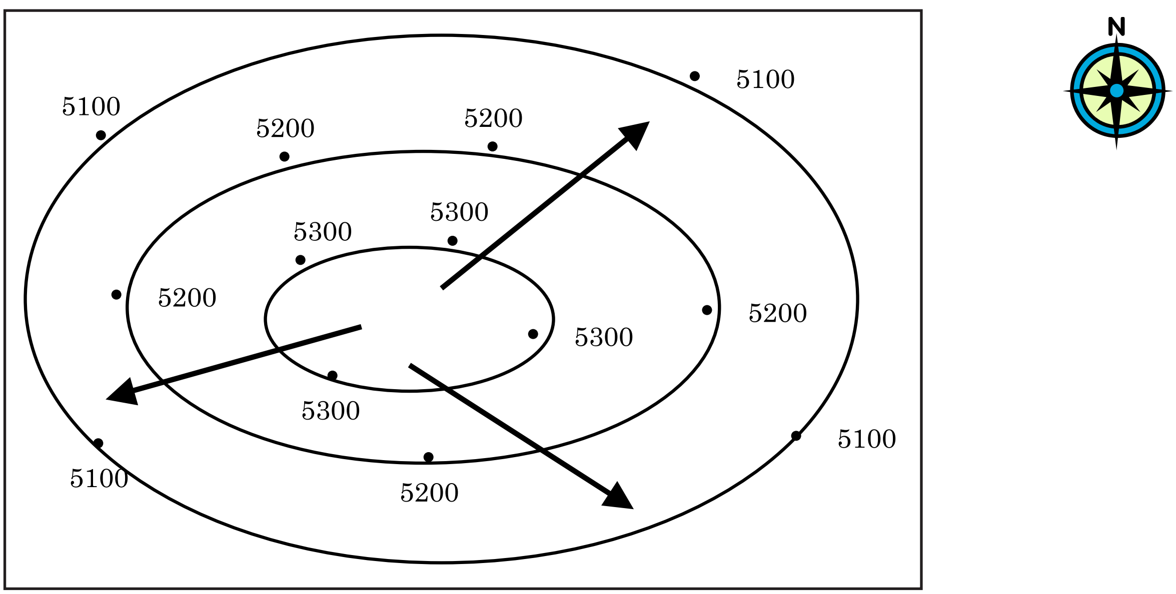
- An excellent resource for this activity is *How to Teach with Topographic Maps*, by Dana Van Burgh, Elizabeth Lyons, and Marcy Boyington (published by NSTA in 1994).
- See the Hydroville Web site for links to Web resources for this activity at http://www.hydroville.org/links/ps_resources.aspx.

Teacher Key

Worksheet 1: Reading for Understanding Questions

1. What does a contour line indicate on a topographic map?
   A contour line on a topographic map joins points of equal elevation to represent the vertical dimension of the landscape.
2. What is a contour interval?
   A contour interval is the difference in elevation between two adjacent contour lines.
3. On a topographic map showing the Cascade Mountains, would the contour interval most likely be 2 feet, 25 feet, or 100 feet? Explain your answer.
   The best contour interval would be 100 feet. The terrain in the mountains would be very steep, so the contour interval would be large.
4. If you were planning a hike and saw that the trail crossed contour lines very close together, what do you think the hiking would be like?
   The trail would be very steep.

Map #1. A Cone-shaped Mountain

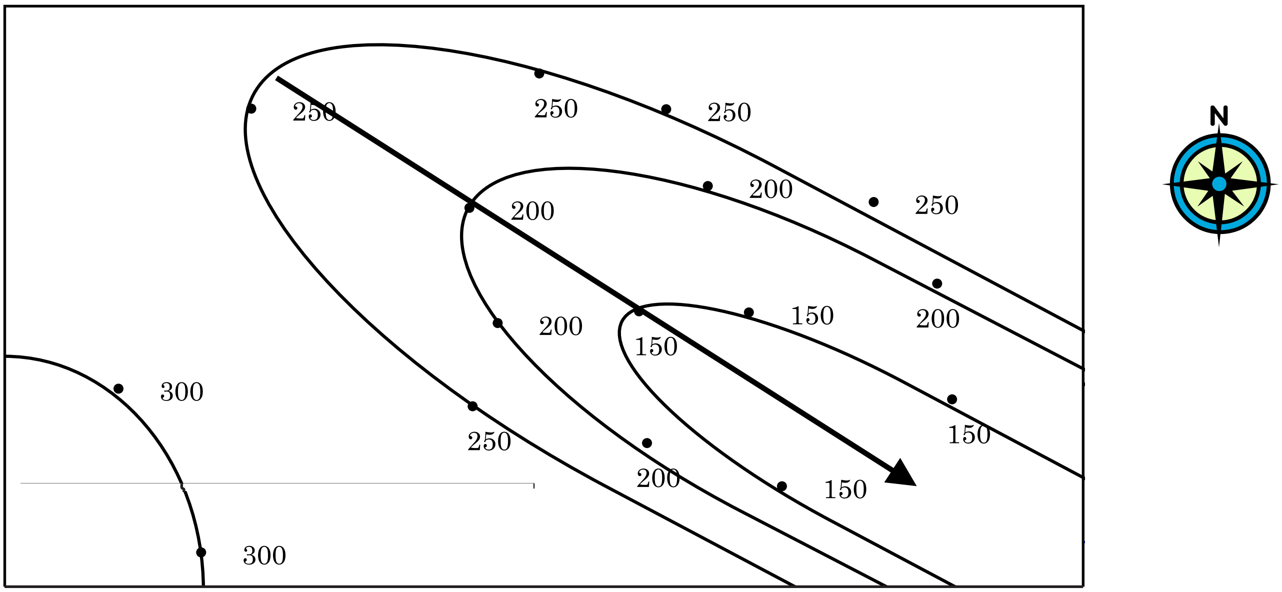


Contour interval = 100 feet

Teacher Key

Worksheet 1 (continued)

Map #2. A Valley with a River Flowing Southeast



Contour interval = 50 feet

Conclusion Questions

1. On your model, label Riverview Drive. What is the elevation of the road where the tanker truck spilled?
   855 feet.
2. Find the lowest elevation at the spill site. What is the difference in elevation from the road to this point?
   855 feet - 843 feet = 12 feet.
3. Describe the path that the pesticide may have taken at the spill site and where it ended up.
   The pesticide flowed from the tanker truck and into a ditch that is 12 feet lower than the road. It spread out along the bottom of the ditch and collected in a "pool" with the lowest elevation.
4. Approximately 10,000 gallons of pesticide spilled before the tank was sealed. (To visualize how much this is, it is about the same as the amount of water that would fill a swimming pool 20 feet long, 12 feet wide, and 5 feet deep.) The pesticide pooled at the lowest elevation of the ditch. The size of this pool is approximately 60 feet by 10 feet by 2 feet.
   a. What is the volume of this pool?
      60 ft x 10 ft x 2 ft = 1,200 ft^3.
   b. If 1 ft^3 = 7.5 gallons, how many gallons of pesticide can the pool hold? Show your work.
      1,200 ft^3 x 7.5 gallons/1 ft^3 = 9,000 gallons.
   c. Speculate – where did the remaining pesticide go?
      Seeped into soil.

Worksheet 3

Environmental Toxicologist Career Information

Job Description:

- Toxicologists are scientists who are specially trained to examine the nature of harmful effects of chemicals on living organisms. They study which chemicals are toxic to living organisms and in what amounts those chemicals are toxic. In addition, they are interested in the concentrations of a chemical that might cause disease, tissue damage, genetic alterations, or cancer.
- An environmental toxicologist studies the effects of pollutants on organisms, populations, ecosystems, and the biosphere. Areas of specialties include air and industrial hygiene, radiological health, environmental chemistry and biology, environmental management, water resources, and food protection.
- Environmental toxicologists or environmental health specialists, at the technician level, collect and analyze hazardous samples; record information and prepare reports; maintain monitoring equipment; inspect restaurants, food, and swimming pools for cleanliness and safety; and provide supportive services to environmental engineers and scientific professionals. Environmental specialists, at the professional level, act as consultants, investigators, evaluators, and/or designers of engineering systems to handle and dispose of toxic wastes for environmental safety. They make decisions based on concrete evidence. Their work must meet strict standards, and the tasks may be repetitive following standard procedures.
- There are many types of toxicologists. Some investigate the toxicity of chemicals using animal models; others investigate the health risk of certain chemicals; and others study the mechanism of actions of certain chemicals in the human body.

Training and Qualifications:

- Requires a Bachelor of Science degree as a foundation, with required courses in biochemistry, physiology, pathology, molecular biology, genetics, pharmacology, analytical chemistry, calculus, and statistics.
- A practicing toxicologist requires a Master's degree or Ph.D. in toxicology.

Teacher Key

Worksheet 3 (Environmental Toxicologist)

Working Conditions/Typical Day:

- Toxicologists who work in industries or government work regular hours, while those who work as research scientists work independent hours.
- Research toxicologists work with animals and toxic substances in laboratories.

Employment Opportunities:

- Toxicologists work as independent consultants or are employed by federal agencies such as the Environmental Protection Agency, by private industry, and by universities.

Salary:

- The average annual salary depends on the level of educational training. Information on salaries comes from the Society of Toxicology Web site. Entry level positions for those with doctoral degrees are often in the range of \$35,000 to \$60,000. Mid-range professionals with a Ph.D. degree and 10 years of experience can expect to earn \$70,000 to \$100,000 annually. Most executive positions in toxicology exceed \$100,000 per year, and some corporate executive toxicologists earn \$200,000 or more.

Sources:

- Society of Toxicology career information: http://www.toxicology.org/AI/CRAD/careerguide.asp
- Society of Environmental Toxicology and Chemistry. www.setac.org/
- Toxicology: Academic Requirements, Professional Outlook. http://www.environmentalprograms.net/guidance/toxicology/

Worksheet 3

Mechanical Engineer Career Information

"Engineering…in a broad sense…is applying science in an economic manner to the needs of mankind." —Vanevar Bush (1939)

Job Description:

- Mechanical engineering applies the principles of mechanics and energy to the design of machines and devices. Perhaps the broadest of all engineering disciplines, mechanical engineering is generally combined into three broad areas: energy, structures and motion in mechanical systems, and manufacturing.
- Mechanical engineers use the principles of science, together with mathematics, to design and develop small devices, large equipment, and processes for society. They play major roles in the design, testing, and operation of mechanisms, machines, and systems, including processes for energy conversion and equipment used in transportation and manufacturing.
- Mechanical engineers solve problems related to mechanical, material, fluid, thermal, and environmental systems. They spend time being creative and innovative and work in a broad-based spectrum of industries – virtually every type of industry employs mechanical engineers.

Training and Qualifications:

- High school students should take 1 year each of chemistry and physics and 2 years of algebra. Calculus is recommended but not required. High school students are also encouraged to take biology, mechanical drawing/drafting, and computer courses.
- The way to prepare for a mechanical engineering career is to attend a college or university offering an accredited program of study leading to a bachelor's degree in mechanical engineering. The first 2 years of preparation will be in general coursework, including calculus, physics, differential equations, humanities electives, and an introduction to mechanical engineering. In the second half of your sophomore year, you will begin the technical core courses in the engineering program. In your junior and senior years, electives are available that examine technical subjects more thoroughly, and laboratory work provides hands-on experience with mechanical and thermal systems.
- Workers must have a bachelor's degree to gain the necessary skills for this occupation. However, those with a master's degree have a competitive advantage in this labor market.

Teacher Key

Worksheet 3 (Mechanical Engineer)

Working Conditions/Typical Day:

- Mechanical engineers work in industry, consulting practices, universities, and government research. The vast majority are employed in industry at equipment manufacturers, aerospace companies, utilities, material processing plants, transportation companies, petroleum companies, and a host of other firms large and small.

Employment Opportunities:

- Large numbers of mechanical engineers do research, test, and design work while others work in maintenance, technical sales, and production operations. Many are administrators or managers. Some work as consultants. High-technology companies seek mechanical engineering graduates for product design applications such as: plastic enclosures, thermal analysis, electromechanical components, and product testing.

Salary:

- Bachelor's degree candidates in mechanical engineering received starting offers averaging $52,820 a year, master's degree candidates had offers averaging $58,940, and Ph.D. candidates were initially offered $73,890. (Source: 2005 data from www.engineersalary.com/Mechanical.asp.)
- Median annual earnings in the industries employing the largest numbers of mechanical engineers in 2005 were:
  Federal government: $62,320
  Engineering and architectural services: $63,800
  Motor vehicles and equipment: $65,400
  Construction and related machinery: $57,480
  Manufacturing: $71,090

Sources:

- Oregon Labor Market Information System (OLMIS). www.olmis.com.
- "What is a Mechanical Engineer?" The American Society of Mechanical Engineers, and Oregon State University College of Engineering-Mechanical Engineering.
- Engineering Salary Calculator. /www.engineersalary.com/

Teacher Key

Worksheet 3

Analytical Chemist Career Information

Job Description:

- Conduct qualitative and quantitative chemical analyses or chemical experiments in laboratories for quality or process control or to develop new products or knowledge.

  Analytical chemists are generally involved with making measurements using sophisticated state-of-the-art computer-controlled instrumentation in government laboratories as well as in laboratories in the chemical, pharmaceutical, biotechnology, and food industries. They may also be involved in developing these techniques in these laboratories or in the laboratories of instrumentation vendors. Analytical chemists are also suited for positions as quality assurance specialists to ensure that procedures and protocols are followed.

Training and Qualifications:

- With a bachelor's degree in chemistry or biochemistry, the student can enter directly into a career in industry or government, or undertake graduate level studies. Good laboratory and mechanical skills and the patience to perform sometimes tedious procedures is necessary for precise and accurate measurements. Good communication skills and the ability to learn about and keep up with new techniques and instrumentation and technology are essential for troubleshooting and problem solving.

  A solid background in chemistry and good laboratory, computer, and communication skills are important for handling a wide variety of chemical measurements. Because analytical chemistry is a service discipline, combining the skills of a chemical analyst with knowledge of the unique problems of other chemical disciplines (such as organic, polymer, inorganic, and environmental chemistries) is a valuable asset. Course work in advanced instrumental methods enhance the chemist's versatility. In addition, customer service, business, and management skills are more important today than ever before.

Working Conditions/Typical Day:

- An entry-level chemical analyst would most likely be considered a "bench" chemist or technician and would work in a private industry or a government lab doing contract work, testing for common contaminants such as gasoline, pesticides, etc. Duties include: processing samples from field sites, running and repairing instruments, ordering chemicals, and analyzing data on spreadsheets.
- Chemists with doctoral degrees could run research labs and design experiments.

Teacher Key

Worksheet 3 (Analytical Chemist)

Employment Opportunities:

- Private industries, such as pharmaceutical and biotech companies, are scrambling to find chemists to assist in drug discovery and development. Other chemical and life science companies are hiring chemists and chemical engineers to increase innovation and improve commercial processes. Teaching vacancies are continuing to open up across the nation. And the federal government needs hundreds of patent examiners with expertise in chemistry.
- Employment in this occupation is estimated to be in the average range. Growth is projected to be much faster than average. Annual new openings are expected to be higher than average.

Salary:

According to the Bureau of Labor: "Median annual earnings of chemists in 2000 were $50,080. The middle 50 percent earned between $37,480 and $68,240. The lowest 10 percent earned less than $29,620, and the highest 10 percent earned more than $88,030. A survey by the American Chemical Society reports that the median salary of all their members with a bachelor's degree was $55,000 a year in 2000; with a master's degree, $65,000; and with a Ph.D., $82,200. Median salaries were highest for those working in private industry; those in academia earned the least. According to an ACS survey of recent graduates, inexperienced chemistry graduates with a bachelor's degree earned a median starting salary of $33,500 in 2000; with a master's degree, $44,100; and with a Ph.D., $64,500. Among bachelor's degree graduates, those who had completed internships or had other work experience while in school commanded the highest starting salaries. In 2001, chemists in non-supervisory, supervisory, and managerial positions in the Federal Government averaged $70,435 a year."

Sources:

- ChemCenter. www.acs.org/careers.html
- American Chemical Society. http://pubs.acs.org/hotartcl/cenear/991115/7746eointro.html
- Environmental Chemist: Academic Requirements, Professional Outlook. http://www.environmentalprograms.net/guidance/env-chemistry/

Worksheet 3

Soil Scientist Career Information

"You need to understand statistics, have an understanding of how an experiment might work and know how to design it appropriately, and then you need the ability to interpret and communicate the results. You need to b einnovative in your thinking and full of bright ideas." – Trish Fraser, Soil Scientist

Job Description:

- Soil scientists give advice on the correct management and best use of land and soil. They also encourage land and soil conservation.
- Soil scientists need to be accurate, persistent, and inquiring. It is also important that they are self-motivated and concerned for the environment. They also need to be able to get along with a wide range of people with different land-use needs.

  A soil scientist may do some or all of the following:

  - Study the origin of soils and what they are made of
  - Develop ways of altering soils to suit different plants
  - Investigate soil problems and poor water quality
  - Study the movement of nutrients from soil to the atmosphere or water systems
  - Study the biological, physical, and chemical activity of soil
  - Advise on irrigation, drainage, and waste disposal
  - Study and advise on how to restore damaged land
  - Study how best to use land and preserve it for future use
  - Study how to make nutrients available to plants
  - Study methods for maintaining soil quality
  - Make recommendations on types of fertilizer

Training and Qualifications:

- Soil scientists need to have skill in analyzing information and interpreting scientific results. They need to have some mathematical and problem-solving ability and an eye for detail. Good communication skills are also important.
- Soil scientists need to have background knowledge of physics, chemistry, biology, math, and statistics. They should also understand the processes that shape the earth (geology). It is also important that they stay up to date with new information, research, and equipment.

Teacher Key

Worksheet 3 (Soil Scientist)

- Soil scientists need at least a Bachelor of Science with Honors, and preferably a Master of Science or a Doctorate degree, in soils or a related discipline such as earth science. Many soil scientists have a Master's degree or a Doctorate in agricultural science.

Working Conditions/Typical Day:

- Soil scientists work indoors and outdoors. Sometimes they may need to work outdoors in all weather conditions. Some soil scientists need to be reasonably fit to cope with the physical requirements involved in digging pits and collecting samples.
- Soil scientists may also work indoors in laboratories, offices, universities, and research centers. They often travel around the country to work on farms and in forest areas. They may travel overseas to attend conferences or work with overseas colleagues, and to learn new techniques.
- Soil scientists usually work alone and/or as part of a team.

Employment Opportunities:

- Many careers are available in soil science. Some are with resource management agencies such as the Natural Resource Conservation Service or Soil Conservation Districts. Private companies employ soil scientists for plant growth, irrigation, or waste management positions.

Salary:

- Based on a 2006 survey, the median salary for a Soil Scientist is $57,877 (source: Salary.com).
  BS: $21,000–$26,000; MS: $25,000–32,000; Ph.D.: $35,000+

Sources:

- Salary.com: http://swz.salary.com/
- Kiwi Careers. www.careers.co.nz/index.htm

Student Pages for

DATA COLLECTION

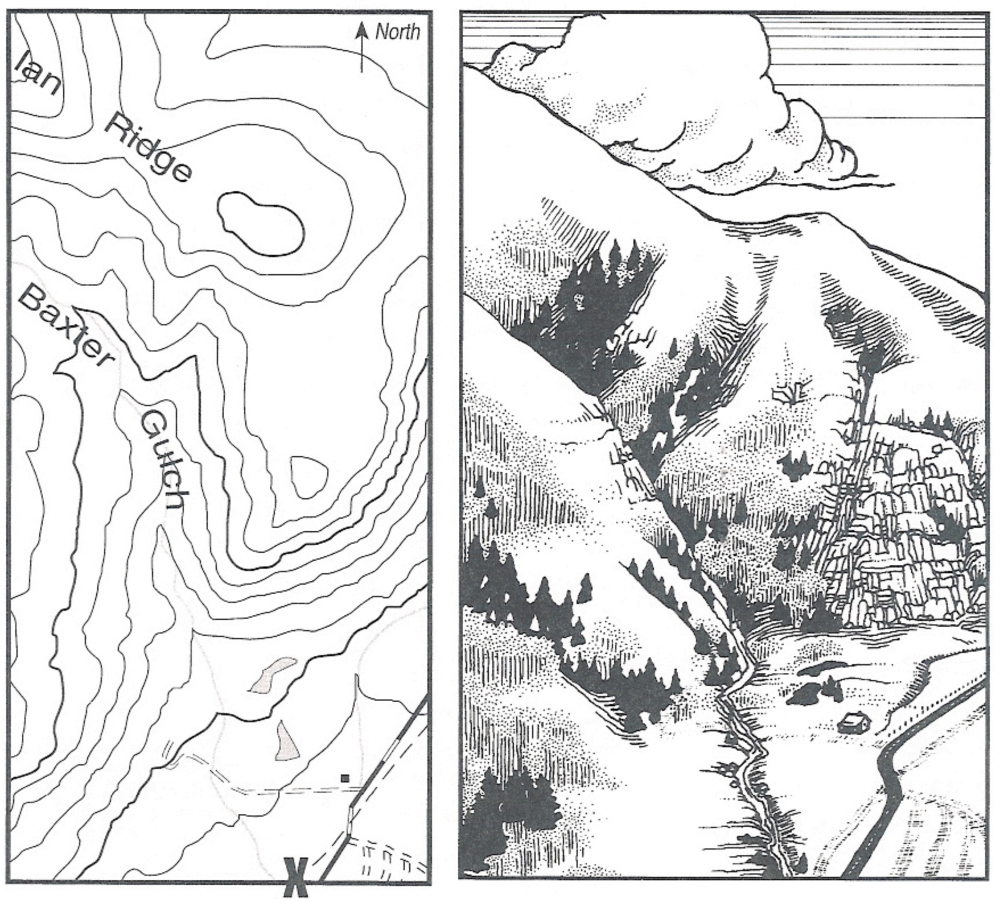
Follow this Page

Reading 1

Topographic Maps

What Makes a Topographic Map Different from Other Maps?

Many people have trouble visualizing three dimensions of a landscape from a map. Topographic maps can help. The distinctive characteristic of a topographic map is that the shape of the Earth's surface is shown by contour lines. These squiggly lines represent the vertical elevation of the landscape, giving the map-reader an opportunity to see it as a 3-dimensional (3-D) view.



Standing at the "X" on the topo map (above left), someone looking north would see the scene depicted above, right, including the secondary highway, streams, house, unfinished roads, ponds, and mountain ridges.

Figure 1. Topographic View Versus Actual View
(From *How To Teach With Topographic Maps* by Van Burgh, Lyons, and Boyington)

Contour lines are imaginary lines that connect points of equal elevation and are used to illustrate topography, or the vertical dimensions on a map. Each contour line on a map represents an elevation above or below a reference surface, such as mean sea level. Since every point on the line is the same elevation Contours make it possible to measure the height of mountains, depths of the ocean bottom, and steepness of slopes. The number of feet or meters is written along the contour line.

Drawing Contour Lines

First the area represented by the map must be surveyed. A surveyor uses established benchmarks to determine the elevation above mean sea level of various locations. Benchmarks throughout the world mark locations where elevation, as well as latitude and longitude, have been accurately measured and recorded. A benchmark is often installed as a brass monument secured to solid rock, a building, or something that is unlikely to move.

Figure 2. Example of Topographic Map with Contour Lines

Once the elevations are noted on the map, contour lines are drawn between points that have the same elevations. Map keys will note the contour interval, the difference between the elevations of two adjacent contour lines. The contour interval can vary from map to map depending upon the detail of the map. Some maps have a contour interval of 20 feet; others, 2 feet or 80 feet. Flat terrain will have small contour intervals since there is little difference in land elevations. Maps with large land formations, such as in the Rocky Mountains, will have large contour intervals.

Contour lines follow a few simple rules:

- Contour lines never cross each other.
- Contours that are very close together represent steep slopes. Widely spaced contours or an absence of contours means that the ground slope is relatively level.
- A map of a relatively flat area may have a contour interval of 10 feet or less. Maps in mountainous areas may have contour intervals of 100 feet or more.

A topographic map shows more than contours. The map includes symbols that represent such features as streets, buildings, streams, and vegetation. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or reduce production cost.

Worksheet 1

Name______________________________

Date_________________ Period______

Reading for Understanding Questions

1. What does a contour line indicate on a topographic map?

2. What is a contour interval?

3. On a topographic map showing the Cascade Mountains, would the contour interval most likely be 2 feet, 25 feet, or 100 feet? Explain your answer.

4. If you were planning a hike and saw that the trail crossed contour lines very close together, what do you think the hiking would be like?

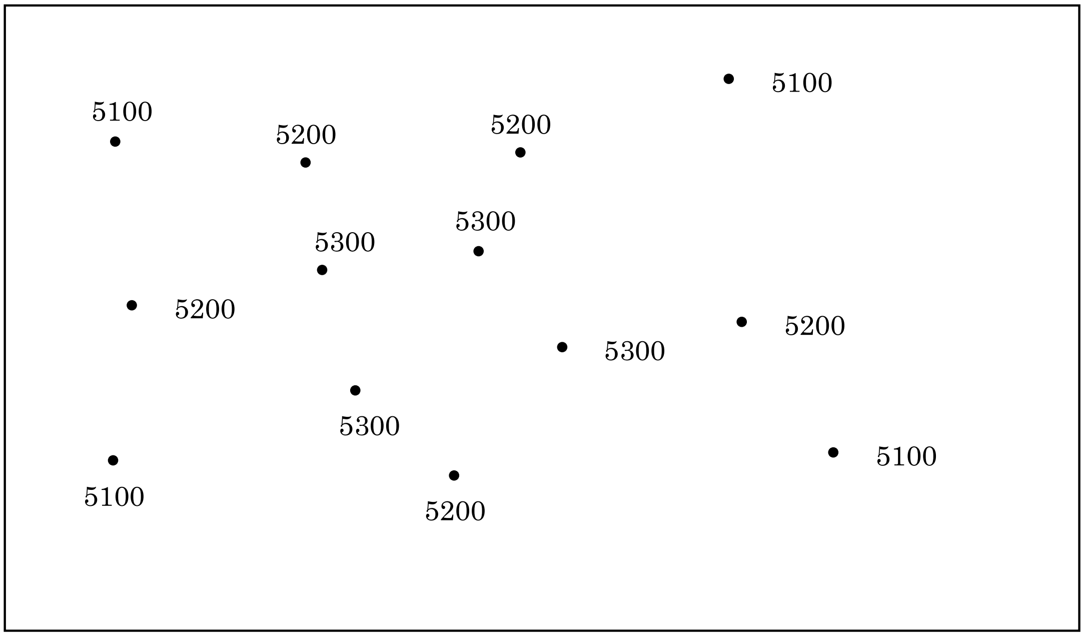
5. Drawing Contour Lines
   a. Practice drawing contour lines on the "maps" on the next page. Connect similar elevations (benchmarks) to show the general shape of the terrain.
   b. After completing the contours, draw arrows on both maps to show the direction that water would flow.
   c. Identify the topography of each map from the following list. Write your answer above the map.
      - A valley with a river flowing southeast
      - A cone-shaped mountain

Worksheet 1, Page 2

Name ______________________________

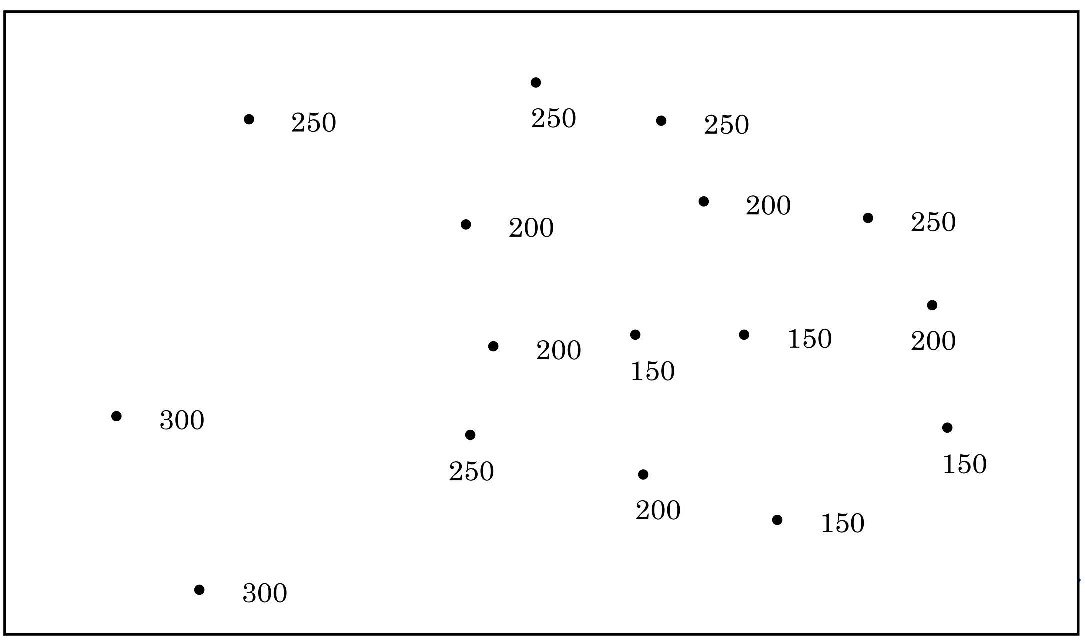
Date ________________ Period ______

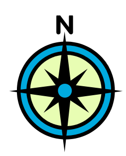
Map #1: ______________________________



Contour interval = 100 feet

Map #2: ______________________________





Contour interval = 50 feet

Instructions

Building a 3-D Model of the Spill Site

Introduction:

Topographic maps show many things: elevation, topography, vegetation, etc. Yet, it may be difficult to visualize land formations from contour lines that appear on these maps. Working in your Southerville EnviroClean team, you will use a topographic map of Hydroville to construct a 3-dimensional (3-D) model of the spill site. This will help in determining the movement and location of the pesticide that spilled from the tanker truck and the area that is affected.

Materials:

- ☐ Thirteen copies of *Topographic Map of Spill Site*
- ☐ Highlighter
- ☐ Scissors
- ☐ Three pieces of foam core or cardboard
- ☐ Utility or Exacto® knives
- ☐ Cardboard for cutting surface
- ☐ Ruler
- ☐ Multi-purpose glue
- ☐ Colored markers or pencils

Procedure:

1. Assign one person on your team to be the team leader.
2. On each topographic map, the team leader will highlight a contour line that represents the elevation of that map. The other team members will cut along the contour line to build the model.

   Note: Each contour line represents a specific elevation above sea level. There is one map for each elevation, for a total of 13 maps. The contour interval is 2 feet.
3. The first map will be the base of the model, which is the lowest elevation at 833 feet (Beaver Creek). This piece requires no cutting.
4. On the second map, highlight contour lines that represent 835 feet. On the next map, highlight contour lines at 837 feet, and so on.
5. Give one map to each team member, who will use scissors to cut along the contour line that has been highlighted. Label the elevation of each piece.

Instructions, Page 2

6. Lay out all of the map pieces onto the pieces of foam core or cardboard. Make sure that there are 13 pieces representing 833 feet to 857 feet (Figure 1).

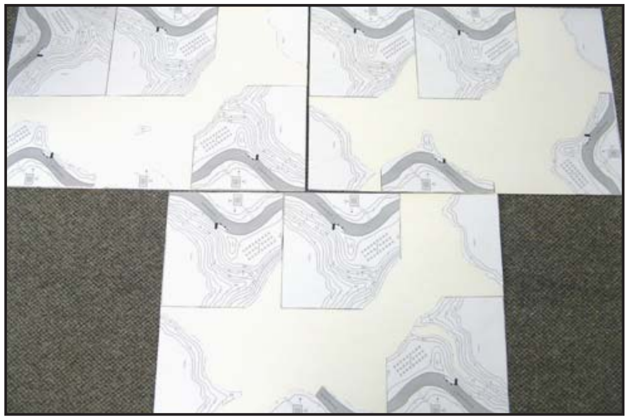


Figure 1. Lay Out and Label All 13 Pieces of the Model on Foam Core or Cardboard

7. Once your teacher has approved your layout, glue the map pieces onto the cardboard or foam core.
8. Cut out the glued map pieces using a utility or Exacto® knife. Remember to use a scrap piece of cardboard as a cutting surface; do not cut directly on the table (Figure 2).

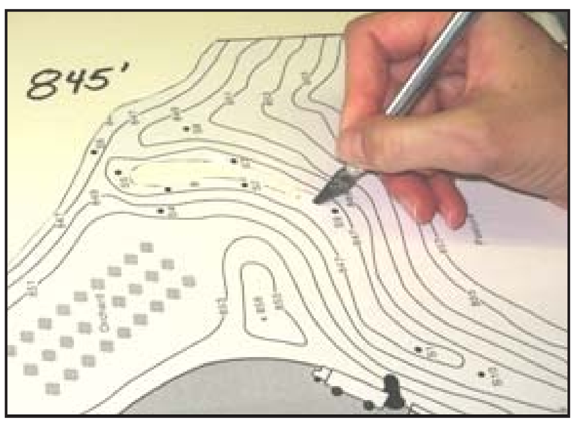


Figure 2. Cutting Out Contour Lines

9. When all the pieces have been cut out, you are ready to assemble the 3-D model of the spill site. Begin with the base piece (833 feet) and glue the next elevation (835 feet) onto the base and work your way up. Continue until all the pieces are set in place.

Instructions, Page 3

10. Your final map should look somewhat like the one in Figure 3.

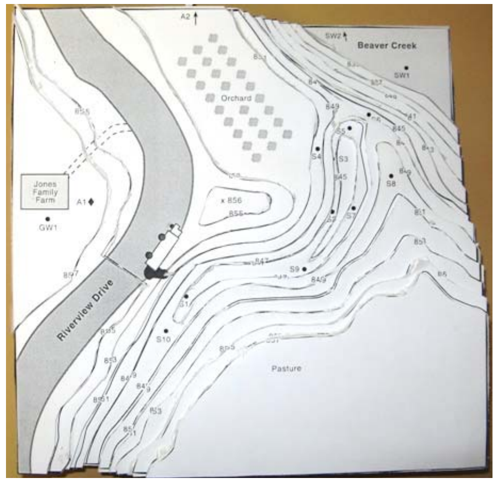
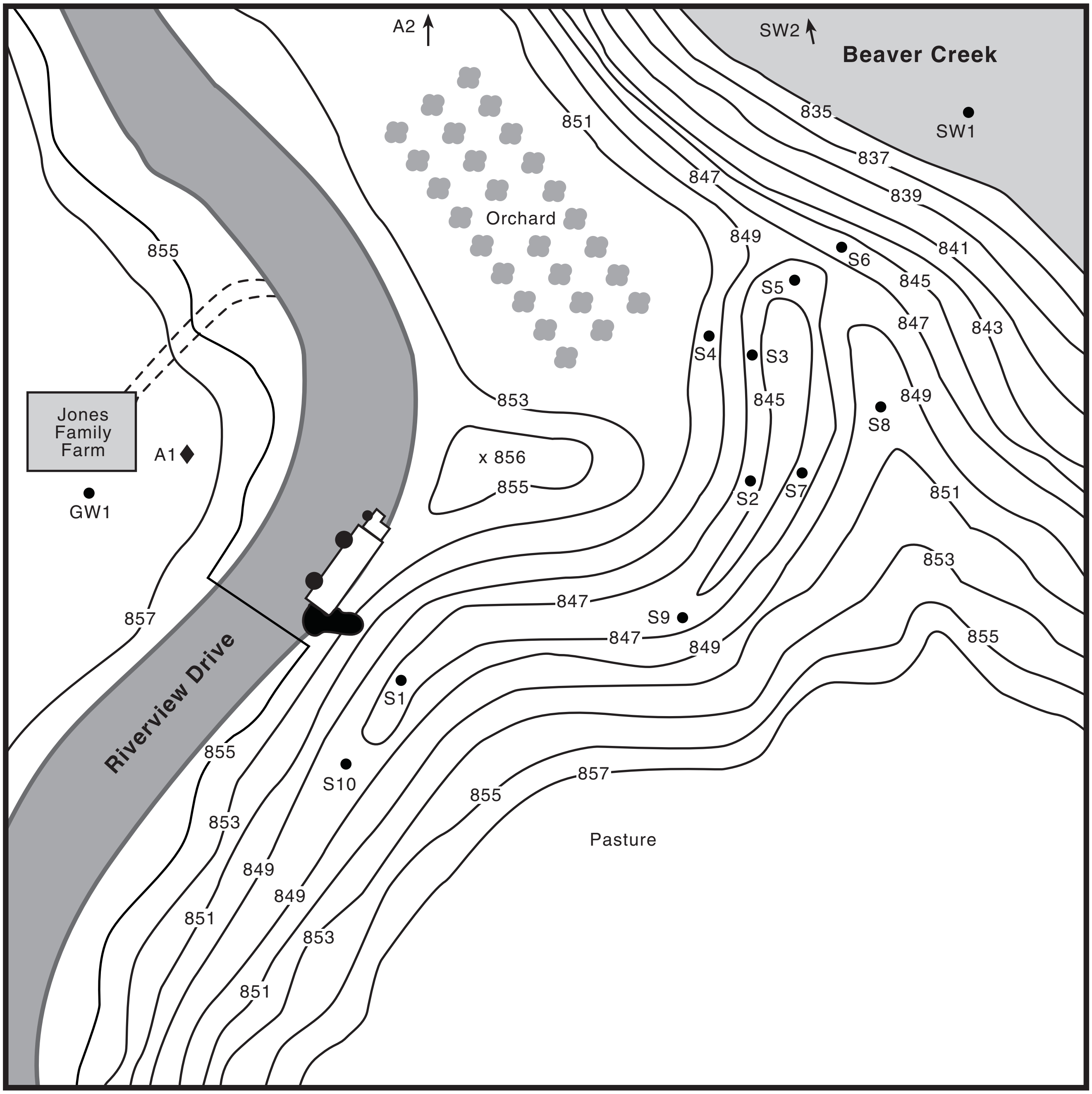


Figure 3. A 3-D Model of the Spill Site

11. Color water areas blue (Beaver Creek). Color vegetation green (yard around Jones' Farm, pasture in southeast corner, and orchard located north).
12. Color the pesticide "pool" red (the lowest elevation in the ditch, 843 feet). Predict the path that the pesticide flowed from the truck to the pool. Color this path red as well.
13. Fill in the key on the model with the features that you have added.

Topographic Map of Spill Site



KEY

Sample Sites

SW	**surface water**	●	**metam sodium**
GW	**groundwater**	◆	**MITC**
A	**air**		
S	**soil**		

0 10 20 30 40 50 ft

1/4 inch = 10 feet

Contour Interval 2 feet

N

Worksheet 2

Name______________________________

Date_________________ Period______

Conclusion Questions

1. On your model, label Riverview Drive. What is the elevation of the road where the tanker truck spilled?

2. Find the lowest elevation at the spill site. What is the difference in elevation from the road to this point?

3. Describe the path that the pesticide may have taken at the spill site and where it ended up.

4. Approximately 10,000 gallons of pesticide spilled before the tank was sealed. (To visualize how much this is, it is about the same as the amount of water that would fill a swimming pool 20 feet long, 12 feet wide, and 5 feet deep.) The pesticide pooled at the lowest elevation of the ditch. The size of this pool is approximately 60 feet by 10 feet by 2 feet.
   a. What is the volume of this pool? (Length x width x depth = ft^3)

   b. If 1 ft^3 = 7.5 gallons, how many gallons of pesticide can the pool hold? Show your work.

   c. Speculate – where did the remaining pesticide go?

Copy of Truck Manifest

Touhey's Family Farm Supply
Delivering Quality Service since 1924
1660 W. 104 St.
Cloverdale
1(773) 991-0052

24 Hour Emergency Contact
1(800) 517-4953

No. & Type of Packages	Description of Articles	Hazard Class	ID No.	Packing Group	Quantity
1 Tank Truck	Metam Sodium	8	UN3266	II	20,000 Gal.

Hazard Placard

News Release

HTV Newsflash

Tuesday, 10:00 a.m.

We interrupt our regularly scheduled programming to bring you an important newsflash:

At 5:30 a.m. this morning, a 20,000-gallon tanker truck overturned, spilling metam sodium pesticide into a farmer's field near Beaver Creek. Riverview Drive is still closed at this time while crews work to clean up the site and remove the tanker. Midday commuters will want to consider taking alternate routes as much as possible for the afternoon rush hour.

We have spoken with our reporter at the scene and have more information about the situation.

- The HazMat team that contained the spill has estimated that approximately 10,000 gallons of pesticide spilled before they were able to seal the top of the tanker. They have contained the pesticide with booms in a ditch to prevent it from getting into Beaver Creek.
- The police evacuated the Jones' farm to the west of the spill site. Our reporter talked with some of the family members. They report smelling an unusual odor, similar to horseradish; several complained of eye and nose irritation before evacuation.
- The cleanup team from Southerville EnviroClean arrived on the site at 8:00 a.m. and immediately took site samples from the water, soil, and air.
- The cleanup team is constructing a pump to remove the spilled pesticide and has indicated that pumping will begin at 11:30 a.m.
- The Hydroville Water Treatment facility has closed the water intakes from Beaver Creek and is using water from groundwater wells and revervoirs. Residents are advised to drink bottled water until further notice.
- Weather is also a concern in the cleanup for the site. The forecast for today is clear and cool (high of 45°F and low of 30°F) with light winds from the east. A major storm front is moving our way from the west, with high winds and lots of rain. It should reach the Hydroville area by late Wednesday or early Thursday. Last week's rain saturated the soil in the field where the spill occurred.

More information will be provided as soon as it becomes available.

We now return to our regularly scheduled programming.

Newspaper Article

Toxic Pesticide Spill Near Hydroville

Tanker with metam sodium overturns by Beaver Creek

By ROSINA BUSSE
Hydroville Staff Reporter

HYDROVILLE (HYDROVILLE WIRE REPORTS)—Hydroville residents living near Beaver Creek were suddenly evacuated early this morning after a tanker truck overturned, spilling 10,000 gallons of metam sodium pesticide.

The truck tipped at 5:30 a.m., apparently due to the driver hitting a patch of black ice on Riverview Drive. The road is still closed as cleanup crews try to ensure the safety of passing traffic.

The spilled pesticide, metam sodium, breaks down quickly into a toxic gas, known as methyl isothio-cyanate (MITC). This chemical causes eye and lung irritation, as well as nausea.

Along with being evacuated from their nearby homes, several Hydroville residents are reporting to the Borden Health Clinic with complaints of the tell-tale eye irritation and nausea. Also, dead fish are being spotted near the spill site in Beaver Creek, as well as farther downstream.

The implications are still unclear as to how this will affect the town's drinking water quality.

As reports of illness continue to flood the Hydroville Health Department, officials are concerned about the far-reaching effects of such an unpredictable event.

Cynthia Stevenson, spokesperson for the trucking company's insurance firm, has said that, "first and foremost we are concerned with the health and safety of the citizens of Hydroville. We have called in a team of experts from Southerville EnviroClean who are at the site, assessing the situation and cleaning up the spill."

These experts from Southerville EnviroClean will make a presentation to an open town meeting of the Hydroville City Council in the Hydroville Library meeting room, Wednesday evening at 7:00 p.m. All concerned citizens of Hydroville and in surrounding areas are encouraged to attend.

Reading 2

Getting Factual and Accurate Information from the Web

You need to know that there are no quality standards for statements posted on the Web. Anyone with a computer can have a Web page, blog, etc., and post whatever information she or he wants. So you need to be a skeptic when you go online and not accept information as the truth just because it is found on a Web site.

When you use a search engine to find related sites on the Web, you can find thousands of documents on the topic you selected. How do you know what information is reliable and what is questionable? As you look at information on the Web, keep in mind the following:

1. Look at the sources of the information. Professional organizations such as the Centers for Disease Control or the U.S. Environmental Protection Agency are more likely to have credible, factual information than an unknown person or group or a single-issue site.
2. Web addresses that end in *.gov*, *.org*, or *.edu* are most likely to contain reliable information. Anyone can get an address ending in *.com*. Be especially wary of a site whose URL contains the word *user*. This is a personal page. You can find out who created a site by going to www.easywhois.com.
3. Go to Ask.com and Answers.com, which are better search engines for school-related questions than Google.
4. Check the author and dates. As they say, *old news is no news*. Make sure the information is up-to-date. Updated sites have the latest facts and findings.
5. Beware of *never*. Science is rarely absolute. Think twice about advice to *never eat this* or *never do that*.
6. Be cautious of anecdotes. One individual's personal story and word-of-mouth reporting does not qualify as scientific evidence. Is the information you found based on reports published in leading scientific journals? Are there references? If there are no references, the information may be based on opinion and not fact.
7. Be reasonable. Don't believe everything you read. Maintain a healthy skepticism. Watch out for loaded words like *poison* or *conspiracy*. Here are some examples of emotionally charged phrases that should make you question the site. Can you think of others?
   - Four out of five doctors agree…
   - Are we poisoning our children?
   - Completely safe and harmless.
   - What you don't know can hurt you!
   - All natural, no artificial flavors or colors.
   - Chemical poisons are everywhere. They are killing us all!

Reading 3

Protocol for Conducting Interviews

You will need to set up an appointment to speak with an expert. Sometimes it can be several days before the expert has time in his or her schedule for an interview. If the expert cannot speak with you in a reasonable length of time, you might ask whether you could send the questions by e-mail. That way the expert can respond when it is most convenient.

1. Introduce yourself, giving your full name, school name, and a brief description of this project.

   Good afternoon, my name is Jamie Peterson and I am a freshman at Grant High School. My science class is participating in a simulation of a pesticide spill cleanup.

2. Explain that you would like to ask the person several questions about his or her career and tell him or her approximately how much time it will take.

   I would like to ask you several questions about your career, what your position entails, and what your training has been. The interview should take about 10 minutes.

3. Ask whether this is a convenient time. If not, ask when you could call back or make an appointment to talk with them.

   Is this a convenient time for you, or would you like me to call back at another time?

4. If the person says that she or he doesn't have time for the interview, don't be offended. Often people's schedules don't allow time for such interviews. Just thank the person politely and ask whether he or she has a suggestion of someone else you could call to get the information that you need. When you call the second person, you can say that the first person suggested you call.

   I appreciate your talking with me and am sorry that you don't have time for the interview, but could you suggest someone else I could contact? Could you give me their name and phone number?

5. Ask the questions on the Career Information worksheet.

6. When you have finished interviewing the person, ask whether there is anything else he or she would like to share with you or ask you. If not, thank the expert very much. It is important to follow up your phone or personal interview with a written thank-you note.

Worksheet 3

Name________________________________

Date__________________ Period_______

Career Information

Expert Area:

Job Description:

Training and Qualifications:

Working Conditions/Typical Day:

Employment Opportunities:

Salary:

Why would the skills of this expert be important for the cleanup team to have?

DATA ANALYSIS

Hydroville, USA

DATA ANALYSIS

Description:

The same experts from different student teams get together (jigsaw) to investigate one aspect of the pesticide spill. They collect and analyze data in their specific expert area.

Purpose/Goals:

Students will be able to:

- take on the roles of scientists or specialists
- collect and analyze data from the spill site
- prepare an expert report to share with their teams

Prerequisites:

Background Activities 1–10 and *Data Collection* section

Time Estimate:

Prep: About 120 minutes to prepare materials for all four expert groups

Activity time: Three 50-minute periods to allow expert groups to finish their work

Background Information:

This part of the curriculum is critical to the success of the student teams and to having each student taking ownership for his or her part of the team's remediation plan. You will have four groups working on different activities at the same time in your classroom. This jigsaw method will test your organizational skills and abilities to be a facilitator of student learning.

Volunteer Mentors: Inviting professional volunteer mentors or parents to work with each of the expert groups will make your job of coordinating this section much easier. Experts enjoy sharing their knowledge with students and helping them analyze this problem. Call and invite the volunteers several weeks in advance. Send them copies of the scenario story (page 1 of the *Scope and Sequence* section), the fact sheet for their expert group, and the student worksheets for the expert group. Explain that their role is to mentor and guide the students in their data collection and analysis, NOT to give the students the answers.

Suggested Lesson Plan:

Getting Started

1. Assemble the materials for each expert group.
   - Environmental Toxicologists – videotaping equipment
   - Mechanical Engineers – pump kits and tool table
   - Analytical Chemists – sets of chromatograms
   - Soil Scientists – soil column equipment and plume demonstration
2. Organize the materials for each expert group in a different part of your room.
3. Each team of students representing Southerville EnviroClean has four experts. During the data analysis, the teams jigsaw. Experts from each team get together and collect data specific to their subject area. You can allow teams to divide up themselves into the expert areas or you can assign students to expert groups.

Classroom Hints: If you assign students to expert groups, you will want a mix of students in each group, but it is important that:

- the Soil Scientists have students with strong mathematical skills
- the Mechanical Engineers have students who work well with their hands
- there are extra students in each expert group that can float between teams to cover for absent students when the teams ae sharing data from expert groups

4. Hand out the *Instructions* and *Worksheets* to each expert group. Each group should read the day's instructions before starting:

Doing the Activity

Day 1

1. Environmental Toxicologists
   - Work in pairs
   - Read the MSDS and Fact Sheets
   - Prepare a public service announcement (PSA)
2. Mechanical Engineers
   - Work in groups of two or three to make one pump per team
   - Complete Part I *Designing a Model Pump*
   - Get teacher's signature on each pump design to make certain it meets the requirements before beginning to build the pumps

3. Analytical Chemists
    - Work in pairs
    - Create a standard for metam sodium
4. Soil Scientists
    - Work in groups of two or three students
    - Determine the soil permeability at the spill site

Day 2

1. Environmental Toxicologists
    - Practice and revise PSA
    - Videotape PSA
2. Mechanical Engineers
    - Build and test pumps and transport vehicle
3. Analytical Chemists
    - Read and analyze sample chromatograms
4. Soil Scientists
    - Observe the Pesticide Plume Demonstration
    - Calculate the volume of the contaminated soil

Day 3

1. Environmental Toxicologists
    - Select best method of communication and calculate cost
    - Work as a group to complete the expert group report
2. Mechanical Engineers
    - Calculate cost of disposal, pump, and transport vehicle
    - Work as a group to complete the expert group report
3. Soil Scientists
    - Complete the conclusion questions
    - Work as a group to complete the expert group report
4. Analytical Chemists
    - Develop a monitoring plan and calculate costs
    - Work as a group to complete the expert group report

Wrap up: Students place their expert group report in their Hydroville Science Journal to share with their team as they begin the *Data Synthesis* activity.

ENVIRONMENTAL TOXICOLOGISTS

Hydroville, USA

ENVIRONMENTAL TOXICOLOGISTS

Description:

The Environmental Toxicologists review information about the pesticide metam sodium and its breakdown product, methyl isothiocyanate (MITC). They assess the potential risk of metam sodium and MITC to human health. They prepare a public service announcement to inform Hydroville citizens of the potential health impact of the pesticide spill.

Purpose/Goals:

Students will be able to:

- use the fact sheets on metam sodium and MITC to summarize health risk information
- understand the difference between acute and chronic toxicity
- create an informational public service announcement (PSA) about metam sodium and MITC for their team presentation
- address community concerns about metam sodium and MITC

Prerequisites:

Background Activity 1: *Reading Household Product Labels*

Background Activity 2: *Toxicity Testing – Dose Makes the Poison*

Time Estimate:

Prep: 15 minutes (making copies)

Activity: Three 50-minute periods

- Days 1–2: Create a 60-second public service announcement about metam sodium and MITC
- Day 3: Select the best methods for communication and complete Environmental Toxicologist report

Materials:

Each Student:

- ☐ Hydroville Science Journal

Group of Environmental Toxicologists:

- ☐ Video camera, tripod
- ☐ Screen, backdrop material, or clear wall for filming
- ☐ Colored markers
- ☐ Poster board for cue cards and visual props

Pages to Photocopy:

One copy/student:

- Instructions: *Environmental Toxicologists*
- Reading 1: *Metam Sodium and MITC Fact Sheet*
- Reading 2: *Metam Sodium Material Safety Data Sheet*
- Worksheet 1: *Fact Sheet and MSDS Questions*
- Reading 3: *Public Service Announcements*
- Worksheet 2: *Environmental Toxicologists Report*

Terminology:

Acute toxicity	Half-life
Chronic toxicity	Public service announcement (PSA)

Suggested Lesson Plan:

Getting Started

1. Obtain video camera and tripod and find quiet spaces for students to rehearse and a room for them to film their PSAs.
2. If you do not have video recording equipment, students can make an informational flier or a poster to put in the Hydroville library with the same information that they would have in their PSAs.

Doing the Activity

Days 1–2. Creating a 60-second Public Service Announcement about Metam Sodium and MITC

1. Students work in pairs to develop a public service announcement.
2. Students should brainstorm and write their public service announcement (PSA) script on the first day. They will rehearse, and then film their PSA on the second day.

3. Encourage students to be creative but serious. Review the PSA handout for tips and guidelines.
4. Each student should read the *Metam Sodium and MITC Fact Sheet* and *Material Safety and Data Sheet*, underlining or highlighting the most important information to include in their public service announcement. With their partner, they share the information they thought was important and agree what to put in the PSA.
5. Make sure these student experts understand that health effects of immediate concern would be due to short-term exposure to metam sodium or MITC. This is the result of *acute toxicity* of chemicals. Students must also understand that if metam sodium or MITC enter the groundwater (the drinking water source for Hydroville), citizens may have long-term exposure to metam sodium or MITC. There is potential for negative health effects due to the *chronic toxicity* of metam sodium or MITC. Review these definitions with students:
   - **Acute Toxicity** – The ability of a substance to cause harm after an exposure during a short time, less than 24 hours. Usually, acute toxicity is associated with a high level of exposure.
   - **Chronic Toxicity –** The ability of a substance to cause harm after a long-term (over weeks to years), low-dose exposure.
6. **Important:** Students should study their fact sheets and be prepared to answer questions during the team presentation about the physical and chemical properties of metam sodium and MITC and the risk to human health.

Classroom Hint: For variety, you can assign each pair a different information focus for their PSAs. For example: informing citizens about spill cleanup efforts; health effects and symptoms of exposure; information for citizens who live downwind of the spill site; pet owners.

Day 3. Environmental Toxicologist Report

1. On Day 3, students should complete the environmental toxicologist team report. They must:
   a. decide what information the public needs to know
   b. decide what information they must share with their team and what information they must obtain from their team
   c. decide how the information will be disseminated to the public
   d. calculate the costs for their methods of communication

Resources:

- National Pesticide Information Center. (NPIC) 1-800-858-7378. http://www.npic.orst.edu. NPIC is a cooperative effort between Oregon State University and the U.S. Environmental Protection Agency. NPIC provides objective, science-based information about a wide variety of pesticide-related subjects, including pesticide products, recognition and management of pesticide poisonings, toxicology, and environmental chemistry. Pesticide specialists are available to answer calls 7 days a week, 6:30 a.m. to 4:30 p.m. Pacific Time.
- See Internet resources on the Hydroville Web site: http://www.hydroville.org/links/ps_resources.aspx

Teacher Key

Environmental Toxicologist Fact Sheet

- The toxicity of metam sodium is moderate, but the toxicity of its breakdown component, methyl isothiocyanate (MITC), is moderate to high.
- The routes of exposure to metam sodium are from skin exposure to the liquid pesticide and ingestion of contaminated drinking water. MITC exposure may be from inhalation of vapors or exposure of eyes and respiratory passages to vapors, especially during cleanup procedures or if citizens are downwind of the spill site.
- This spill situation involves a high concentration of metam sodium and subsequent MITC levels.
- Metam sodium is in highest concentration in the ditch where it pooled and in the soil around the ditch.
- The time it takes for metam sodium to break down depends on temperature, soil texture, and moisture.
- The US EPA has not set drinking water standards for metam sodium or MITC because these chemicals are not expected to leach into drinking water sources when used as directed.
- Metam sodium is acutely toxic to fish and other aquatic invertebrates.
- During cleanup efforts, spill cleanup workers may be exposed to metam sodium on their skin. Workers may also be exposed to MITC via inhalation and may experience eye, nose, and throat irritation.
- The greatest risk of exposure for the Hydroville citizens is through inhalation of MITC. Citizens are not expected to be exposed to metam sodium since public access to the spill site is restricted.
- All recreational activity involving Beaver Creek and areas near the spill site should be restricted until further testing is done.

Teacher Key

Worksheet 1

1. What is metam sodium? What is MITC?
   Metam sodium is a liquid pesticide that is applied to soils before planting to control weeds and pests. MITC is the chemical produced when metam sodium interacts with water and is the active pest-killing substance. MITC is a gas.
2. What are the health effects of metam sodium? MITC? Which is more toxic?
   Metam sodium causes irritation, weakness, headache, nausea, and death at very high doses. MITC causes irritation, nausea and vomiting, injury to the nervous system, and death. MITC is more toxic than metam sodium.
3. How might someone in Hydroville be exposed to metam sodium? What is the route of exposure?
   Anyone handling the liquid pesticide during the cleanup could be exposed. If any metam sodium got into Beaver Creek or the groundwater then people drinking the water could be exposed. The routes of exposure would be ingestion and skin absorption.
4. How might someone in Hydroville be exposed to MITC? What is the route of exposure?
   The cleanup crew and anyone downwind of the spill site could be exposed to MITC. The route of exposure is inhalation and skin absorption. MITC smells like horseradish.
5. What should someone do if he/she is experiencing symptoms that might be related to the metam sodium spill?
   He/she should contact his/her physician or go to the emergency room.
6. What recommendations would you make to the citizens of Hydroville?
   Answers will vary.
7. How long should the contaminated sites be tested?
   Until concentrations of metam sodium and MITC are below 1 ppb.

Teacher Key

Worksheet 2

1. Based on your answers on Worksheet 1, summarize the most important information about metam sodium and MITC below.
   The toxicity of metam sodium is moderate. The toxicity of MITC is moderate to high. During cleanup efforts, spill cleanup workers may be exposed to metam sodium on their skin. Workers may also be exposed to MITC via inhalation and may experience eye, nose, and throat irritation. The greatest risk of exposure for the Hydroville citizens is through inhalation of MITC. Citizens are not expected to be exposed to metam sodium since public access to the spill site is restricted.
2. List the information you need to provide to other members of your Southerville EnviroClean team
   The mechanical engineers must know of the potential for inhalation of MITC while working in the spill area. The team needs to know that site monitoring should continue until concentrations of metam sodium and MITC are less than 1 ppm.
3. What information do you need from other members of your team?
   Answers will vary.
4. List the communication methods you plan to suggest to your team:

Communication method	No. times used	Cost

Answers will vary.

5. Total cost of your communication proposal: ____________________________
   Answers will vary.

Student Pages for

ENVIRONMENTAL TOXICOLOGISTS

Follow this Page

Environmental Toxicologists

Introduction/Goals:

As environmental toxicologists employed by Southerville EnviroClean, your job is to understand the toxicity of metam sodium and its breakdown product, MITC. Also, you will need to communicate any human health risk information to the citizens of Hydroville. Specifically you will need to:

- Review the *Metam Sodium and MITC Fact Sheet* and *Material Safety Data Sheet* for health and emergency information.
- Decide what the Hydroville citizens need to know to protect their health.
- Create and videotape a 60-second public service announcement (PSA) for television.
- Using a budget, select the most effective way to communicate health information to the public.

Materials:

Each Student:

- ☐ Hydroville Science Journal
- ☐ Reading 1: *Metam Sodium and MITC Fact Sheet*
- ☐ Reading 2: *Metam Sodium Material Safety Data Sheet*
- ☐ Worksheet 1: *Fact Sheet and MSDS Questions*
- ☐ Reading 3: *Public Service Announcements*
- ☐ Worksheet 2: *Environmental Toxicologists Report*

Group of Environmental Toxicologists:

- ☐ Video camera, tripod
- ☐ Screen or backdrop for filming
- ☐ Poster board
- ☐ Colored markers

Procedure:

1. On your own, carefully read the *Metam Sodium and MITC Fact Sheet* and the information from the *Metam Sodium Material Safety Data Sheet*. Highlight or underline important facts.
2. Answer the questions on Worksheet 1.
3. Select a partner from the environmental toxicologist group. Share your findings with a partner. Decide what information the public needs to know.

Instructions, Page 2

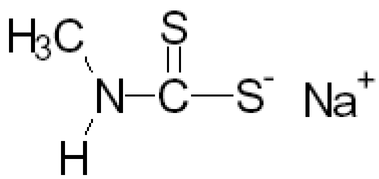
4. Read the *Attention Citizens of Hydroville! Public Service Announcements (PSA)* handout.
5. Brainstorm ideas for your PSA with your partner. You can be creative. However, your PSA should be serious and informative. Remember that the citizens know very little or nothing about metam sodium and MITC.
6. With your partner, write a script for your video.
7. Rehearse your script with your partner. Time your PSA. It cannot be longer than 60 seconds or it won't be put on the air.
8. Create cue cards to prompt you during the filming.
9. Create or bring any visual aids that will be useful but not distracting.
10. Film your PSA. Be certain not to go over the 60-second limit.

Reading 1

Metam Sodium and MITC Fact Sheet

Metam Sodium (sodium N-methyldithiocarbamate) (liquid)	Breaks down in water	**MITC** (methyl isothiocyanate) (gas)

Chemical Structure



What Is It?

Metam Sodium

- Metam sodium is a broad-spectrum pesticide that is used to control weeds, nematodes, soil bacterial diseases, viruses, fungi and insects.
- Metam sodium is a liquid usually applied to soil before crops are planted.
- Typical agricultural application rates range from 60–320 pounds per acre.[1]

MITC

- MITC is the toxic gaseous breakdown product of metam sodium.
- **MITC is more toxic than metam sodium.**
- MITC is the active pest-killing compound.
- MITC is formed when metam sodium comes into contact with water or moisture in soil.
- MITC has a faint horseradish odor.[1]

What Are Possible Health Effects of Acute Exposure?[2, 7, 8, 9]

Exposure Level	Metam Sodium	MITC
Low		• Discomfort • Eye irritation • Running nose • Irritation of skin, throat, and airways
Medium	• Irritation of skin, throat, and airways • Weakness, headache • Dizziness, nausea	• Headache, nausea, vomiting • Mild to severe injury of the nervous system • Death (at high doses)
High	• Death (at very high doses)	

Reading 1, Page 2

How Toxic Is It?[3, 4, 6, 10]

Route of Exposure	Metam Sodium	MITC
Ingestion	Low toxicity	Moderate toxicity
Absorption	Low toxicity	Moderate-high toxicity
Inhalation	Low toxicity	Moderate toxicity

What Happens to It in the Environment?[1]

	Metam Sodium	MITC
Soil	• Metam sodium quickly breaks down into MITC in soil, usually within 1 hour to 1 day. • Breakdown depends on soil temperature, soil texture, and soil moisture. • If present in very large amounts, metam sodium may reach the groundwater before breakdown to MITC is complete.	• Evaporation is the main way that MITC leaves the soil. • MITC evaporation rates are highest in sandy loam and clay soils. • In very wet or very cold soils, evaporation rate is very slow. • In agricultural field applications, about 60% of MITC is lost through evaporation within 14 days. The remainder is broken down by soil bacteria and reaction with water.
Water	• In sunlight, the half-life* of metam sodium in water is less than 1 hour. • In the dark, the half-life is about 35 hours.	• MITC will evaporate out of water, especially if the water is flowing (streams or rivers). • MITC will also break down in water, although this is slow. One reported half-life of MITC in water is 55 days.
Air	• Metam sodium does not evaporate readily. It is not expected to be in the air.	• MITC concentration in air can be very high in locations near a spill site of metam sodium. • However, once evaporated into air, MITC concentration decreases as it is diluted by the surrounding air. • MITC will break down with exposure to sunlight.

**Half-life: The time required for half of the original amount to break down or dissipate. In one half-life, one half of the original amount will remain. In two half-lives, one-fourth will remain.*

Reading 1, Page 3

What Do I Do During an Emergency?[3]

General Public

- Listen for evacuation notices on radio or TV. Evacuate affected areas immediately.
- Contact your physician or emergency room if you have symptoms due to metam sodium or MITC exposure.
- Contact the National Pesticide Information Center at 1-800-858-7378 if you are interested in more information about metam sodium or MITC.

Spill Response and Cleanup Crews

- Use ventilation respirators as well as protective clothing and safety goggles.
- Put barriers around the spill area to keep citizens safe.
- Keep citizens upwind and away from the spill
- In the event of a large spill, contain the spill to prevent contamination of local water sources. Pump the liquid into drums for use or disposal.
- Inform the public and the media about the health hazards and respond to media and public questions.
- Test air and water to see if there is contamination by metam sodium or MITC.
- Provide health and safety information to the public living around the area, and notify them when it is safe to return to their homes.
- Continue to test the site until the concentrations of metam sodium and MITC are less than 1 ppb.

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Reading 2

Metam Sodium Material Safety Data Sheet (MSDS)

The following information is an excerpt from the MSDS for metam sodium.

EMERGENCY OVERVIEW:
DANGER! Dilution with water may generate poisonous gases (methyl isothiocyanate (MITC) or hydrogen sulfide). Dilution with acids may generate flammable gases (carbon disulfide or monomethylamine).

WARNING:
Product is corrosive to skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Harmful if swallowed. Harmful if inhaled. Harmful if absorbed through the skin. Irritating to eyes, nose, and throat. Do not get on skin or clothing. Avoid breathing vapor or spray mist. Do not get in eyes.

Toxic to fish. Do not contaminate water bodies.

POTENTIAL HEALTH EFFECTS
Routes of entry: Skin contact, inhalation, ingestion, and eye contact with the liquid product. As a result of use of the product in agricultural fields, people applying the product and other persons present in the area of the application can be exposed to MITC and/or hydrogen sulfide. MITC has a horseradish-like odor and can be very irritating to the eyes.

Signs of acute overexposure: Acute exposure to metam sodium may result in damage to the skin, skin irritation, excessive salivation, sweating, fatigue, weakness, nausea, headache, dizziness, and eye, nose, throat, and respiratory tract irritation.

Acute exposure to MITC may result in strong skin and eye irritation, running nose, dizziness, cramps, nausea, vomiting, and mild to severe disturbances of the nervous system. High doses can result in difficulty breathing, chronic pulmonary edema, coma, and death.

ACCIDENTAL SPILL MEASURES
General: Use adequate ventilation and air-supplied respirators, as well as impervious clothing and safety goggles. Contact of metam sodium with moisture in the soil can generate the flammable and toxic gas MITC. Keep bystanders upwind and away from the spill.

Small spill: Cover with absorbent (clay, sawdust, straw, kitty litter, etc.), to absorb the liquid and vapors. Sweep into an open drum. Clean the area with common powdered household detergent and a stiff brush and just enough water to make a slurry. Absorb and sweep into the same open drum. Rinse with water, absorb, and add to the waste drum. Close the drum and dispose of properly.

Large spill: Dike the spill to prevent contamination of local water sources. Siphon the majority of the liquid into drums for use or disposal, depending on the circumstances.

Worksheet 1

Name_______________________________

Date__________________ Period______

Fact Sheet and MSDS Questions

Answer the following questions and use your answers to help you decide what information to include in your PSA:

1. What is metam sodium? What is MITC?

2. What are the health effects of metam sodium? MITC? Which is more toxic?

3. How might someone in Hydroville be exposed to metam sodium? What is the route of exposure?

4. How might someone in Hydroville be exposed to MITC? What is the route of exposure?

Worksheet 1, Page 2

Name______________________________

Date_________________ Period______

5. What should someone do if he/she is experiencing symptoms that might be related to the metam sodium spill?

6. What recommendations would you make to the citizens of Hydroville?

7. How long should contaminated sites be tested?

Reading 3

Public Service Announcements

Have you been watching TV and noticed that some commercials aren't really selling you anything? Maybe they were telling you information about health or safety. These clips are called public service announcements, or PSAs. Unlike commercials, which try to sell you a product or service, a PSA is meant to inform the public.

PSAs usually follow a similar pattern:

1. The hook – a phrase or sentence to catch your attention
2. The main point – information telling you why this idea is important
3. The call to action – this portion tells you what you should do

To be effective, a PSA should:

- be serious
- have a clear message
- have important and accurate information
- use short and simple sentences
- use a person who is respectable and dressed appropriately
- use a person who speaks slowly and clearly

Examples of good PSAs can be found on the Hydroville Pesticide Spill Resources Web page: http://www.hydroville.org/links/ps_resources.aspx

Some organizations have a mascot or catchy phrases that help you remember their message. Below are some popular mascots. Can you remember the characters and their slogans? (Answers are below.)

a.

b.

c.

a. McGruff the Crime Dog ("Take a bite out of crime.") b. Vince and Larry ("You could learn a lot from a dummy. Buckle your safety belt.") c. Smokey Bear ("Only you can prevent forest fires.")

Worksheet 2

Name ______________________________

Date _________________ Period ______

Environmental Toxicologists Report

Public Information

1. Based on your answers on Worksheet 1, summarize the most important information about metam sodium and MITC below.

2. List the information you need to provide to other members of your Southerville EnviroClean team.

3. What information do you need from other members of your team?

Worksheet 2, Page 2

Name ______________________________

Date __________________ Period _______

Method of Communication

As the environmental toxicologist, you need to decide what method is most effective in distributing this information to the public. Be certain that your choice(s) will reach all of the citizens of Hydroville. You can use a method more than once (for example, using a TV PSA every day for a week).

- PSA, television, 1 minute – $2,000 to create, free to broadcast
- PSA, radio, 1 minute – $1,000 to create, free to broadcast
- Newspaper ad – $500 per 1/2 page per day
- Telephone information hotline (manned 8 hours a day) – $200 per day
- Press conference – $400
- Educational brochures for Hydroville residents – $500 for 1,000 brochures
- Education poster in the library – $300

What information do you need from other members of your team?

4. List the communication methods you plan to suggest to your team:

Communication method	No. times used	Cost

5. Total cost of your communication proposal: ____________________________

MECHANICAL ENGINEERS

Hydroville, USA

MECHANICAL ENGINEERS

Description:

The mechanical engineers will build a model of a pump that will remove as much of the pesticide as possible from the ditch without exposing humans to the hazardous substance.

Purpose/Goals:

Students will be able to:

- build a pump and transport vehicle that meets design requirements from the materials supplied
- calculate the cost of the pump
- calculate the time it took to remove the pesticide from the ditch
- calculate the total cost of pesticide removal, hauling, and disposal

Prerequisites:

Background Activity 3: *Pump it Up! Part I – Analyzing Pumps*

Background Activity 4: *Pump it Up! Part II – Designing a Supersoaker*

Time Estimate:

Prep: 60 minutes

Activity: Three 50-minute periods:

- Day 1: Design a pump and transport vehicle.
- Day 2: Build and test pump and transport vehicle.
- Day 3: Complete Mechanical Engineers report, including cost calculations.

Materials:

Each Student:

- ☐ Hydroville Science Journal
- ☐ 3-D model of spill site

Each Group of Two to Three Students:

- ☐ Super Soaker models (from Background Activity 4)
- ☐ A selection of the materials listed on Worksheet 1

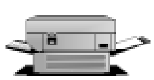
Class Materials on Tool Table:

- ☐ Hammer
- ☐ Hot glue gun and glue sticks
- ☐ Scissors
- ☐ Extra parts: washers, paper clips, staples, etc.
- ☐ Leftover materials from Background Activity 4

Spill Site Setup:

- ☐ Masking tape
- ☐ Tape measure or meter stick
- ☐ One drawer organizer (3" x 12") to represent the ditch
- ☐ 500 mL of colored water
- ☐ One 250 mL graduated cylinder

Pages to Photocopy:



One copy/student:

- Instructions: *Mechanical Engineers*
- Worksheet 1: *Materials Cost Sheet*
- Worksheet 2: *Mechanical Engineers Report*

Terminology:

Closed system

Suggested Lesson Plan:

Getting Started

1. Organize materials for students to work in groups of two to three. (See *Materials Cost Sheet*.) Set up the tool table along with extra miscellaneous parts.
2. Identify an area in the classroom or hallway to set up a simulation of the spill site, allowing enough space for a circle 10 feet in diameter. Use masking tape to construct an outline of a 10-foot circle. This represents the "hazard zone." Even with HazMat suits, the mechanical engineers must operate their pumps from outside the circle (hazard zone) for extra personal safety.

3. Set the drawer organizer with 500 mL of colored water inside the middle of the circle. This represents the ditch containing metam sodium.
4. Organize materials on tool table. Have lots of extra materials from Background Activity 4 for students to use to be creative on their pumps. Price each of the materials at your discretion.

Doing the Activity

Day 1

1. Working in groups of two or three, the mechanical engineers will design a pump and transport system to remove the metam sodium from the ditch. Since the students controlling the pump must stay outside the hazard zone, they will also need to design a transport vehicle that moves the hose to the ditch.
2. Mechanical engineers from each team will design and build a model of a pump. If there is only one mechanical engineer per team, pair him/her up with another member of a team. They can share the model they create.
3. Students should read steps 1 and 2 of the Procedure before designing a pump and transport system. If the mechanical engineers are having trouble beginning, lead them in a brainstorming session.
4. Give students 1 day to complete *Part I. Designing a Model Pump*.
5. Once a team completes their pump design, transport vehicle, and storage tank, sign off on their student worksheet and allow them to continue to *Part II. Building the Pump*. Students then build a model of their pump design using the materials provided.

Day 2

6. Allow students to test their pumps on the model of the spill site. On Day 2, each team must remove 400 mL of liquid from the ditch.
7. Observe each group as they test their models and assess that performance requirements are met.

Day 3

8. Each student must complete a *Mechanical Engineers Report* to share with their team.

Mechanical Engineers Fact Sheet

Facts:

- A 20,000-gallon tanker truck overturns and about 10,000 gallons flow into the ditch before the HazMat team seals off the truck. Booms are placed in the ditch by the HazMat team to prevent flow of pesticideinto the creek.
- The spill occurs at 5:30 a.m. on a Tuesday in February.
- A cleanup team from Southerville EnviroClean arrives at the site at 8:00 a.m.
- Pumping begins at 11:30 a.m., 6 hours after the spill.
- Approximately 8,500 gallons remain in the ditch to be pumped out.
- Pumps can remove 40 gallons/minute from the ditch.

Teacher Key

Worksheet 2

1. Draw your final pump design on a separate sheet of paper and attach it to this report. Label all parts on your drawing.
   Will vary by team.
2. What is the total cost of the pump and transport system?
   Will vary by team.
3. The pumping capacity of your actual (not model) pump is 40 gallons/minute. How long (in hours) would it take for your pump to remove 8,500 gallons of pesticide from the ditch?
   8,500 gallons x 1 minute/40 gallons = 212.5 minutes x 1 hour/60 minutes = 3.5 hours.
4. The cost to dispose of the removed pesticide needs to be added into the budget for the cleanup. A hazardous waste disposal site will take the spilled pesticide for a cost of $1.00/gallon. The tanker truck that will haul the pesticide from the site costs $180/hour to operate, including the driver. It will take the driver 3 hours driving at 50 mph to haul the pesticide to the disposal site (150 miles from the spill). To calculate the total cost, you also must take into account how long the truck must wait at the site to be filled by the pump.

   Cost to drive the truck to the spill site from the disposal site .... *$540.00 ($180/hr x 3 hr)*

   Cost of waiting while pumping the pesticide............................. *$630.00 ($180/hr x 3.5 hr)*

   Cost of hauling pesticide back to the disposal site......................... *$540.00 ($180/hr x 3 hr)*

   Cost of disposal of pesticide.. *$8,500.00 ($1/gal x 8,500)*

   Total disposal cost: *$10,210.00*

   Teams may come up with other alternatives for disposal of the pesticide, such as selling it to farmers in the surrounding area for a reduced price.
5. Total cost for disposal, pumping, and transport vehicle.
   Answers will vary.
6. List the information you need to provide to other members of your team.
   Answers will vary. The soil scientists will need to know how long it took to remove all the pesticide from the ditch.
7. What information do you need from other members of your team?
   Answers will vary.

Teacher Key

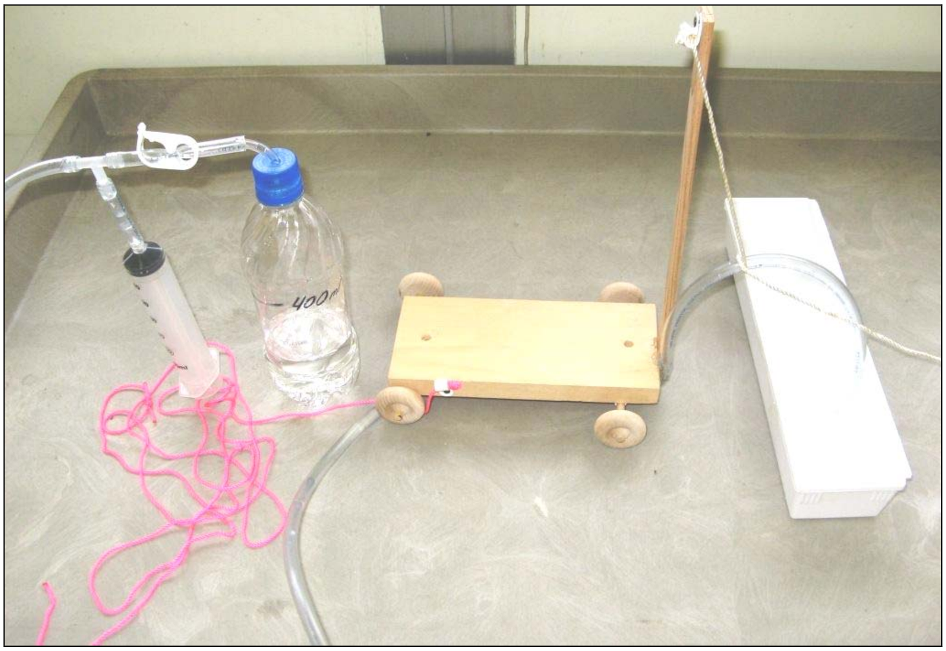


Figure 1. Example of a Transport Vehicle and Pump

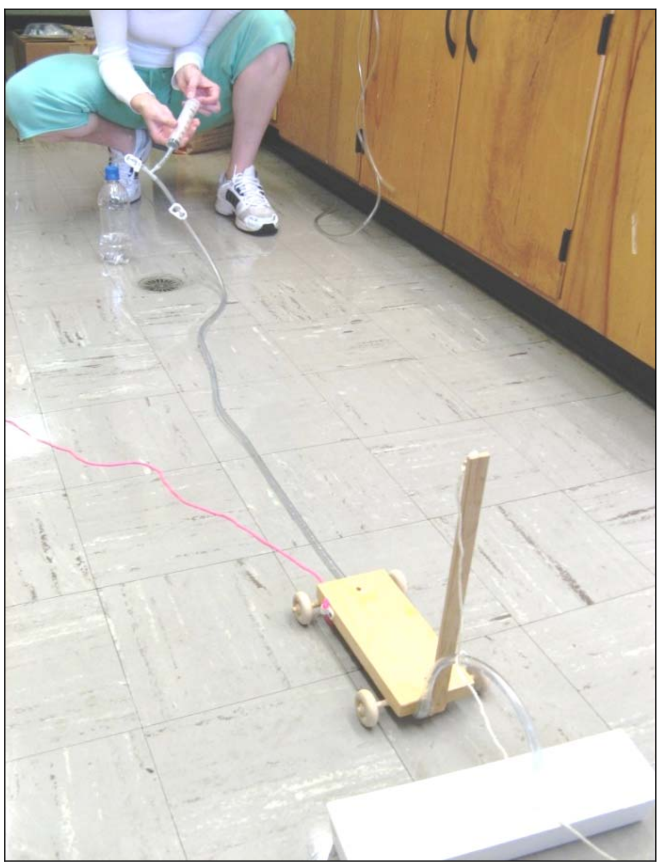


Figure 2. Spill Setup – Pump Is 5 Feet away from Ditch

Student Pages for

MECHANICAL ENGINEERS

Follow this Page

Mechanical Engineers

Introduction/Goals:

Southerville EnviroClean has hired you as a mechanical engineer to remove the metam sodium from the ditch. Before you can build a system to pump out the remaining pesticide, you need to survey the spill site to better understand the situation. You arrive at the spill site at 8:00 a.m. on a Tuesday morning in February, just 2 1/2 hours after the spill occurred.

At the spill site, you learn that the HazMat team has marked off a 50-foot hazard zone. No one is allowed in the area at this time. (The 10-foot diameter circle your teacher has created represents the hazard zone.) Therefore, you will need to build a customized transport system vehicle that allows you access inside the hazard zone. This system must move the pump and hoses to the ditch, while the pump and collection tank remain on the road.

You will work with other mechanical engineers in a team to design a pump and transport vehicle that will remove the metam sodium from the ditch.

Part I. Designing a Model Pump

Materials:

- ☐ Hydroville Science Journal
- ☐ Worksheet 1: Materials Cost Sheet
- ☐ All materials listed on *Materials Cost Sheet*
- ☐ Extra parts on tool table

Procedure:

1. Read the *Pump and Transport System Performance Requirements* on page 2 before getting started.
2. Look over all of the materials listed on the *Materials Cost Sheet* and on the tool table.
3. Working in groups of two or three, brainstorm how you can design a pump and transport system that will remove metam sodium from the ditch.
4. In your Hydroville Science Journal, make sketches of your pump and transport vehicle. Don't get stuck on one design and try to force it to work. Remember to listen to the other members in your group. **All ideas are good ideas!**
5. When your design is completed and meets all of the performance requirements, ask your teacher to review and initial it before moving on to Part II.

Instructions, Page 2

Pump and Transport System Performance Requirements

(Read this carefully before you begin brainstorming your design.)

- The pump and transport system must be constructed from only the materials provided. See materials on the tool table.
- The pump must remove at least 400 mL of metam sodium from the container representing the ditch.
- The metam sodium must be transferred from the ditch into a storage container (soda bottle) that remains outside of the hazard zone.
- The pump and storage container need to be a closed system. Once the metam sodium is pumped from the ditch, none of the hazardous substance can be exposed to the air.
- You must remain outside the hazard zone (represented by the 10-foot-diameter circle). Even with HazMat suits, this requirement is for additional personal safety.
- Design a transport system/vehicle that can move inside the hazard zone and remove the liquid metam sodium from the ditch. It must then move back to the road.
- Power needed to operate and control the transport vehicle may be generated by one or more participants using string, representing rope.
- Keep track of the cost of all materials used, because you want to keep costs to a minimum. Don't use extra materials if you don't need them. See *Materials Cost Sheet* for prices.

Teacher Approval of Design____

Part II. Building the Pump

1. Build the pump based on your design sketch.
2. Calibrate the storage container (20-oz. soda bottle). Measure 400 mL of water and pour it into the soda bottle. Using a permanent marker, draw a line to show the 400 mL level. This is how much metam sodium your pump must remove from the ditch.
3. Test your pump.
4. If your pump cannot successfully remove the pesticide, brainstorm modifications that will improve the pump.
5. Redesign the pump and test it again.
6. Repeat steps 4 and 5 until your pump meets all the requirements.
7. Calculate the cost of your pump on the *Materials Cost Sheet*.

Part III. Testing the Pump

With your teacher as an observer, demonstrate that your pump meets the performance requirements listed below. If not, redesign the pump to meet the requirements.

- ☐ 1. The pump is constructed from only the materials provided.
- ☐ 2. The pump removes at least 400 mL of metam sodium from the ditch.
- ☐ 3. The metam sodium is transferred from the ditch to a storage container that remains outside of the hazard zone.
- ☐ 4. The pump and storage container are a closed system.
- ☐ 5. The team remained outside the hazard zone.
- ☐ 6. The transport vehicle is able to move inside the hazard zone to the ditch and back.
- ☐ 7. The transport vehicle is powered by participants.
- ☐ 8. The team calculated total cost of materials used on *Materials Cost Sheet*.

_____ **SCORE**

8 = Excellent

7 = Very Good

6 = Satisfactory

<5 = Unsatisfactory (need to redesign)

Part IV. Mechanical Engineers Report

Work with the other mechanical engineers to complete Worksheet 2: *Mechanical Engineers Report*.

Worksheet 1

Name ______________________________

Date __________________ Period ______

Materials Cost Sheet

Components	Cost*/Unit	Quantity Used	Total Cost
60cc syringe	$365.00 each		
1/4" vinyl tubing	$53.00/foot		
1/8" vinyl tubing	$40.00/foot		
1/4" T-connector (for 1/4" tubing)	$119.00 each		
1/8" T-connector (for 1/8" tubing)	$110.00 each		
1" x 4" x 8" wood block	$42.00 each		
1/4" x 3/4" x 12" wood strip	$42.00 each		
1/4" x 1 5/16" x 8" wood strip	$39.00 each		
6" wooden dowel (wheel axle) – 1/4" diameter	$33.00/foot		
1/8" x 12" steel rod	$600.00/foot		
Nylon string	$20.00/foot		
Polyclamps (hold axle to block) – 1/4"	$27.00 each		
Rubber bands	$10.00 each		
Storage container (soda bottle) to hold 400 mL	$149.00 each		
Rubber stoppers	$56.00 each		
Steel tacks or nails	$20.00 each		
Tape (masking or duct)	$50.00/foot		
Tubing (shutoff) clamps	$56.00 each		
Wheels (1/4" fits dowel)	$21.00 each		
Extra materials (from tool table)	See teacher for prices		
		Total	

*Costs are for actual size components that the pump model represents.

Worksheet 2

Name ______________________________

Date _________________ Period ______

Mechanical Engineers Report

1. Draw your final pump design on a separate sheet of paper and attach it to this report. Label all of the parts on your drawing.
2. What is the total cost of the pump and transport system? _________________________
3. The pumping capacity of your actual (not model) pump is 40 gallons/minute. How long (in hours) would it take for your pump to remove 8,500 gallons of pesticide from the ditch?

$$\frac{\text{total gallons}}{\text{pumping capacity}} = \text{\# of minutes}$$

$$\frac{\text{\# of minutes}}{\text{60 minutes/hour}} = \text{\# of hours}$$

4. The cost to dispose of the removed pesticide needs to be added into the budget for the clean up. A hazardous waste disposal site will take the spilled pesticide for a cost of $1.00/gallon. The tanker truck that will haul the pesticide from the site costs $180/hour to operate, including the driver. It will take the driver 3 hours driving at 50 mph to haul the pesticide to the disposal site (150 miles from the spill). To calculate the total cost, you also must take into account how long the truck must wait at the site to be filled by the pump.

	Truck cost/ hour	Number of hours	Total cost
Cost to drive the truck to the spill site from the disposal site			
Cost of waiting while pumping the pesticide (time from #3)			
Cost of hauling pesticide back to the disposal site			
	Cost/gallon	No. of gallons	
Cost of disposal of pesticide			
Total disposal cost			

5. Total cost for disposal, pump, and transport vehicle: ______________

Worksheet 2, Page 2

Name______________________________

Date_________________ Period______

6. List the information you need to provide to other members of your team.

7 What information do you need from other members of your team?

ANALYTICAL CHEMISTS

Hydroville, USA

ANALYTICAL CHEMISTS

Description:

The analytical chemists will examine samples taken from Beaver Creek, groundwater, and soil at the spill site for metam sodium. They will also analyze air samples for MITC. Students will apply their knowledge of standards and chromatography to determine the location and concentration of the pesticide.

Purpose/Goals:

Students will be able to:

- analyze gas chromatographs of each sample site to identify presence and concentration of metam sodium
- estimate concentration of MITC in the air
- calculate overall cost of sampling and a monitoring plan

Prerequisites:

Background Activity 5: *Constructing and Analyzing Graphs – Circumference and Diameter*

Background Activity 6: *Using Paper Chromatography*

Time Estimate:

Prep: 50 minutes

Activity: Three 50-minute class periods

- Day 1: Graph Standards of Metam Sodium
- Day 2: Analyze Gas Chromatograms of Samples from Spill Site
- Day 3: Calculate Costs and Complete Analytical Chemists Report

Materials:

- ☐ Hydroville Science Journal
- ☐ 3-D model of spill site
- ☐ Rulers
- ☐ Colored paper or small Post-it® Notes (yellow, blue, green)
- ☐ Toothpicks
- ☐ Colored markers or pencils

Pages to Photocopy:

Transparency of Gas Chromatography diagram in student section

One copy/student:

- Instructions: *Analytical Chemists*
- Worksheet 1: *Graph Standards for Metam Sodium*
- Worksheet 2: *Analyze Gas Chromatograms of Samples from Spill Site*
- Worksheet 3: *Analytical Chemists Report*
- *Map of Hydroville*
- *Topographic Map of Spill Site*
- Two pieces of graph paper/team (five squares/inch)

One set/pair of students:

- Chromatograms (laminate and use for every class):
  - Standard chromatograms (on yellow paper)
  - Quality Check chromatogram (on green paper)
  - Spill Site Sample chromatograms (on white paper)

Terminology:

Detector
Concentration
Parts per billion
Parts per million
Calibration curve
Chromatography
Chromatogram
Gas chromatography (GC)
Standard

Background Information:

Gas Chromatography

By Ralph Reed, Analytical Chemist, Oregon State University

Detection of Chemicals in a Sample

One technique to separate and identify chemicals in a sample is chromatography. The word *chromatography* literally means "color graph." A nice example of chromatography is to put a spot of ink from a felt-tip marker on a piece of paper, then put the edge of the paper in alcohol. The alcohol will wick up the paper, and the ink will rise up the paper (with the alcohol) and separate into multiple spots or layers, which are individual chemicals.

Each of the chemicals has a different tendency to stick to the paper or be dissolved in the alcohol. In paper chromatography, the paper is called the *stationary phase* and the alcohol is the *mobile phase*. Chemicals that are more attracted to the alcohol will be less attracted to the stationary phase and will travel further up the paper. Chemicals that have a greater attraction to the mobile phase will not move as far. Almost all types of chromatography are based on a chemical's attraction or "affinity" to either the mobile or stationary phase which is how a mixture of chemicals is separated and then the individual chemicals can be identified.

As a variation on this basic demonstration, we could grind up the paper and put it in a long tube, apply a dot of ink at one end, and then drip alcohol through the tube to separate the ink components. Each of the components of the ink would drip out the end of the tube at a different time, depending on their relative tendencies to bind to the stationary phase. We also could use some other material in the tube for separation, depending on what chemicals we want to examine. Once the ink components, or *analytes*, are separated (either using a strip of paper or paper powder in a tube), we can detect the chemicals that come out the end of the tube by looking at them visually. We could also use a machine, termed a *detector*, to measure the spots more accurately than our eyes do.

Gas Chromatography

Gas chromatography, also called GC, has been used to separate, detect, and measure the chemical, metam sodium, in your Hydroville experiment. For its mobile phase, a GC (gas chromatograph instrument) uses a gas, such as helium or nitrogen. For its stationary phase, a GC has a long glass tube that is open at both ends and coated on the inside with a material that absorbs chemicals.

Using a syringe, we inject our sample into a heated part of the GC, so that the sample quickly evaporates into a gas. This gaseous sample then enters the stationary phase in the long glass tube. Because our mobile phase is a gas, the sample components are carried along in the gas phase.

The long glass tube is about half the length of a city block (30 or 60 meters) and has a very small diameter. Like the ink spot components that are wicked by the alcohol in paper chromatography, the chemicals in the Hydroville samples will have different tendencies to interact with the stationary phase (the tube coating). This will cause the chemicals to exit the tube (at the opposite end) into the detector at different times. To speed up the process, the glass tube of the GC is inside an oven so that it can be carefully heated.

Now that the chemicals have been separated (they will exit the tube at different times after being injected), we need to detect them. There are several types of detectors used for GCs. For the Hydroville samples, a computer is used to detect the chemicals as they come off the tube so that we can tell what each compound is by using the time it takes to come out of the tube. Metam sodium will come off the gas chromatograph column and be detected as a peak on the chromatogram at 13.13 ± 0.02 minutes. We can also calculate the exact *concentrations* (in ppm) of each chemical from the graphs produced by the computer. (See diagram in student section.)

Suggested Lesson Plan:

Getting Started

1. Read the *Teacher's Fact Sheet* to understand the data that the analytical chemists will analyze and where the metam sodium and MITC occurs at the spill site. Your role is to facilitate the group, not to lead the activity.
2. Hand out Instructions. Set the stage by discussing analytical chemists' goals.
3. Remind the analytical chemists that they are responsible for understanding and sharing this information with the others on their Southerville EnviroClean team.
4. Before starting this activity, have students read *Chromatography* in the Instuctions. Have each student underline key concepts and new words. If they need more information about gas chromatography, they can search on the Web.
5. Working with a partner, they answer the Chromatography Questions in Instructions.

Doing the Activity

Day 1. Graph Standards for Metam Sodium

1. Just as they did in Background Activity 5, *Constructing and Analyzing Graphs – Circumference and Diameter*, students begin by creating a standard graph or "calibration curve." Known concentrations of a specific chemical are used to calibrate or standardize the gas chromatograph before running any samples with unknown substances. In this case, three known concentrations of metam sodium are run through the gas chromatograph to calibrate it before testing samples that were collected at the spill site.
2. Students are given three chromatograms: Standard #1, Standard #2, and Standard #3. These "pictures" were produced after three known concentrations of metam sodium were run through the gas chromatograph.
3. On each chromatogram, students need to locate the specific peak for metam sodium. Remind students that metam sodium will come off the column and be detected as a peak on the chromatogram at **13.13 $\pm$ 0.02 minutes (13.11–13.15).**
4. Next, students measure the height of this peak (in centimeters) to the nearest tenth. Each chromatogram is a different height, depending on the amount (concentration) of metam sodium present. Refer to the Teacher Key, Worksheet 1 to see how to set up the calibration curve for metam sodium.

5. Once students create a standard curve, they use a Quality Check chromatogram to check the accuracy of their graph.

Classroom Hints: To save time, you may choose to give the students a completed standard graph for metam sodium.

Day 2. Analyze Gas Chromatograms of Samples from Spill Site

1. Students analyze 15 chromatograms for metam sodium from samples of surface water (SW), groundwater (GW), and soil (S) taken around the spill site.

Classroom Hints: To shorten this activity, have students analyze only a few of the chromatograms. Provide the data for peak height and/or concentration of metam sodium for the remaining samples. See Table 2 in Teacher Key.

2. Metam sodium was not detected in some of the samples. If you look at these chromatograms, there are no peaks in the region of metam sodium (13.13 ± 0.02 minutes).
3. On the 3-D model of the spill site or on the map, *Topographic Map of Spill Site*, students record concentrations of metam sodium at the respective sample locations.

Day 3. Calculate Costs and Complete Analytical Chemists Report

1. All of the analytical chemists should get together to discuss the sampling results and determine which locations are contaminated with metam sodium. As a group, they need to predict the movement of metam sodium in the soil and whether it will enter Beaver Creek or the groundwater.
2. Students calculate cost of initial sampling and also estimate costs for a monitoring plan for 1 month. They calculate a total cost for sampling and monitoring to present to the Hydroville City Council.
3. Students complete *Analytical Chemists Report* to share with their Southerville EnviroClean team.

Resources:

- See Internet resources on the Hydroville Web site: http://www.hydroville.org/links/ps_resources.aspx

Teacher Key

Analytical Chemist Fact Sheet

- The pesticide spill occurs at 5:30 a.m. Approximately 10,000 gallons of metam sodium spill out of the truck before the HazMat Team arrives.
- Three types of samples are taken to detect metam sodium at the spill site: surface water (Beaver Creek), groundwater (private well), and soil (at 5-foot depths near pool and ditch).
- All samples are collected on Tuesday, the same day as the spill occurs.
- Water samples are collected from Beaver Creek at sample locations SW1 and SW2 at 8:30 a.m. (SW 2 is on *Map of Hydroville*). No pesticide is detected in Beaver Creek at this time because the spill had been initially contained using booms.
- Additional water samples are taken from Beaver Creek after the mechanical engineers pump the pesticide from the pool. Metam sodium is not detected in Beaver Creek at 4:00 p.m.
- Groundwater sampled from a private well at the Jones' Farm (GW1) located west of the spill site at 4:00 p.m. does not contain metam sodium.
- Ten soil samples (S1–S10) are taken at soil depths of 5 feet at various locations around the ditch and pool. Metam sodium is detected at 845 feet, which indicates that it is spreading into the soil from the pool where it originally collected.
- Air samples were collected and analyzed for MITC near the Jones' Farm (A1) starting at 8:00 a.m. MITC levels exceed safe levels (0.6 ppb) and occupants west of the spill site are evacuated.
- Air samples are also taken 1,000 feet north of spill site at A2 (*Map of Hydroville*) starting at 8:00 a.m. MITC does not exceed safe levels, so Hydroville residents do not have to be evacuated unless the wind changes direction. The wind is currently blowing west.
- Additional air samples are taken every 3 hours at both locations. The levels of MITC are decreasing over time.
- Students should recommend continued monitoring of groundwater, surface water, and soil to ensure that all of the metam sodium was removed from the spill site and none has leached into the surrounding area. Air monitoring at A1 should continue until MITC levels are below 0.6 ppb.

Teacher Key

Instructions:

a. Compare gas chromatography (GC) with paper chromatography. What do both processes have in common?
Both paper and gas chromatography are used to separate chemicals from a mixture or compound for identification. Both have a stationary and mobile phase.

b. What is the mobile phase in GC? In paper chromatography? What is the stationary phase in both?
The mobile phase in GC is helium gas. The mobile phase in paper chromatography is alcohol. In GC, the stationary phase is the long glass tube coated with an absorbent material. In paper chromatography, it is the paper.

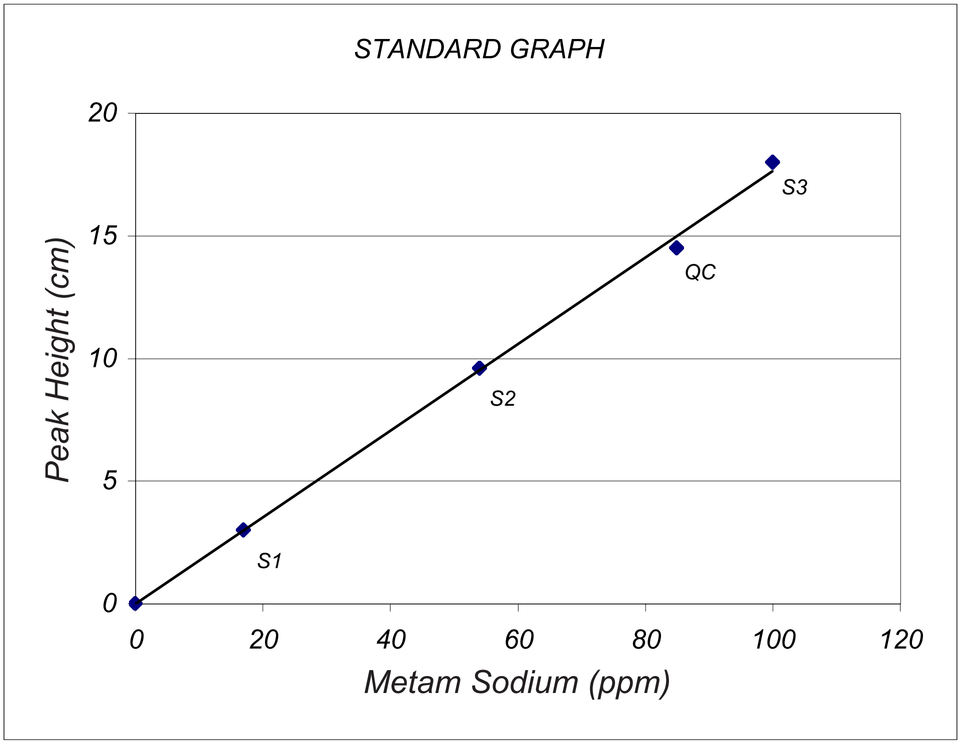
c. Looking at the chromatogram of metam sodium, how do you know if this chemical is present?
Metam sodium is detected at 13.13 minutes (+ or - 0.2). You will find a peak in between 13.11-13.15 if it is present.

Worksheet 1

Table 1. Standards for Metam Sodium

Chromatogram	Metam sodium concentration (ppm)	Peak height (cm)
Standard #1 (S1)	17	3.1
Standard #2 (S2)	54	9.7
Standard #3 (S3)	100	18.0
Quality Check (QC)	85	15.4

Worksheet 1 continued



Teacher Key

Worksheet 3

Table 2. Spill Site Samples Tested for Metam Sodium

Sample	Sample type	Sample location	Time	Peak height (cm)	Metam sodium (ppm)
A	surface water	SW1 – Beaver Creek	8:30 a.m.	0	0
B	surface water	SW2** – Beaver Creek	8:30 a.m.	0	0
C	surface water	SW1 – Beaver Creek	4:00 p.m.	0	0
D	surface water	SW2** – Beaver Creek	4:00 p.m.	0	0
E	groundwater	GW1 – well at Jones' Farm	4:00 p.m.	0	0
F	soil*	S1 – south edge of ditch @ 845 feet	4:00 p.m.	7.9	42
G	soil*	S2 – west edge of pool @ 845 feet	4:00 p.m.	9.7	54
H	soil*	S3 – west edge of pool @ 845 feet	4:00 p.m.	15.4	85
I	soil*	S4 – 12 feet west of pool @ 849 feet	4:00 p.m.	0	0
J	soil*	S5 – north edge of pool @ 845 feet	4:00 p.m.	15.9	88
K	soil*	S6 – 15 feet north of pool @ 845 feet	4:00 p.m.	0	0
L	soil*	S7 – east edge of pool @ 845 feet	4:00 p.m.	13.9	78
M	soil*	S8 – 15 feet east of pool @ 847 feet	4:00 p.m.	0	0
N	soil*	S9 – east edge of ditch @ 847 feet	4:00 p.m.	4.6	27
O	soil*	S10 – south edge of ditch @ 847 feet	4:00 p.m.	0	0

*All soil samples taken at depth of 5 feet
**SW2 is located on *Map of Hydroville*

Analytical Chemists Report

Worksheet 3: Conclusion Questions

1. Based on the data you analyzed in Table 2, which three sample locations have the highest concentration of metam sodium? Provide a hypothesis that explains these results.
   Soil samples S3, S5, and S7 have the highest levels of metam sodium because they were taken at the edge of the pool where the pesticide collected and the pesticide had begun to permeate into the soil.
2. Where else was metam sodium detected?
   Metam sodium was detected in lower concentrations in soil at S1 (south edge of ditch), S2 (west edge of pool), and S9 (south of pool).
3. Right after the pesticide spill occurred, both Hydroville Water Treatment Plants stopped using the water from Beaver Creek for drinking water. Based on samples from SW1 and SW2, when can they begin pumping water from Beaver Creek?
   Answers will vary, but there is no evidence that metam sodium got into Beaver Creek. Students might recommend continuing monitoring for a period of time.
4. The residents of the Jones' Farm will want to know if they can drink the water from their well (GW1) when they return home. What do you recommend? Give reasons to support your answer.
   For the next few days, the Joneses should not use the water from their well, because the pesticide may leach into the groundwater. Students may advise them to continue to drink bottled water until further sampling is done.
5. MITC is a gas that is produced when metam sodium breaks down in soil and water. When MITC levels are above 0.6 ppb, the gas is harmful if inhaled. Based on data from air samples taken at A1 on Table 3, how would you know when it is safe for residents on the west side of the spill to return to their homes?
   At this time, it is not safe for the residents on the west side of the spill to return to their homes. More sampling is required until the level of MITC is below 0.6 ppb.
6. Based on data in Table 4 from air samples taken at A2 (on the *Map of Hydroville*), what recommendations would you make to protect the residents of Hydroville who live north of the site from exposure to MITC?
   At this time, residents on who live north of the site are safe. Air samples will continue to be taken at A2 in case the wind direction changes.

Analytical Chemists Report (continued)

7. Calculate the total cost for all of the samples collected at the spill site, including the analytical laboratory charges. Include air samples, four per sample location.
   $8,050 = 23 x $350.
8. Develop a monitoring plan to ensure the citizens of Hydroville that your team's cleanup was effective. In addition, you will need to provide an itemized budget of monitoring costs to the Hydroville City Council.

Monitoring Plan

Sample location	Frequency (# samples /month)	Sampling Cost ($150/sample)	Analytical Lab Charge ($200/sample)	Total Cost /Sample Location
For example: GW1	*4*	*$600*	*$800*	*$1,400*
Answers will vary				
Total Cost of Monitoring Plan (for one month)				*Answers will vary*

9. How many months will you continue to monitor?
   Answers will vary.
10. Estimate Total Cost of Monitoring Plan for this time period.
    Answers will vary.
11. Total Cost of Initial Sampling and Monitoring Plan.
    Answers will vary.
12. List the important facts and conclusions that you want to share with other members of your team.
    Answers will vary.

Student Pages for

ANALYTICAL CHEMISTS

Follow this Page

Instructions

Name ____________________________

Date ________________ Period ______

Analytical Chemists

Introduction/Goals:

As analytical chemists employed by Southerville EnviroClean, your job is to analyze samples collected from groundwater, Beaver Creek, and soil around the spill site for metam sodium. You will also look for concentrations of MITC in air samples. Samples from Beaver Creek were taken at 8 a.m., 2.5 hours after the spill occurred. Other samples were taken at 4 p.m. after the mechanical engineers pumped the pesticide from the ditch. Air samples were collected every 3 hours throughout the day. Specifically, you will:

- Analyze gas chromatograms of metam sodium to determine amount present at sample locations.
- Identify and outline area of pesticide spill.
- Calculate cost of collecting samples and analytical lab charges.
- Develop a monitoring plan.

Analyzing Samples Using Gas Chromatography

Laboratories use various techniques for analyzing samples containing unknown substances. As analytical chemists working on the pesticide spill in Hydroville, you send your samples to an analytical laboratory to determine the presence of metam sodium. The samples taken from surface water, groundwater, and soil will be analyzed using *gas chromatography*, called GC for short.

Procedure:

1. Before getting started, read the information on *Chromatography*. Underline key concepts and new words. If you need more information about gas chromatography, search on the Web.
2. Working with a partner, answer the following Chromatography Questions:
   a. Compare gas chromatography (GC) with paper chromatography. What do both processes have in common?

   b. What is the mobile phase in GC? In paper chromatography? What is the stationary phase in both?

   c. Looking at the chromatogram of metam sodium, how do you know if this chemical is present?

Chromatography

The word *chromatography* literally means "color graph." There are many types of chromatography, but all do the same thing. They separate the components of a mixture of chemicals. In paper chromatography, a spot of ink from a felt-tip marker is put on a piece of paper, then the edge of the paper is put in alcohol. The alcohol will wick up the paper, and the ink will rise up the paper (with the alcohol) and separate into multiple colors or layers, which are individual chemicals in the mixture called ink.

Each chemical has a different tendency to stick to the paper or dissolve in the alcohol. The ones that stick less tightly to the paper will travel further up the paper. In paper chromatography, the paper is called the *stationary phase*, and the wicking alcohol is the *mobile phase*. Almost all types of chromatography are based on differences in attractions of a chemical for the phases that are used to separate them.

We could also grind up the paper and put it in a long tube, apply a dot of ink at one end, and then drip alcohol through the tube to separate the chemicals in the ink. Each of the components of the ink would drip out the end of the tube at a different time, depending on their relative tendencies to bind to the stationary phase (the paper in the tube). Once the ink components are separated, we can detect the different chemicals that come out the end of the tube by looking at them visually. We could also use a machine, called a *detector*, to measure the spots more accurately than our eyes do.

Gas Chromatography

Gas chromatography, also called *GC*, is the technique used to separate, detect, and measure the chemical metam sodium in Hydroville. In its mobile phase, a gas chromatograph instrument uses a gas, such as helium or nitrogen. For its stationary phase, a GC has a long glass tube that is open at both ends and coated on the inside with a material that absorbs the chemicals in the sample.

Using a syringe, a sample is injected into a heated part of the GC, so that the sample quickly evaporates into a gas. This gaseous mixture then enters the stationary phase in the long glass tube. Because the mobile phase is a gas, the various chemicals in the mixture are carried along in the gas phase.

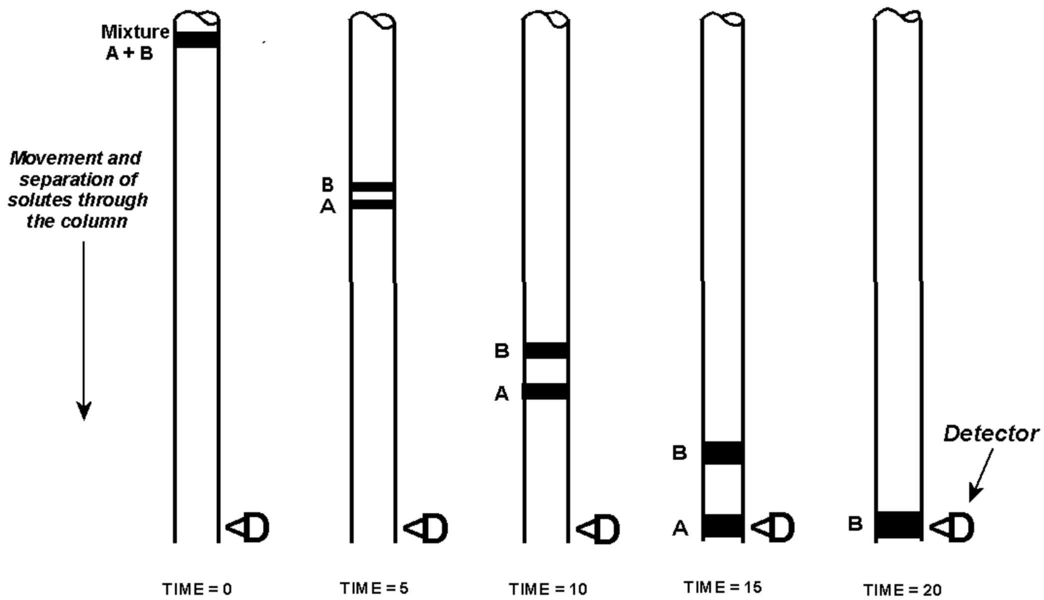
The tube in a GC is about half the length of a city block (30 or 60 meters) and has a very small diameter. Like the ink spot components that are wicked by the alcohol in paper chromatography, the chemicals in the GC sample will have different tendencies to interact with the stationary phase (the tube coating). This will cause each chemical in the sample to exit the tube (at the opposite end) into the detector at different times. The detector records the sample as it comes off as a peak in a "picture" known as a *chromatogram*. The higher the peak, the more of that specific chemical is in the sample. Each chemical will come out of the tube at a specific time (see diagram).

Gas Chromatograms of Metam Sodium

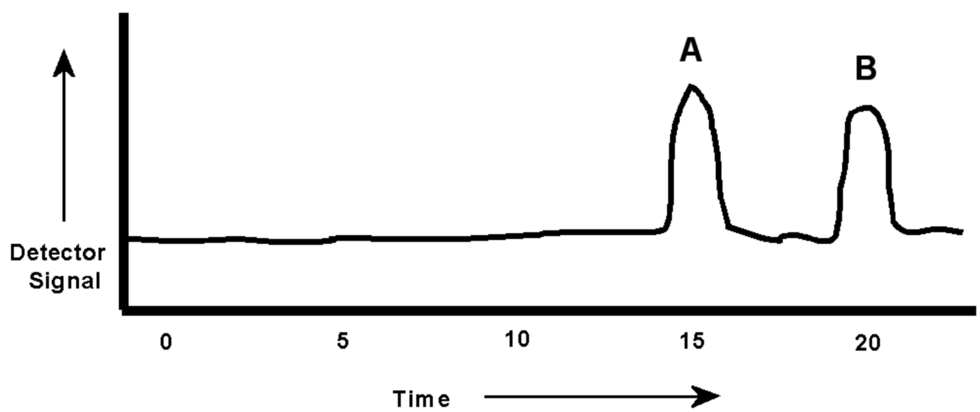
By injecting a known sample of metam sodium into the gas chromatograph, the analytical chemist has determined that the metam sodium will exit the tube at 13.13 ± 0.02 minutes in the chromatogram. *If metam sodium is present in the sample, there will be a peak between 13.11 and 13.15 minutes on the chromatogram.*

Gas Chromatography

What is happening in the column:



What is recorded on the chromatogram:



Because "A" is the faster moving solute, it reaches the detector first. The slower moving solutes, like "B", are recorded at later times

Worksheet 1

Name ______________________________

Date _________________ Period ______

Graph Standards for Metam Sodium

Before beginning analyzing samples, an analytical chemist must calibrate the gas chromatograph by running known concentrations of metam sodium through it. A standard graph of that machine is then created. You will graph a standard with a line of best-fit from three chromatograms of metam sodium (like the standard you made for pi in Background Activity 5). This standard graph, known as a “calibration curve”, will help you identity if metam sodium is present in the samples collected from the spill site.

Materials:

- ☐ Graph paper – five squares/inch (one sheet/student)
- ☐ Pencil
- ☐ Ruler
- ☐ Set of chromatograms (one set/pair):
  - Three Standard (S1, S2, S3) chromatograms (yellow paper)
  - One Quality Check (QC) chromatogram (green paper)

Procedure:

1. Look on the chromatogram of Standard #1 (17 ppm) to find the metam sodium peak.

   Note: Because of metam sodium’s retention time, it exits this chromatogram between 13.11 and 13.15 minutes. Identify the metam sodium peak at 13.13 minutes.
2. Measure the peak (in centimeters) from the base line to the top of the peak. Round your answer to the nearest 0.1 cm, and record in Table 1.
3. Repeat steps 1 and 2 for Standard #2 (54 ppm) and Standard #3 (100 ppm).

Table 1. Standards for Metam Sodium

Chromatogram	Metam sodium concentration (ppm)	Peak height (cm)
Standard #1 (S1)	17	________________
Standard #2 (S2)	54	________________
Standard #3 (S3)	100	________________
Quality Check (QC)	85	________________

Worksheet 1, Page 2

Name_______________________________

Date____________________ Period_______

4. On your graph paper, label the Y-axis *Peak Height (cm)* and the X-axis *Concentration of Metam Sodium (ppm)*. Create a scale for Peak Height that is from 0 to 20, and one for Concentration of Metam Sodium that is 0 to 120.

5. Using the data from the table, plot the concentration of metal sodium and the peak height for Standards #1, #2, and #3 on the graph. Label each point S1, S2, and S3.

6. Use a ruler to draw a line of best fit from the origin (0,0) through the three points.

7. Use the Quality Check chromatograph to check the accuracy of your calibration curve.

8. If your quality check point falls on the best-fit line at 85 ppm, then you are ready to proceed. If not, check your data.

Worksheet 2

Name ______________________________

Date __________________ Period ______

Analyzing Gas Chromatograms of Samples from Spill Site

As analytical chemists, it is your job to determine if metam sodium from the spill has gotten into the groundwater and the surface water. You also need to know the perimeter of the soil contamination after the pesticide has been removed by the mechanical engineers who complete the pumping of the pesticide by 4:00 p.m.

Materials:

- ☐ Samples A – O chromatograms (white paper)
- ☐ Ruler
- ☐ Calibration curve (standard graph) from Day 1

Procedure:

1. With your partner, read the following carefully.

   Surface water samples were taken at two locations (SW1 and SW2) right after the spill at 8:30 a.m. and again at 4:00 p.m. Soil samples were taken in 10 locations and a groundwater sample was also taken at 4:00 p.m. from the well at the Jones farm (GW1). These samples were run on a gas chromatograph to see if they contain metam sodium.

   Metam sodium quickly breaks down into a gas called MITC. Breathing MITC can be very harmful to a person's health. Air samples testing for MITC were taken repeatedly throughout the day at two sites, A1 and A2.

   Chemical pollutants, such as metam sodium, are often present in very small amounts. The units used to measure these small concentrations are parts per million (ppm) or parts per billion (ppb). One ppm is equivalent to 1 penny in $10,000, or 1 inch in 16 miles. One ppb is equivalent to one penny in $10,000,000.

2. Now look at the 15 chromatograms for the samples taken to test for metam sodium.
3. Look on each chromatogram to see if the metam sodium peak is present. Remember metam sodium peak is found between 13.11 and 13.15 minutes on the gas chromatogram.
4. Separate the chromatograms into two piles: one with metam sodium peaks and one without. If there is no peak, then metam sodium was not detected in the sample.
5. For those samples with chromatograms with no peaks, record 0 ppm for the concentration of metam sodium in the last column in Table 2 on *Analytical Chemists Report*.

Name______________________________

Date_________________ Period______

6. For those samples with chromatograms with a metam sodium peak, measure the peak height and round to the nearest 0.1 cm.
7. Record the peak height for these samples in the column labeled Peak Height (cm) in Table 2 on the *Analytical Chemists Report*.
8. Use your calibration curve (standard graph) from Day 1 to estimate the concentration of metam sodium in each sample.
9. For each sample, find the peak height on the Y-axis of the calibration curve, and use a ruler to draw a horizontal line to the line of best fit. From that point on the line, draw a vertical line perpendicular to the X-axis to determine the concentration of metam sodium for this sample.
10. Record concentration of metam sodium in ppm in the last column of Table 2.

Worksheet 3

Name ______________________

Date ______________ Period ______

Analytical Chemists Report

As analytical chemists, you want to ensure that there is little or no risk to the citizens of Hydroville from exposure to the metam sodium or its breakdown product MITC. Get together with the other analytical chemists to finish your report.

Materials:

- ☐ *Topographic Map of Spill Site*
- ☐ *Map of Hydroville*
- ☐ Colored pens or pencils
- ☐ Colored paper or Post-it® Notes
- ☐ Toothpicks and glue stick
- ☐ 3-D model of the spill site

Table 2. Spill Site Samples Tested for Metam Sodium

Sample	Sample type	Sample location	Time	Peak height (cm)	Metam sodium (ppm)
A	surface water	SW1 – Beaver Creek	8:30 a.m.		
B	surface water	SW2** – Beaver Creek	8:30 a.m.		
C	surface water	SW1 – Beaver Creek	4:00 p.m.		
D	surface water	SW2** – Beaver Creek	4:00 p.m.		
E	groundwater	GW1 – well at Jones' Farm	4:00 p.m.		
F	soil*	S1 – south edge of ditch @ 845 feet	4:00 p.m.		
G	soil*	S2 – west edge of pool @ 845 feet	4:00 p.m.		
H	soil*	S3 – west edge of pool @ 845 feet	4:00 p.m.		
I	soil*	S4 – 12 feet west of pool @ 849 feet	4:00 p.m.		
J	soil*	S5 – north edge of pool @ 845 feet	4:00 p.m.		
K	soil*	S6 – 15 feet north of pool @ 845 feet	4:00 p.m.		
L	soil*	S7 – east edge of pool @ 845 feet	4:00 p.m.		
M	soil*	S8 – 15 feet east of pool @ 847 feet	4:00 p.m.		
N	soil*	S9 – east edge of ditch @ 847 feet	4:00 p.m.		
O	soil*	S10 – south edge of ditch @ 847 feet	4:00 p.m.		

*All soil samples taken at depth of 5 feet

**SW2 is located on *Map of Hydroville*

Worksheet 3, Page 2

Name ______________________________

Date _________________ Period ______

In addition to sampling for metam sodium, air samples were taken at two locations during the same day and were analyzed for MITC. Tables 3 and 4 show the results of those tests.

Table 3. Air Samples of MITC Taken at A1 (Jones' Farm)

Sample	Sample type	Time	MITC (ppb)
P	air	9:00 a.m.	2,110
Q	air	12:00 p.m.	1,022
R	air	3:00 p.m.	54
S	air	6:00 p.m.	0.75

Table 4. Air Samples of MITC Taken at A2 (1,000 feet north of spill)

Sample	Sample type	Time	MITC (ppb)
T	air	9:00 a.m.	0.27
U	air	12:00 p.m.	0.32
V	air	3:00 p.m.	0.05
W	air	6:00 p.m.	0

*A2 is shown on the *Map of Hydroville*.

Mark Sample Sites on Maps and 3-D Model of the Spill Site

1. Locate the groundwater (GW) and surface water (SW) sampling sites on the *Topographic Map of the Spill Site* and the *Map of Hydroville*. Color the dots at these sites blue.
2. Locate the soil sample sites (S) on the topographic map. Color those dots green.
3. Locate the air sampling sites on the topographic map and the map of Hydroville. Color these triangles yellow.
4. Using colored paper or Post-it® Notes and toothpicks, create markers or flags to be added to the model. The Post-it® Notes can be folded around the toothpick and stuck together. You will have to glue the paper flags to the toothpicks. Use blue for water samples and green for soil samples.
5. On the flags, write the concentration of metam sodium at each sample site. For example, 88 ppm. Place the flags in the sample sites on the 3-D model.

Worksheet 3, Page 3

Name________________________________

Date__________________ Period_______

6. For air sampling site A1, write the time and the concentration of MITC on one yellow paper or Post-it® Note. Attach it to the model next to the Jones Farm.
7. Add descriptions for your color flags to the Key on the 3-D map.

Conclusion Questions

1. Based on the data you recorded in Table 2, which three sample locations have the highest concentration of metam sodium? Provide a hypothesis that explains these results.

2. Where else was metam sodium detected?

3. Right after the pesticide spill occurred, both Hydroville Water Treatment Plants stopped using the water from Beaver Creek for drinking water. Based on samples from SW1 and SW2 and your expert opinion, when should they begin pumping drinking water from Beaver Creek?

4. The residents of the Jones' Farm will want to know if they can drink the water from their well (GW1). What do you recommend? Give reasons to support your answer.

Name______________________________

Date_________________ Period______

5. MITC is a gas that is produced when metam sodium breaks down in soil and water. When MITC levels are above 0.6 ppb, the gas is harmful if inhaled. Based on data from air samples taken at A1 on Table 3, how would you know when it is safe for residents on the west side of the spill to return to their homes?

6. Based on data in Table 4 from air samples taken at site A2 (on the *Map of Hydroville*), what recommendations would you make to protect the residents of Hydroville who live north of the site from exposure to MITC?

Worksheet 3, Page 5

Name ______________________________

Date _________________ Period ______

7. Calculate the total cost for all of the samples collected at the spill site, including the analytical laboratory charges. Include air samples, four per sample location.

   Sample collection is $150/sample and analytical lab charges $200/sample for gas chromatography results.

Number of soil and water samples	+	Number of air samples	=	Total number of samples taken
____________	+	____________	=	____________

Collection cost/sample	+	Analytical lab charge/sample	=	Total sampling cost/sample
____________	+	____________	=	____________

Total sampling costs	=	Total number of samples taken	x	Total sampling cost/sample
____________	=	____________	x	____________

8. Develop a monitoring plan to ensure the citizens of Hydroville that your team's cleanup was effective. In addition, you will need to provide an itemized budget of monitoring costs to the Hydroville City Council. Include sample locations or select your own sites, and indicate how many samples to collect per month.

Monitoring Plan

Sample Location	Frequency (# samples /month)	Total Collection and Analysis Charge ($350/sample)	Total Cost /Sample Location
Total Cost of Monitoring Plan (for one month)			

Worksheet 3, Page 6

Name ______________________________

Date _________________ Period ______

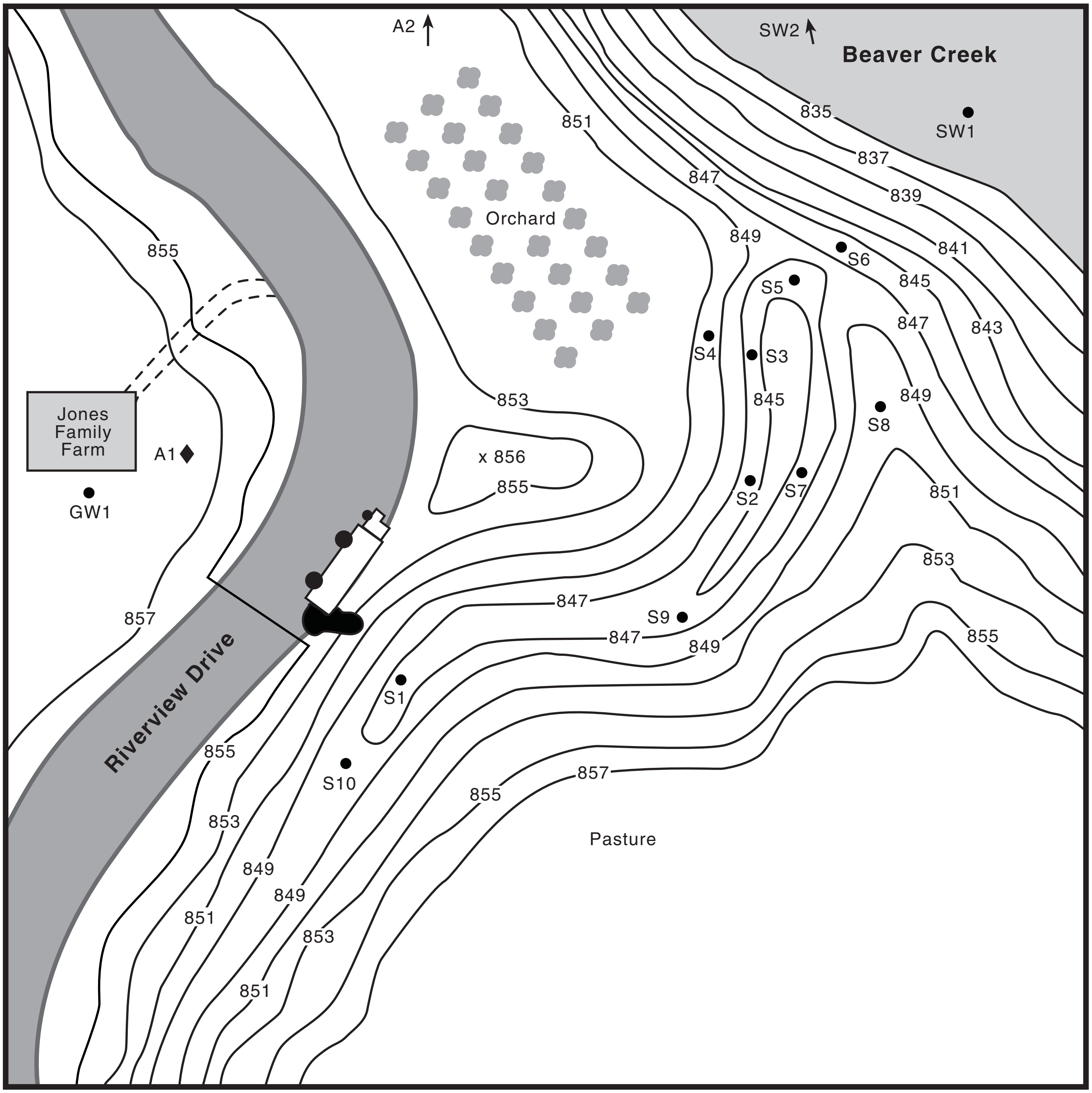
9. How many months will you continue to monitor? ___________________________

10. Estimate Total Cost of Monitoring Plan for this time period. ____________________

11. Total Cost of Initial Sampling and Monitoring Plan: __________________________

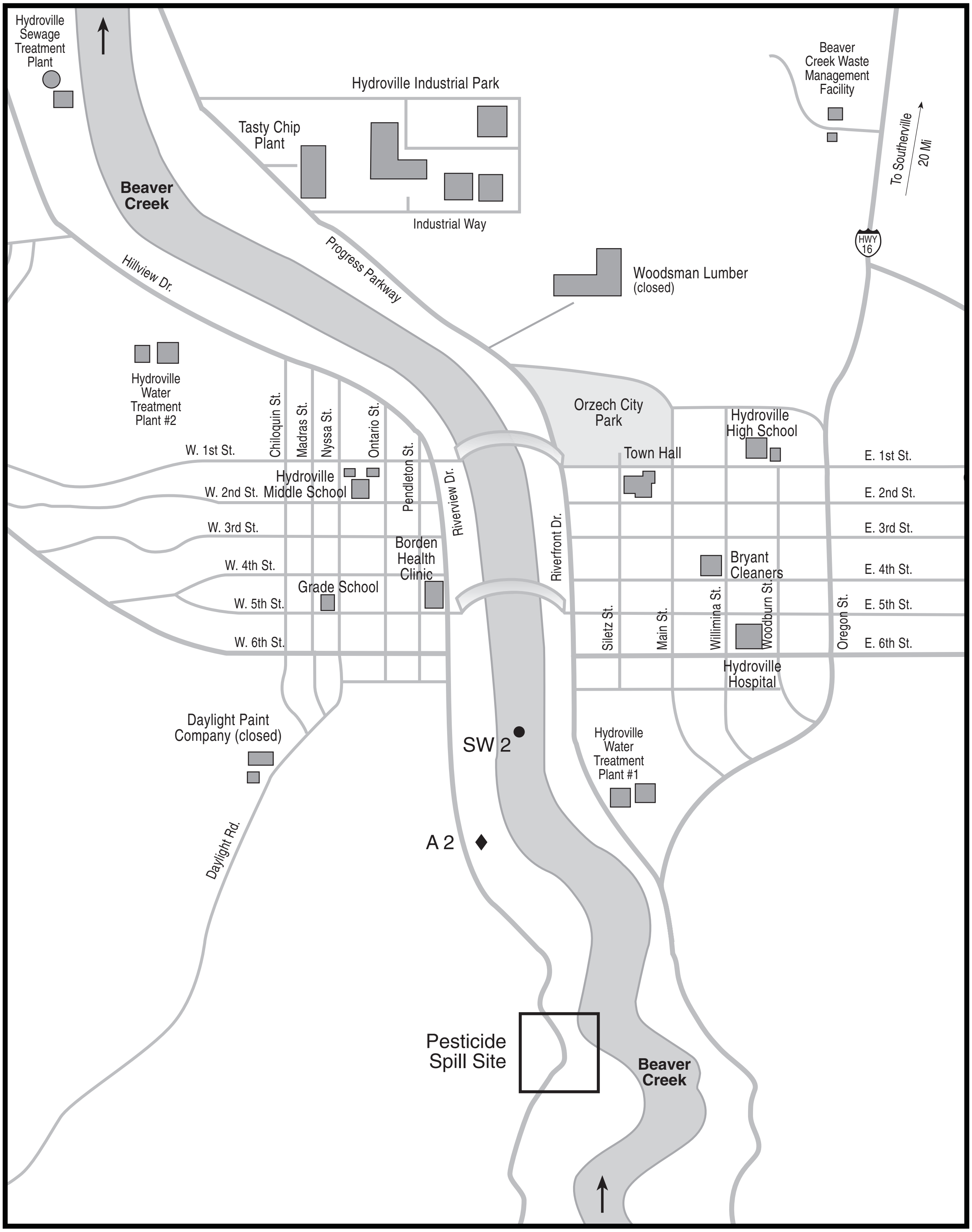
12. List the important facts and conclusions that you want to share with other members of your team.

Topographic Map of Spill Site

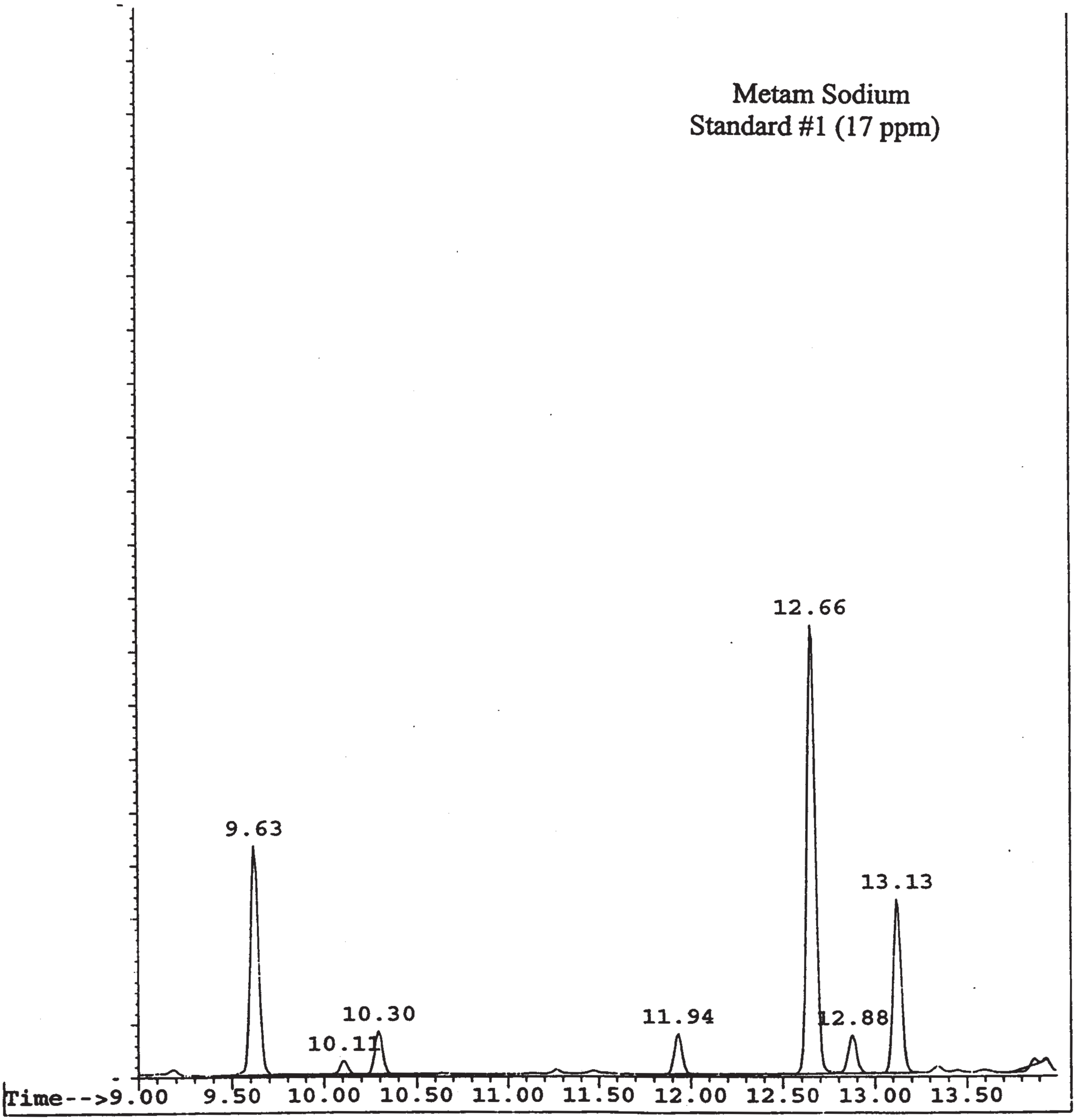


KEY	**Sample Sites**	**SW** surface water **GW** groundwater **A** air **S** soil	● **metam sodium** ◆ **MITC**	0 10 20 30 40 50 ft 1/4 inch = 10 feet Contour Interval 2 feet	N

Map of Hydroville

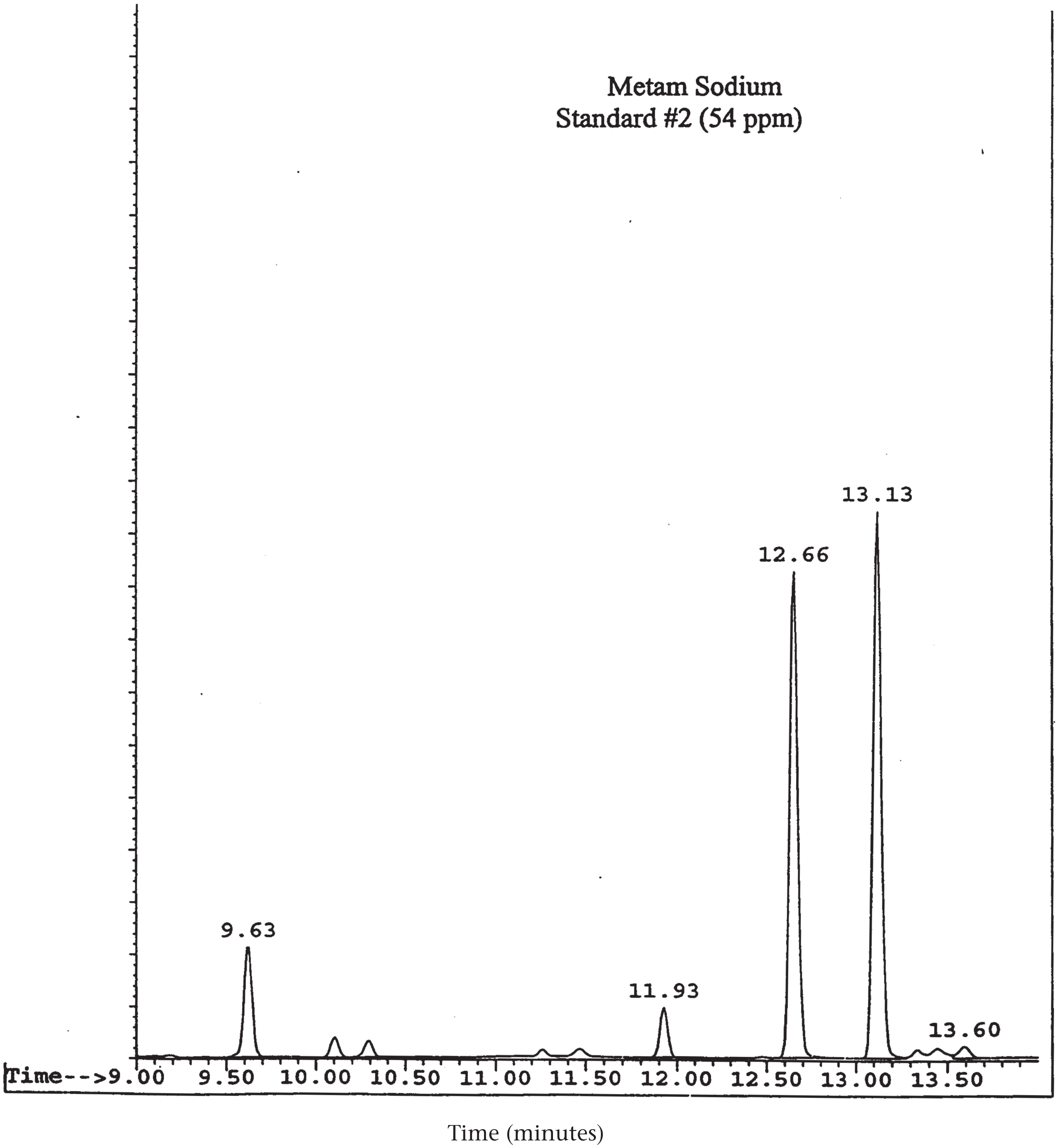


KEY	Sample Sites	SW surface water	● metam sodium	0 500 1000	N
		A air	♦ MITC	1/2 inch = 500 ft	



Time (minutes)

metam sodium peaks between 13.11 – 13.15 minutes



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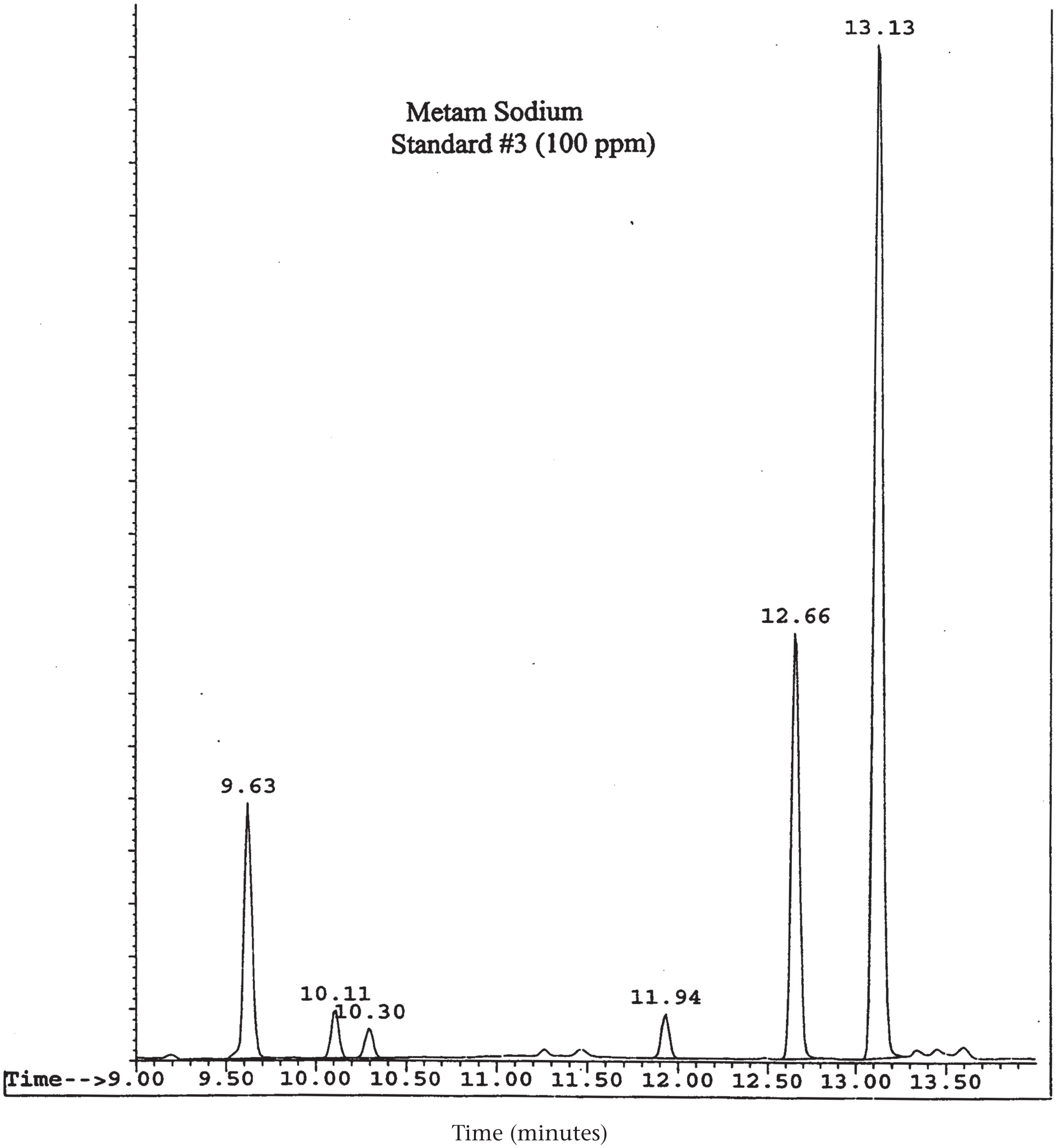

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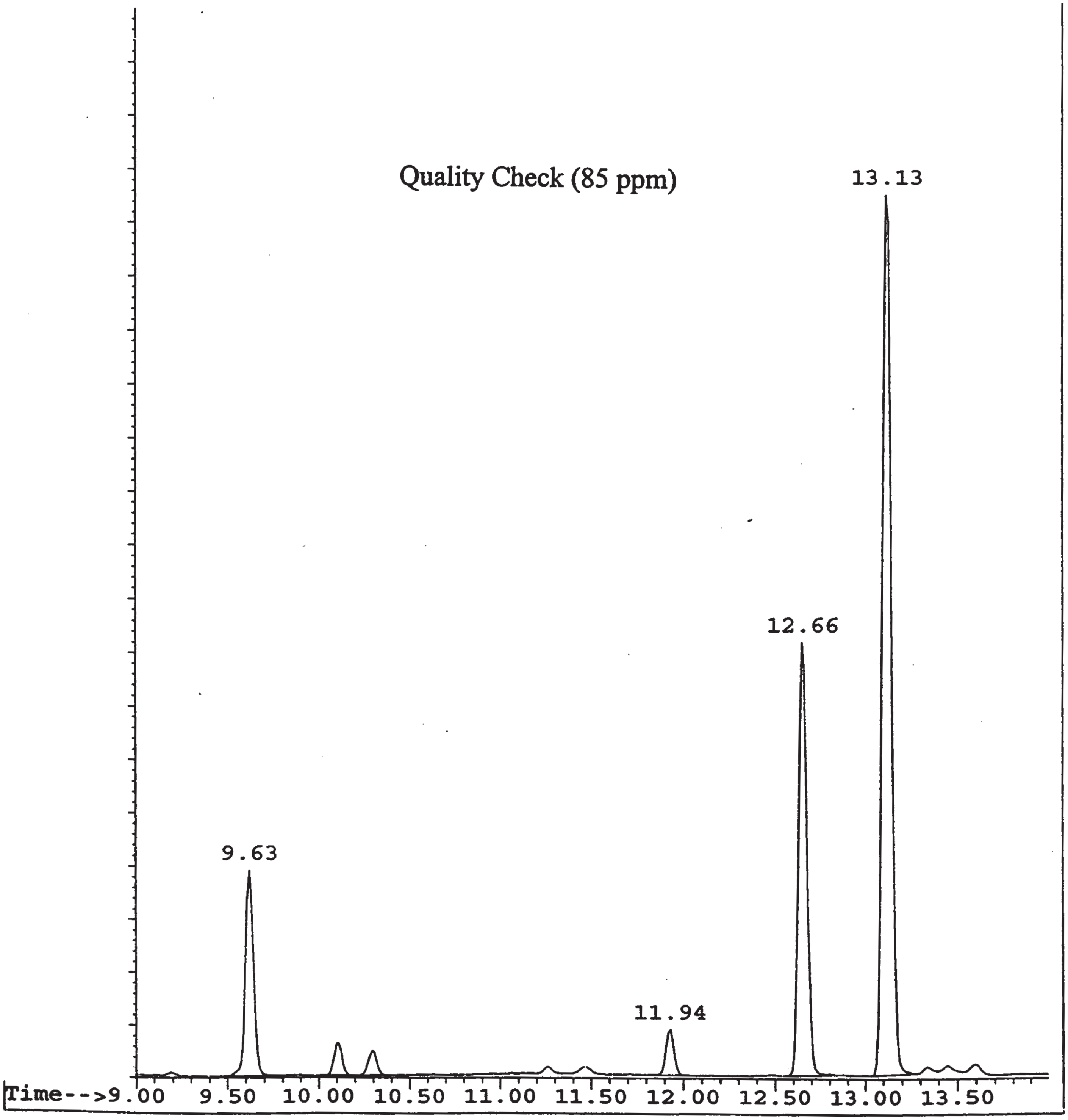

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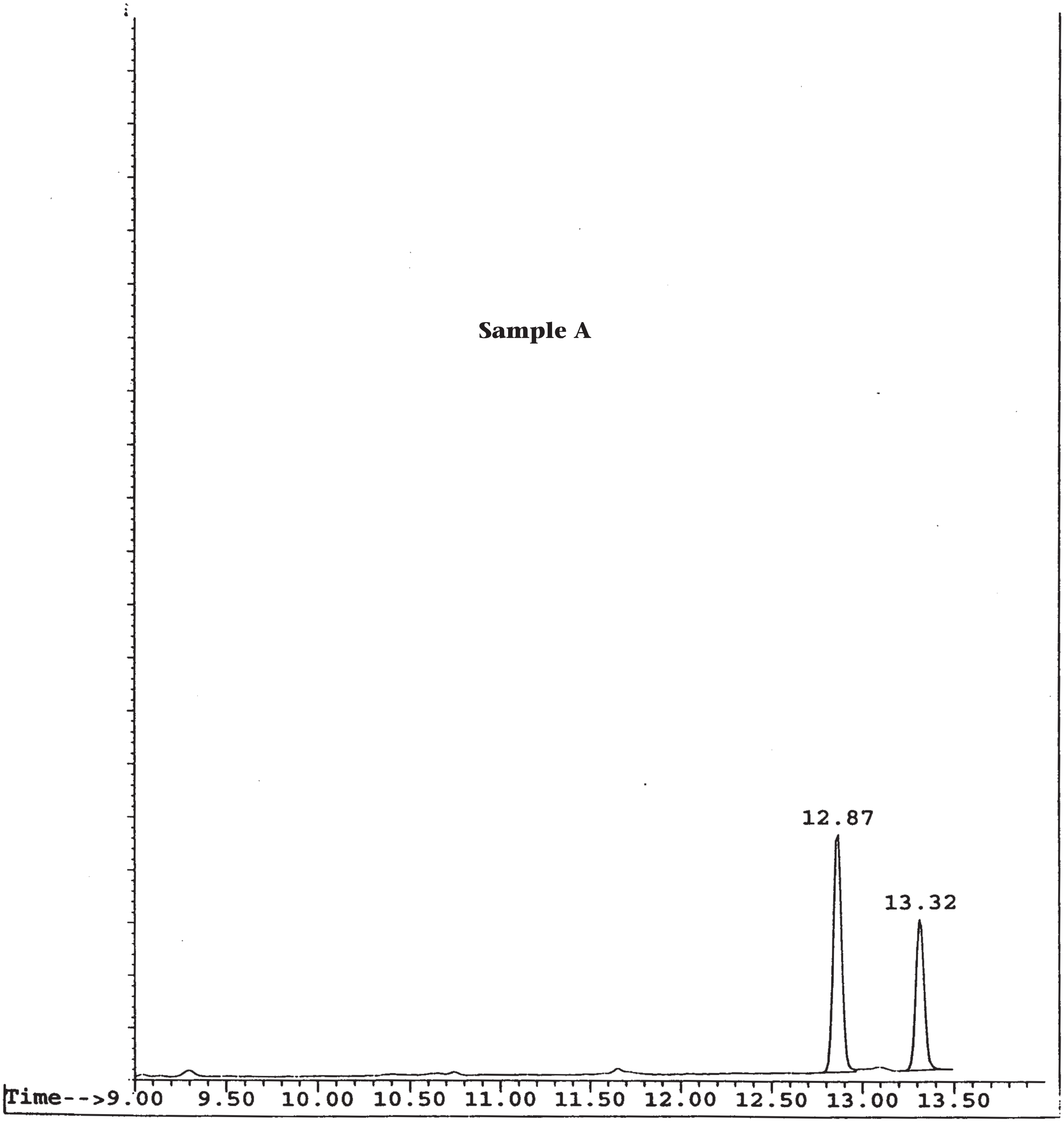

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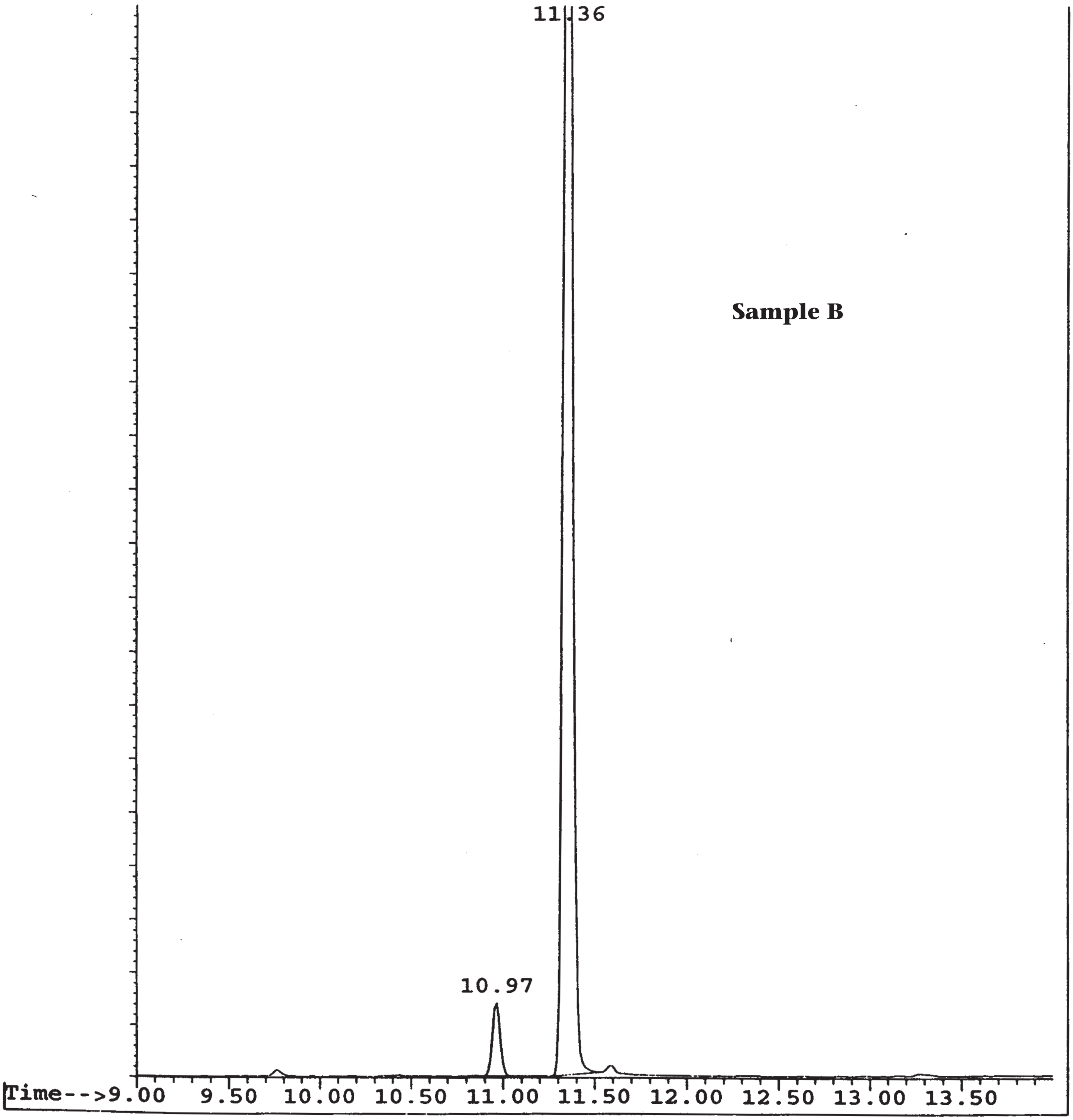

Time (minutes)

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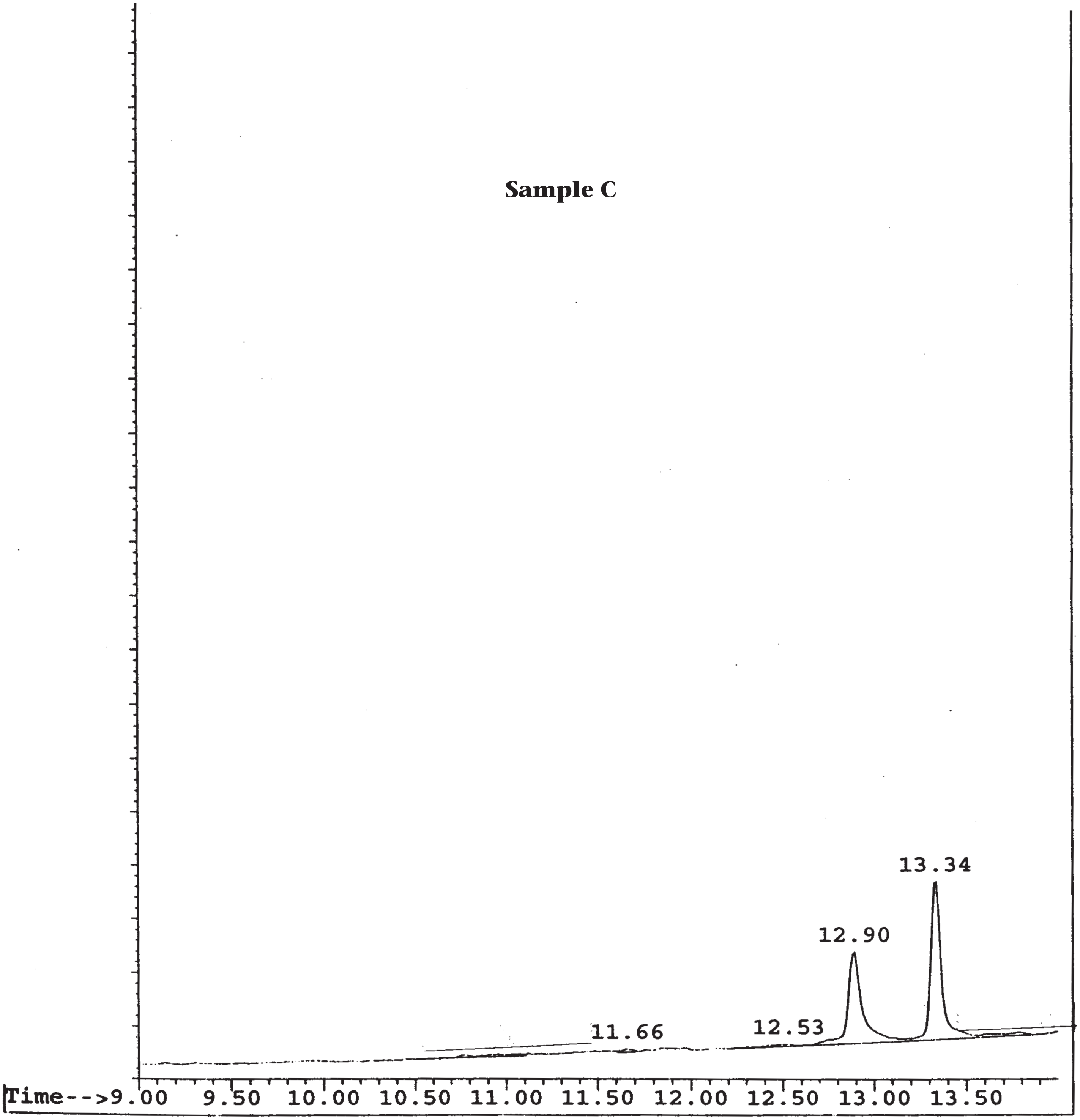
Sample C



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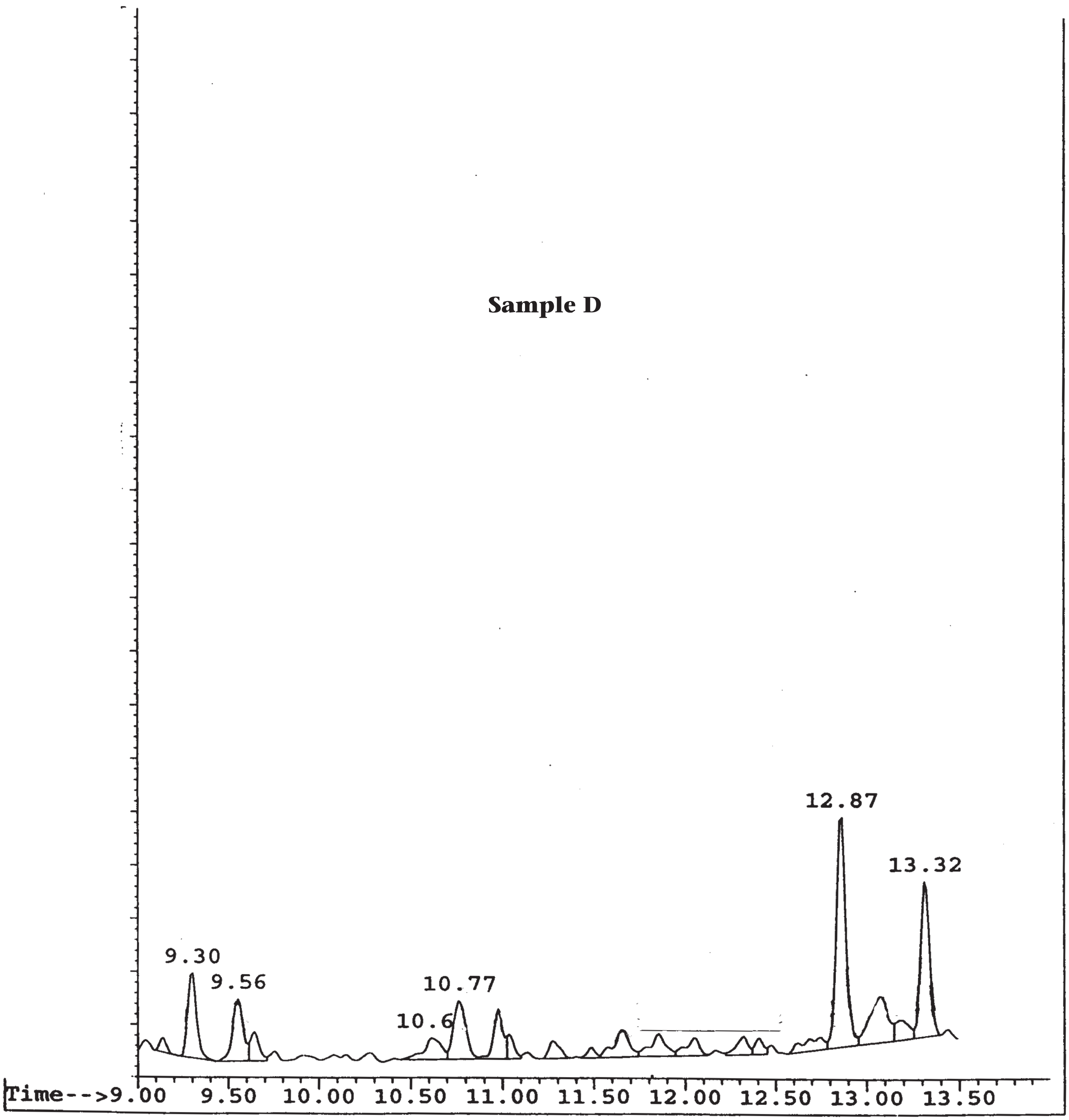

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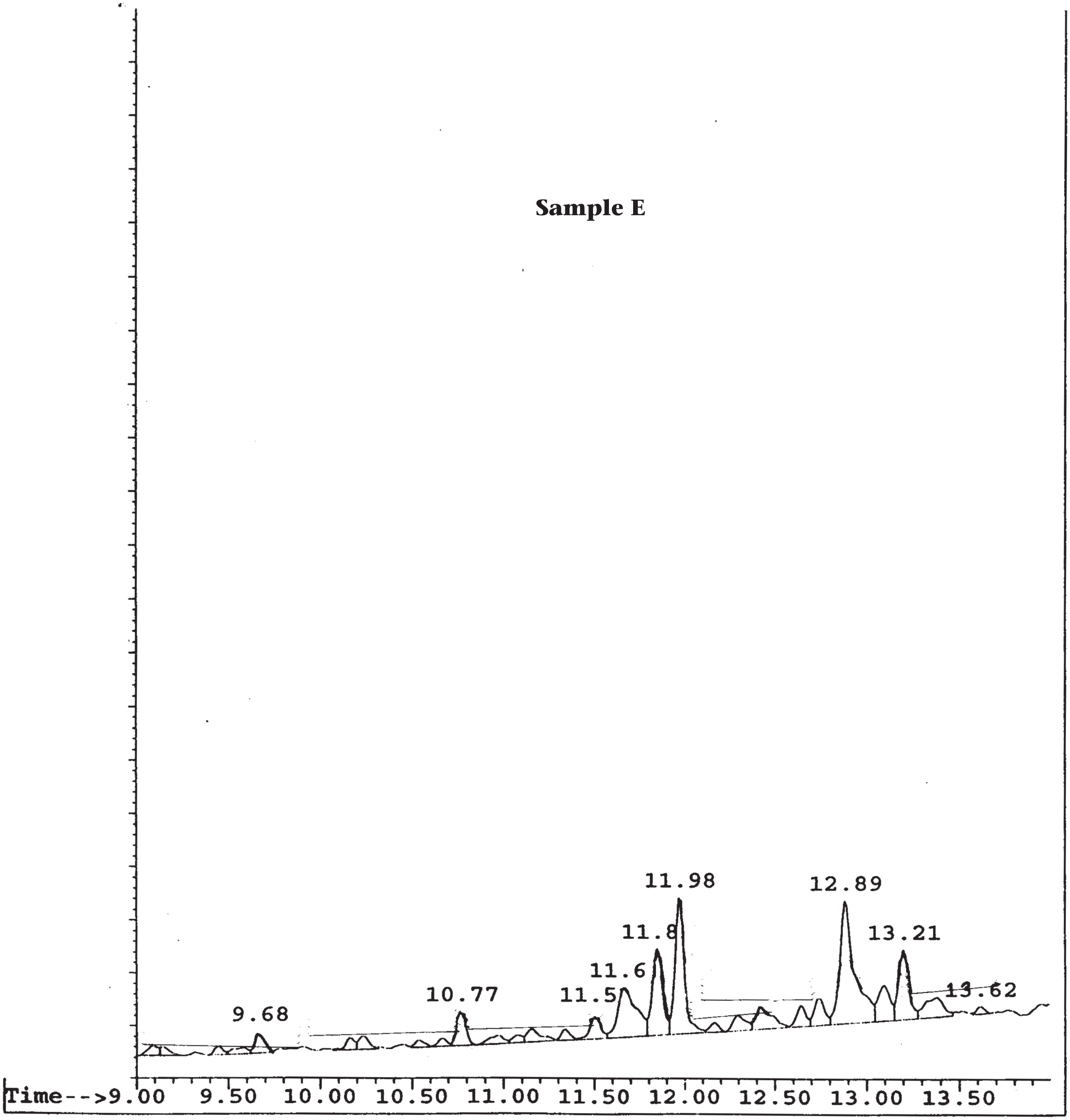

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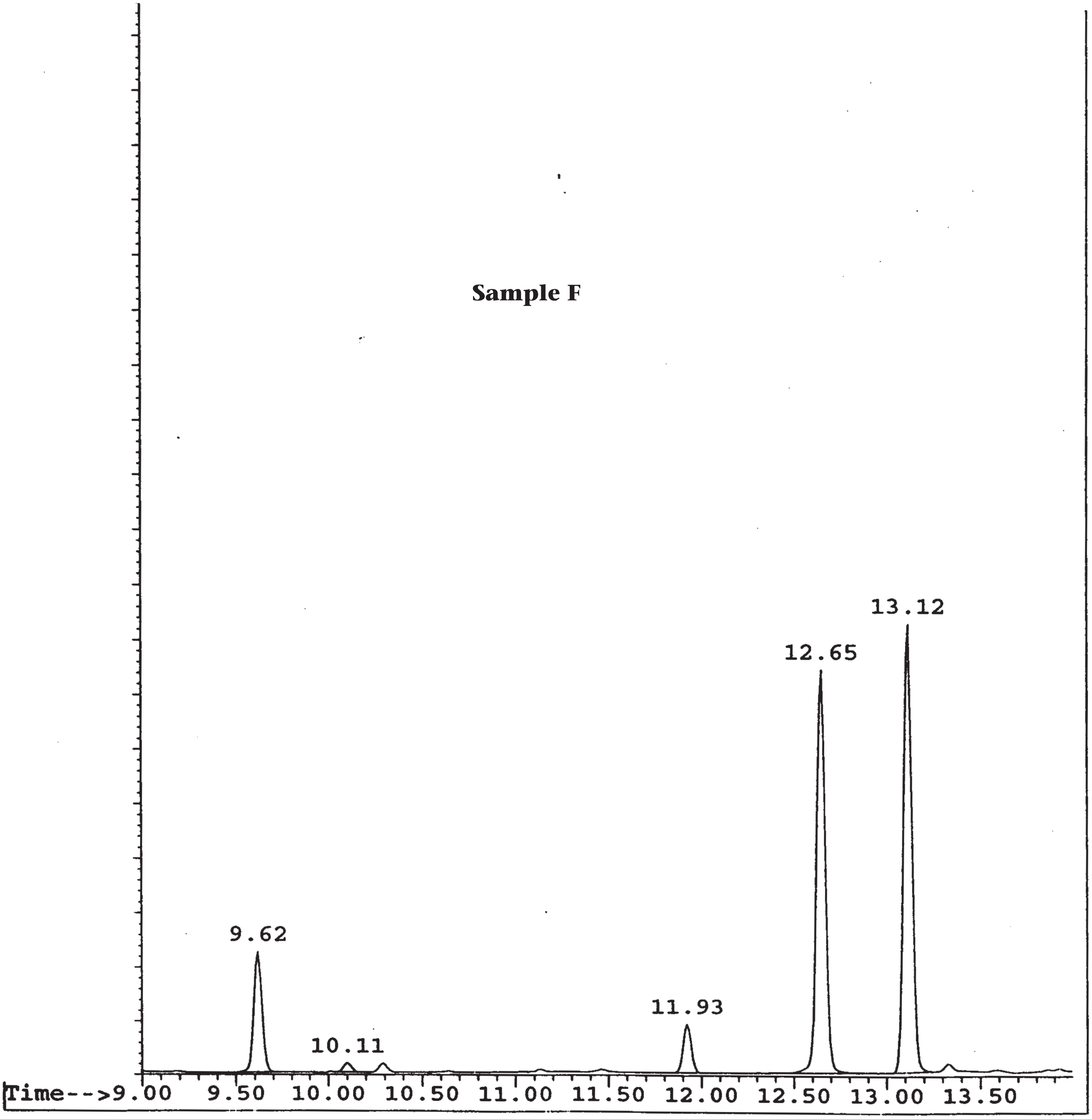

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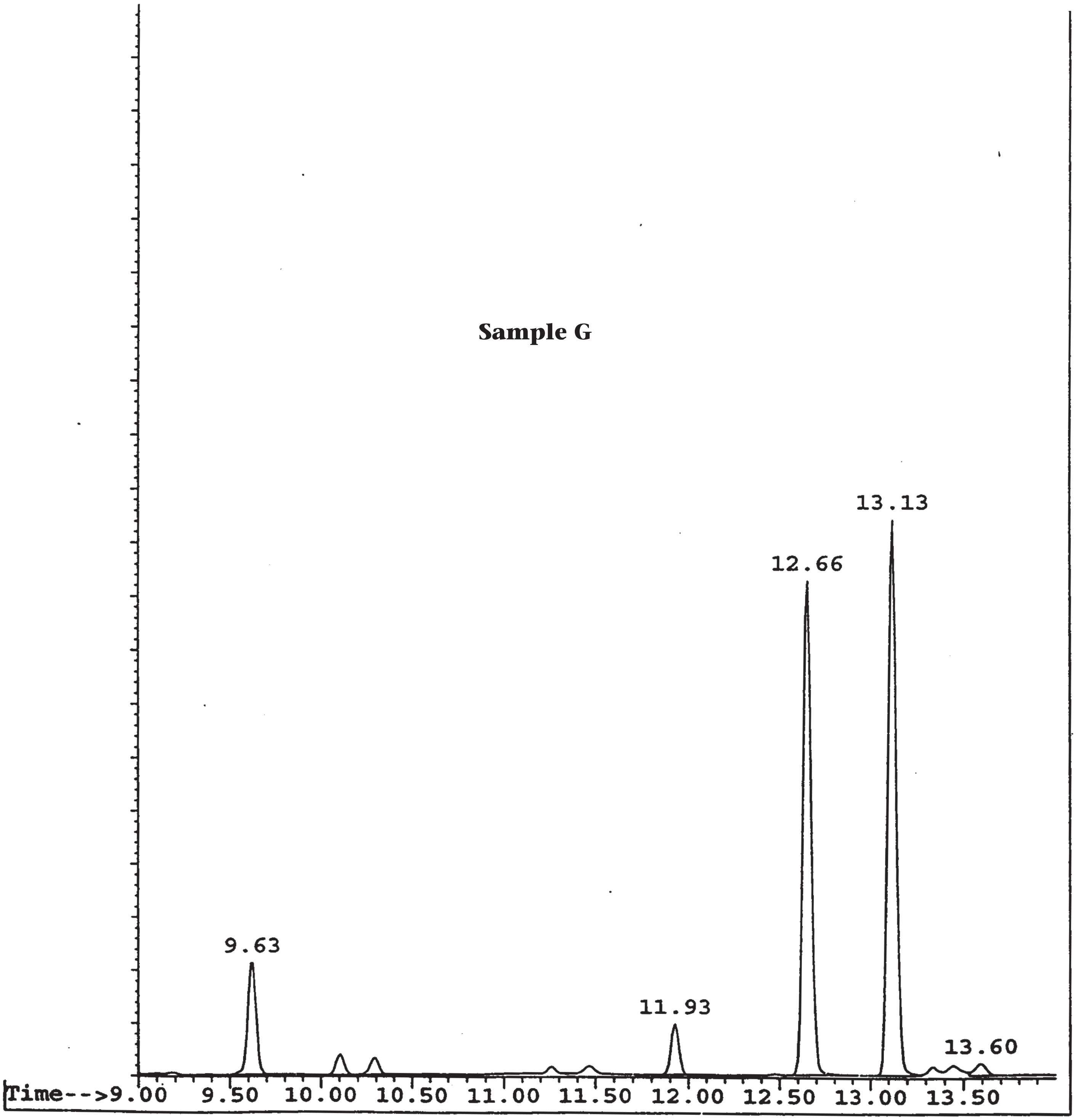

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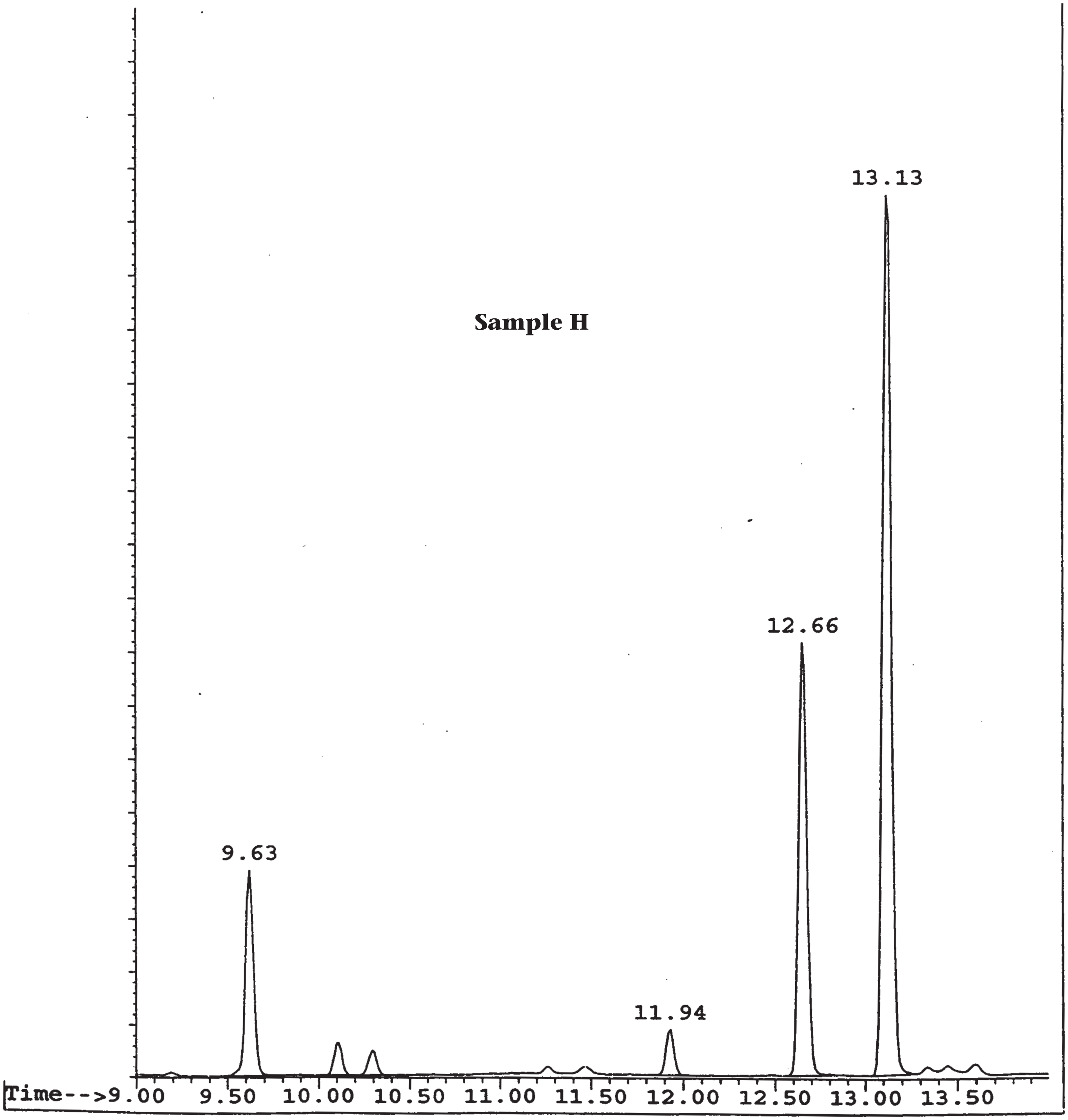

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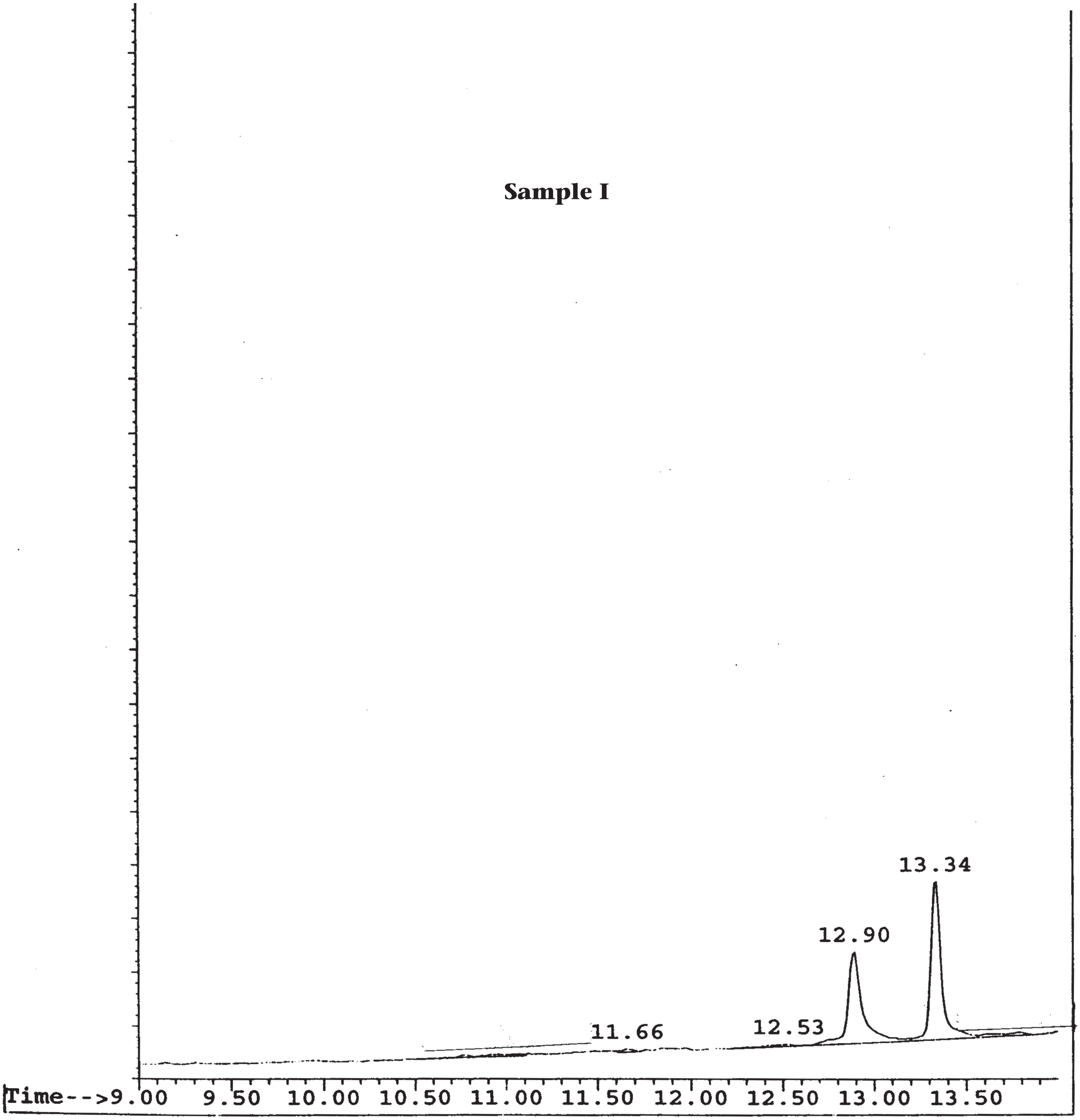
Sample I



Time (minutes)

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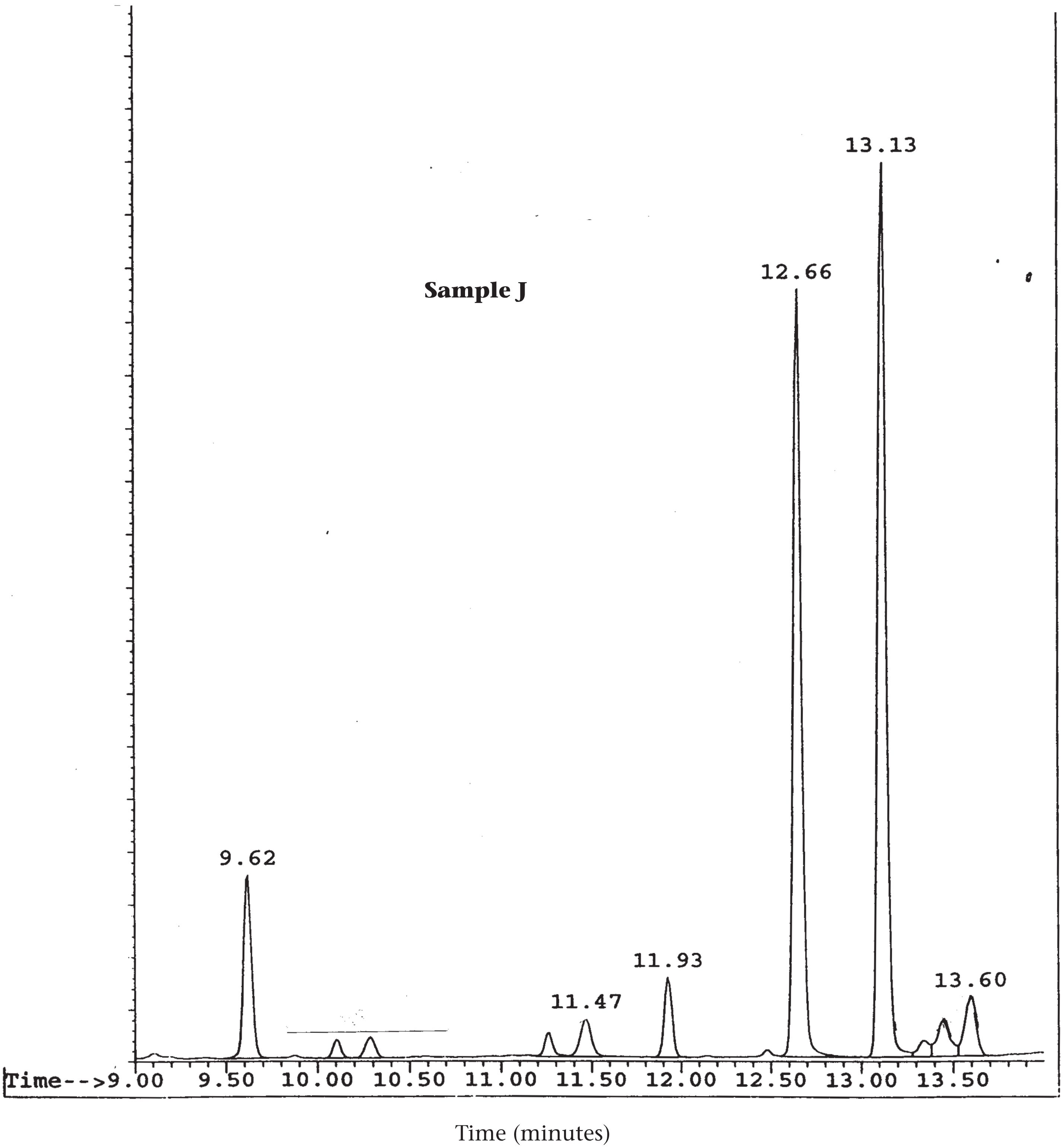

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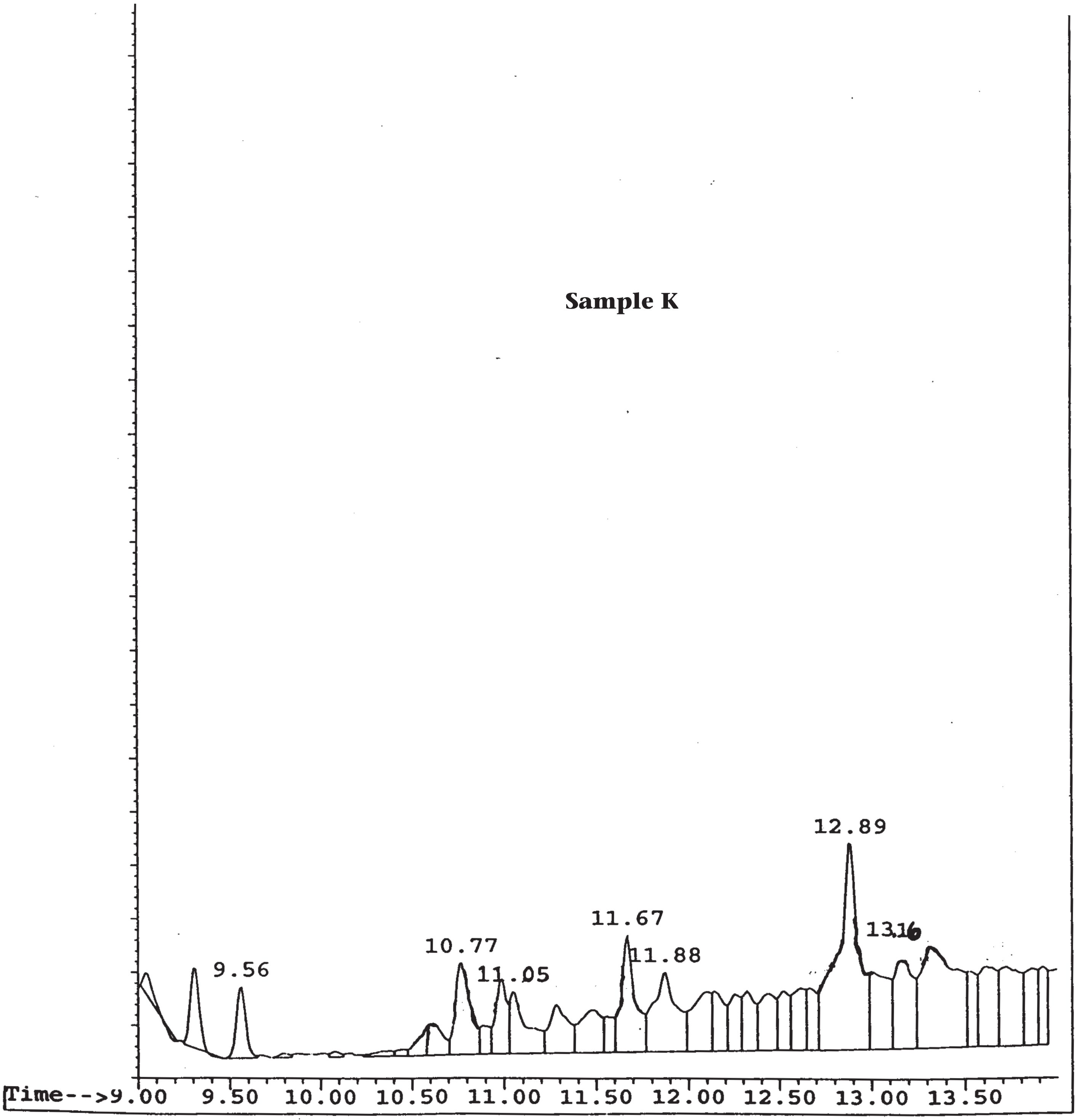

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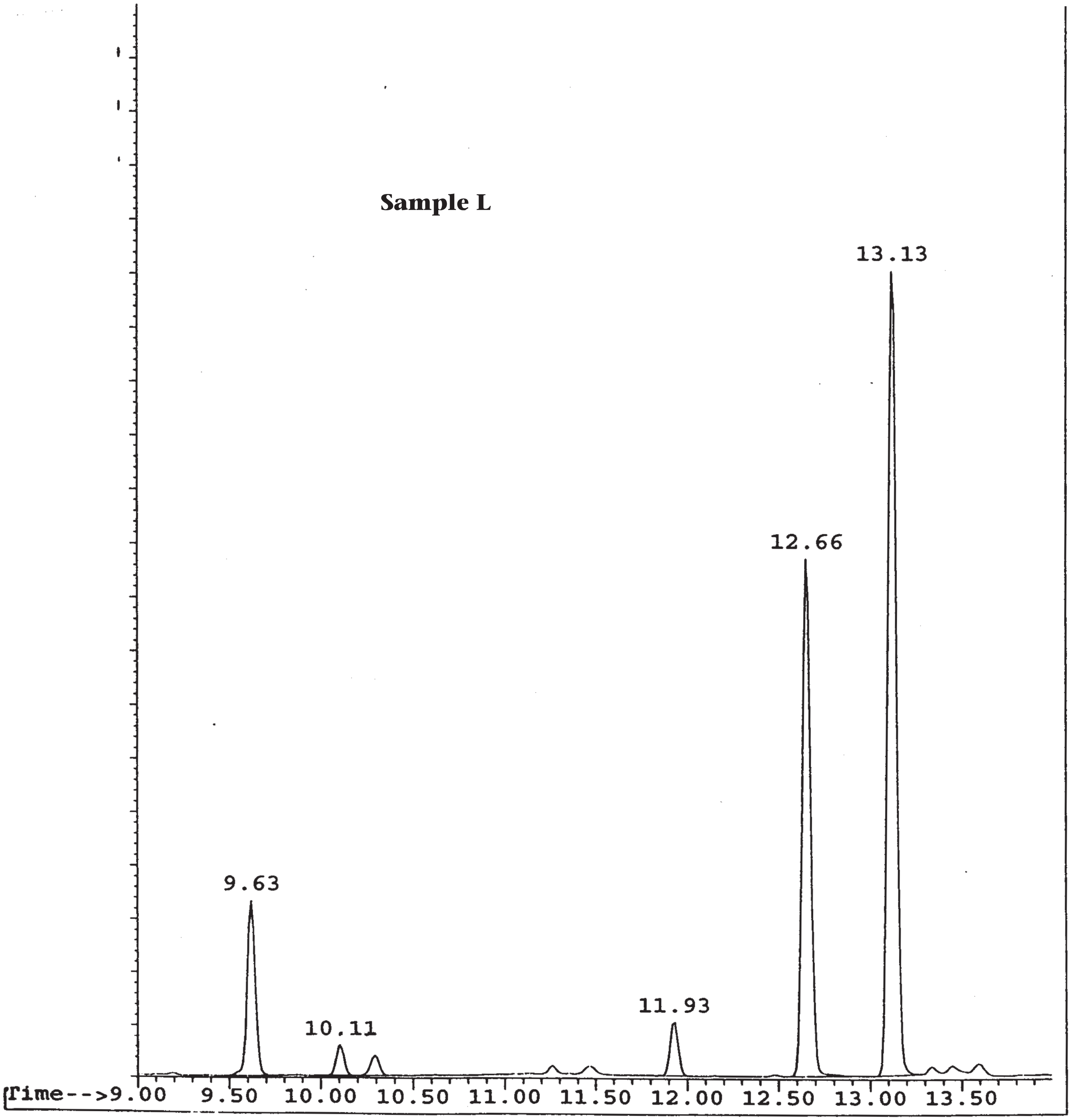

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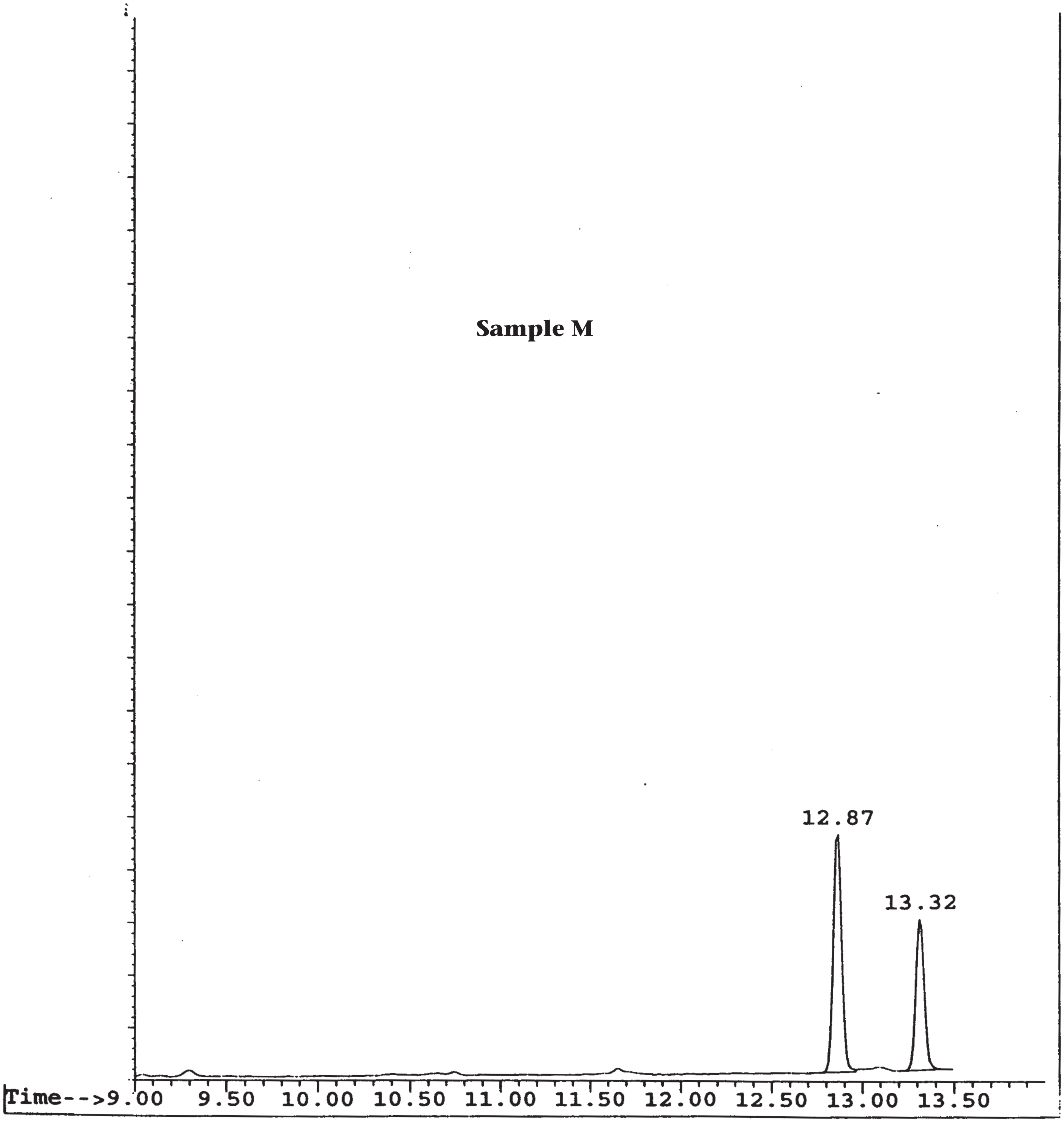

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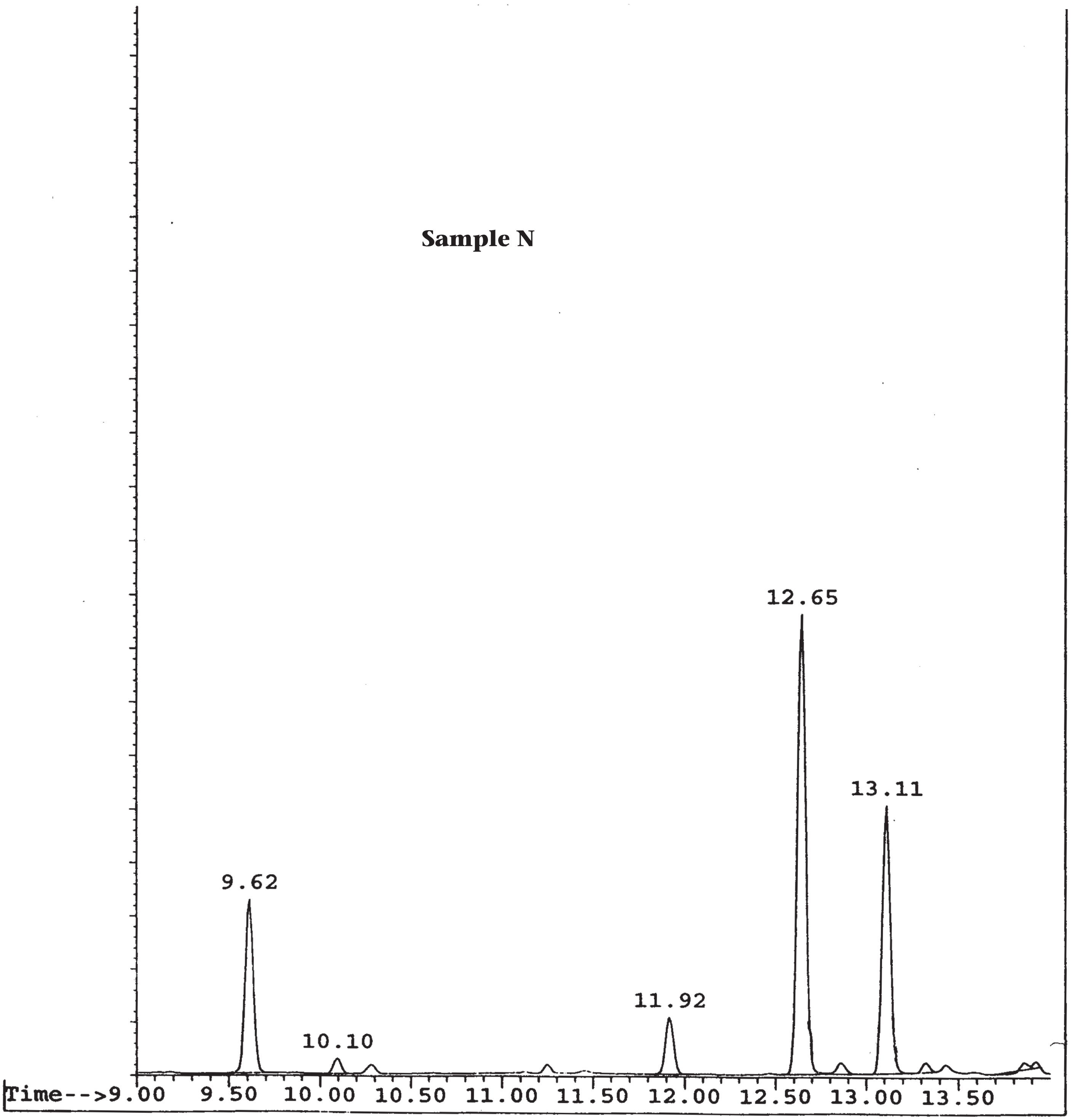

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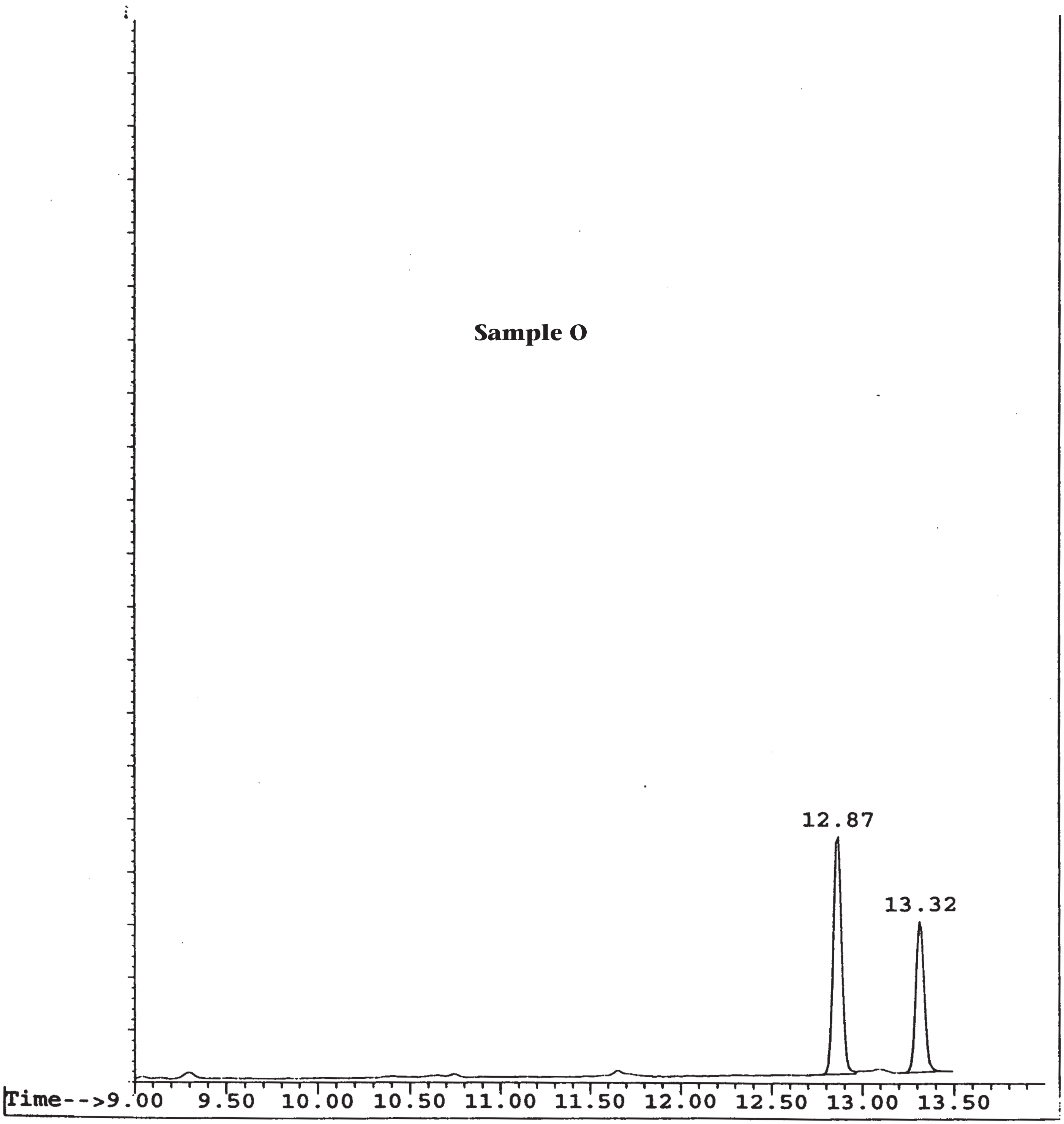


Time (minutes)

metam sodium peaks between 13.11 – 13.15 minutes

SOIL SCIENTISTS

Hydroville, USA

SOIL SCIENTISTS

Description:

The soil scientists will determine the permeability of the soil at the spill site and use a cross-section model to calculate the volume of soil contaminated.

Purpose/Goals:

Students will be able to:

- determine the rate of permeability of pesticide in the soil
- observe a model of the pesticide plume in a cross-section of soil to estimate the volume of contaminated soil at the site
- calculate the volume of contaminated soil at a given time after the spill
- estimate the costs for various remediation actions

Prerequisites:

Background Activity 7: *Soil Texture*

Background Activity 8: *Soil Permeability*

Time Estimate:

Prep: 60 minutes (to set up soil plume demonstration, mix soils, and assemble equipment)

Activity: Three 50-minute periods

- Day 1: Soil Permeability of Spill Site
- Day 2: Pesticide Plume Demonstration and Calculations
- Day 3: Soil Scientists Report

Materials:

Each Student:

- ☐ Hydroville Science Journals
- ☐ Calculators

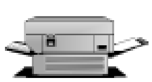
Day 1. Soil Permeability Test

- ☐ 250 g of soil samples:
  - Coarse sand (Industrial Quartz – 20 mesh), represents sand
  - Fine sand (Industrial Quartz – 70 mesh), represents silt
  - Powdered clay (from ceramics supply store)
- ☐ Balance that can measure 5–250 grams
- ☐ 4" diameter x 6" thin -walled PVC pipe (from hardware or plumbing stores)
- ☐ Two basket-style coffee filters
- ☐ Duct tape or masking tape
- ☐ One 800 or 1,000 mL beaker
- ☐ One 250 mL graduated cylinder
- ☐ Stopwatch or a wall clock with a second hand
- ☐ Ring stand with 4" ring
- ☐ Non-permanent marker

Day 2. Pesticide Plume Demonstration

- ☐ Two pieces of 1/4" x 12" x 12" Plexiglass
- ☐ Two strips of 1/4" x 3/8" x 12"-thick non-compressible foam (Polyethylene XPE)
- ☐ Six large (2") binder clips
- ☐ Clear packing tape
- ☐ One liter of Industrial Quartz sand (70 mesh)
- ☐ Food coloring
- ☐ Wash bottle
- ☐ Transparency with 1" grid
- ☐ Overhead transparency marker

Pages to Photocopy:



- Transparency 1: *Pesticide Plume Grid*

One copy/student:

- Instructions: *Soil Scientists*
- Worksheet 1: *Soil Permeability of Spill Site*
- Worksheet 2: *Contaminated Soil Calculations*
- Worksheet 3: *Pesticide Plume Diagram*
- Worksheet 4: *Soil Scientists Report*

Terminology:

Plume

Suggested Lesson Plan:

Getting Started

1. Prepare a soil sample for each group of students who will complete this activity. For each soil sample, prepare 250 grams of soil as follows:
   - 125 grams coarse sand (see Materials List for sources and description)
   - 120 grams silt
   - 5 grams dry clay
2. Weigh out each soil sample into a plastic bag or container. Close tightly and mix well.
3. Hand out *Instructions to Soil Scientists*. Review goals and outcomes.

Doing the Activity

Day 1. Soil Permeability of Spill Site

1. Students follow the instructions on the Instructions: *Determining Soil Permeability* to set up the equipment, saturate the soil, and take three soil permeability readings.
2. To save time, make up soil mixture ahead of time. Have students weigh out 250 grams of soil. Put information about the composition of the soil mixture on the board so that students can determine the soil type.

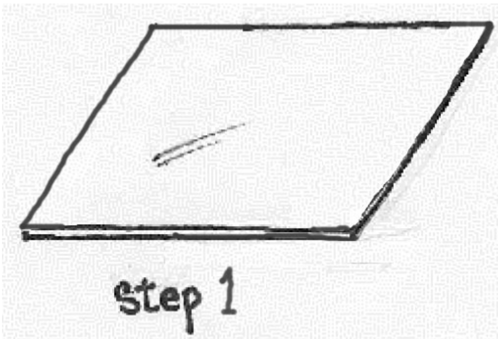
   250 grams of soil mixture contains:
   - 125 grams coarse sand
   - 120 grams silt
   - 5 grams clay
3. Test results for soil permeability can be HIGHLY variable. When students conduct permeability trials of the soil samples taken from the spill site, the time (in seconds) for 1/2" of water to drain through a permeability column can range from 350 to 750 seconds; however, optimal trials are those that are <560 seconds. Stop trials that exceed 560 seconds, and in those cases use 560 seconds as the upward limit of time it will take to drain 1/2" of water through the soil column.

Classroom Hint: It is important for the students to understand that these activities model what the pesticide will do at the site.

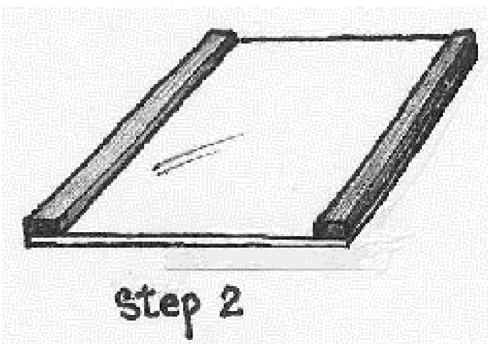
Often scientists use models (computer or physical) of areas of the earth, ocean, or sky that they cannot see. These models are just approximations for what is really happening. The real world is much more complex, and students should take that into account when they are developing their remediation plan. For example, to look at the pesticide plume, we have made the model using 70-mesh quartz sand. In reality, the site will contain mixtures of soil types intruding on one another. You might want to create a second plume model with a layer of clay or Portland cement coming in from the side and going almost across the plate. You can also put some organic material in the top layers of the sand. Students can then see how these additions affect the plume shape when the pesticide is poured on the top.

Day 2. Pesticide Plume Demonstration

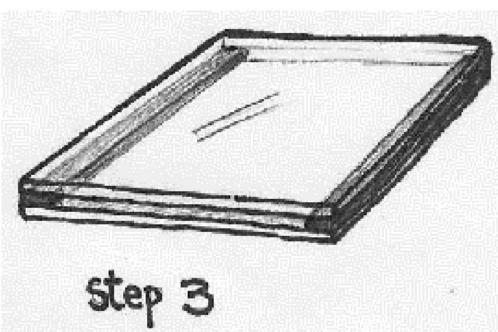
Set-up: This is a messy activity! You may want to cover the table with newspaper to catch the "soils" that fall outside the set-up. Create one set-up before class or while students are measuring the soil permeability and use it as a demonstration.



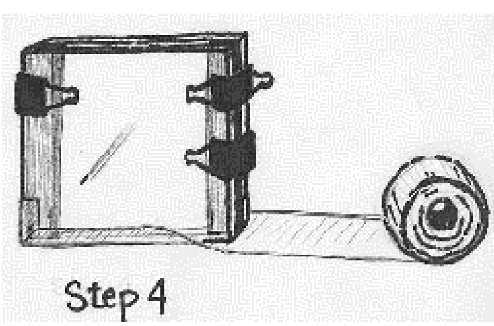
Step 1: Gather all the materials. See Materials List.



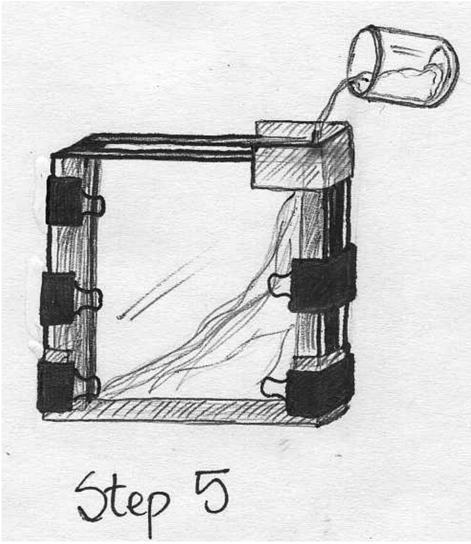
Step 2: Place one foam strip along the two vertical sides of the Plexiglass.



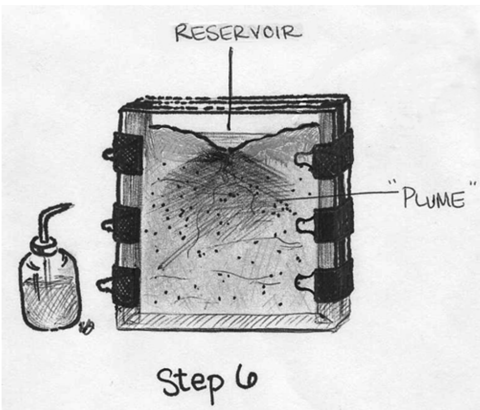
Step 3: Place the second piece of Plexiglass on top of the first to form a sandwich.



Step 4: Binder clip the Plexiglass pieces together along the sides. Run clear packing tape across the bottom edge.



Step 5: Remove one binder clip from the upper right-hand corner of the Plexiglass. Attach a 6-inch strip of clear packing tape around the upper right-hand corner of the Plexiglass plates, forming a trough to catch excess sand as you pour. Tip the Plexiglass toward you and pour approximately 1 liter of the 70-mesh (fine) quartz sand (also used as silt in the background activities) into the trough and between the two pieces of Plexiglass. By slowly filling the space, you can ensure the sand is uniformly thick, without large air pockets. Do not pack the soil.



Step 6: Continue to fill the Plexiglass form until the soil is about 1/2 inch from the top of the Plexiglass. Remove the tape that served as the pouring guide and replace the binder clip. Form an indentation in the center of the top layer of sand in which to slowly drip the "pesticide."

Step 7: Prepare the "pesticide solution." Mix 200 mL water with 5–10 drops food coloring in a plastic squeeze bottle to make a dark solution.

Soil Plume Demonstration:

1. Create and attach a transparency with a 1-inch grid to the front of the model (see Transparency).
2. Make a 1/2-inch indentation in the soil at the center of the plates. Before proceeding, ask students how they expect the plume to form in the model.
3. Using a wash bottle, position the tip of the bottle in the indentation in the center of the plume model, touching the sand. A "pesticide spill" is simulated by GENTLY AND SLOWLY squeezing a trickle of colored water for 10 seconds and then stopping. This simulates a point source of pesticide. The colored water should not pool or spread across the top of the model, but instead should permeate directly into the sand and spread out in a fan shape under the surface of the model.

4. Use an overhead transparency marker to draw the shape of the plume as it permeates into the model.
5. Students should use Worksheet 3: *Pesticide Plume Diagram*, to record their observations. Have students observe what happens to the plume when there is no "pesticide" left at the source. They should observe the "pesticide" until it stops moving through the soil, then describe and draw the shape of the "pesticide" plume.
6. Repeat steps 3 and 4 twice with clear water (representing rain).
7. Help students with calculating volume of contaminated soil on Worksheet 3.
8. Students should work together to answer the "Conclusion Questions" in the student worksheets.

Wrap-up

Using the *Soil Scientists Report*, students should decide:

- How much soil they will remove from the spill site
- How they will dispose of the soil
- The cost associated with their choice

Teacher key

Soil Scientist Fact Sheet

- The spill occurs at 5:30 a.m. on Tuesday morning in February.
- The cleanup team from Southerville EnviroClean arrives at the spill site at 8:00 a.m.
- The soil scientists study the soil and determine how much soil is contaminated and must be removed.
- The team will present their remediation plan at a Hydroville town meeting on Wednesday evening in the Hydroville Library meeting room.
- Weather: It has been raining the past few weeks, so the ground is saturated. The weather turned sunny and cold for a few days, but the forecast is for heavy rains by Wednesday or Thursday.
- The pesticide that spilled has collected at the bottom of the ditch, located 50 feet from Beaver Creek and 80 feet from the roadbed.
- The depth of the groundwater at this point is 11 feet.
- The volume of contaminated soil at the spill site is calculated using the dimensions of the ditch:

  Length = 60 ft.

  Width = 12 ft.

  Depth = 11 ft.

Teacher Key

Worksheet 1

Answers will vary. An example of permeability rates has been provided.

Table 1: Soil Permeability at Spill Site

Permeability Test	Permeability Rate (seconds)
Trial 1	*420*
Trial 2	*557*
Trial 3	*335*
Average Permeability Rate (seconds)	*437*

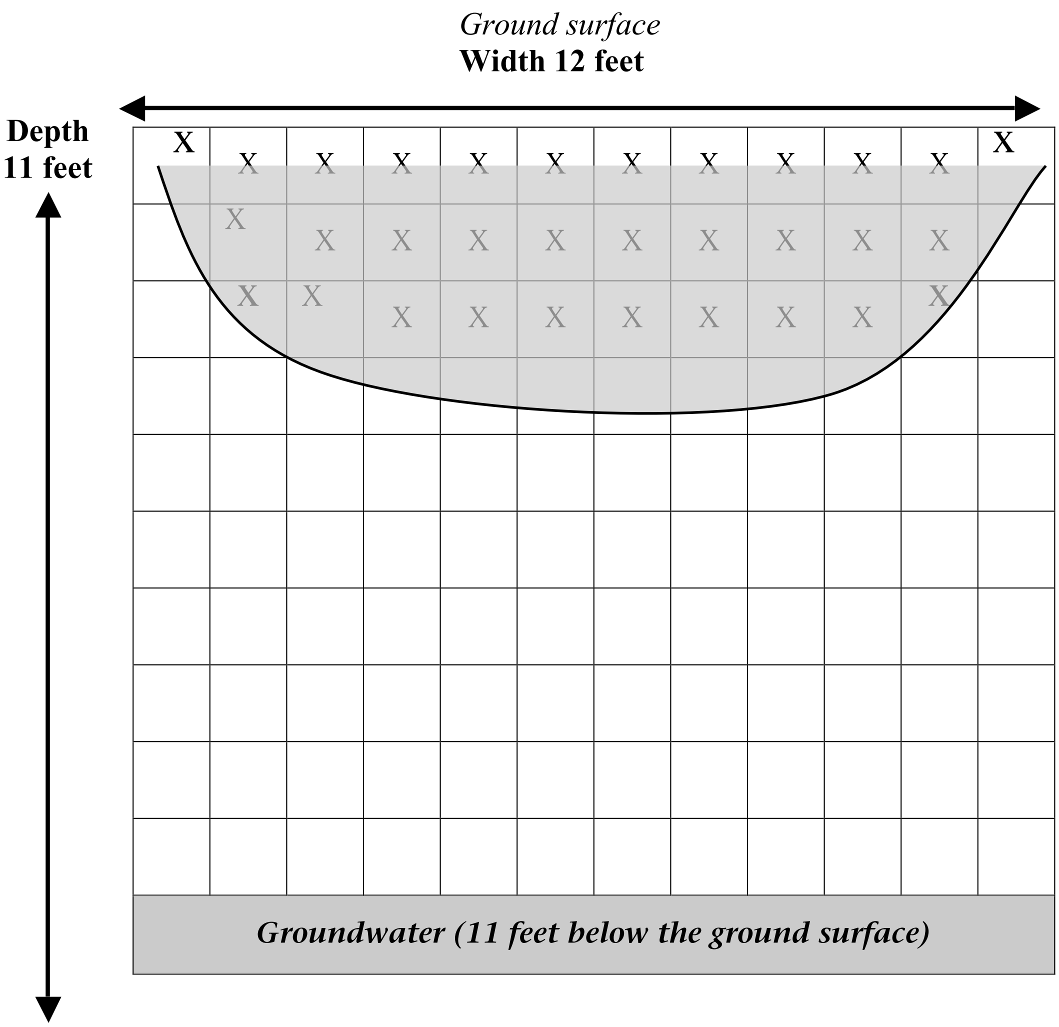
1. Complete the calculations below to answer the following question: “How many feet will the pesticide move down into the soil at the spill site in 1 hour?”
   a. *Permeability rate = 437 seconds* (answer from Table 1)
   b. *Permeability rate = 7.3 minutes*
   c. *Permeability rate = 0.68 inches/minutes*
   d. *Permeability rate = 4.1 inches/hour*
   e. *Permeability rate = 0.34 feet/hour*

Worksheet 2

1. What is the permeability rate of the pesticide in the soil? In other words, how many feet does it travel in 1 hour? (Insert *answer e* from Worksheet 1.)
   Permeability rate = 0.34 feet/hour
2. The spill occurred at 5:30 a.m. The mechanical engineers started pumping the pesticide from the ditch at 11:30 a.m. The mechanical engineers spent 3.5 hours pumping the pesticide from the ditch. What is the amount of time the pesticide has been seeping into the soil?
   Total time = 9.5 hours
3. Calculate how far the pesticide permeated into the soil during this time. (What is the depth of contaminated soil?)
   Depth = permeability rate (feet/hour) x total time (hours)
   Depth = 3.2 feet
4. Estimate the area of contaminated soil using the diagram on Worksheet 3.
   What is the area of contaminated soil? Count the total number of squares. **Hint:** Each square equals 1 foot x 1 foot. Include partially contaminated squares, e.g., 1/4, 1/2, and 3/4.
   Area of contaminated soil = 30 ft^2
5. Calculate the volume of soil that was contaminated.
   Volume = Width x Depth x Length (see *Pesticide Plume Diagram* for Length)
   Volume of contaminated soil = 1,800 ft^3

Teacher Key continued

Worksheet 3



Worksheet 4

1. Calculate the percentage of each of the soil components to identify the soil type at the spill site.

Soil Component	Amount of Soil Component (grams)	Total Soil Sample (grams)	Percentage of Soil Component (%)
Sand	125	250	*50*
Silt	120		*48*
Clay	5		*2*

Teacher Key continued

2. Using the *Soil Texture Triangle*, identify the soil texture at the spill site. Describe the texture of this soil, soil permeability, water-holding capacity, and possible land uses.
   Sandy loam is primarily sand and silt so it is both a coarse and medium- textured soil with a moderate permeability rate and water-holding capacity. It would be ideal for agriculture.
3. What do you think would happen to the metam sodium in the soil if it rained in the next 2 or 3 days in Hydroville?
   The rain would saturate the soil even more and cause the metam sodium to permeate farther down into the soil, and possibly contaminate the groundwater.
4. Consider the following. In your opinion…
   a. Is Beaver Creek at risk of being contaminated? Why?
      Beaver Creek is at risk of being contaminated if it rains heavily in the next couple of days. Currently, the metam sodium plume is at 3.5 feet and the rain on the already saturated soil could cause the pesticide plume to spread out and widen and possibly reach Beaver Creek.
   b. Is the groundwater at the Jones' Farm at risk? Why?
      The groundwater is at risk of being contaminated, especially if it rains as predicted. The pesticide plume is now only 3.5 feet deep and it could permeate into the soil and reach the groundwater at 11 feet if the rains come.

Disposal Options and Costs

5. Calculate the cost of each option based on the volume of contaminated soil you estimated on Worksheet 2, question 5. Record your answers in Table 2 in the last column.
   Volume of contaminated soil = 1,800 ft^3

Table 2. Disposal Options and Costs

Options	Cost of Option	Cost/Volume of contaminated soil
Excavation (remove soil from site)	\$ 5.00 /ft^3	*\$9,000*
Transport soil to disposal site	\$10.00 /ft^3	*\$18,000*
Dispose of contaminated soil (government approved methods)		
Landfill disposal	\$ 2.50 /ft^3	*\$4,500*
Soil incineration/burning (at certified site)	\$ 5.00 /ft^3	*\$9,000*
Spread onto field	\$ 0.25 /ft^3	*\$450*
Do not excavate (remove soil from site)		
Cover with heavy plastic	\$ 0.80 /ft^2	*\$1,440*
Allow pesticide to degrade into soil and air naturally without any intervention	\$ 0.00	*\$0.00*
Other?		

Teacher Key continued

6. Select a disposal method or a combination of methods based on these costs. All options have costs and benefits/drawbacks associated with them. Give reasons for your choice(s).
   Answers will vary.

7. Summarize the important information you want to share with the other members of your team.
   Answers will vary.
   - *Permeability rate and soil type of the soil at the spill site*
   - *Volume of contaminated soil*
   - *Recommended disposal options and costs*

Transparency 1

Pesticide Plume Grid

Student Pages for

SOIL SCIENTISTS

Follow this Page

Soil Scientists

Introduction/Goals:

As soil scientists employed by Southerville EnviroClean, your job is to clean up the contaminated soil at the spill site. You arrive at the site at 8:00 a.m. on a Tuesday morning in February, just 2 1/2 hours after the spill occurred. You observe that the pesticide has pooled in a ditch near Beaver Creek. From well records, you discover that the depth of the groundwater at this point is 11 feet below the ditch.

The soil at the spill site is saturated from recent rains. The weather forecast is for more rain in the next 2 or 3 days.

In addition to deciding what you should do about the contaminated soil, the soil scientists will:

- determine the rate of permeability and identify the soil type of the soil at the spill site
- calculate the volume of contaminated soil at the site
- select disposal option and calculate the cost of the cleanup efforts
- advise your team about a course of action for the cleanup of the soil

Day 1. Soil Permeability of Spill Site

Materials:

Each Student:

- ☐ Hydroville Science Journal

Each Group of Two or Three Students:

- ☐ One soil column (4" diameter PVC pipe)
- ☐ Two basket-style coffee filters
- ☐ Masking tape or duct tape
- ☐ 250 mg of soil sample
- ☐ Balance
- ☐ Stand with 4" ring
- ☐ Calculator
- ☐ One 800 or 1,000 mL beaker
- ☐ One 500 mL beaker
- ☐ One 250 mL graduated cylinder
- ☐ Non-permanent marker
- ☐ Stopwatch or wall clock with second hand
- ☐ Worksheet 1: *Soil Permeability of Spill Site*

Instructions, Page 2

Part 1. Soil Column Setup

1. Cover one end of a PVC pipe (soil column) with two basket-style coffee filters. Hold the filters in place. Tape over the edge of the coffee filters with tape so they are securely fastened. *Be careful not to tear the filters.*
2. Measure 250 mg of soil from the spill site and add to the soil column. Flatten the surface of the soil.
3. Set the soil column onto the top of a ring stand. Place an 800 or 1,000 mL beaker on the base of the stand. Make sure it is directly underneath the soil column.
4. Measure 125 mL of water into a graduated cylinder and pour over the soil to pre-moisten (saturate) it.
5. Wait until all of the water has drained through the soil (when the water is no longer visible on the top of the soil and when the water has stopped dripping).
6. Remove the beaker and pour the water into a waste container designated by your teacher. Wipe out the beaker so that is clean and dry.

Part 2: Soil Permeability Testing

1. Measure 150 mL of water into a graduated cylinder and pour into the beaker. Mark the 150-mL level with a non-permanent marker on the beaker. *Do not use the graduations on your beaker.*
2. Place the marked beaker under the soil column.
3. Measure 300 mL of water into a graduated cylinder. Pour into another beaker.
4. When your lab partner begins timing, pour the water into the center of the soil in the column. *The permeability rate of sand may be very fast, so watch carefully.*

5. Stop timing when the water is even with the 150 mL mark on the beaker. Record starting and ending times in Table 1 on Worksheet 1.
6. Empty the beaker into the designated waste container when the rest of the water has permeated through the soil. *Do not pour water with soil into sinks.*
7. Record the permeability rate (in seconds) in Table 1.
8. Repeat steps 1–6 in Part 2 two more times using the same soil. *Rinse and dry beaker and smooth out the surface of the soil before starting another trial.*
9. Calculate the average permeability rate for your soil based on three trials. Record in Table 1.
10. Discard soil and filter into designated waste container.

Day 2. Pesticide Plume Demonstration

Introduction:

The pesticide plume is a model that shows how the pesticide would permeate into the soil at the spill site in Hydroville. A *plume* is a visible or measurable discharge of a contaminant from a given point of origin. The real world is much more complex, so take this into account when you are observing this demonstration. The "soil" in the model is quartz sand, which is the same material that represented silt in Background Activity 8: Soil Permeability. In reality, the pesticide spill site contains a mixture of soils: sand, silt, and clay.

Materials:

- ☐ Hydroville Science Journal
- ☐ Pesticide plume demonstration
- ☐ 1 L of 70-mesh industrial quartz
- ☐ Colored water
- ☐ Wash bottle
- ☐ Overhead marker
- ☐ Transparency 1: *Pesticide Plume Grid*
- ☐ Worksheet 2: *Contaminated Soil Calculations*
- ☐ Worksheet 3: *Pesticide Plume Diagram*

Procedure:

1. Observe the shape of the plume as your teacher slowly adds the colored water ("metam sodium") to the model.
2. When the pesticide stops moving through the soil, tape Transparency 1: *Soil Plume Grid* to the front of the plume. Trace the outline of the plume on the transparency with an overhead marker.
3. Draw the shape of the plume in your Hydroville Science Journal.
4. Calculate the *area* of the soil that was contaminated in the model. Count the total number of squares in that are colored. If a square is only half colored, count the area of the square as one half. Do the same for squares that are 1/4 or 3/4 contaminated.

   Hint: Each square equals 1 foot x 1 foot.
5. Your teacher will add clean water to the model to simulate rain. Observe what happens to the shape of the plume. Add your observations to your drawing.
6. Complete Worksheet 2 and Worksheet 3.

Day 3. Soil Scientists Report

Materials:

- ☐ Calculators
- ☐ Worksheet 4: *Soil Scientists Report*

Procedure:

1. With your partner, complete Worksheet 4.
2. Meet with all of the other soil scientists to complete your Soil Scientists Report.

Worksheet 1

Name ____________________________

Date ________________ Period ______

Soil Permeability of Spill Site

Table 1. Soil Permeability at Spill Site

Permeability Test	Starting Time	Ending Time	Permeability Rate (seconds)
Trial 1			
Trial 2			
Trial 3			
		Average Permeability Rate (seconds)	

1. Complete the calculations below to answer the following question: "How many feet will the pesticide move down into the soil at the spill site in 1 hour?"
   a. Permeability rate = __________ seconds (*answer from Table 1*)
   b. *(Insert answer a)* seconds x $\frac{\text{1 minute}}{\text{60 seconds}}$ = Permeability rate = __________ minutes
   c. $\frac{\text{0.5 inches}}{\textit{(Insert answer b)}\text{ minutes}}$ = Permeability rate = __________ inches/minute
   d. *(Insert answer c)* inches/minute x $\frac{\text{60 minutes}}{\text{1 hour}}$ = Permeability rate = _______ inches/hour
   e. (*Insert answer d*) inches/hour x $\frac{\text{1 foot}}{\text{12 inches}}$ = Permeability rate = __________ feet/hour

Worksheet 2

Name ______________________________

Date __________________ Period ______

Contaminated Soil Calculations

Introduction

So far, you have measured the permeability rate of the soil at the spill site, and observed the shape of the pesticide plume. You will use this information to calculate the volume of soil that is contaminated and the amount of metam sodium that has permeated into the soil.

1. What is the permeability rate of the pesticide in the soil? In other words, how many feet does it travel in 1 hour? (Insert *answer e* from Worksheet 1.)

   Permeability rate = __________ feet/hour

2. The spill occurred at 5:30 a.m. The mechanical engineers started pumping the pesticide from the ditch at 11:30 a.m. The mechanical engineers spent 3.5 hours pumping the pesticide from the ditch. What is the amount of time the pesticide has been seeping into the soil?

   Total time = before pumping + during pumping

   Total time = __________ hours

3. Calculate how far the pesticide permeated into the soil during this time. (What is the depth of contaminated soil?)

   Depth = permeability rate (feet/hour) x total time (hours)

   (Depth = answer 1 x answer 2)

   Depth = __________ feet

4. Estimate the area of contaminated soil using the diagram on Worksheet 3.

   a. Mark the depth of the plume (from step 3) on the pesticide soil model diagram.

   b. Using your drawing of a plume from the Pesticide Plume Model as a reference, draw a similar shaped plume at this depth.

   c. What is the area of contaminated soil? Count the total number of squares. **Hint:** Each square equals 1 foot x 1 foot. Include partially contaminated squares, e.g., ¼, ½, and ¾.

      Area of contaminated soil = __________ ft^2

5. Calculate the volume of soil that was contaminated.

   Volume = Width x Depth x Length (see *Pesticide Plume Diagram* for Length)

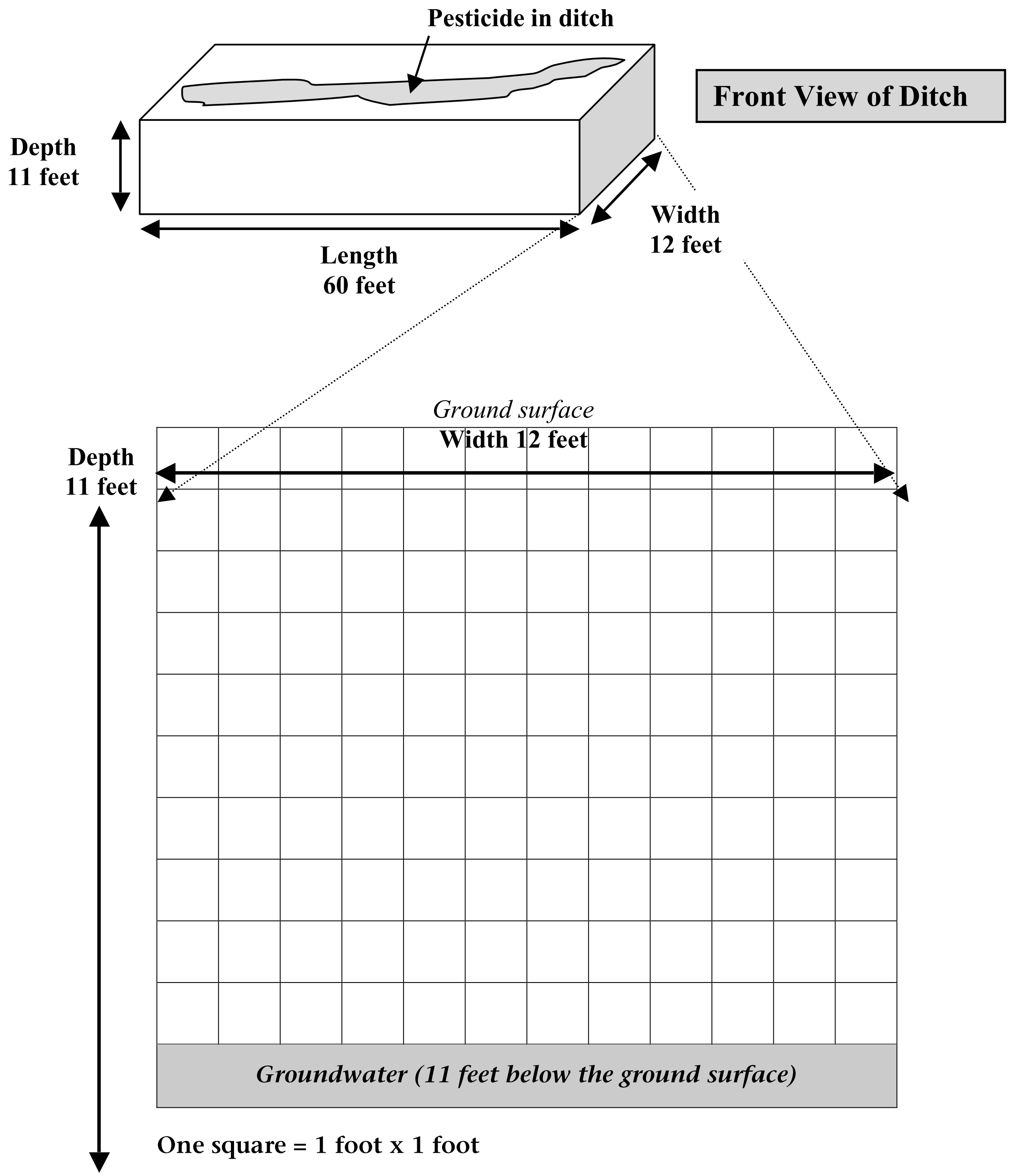
   Volume of contaminated soil = __________ ft^3

Worksheet 3

Name ______________________________

Date _________________ Period ______

Pesticide Plume Diagram



Worksheet 4

Name ______________________________

Date _________________ Period ______

Soil Scientists Report

Conclusion Questions

1. Calculate the percentage of each of the soil components to identify the soil type at the spill site.

   Percentage of soil component = $\frac{\text{soil component}}{\text{total soil sample}}$ x 100 = _____ %

Soil Component	Amount of Soil Component (grams)	Total Soil Sample (grams)	Percentage of Soil Component (%)
Sand	125	250	
Silt	120		
Clay	5		

2. Using the *Soil Texture Triangle*, identify the soil texture at the spill site. Describe the texture of this soil, soil permeability, water-holding capacity, and possible land uses.

3. What do you think would happen to the metam sodium in the soil if it rained in the next 2 or 3 days in Hydroville?

4. Consider the following. In your opinion…
   a. Is Beaver Creek at risk of being contaminated? Why?
   b. Is the groundwater at the Jones' Farm at risk? Why?

Worksheet 4, Page 2

Name ______________________________

Date _________________ Period ______

Disposal Options and Costs

5. Calculate the cost of each option in Table 2 based on the volume of contaminated soil. Record your answers in Table 2 in the last column.

   Volume of contaminated soil = _______ ft^3 (insert the answer from #5 on Worksheet 2)

Table 2. Disposal Options and Costs

Options	Cost of Option	Cost/Volume of contaminated soil
Excavation (remove soil from site)	\$ 5.00 /ft^3	
Transport soil to disposal site	\$10.00 /ft^3	
Dispose of contaminated soil (government approved methods)		
Landfill disposal	\$ 2.50 /ft^3	
Soil incineration/burning (at certified site)	\$ 5.00 /ft^3	
Spread onto field	\$ 0.25 /ft^3	
Do not excavate (remove soil from site)		
Cover with heavy plastic	\$ 0.80 /ft^2	
Allow pesticide to degrade into soil and air naturally without any intervention	\$ 0.00	
Other?		

6. Select a disposal method or a combination of methods based on these costs. All options have costs and benefits/drawbacks associated with them. Give reasons for your choice(s).

7. List the important information you want to share with the other members of your team.

DATA SYNTHESIS

Hydroville, USA

DATA SYNTHESIS

Description:

Student experts share the data they have collected and analyzed with their teams. The teams create a decision chart and develop their remediation plan. This plan must be supported by data and take into account the total cost and interests of all stakeholders. Teams then develop a presentation for the open town meeting.

Purpose/Goals:

Students will be able to:

- share information from each of the four expert groups
- create a decision chart that reflects their findings
- develop a remediation plan based on data collected and cost limitations
- develop problem presentation and visuals for the presentation

Prerequisites:

All of the Background Activities and Expert Groups.

Time Estimate:

Prep: 15 minutes (to assemble presentation materials)

Activity: Five 50-minute periods

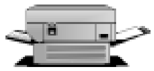
- Days 1–2: Expert sharing and team decision chart revision
- Day 3: Develop remediation plan
- Days 4–5: Presentation preparation and practice

Materials:

Presentation Preparation:

- ☐ Computers to prepare PowerPoint slides
- ☐ Blank transparencies and overhead pens
- ☐ Flip chart paper or poster board
- ☐ Colored markers or pencils
- ☐ Student decision charts from Background Activity 9

Pages to Photocopy:



One copy/student:

- Instructions: *Data Synthesis*
- Reading: *Components to Consider when Preparing a Presentation*

Two copies/team:

- Worksheet 1: *Decision Chart*

One copy/team:

- Worksheet 2: *Presentation Planning Task List* (use Worksheet 2a if you want students to fill in the tasks themselves)
- Worksheet 3: *Designing a 12–15 Minute Team Presentation*
- Worksheet 4: *Team Presentation Planning Checklist*

Background Information:

There is no cleanup standard for metam sodium set by the EPA. There are no anticipated adverse health effects when pesticides are used according to the manufacturer's instructions. However, in the case of a large-scale spill, such as the metam sodium spill in Hydroville, it is realistic to anticipate health threats to citizens in the area and cleanup crews. In this situation, trained cleanup crews would be called in to clean up the spill. Standardized protocols exist to clean up such spills, including requirements for personal protective equipment for the crew. Typically, these spills are reported to and regulated by the state department of environmental quality. To find out the agency that regulates spills in your state, see http://npic.orst.edu/state1.htm.

The regulatory agencies that have jurisdiction over this type of spill in most states are

- the national Environmental Protection Agency (EPA), which sets drinking water regulations
- the state Department of Environmental Quality (DEQ), which oversees the proper cleanup of the site

Methyl bromide has been an alternative pesticide to metam sodium. But methyl bromide has been phased out as a soil fumigant and is not allowed to be used any longer because it depletes the ozone layer. Currently, metam sodium is the number one replacement for methyl bromide in agriculture.

This spill doesn't represent something that would be considered a "Superfund" site. But it might be helpful to share with students the nine criteria that the government uses to oversee the cleanup of a Superfund site.

1. Overall protection of human health and the environment

2. Compliance with specific regulations or requirements
3. Short-term effectiveness to reduce risk
   - Protection of community during remediation
   - Protection of workers cleaning up site
   - Time of cleanup
4. Long-term or permanent effectiveness
   - Residual risk
   - Controls and monitoring measures
5. Reduction of toxicity, mobility, and volume through treatment
6. Implementability/feasibility of plan
7. Cost
   - Immediate action plan
   - Long-term monitoring of the site
8. State acceptance
9. Community acceptance

Suggested Lesson Plan:

Days 1–2. Decision Chart and Expert Sharing

1. Show the transparency of the Decision Chart that the class developed in Background Activity 9. Teams should use this chart as a starting point and revise it based on the information they have learned in their expert groups.
2. One person is designated as the recorder. This person should have a pencil and a blank decision chart (Worksheet 1).
3. Have teams revise the "goals and criteria" on the class decision chart based on the interest of the stakeholders listed or any new stakeholders. When the list is complete and agreed upon by the team, the recorder writes the goals/standards/criteria on the Team Decision Chart.
4. Experts should share their expert reports to the other members of the team. Students should recommend changes in the actions (remove or add actions) listed on the class decision chart, based on their knowledge from their expert group. Each team member must defend additions to the team chart using information gathered and data from their expert group. The recorder writes the agreed upon actions or solutions on the Team Decision Chart.
5. The team works together to rank all of their actions on the team decision chart. Recorder completes the team chart. Emphasize that each team must calculate the cost of the decisions chosen for their presentation.
6. You might also have students discuss organizational strategies for preparing their presentations. Share Worksheet 2: *Presentation*

Planning Task List or have student teams develop their own on the blank form (Worksheet 2a). Which one you choose to use will depend upon the level of your students and on the time you can allot to presentation preparation.

Day 3. Remediation Plan

1. Before the teams begin their work, discuss what getting to consensus means, since all members of the team need to agree on their remediation plan.
2. Using the information on their Decision Chart, teams work together to develop their remediation plan and site monitoring plan. They also calculate the cost of the site cleanup and the ongoing monitoring plan. They decide how they are going to disseminate this information to the public.

Days 4–5. Presentation Preparation and Practice

1. Go over the Reading and Worksheets 3–4 and the scoring guides that will be used.
2. Presentations must include a cost analysis, detailed cleanup specifications, and a long-term monitoring plan.
3. Each team designs its presentation making certain that each member of the team has a responsibility in preparing and making part of the presentation.
4. After members have produced their presentation scripts and visuals, the team needs to practice its presentation, debrief with one another, and then revise the presentation.

Teacher Key

Scenario Fact Sheet

Facts:

- Spill occurs at 5:30 a.m. Tuesday.
- Cleanup team from Southerville EnviroClean arrives at the spill site at 8:00 a.m.
- Cleanup team is composed of:
  - Mechanical Engineers, who build a pump and remove the spilled pesticide.
  - Soil Scientists, who study the soil and determine how much soil is contaminated and must be removed.
  - Analytical Chemists, who take samples and analyze the soil and water contamination by the spill.
  - Environmental Toxicologists, who research the pesticide, its uses, and its effects on humans.
- The team will present their remediation plan at a Hydroville town meeting at 7:00 p.m. Wednesday in the Hydroville Library meeting room.
- There is no cleanup standard for metam sodium set by the EPA. Site monitoring must continue until levels of metam sodium and MITC in soil and water are less than 1 ppm.
- Memo to the cleanup company from the insurance firm encourages them to create a cleanup plan with a budget of no more than $50,000. Long-term monitoring costs will be in addition to the cleanup budget.
- Use a decision chart to evaluate solutions or actions in light of specific goals of the stakeholders.

Decision Chart

Teacher Sample

(Teams Will Differ)

Problem statement: To develop a remediation plan for the metam sodium spill site south of the town of Hydroville.

	Goals/Standards			
Solutions/Actions	Low Cost	Community Acceptance	Meets <0.1 ppm Conc.	Safe Drinking Water
No action	++	- -	- -	0
Cover soil/ditch with plastic	+	-	0	0
Pump pesticide out	-	+	0	+
Pump out, then cover with plastic	-	0	+	+ (if no rain)
Excavate site	-	+	+	+
Soil and water monitoring after cleanup	-	++	+	+

Key to symbols used:
++ = very positive outcome with respect to goal
+ = positive outcome with respect to goal
0 = neither negative nor positive outcome with respect to goal
- = negative outcome with respect to goal

Student Pages for

DATA SYNTHESIS

Follow this Page

Data Synthesis

Days 1–2. Decision Chart Revision and Expert Sharing

1. Choose a team member to act as the recorder. This person will need a pencil and a blank Decision Chart.
2. Use the transparency of the Decision Chart that the class developed in Background Activity 9 as a starting point.
3. Look at the "goals, standards, criteria" on the class Decision Chart. As a team, brainstorm other stakeholders not listed and their goals for the cleanup. Revise the existing goals if needed. When the list of goals and criteria is complete and agreed upon by the team, the recorder writes the goals/standards/criteria on the Team Decision Chart.
4. Based on this memo from the insurance company, add or change the goals and criteria listed on your decision chart.

Interoffice Memo

To: Southerville EnviroClean

From: Premier Insurance Company

RE: Hydroville Cleanup Project

Priority: Urgent

Now that your team is at the scene of the metam sodium spill and has assessed the situation, we want to reemphasize the priorities of our firm.

- Clean up the site quickly.
- Protect the health of the cleanup team.
- Communicate the cleanup plan to citizens of Hydroville.
- Control costs – keep the total cost for the spill site cleanup under $50,000 if at all possible.

CS/RB

5. Team experts should share their expert reports with the other members of the team. Experts should recommend actions
6. Based on your team's expert recommendations, remove or add actions listed on the class Decision Chart. Each team member must defend additions to the team chart using data and information gathered in her or his expert group. The recorder writes the agreed-upon actions or solutions on the Team Decision Chart.

Instructions, Page 2

7. Work together to rank all of the actions on your Team Decision Chart. Use the following ranking system:
   - ++ = very positive result with respect to goal
   - + = positive outcome with respect to goal
   - 0 = not applicable or neither positive or negative effect with respect to goal
   - \- = negative outcome with respect to goal
   - \- - = very negative outcome with respect to goal
8. The recorder then completes the team's Decision Chart.
9. As a team, agree on what actions or solutions on the Decision Chart you are going to recommend.

Day 3. Remediation Plan

1. Work with members of your team to develop a remediation (cleanup) plan for the spill site using the actions and solutions decided upon by your team. Calculate the costs for your plan.
2. Be certain to include with your remediation plan an ongoing site-monitoring plan. Calculate the costs for this monitoring plan.
3. In addition to your presentation to the Hydroville town meeting, you may also be asked to create another mechanism for disseminating information about the spill cleanup and your action plan. You may choose from
   - an informational poster about the spill and its cleanup for the public library
   - a full-page ad for the *Hydroville Times*
   - an informational Web site
   - a public service announcement for *Hydroville TV* about the spill and its cleanup

Days 4–5. Presentation Preparation and Practice

1. Your teacher will go over the *Checklist for Team Presentation Planning, Designing a 12–15 Minute Team Presentation,* and the scoring guides that will be used to evaluate your presentation.
2. Your team's presentation must include a cost analysis, detailed cleanup specifications, and a long-term monitoring plan.
3. When designing your presentation, make certain that each member of the team has a responsibility in preparing and making part of the presentation.
4. Visuals such as charts and diagrams add to the audience's understanding of your presentation.
5. After your team members have produced their presentation scripts and visuals, practice your team presentation, debrief with one another, and then revise your presentation.

Worksheet 1

Name ______________________________

Date _________________ Period ______

Decision Chart

Problem Statement:

Goals/Standards

Solutions/Actions								

Worksheet 2

Name______________________________

Date_________________ Period______

Presentation Planning Task List

Instructions:

1. Brainstorm a list of tasks you need to do in order to complete your project.
2. List each task on the table below.
3. Assign a team member to each task. (Put initials next to task.)
4. Describe how you will complete the project tasks.
5. Assign a completion date and/or time for each task.

Date:______________ **Project Title: Remediation plan and presentation for Hydroville spill site**

	Task	Owner's Initials	How will this task be completed?	Completion Date
1	Expert sharing – Mechanical eng.		Presentation of Expert Report to team	
2	Expert sharing – Soil scientists		"	
3	Expert sharing – Environ. toxicol.		"	
4	Expert sharing – Analytical chemist		"	
5	Develop Team Decision Chart		Whole group	
6	Use facts to develop time line of cleanup		Whole group	
7	Use expert information to develop a monitoring plan		Whole group	
8	Use Decision Chart to develop remediation plan		Whole-group decision	
9	Develop presentation outline		Whole-group decision	
10	Select spokesperson for group		Whole-group decision	
11	Prepare presentation		Each team member prepares note cards and graphic	
12	Practice presentation		Whole group	
13	Revise presentation		Brainstorm ways to improve, all give input	
14	Practice again			
15	Give presentation			
16	Team debrief and evaluation		Go over presentation evaluations	

Worksheet 2a

Name______________________________

Date_________________ Period______

Southerville EnviroClean Project Planning Task List

Instructions:

1. Brainstorm a list of tasks you need to do in order to complete your project.
2. List each task on the table below.
3. Assign a team member to each task. (Put initials next to task.)
4. Describe how you will complete the project tasks.
5. Assign a completion date and/or time for each task.

Date:_______________ Project Title: Remediation plan and presentation for Hydroville spill site

Task	Owner's Initials	How will this task be completed?	Completion Date
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Components to Consider When Preparing a Presentation

In theory, there are **five essential components** that occur at every public speaking event: the Context, the Purpose/Goals, the Audience, the Message, and the Speaker/s.

1. **Context**: What is the climate here for the public, the insurance company, and your team? Consider such things as:
    a. What is the public's concern?
    b. What are the rumors? What are the fears?
    c. What has been reported on TV and in the press?
    d. Is there trust?
    e. What matters most to the insurance company?
    f. What matters most to your consulting team? What matters least, and why?
    g. What tradeoffs do you need to make to support what matters most to your group? Considering the climate that you expect at the meeting, are the tradeoffs easier? More difficult? How and why?

2. **Purpose/Goals**: What do you want to accomplish in your presentation?
    a. Whom do you want to inform? What do you wish to tell them?
    b. What exactly will you use to persuade or convince them?
    c. With whom must you build an ongoing level of trust? How will you accomplish this? How do you demonstrate to the community that you have adequately cleaned up the spill?

3. **Audience**: What does the public *need* to know? How can we make sure they feel involved in the solution to the problem? Consider the following when preparing your presentation:
    a. Community values (a safe community, health, sense of participation in issues)
    b. Public beliefs (government agencies should be trustworthy)
    c. Public fears (government agencies are not trustworthy, resulting in unsafe drinking water, air pollution, toxins in foods)
    d. Questions from the audience (what will they challenge and oppose?)

4. **Message**: What is our remediation plan? Using the decision chart, list your:
    a. Values (safe drinking water, clean air, healthy food, efficient or least expensive approach to maintaining these)
    b. Beliefs (through careful planning we can protect our community)
    c. Assumptions (we are trustworthy)
    d. Cost to insurance company and city of Hydroville

Reading, Page 2

e. Given your team's remediation plan and monitoring program, list your main arguments or key points.
   - What evidence will we use to support each key point? (facts, statistics, expert opinions, illustrations, personal experiences)
   - List any counterarguments that others may make.
   - How will you respond to these counterarguments? How can you build trust with the public?
     1) What do they want to hear?
     2) What can you tell them that you want them to hear?
     3) What must you tell them that they don't want to hear? What risks must you include? Consider the risk vs. cost of monitoring.
     4) How can you best deliver this news?

f. How will you conclude the presentation?
   - What do you need to accomplish?
   - How will you bring your audience "on board" with your point of view?
   - How will you synthesize all main points?
   - What are key words you want to use in conclusion?

5. **Speaker/s**: Will the speakers have credibility with the audience? (Each person is presented with credentials, dresses appropriately, and speaks authoritatively.)
   a. What could get in the way of delivering a strong message? (poor speaking voice, mumbling, lack of eye contact, unclear direction)
   b. How can you earn the public's trust?
   c. How can you best present yourselves as a team of professionals?

Worksheet 3

Name ______________________________

Date _________________ Period ______

Designing a 12–15 Minute Team Presentation

The Purpose/Goals:

Use terms such as "to inform," "to persuade," or "to build trust" in your goal statement.

The Speakers:

1. Select one or two main speakers from your team to present the introduction and conclusion.
   List their names here:

2. Select team members to present individual claims. Use your experts here.
   List their names and topics here:

3. Maintain a "team" approach through clear communication and consensus during design of the presentation, agreement on the message, and commitment to your plan. Listen carefully to one another as you work.

Worksheet 3, Page 2

Name ______________________________

Date_________________ Period______

The Message:

Introduction

1. What is your remediation and monitoring?

   How will you include it in your introduction?

2. Plan to give a brief "roadmap" (overview of main points) to prepare your listeners for the list of key points, each with a key word or phrase. Then refer to each one again with that key word when you reach it during the presentation.

   Key Points

   List your key points. Under each one, list your evidence from data collected. How will you respond to questions or arguments against each one?

   a.

   b.

   c.

   d.

3. What charts, graphs, and visuals will best illustrate our message? List each with names of those who will prepare and present them.

   a.

   b.

Name________________________________

Date__________________ Period_______

c.

d.

e.

Conclusion

4. How will you summarize your information in conclusion?

   What impression do you want to leave with the public?

   Can they contribute in some way to the solution?

   Is there a monitoring plan? If yes, describe the plan. Will the public be promised timely updates?

   How will they know when the problem is solved?

5. How will you know if you have accomplished your goals? List a few measurements.

Worksheet 4

Name______________________________

Date_________________ Period______

Team Presentation Planning Checklist

- ☐ Expert groups share team reports.
- ☐ Review cleanup regulations.
- ☐ Brainstorm cleanup solutions.
- ☐ Design a decision chart.
- ☐ Develop a remediation plan.
- ☐ Enter the timetable of events on poster or overhead.
- ☐ Prepare presentation.
- ☐ Review presentation scoring guides.
- ☐ Presentation is 12 to 15 minutes in length, leaving 5 minutes for audience questions.
- ☐ Visuals are clear and can be read from the back of the room.
- ☐ Attire is professional.
- ☐ Every member of the team participates in preparing and making the presentation.
- ☐ Practice and revise presentation.

Presentation Elements:

- ☐ Company is introduced and credentials of team members are presented. You need to convince the audience that they should believe what you have to say.
- ☐ Overview of the problem is presented.
- ☐ Timetable of events is reviewed.
- ☐ Facts about the spill from each expert group and data to support those facts are clearly presented.
- ☐ Model pump is demonstrated and procedures for use explained. Amount and times of pumping of pesticide presented.
- ☐ Steps for remediation of the site are identified.

    What has been done to the site by 7:00 p.m. on Wednesday

    What still needs to be completed as part of the cleanup

    What future monitoring needs to be done

- ☐ Costs are presented and summarized.
- ☐ Public concerns and safety of citizens of Hydroville, and plant and animal life, are addressed.

SOLUTION PRESENTATION

SOLUTION PRESENTATION

Description:

Student teams present their remediation and monitoring plans to other class members, parents, and invited guests who represent the citizens of Hydroville.

Purpose/Goals:

Students will present their remediation plans within the context of the Pesticide Spill Scenario.

Prerequisites:

Students should complete all of the Background Activities and the first four parts of the Pesticide Spill Scenario.

Time Estimate:

Activity: Three to four 50-minute periods

- Days 1–2: Team Presentations
- Days 3–4: Team debriefs, individual and group assessment – homework assignment or in-class writing exercise

Materials:

- ☐ Hydroville Science Journal
- ☐ Infocus projector, computer
- ☐ Overhead projector

Pages to Photocopy:

One copy/student:

- *Sample Audience Questions for Pesticide Spill Presentation*
- Instructions: *Reflection on Pesticide Spill Scenario*
- Scoring Guides (choose one or more from Appendix D or use one of your own design)

Suggested Lesson Plan:

Getting Started

1. Reserve a room in the school or school district office that will accommodate the team presentations.
2. Invite guests to attend. Include parents, administrators, school board members, the press, etc.
3. Select individuals to represent the Hydroville city council and ask questions of the presentation teams. (See *Sample Audience Questions for Pesticide Spill Presentation.)*

Doing the Activity

There will be two parts to the Solution Presentation:

1. Oral presentation to an open Hydroville town meeting

   The presentations will be evaluated for clarity, use of visual aids and supporting data, professionalism, and inclusion of all interest groups involved. Members of the audience will use *Team Presentation Scoring Guides* to give feedback to the teams.

2. Visual presentation

   These can take many forms and are up to the instructor's discretion and time available.

   Some ideas are:

   - an informational poster about the spill, remediation plan, and the pesticide, which will be posted in the Hydroville Library
   - a full-page ad for the *Hydroville Times*
   - a PowerPoint presentation
   - an informational video about pesticides

Wrap-Up

1. After all the teams have made their presentation, be certain to schedule time for teams to debrief their presentations. Have teams create a flip chart listing what went well, what went poorly, and ideas for improvement.
2. Meet with each team to share a summary of the audience evaluation of their presentation and how it matches up with the team's own assessment.
3. **Journal Prompt: Critical Thinking Question:** If you could do your presentation over again, how would it be different? How could it be improved?
4. Have students write a reflective paper or memo about their experiences in this project. Use *Reflection on Pesticide Spill Challenge Scenario*.

Assessment:

- Teams can be evaluated on their presentation, both spoken and visual.
- Individuals can be evaluated on their demonstration of teamwork skills, or on a science content test.
- Individual students could write a press release or article for the *Hydroville Times* based on their team's presentation.
- You can videotape student presentations and then have students watch the video to assess their own and their team's performance.
- Other scoring guides from the PEERS project have also been included for your use.

Extensions: Language Arts and Social Studies:

Introduction of Ambiguity

This problem can be made more complex by introducing sources of ambiguity and/or uncertainty. One source of ambiguity is inherent in the different values that various stakeholders bring to a problem and its solution. After presenting their solution, students can be assigned to role-play as representatives from stakeholder groups other than the insurance company. For example, a student could be assigned to each of the following roles (these are examples only; others are possible):

- member of a local environmental protection group (Friends of Beaver Creek)
- director of public works for the local community
- a homeowner's group
- a local real estate agent
- a representative from an agricultural industry group
- a prominent town physician
- a science teacher from the local high school

The goals of this activity are to:

1. Expand the student's awareness and understanding of the range of perceptions and values that are a part of real-world environmental decision-making problems.
2. Demonstrate such awareness by identifying how key features of the problem and the process of arriving at a solution would be changed as a result of adopting different value positions (that is, perceptions and values of other interest groups).

In originally adopting the perspective of the insurance company, the students may think that they have what appears to be a single best solution. This role-playing exercise should increase the students' perception of the ambiguity of the problem. The challenge for the student is to resolve this ambiguity by identifying its source(s), and reconciling the ambiguity by various approaches, including gathering additional information and developing problem solutions based on a broader range of values.

Students may encounter new values that are not readily expressible in quantitative or "measurable" terms. For example, a strong desire to protect the environment at any cost may emerge. Some trade-offs may seem either difficult or inappropriate, such as the cost of cleanup versus long-term health effects. Ideally, students would come to recognize that some values can be expressed in tangible terms (for example, economics, acres restored), while others can be expressed only qualitatively (for example, image of the community). Students from all different roles should be able to carry on a dialogue about the problem in a group setting, working toward a problem solution that is at least partially acceptable to all stakeholders. At the least, students should be able to reduce the problem to a set of two or three "short list" candidate solutions and recognize how each solution fits with the various stakeholder positions.

Suggested Lesson Plan:

1. Assign students or groups of students to particular interest groups or roles.
2. Students review the problem, including the research that was done on it, the results that were obtained, and the solutions that were proposed. They then should address the following questions through group or class discussion and/or written form.
3. Small groups of students could review their team's process from their new roles for one period, then participate in a round-table discussion moderated by the teacher or a professional mentor.
4. Suggested discussion questions:
    - What matters most to the insurance company? What matters most to your interest group? What matters least, and why? How does perception of the problem and its solution change as a result of adopting a different role perspective?
    - What new tradeoffs do you need to make to support what matters most to your interest group? Are the tradeoffs easier? More difficult? How and why?
    - What concerns or considerations of your interest group appear to have been left out of the original analysis of the problem?
    - How do you *feel* about the problem in your new role? Are you comfortable with the original solution? Do you feel trust and confidence in how the Southerville EnviroClean team managed the spill?

- Does the original concept or definition of *risk* change in your new role, and if so, how? Are there new risks that you perceive from the perspective of your new role? Do old risks change? If so, how?
- How would cost of the cleanup change? Would a new solution cost more or less?
- Would there be a different emphasis or importance given to long-term health effects?
- Would your interest group be more concerned about the effects of the spill on the image or perceived livability of the community?
- From the perspective of your interest group, are there possible problem solutions that were not previously considered? Is there a *better* solution than the one originally proposed from the insurance company perspective?
- Is there a compromise solution possible that meets both the insurance company's needs and the needs of your interest group?
- After looking at this problem from multiple points of view, what role does science play in reaching a decision? What was the unique contribution of science? What kinds of issues can science address? What kinds of issues can science not address?

Web Site

Create a Web site that documents the students' involvement in this project and the presentation of their solutions.

Public Information

Create a display for the public library or a school display case on the use of pesticides in the United States and their benefits and risks.

Videos: Watch *Erin Brockovich* or *A Civil Action*.

Student Pages for

SOLUTION PRESENTATION

Follow this Page

Sample Audience Questions for Pesticide Spill Presentation

How clean is clean enough? How will you know when the site is clean enough?

What if the city of Hydroville doesn't have the money to spend on continued monitoring of the site? What if there were another emergency at the same time? How do we set priorities on spending the money?

Why isn't "doing nothing" an OK solution?

Hydroville's City Council is working with a budget deficit. What part of your plan's continued monitoring is essential to ensure the safety of the town's drinking water? We need to prioritize our spending.

(Demonstration of pump): When scaled up to actual size, will this pump require the use of a huge crane or helicopter? Why or why not? Have you figured the hourly cost of the crane or helicopter into your budget?

I get my water from a groundwater well about 1 mile from the spill site. Can you tell me for certain that my water is safe to drink? What about watering lawns and washing pets?

Is it safe to eat the fish that I caught in Beaver Creek on Tuesday at a fishing hole 4 miles south of town?

How much soil needs to be removed? From where? How long will the soil removal take?

What is the worst case scenario? If you say the pesticide will not be harmful in 3 weeks, can we just wait? Please clarify the city's options based on time and money. In all cases, as mayor, I need to be assured that there will be no harm to the citizens of Hydroville.

When can we be sure that the citizens can drink the treated water from Beaver Creek? After which test can we determine this? Who will notify the water treatment facility and the citizens of the town?

Reflection on Pesticide Spill Scenario

From your Hydroville Science Journal notes, write a 1- or 2-page memo to your teacher. After the memo heading, briefly give the background to your experience with this project (describe what you did in these activities). Then write about your experiences under the headings that are shown.

Memo Heading

To:

From:

Subject:

Background

Give a brief description of this project and its goals.
How would you explain what you have been doing in this project to someone who is unaware of the project?

What I Learned

Share one or two new concepts that you learned in this project.

What Worked

What aspects of the project went smoothly?

What Were the Challenges?

What was the most challenging part of the project for you?

Teamwork

How did you contribute to your team's effectiveness?
Who did you work well with? Why?
Describe situations when the team worked well together. Explain why.
Describe situations when the team did not work well together. Explain why.
What did you do to help improve the teamwork? What could you or others have done?

Recommendations

How could the teacher improve this curriculum for future students?

STANDARDS

National Science Content Standards

"National Science Education Standards," National Research Council, National Academy Press, 1996

NATIONAL SCIENCE CONTENT STANDARDS	1	2	3	4	5	6	7	8	9	10	s
Pesticide Spill Background and Scenario Activities	**Reading Product Labels**	**Toxicology Testing**	**Pump It Up: Part 1**	**Pump it Up: Part 2**	**Constructing and Analyzing Graphs**	**Using Paper Chromatography**	**Soil Texture**	**Soil Permeability**	**Decision Analysis**	**Siting Yoretown's Landfill**	**Scenario**
UNIFYING CONCEPTS AND PROCESSES											
Systems, order, and organization				X			X				X
Evidence, models, and explanation	X		X	X		X	X			X	X
Change, constancy, and measurement		X			X	X	X	X			X
Evolution and equilibrium											
Form and function			X	X			X	X			X
SCIENTIFIC INQUIRY (A)											
Abilities necessary to do scientific inquiry		X		X	X	X	X	X	X		X
Understandings about scientific inquiry				X	X					X	X
PHYSICAL SCIENCE (B)											
Structure of atoms											
Structure and properties of matter						X	X	X			X
Chemical reactions		X									X
Motions and forces			X								X
Conservation of energy and increase in disorder											
LIFE SCIENCE (C)											
The cell											
Molecular basis of heredity											
Biological evolution											
Interdependence of organisms		X								X	X
Matter, energy, and organization in living systems											
Behavior of organisms		X									

NATIONAL SCIENCE CONTENT STANDARDS	1	2	3	4	5	6	7	8	9	10	s
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicology Testing	Pump It Up: Part 1	Pump it Up: Part 2	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
EARTH AND SPACE SCIENCE (D)											
Energy in the earth system											
Geochemical cycles											
Origin and evolution of the earth system											
Origin and evolution of the universe											
SCIENCE AND TECHNOLOGY (E)											
Abilities of technical design				X							X
Understandings about science and technology											X
SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES (F)											
Personal and community health	X	X							X	X	X
Population growth											
Natural resources										X	X
Environmental quality	X									X	X
Natural and human-induced hazards	X								X	X	X
Science and technology in local, national, and global challenges	X									X	X
HISTORY AND NATURE OF SCIENCE											
Science as a human endeavor	X								X	X	X
Nature of scientific knowledge		X				X			X		X
Historical perspectives											

Grades 9–12 Benchmarks for Science Literacy

"Benchmarks for Science Literacy," American Association for the Advancement of Science, Project 2061, Oxford University Press, New York, 1993.

	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
1. NATURE OF SCIENCE											
1A. Scientific World View				**1A/3**	**1A/1**						
1B Scientific Inquiry			**1B/1,2**	**1B/1,2**	**1B/1,2,3**	**1B/3**					
1C Scientific Enterprise											
2. NATURE OF MATHEMATICS											
2A. Patterns and Relationships					**2A/1**						
2B Mathematics, Science and Technology					**2B/1,3**	**2B/3**					
2C Matematical Inquiry					**2C/2**						
3. NATURE OF TECHNOLOGY											
3A Technology and Science			**3A/3**	**3A/3**							
3B Design and Systems			**3B/1**	**3B/1,6**							
3C Issues in Technology											
4. THE PHYSICAL SETTING											
4B The Earth											
4C Process that Shape the Earth											
4D Structure of Matter											
5. THE LIVING ENVIRONMENT											
5A Diversity of Life											
5B Heredity											
5C Cells											
5D Interdependence of Life											

Grades 9–12 Benchmarks for Science Literacy (continued)

Pesticide Spill Background and Scenario Activities	1 Reading Product Labels	2 Toxicity Testing	3 Pump It Up: Part I	4 Pump it Up: Part II	5 Constructing and Analyzing Graphs	6 Using Paper Chromatography	7 Soil Texture	8 Soil Permeability	9 Decision Analysis	10 Siting Yoretown's Landfill	S Scenario
6. HUMAN ORGANISM											
6D Learning											
7. HUMAN SOCIETY											
7A Cultural Effects on Behavior	7A/1								7A/1	7A/1	7A/1
7C Social Change										7C/2	7C/2
7D Social Trade Offs	7D/1,3								7D/1,3	7D/1,3	7D/1,3
7E Political and Economic Systems										7E/2	7E/2
7F Social Conflict									7F/1,2	7F/1,2	7F/1,2
8. THE DESIGNED WORLD											
8A Agriculture											8A/3
8B Materials and Manufacturing										8B/2	8B/2,4
8E Information Processing											8E/1
9. THE MATHEMATICAL WORLD											
9A Numbers		9A/1,4			9A/1,4						9A/1,4
9B Symbolic Relationships		9B/4			9B/4				9B/4	9B/4	9B/4
9C Shapes		9C/3	9C/1		9C/3					9C/1	9C1,2
9D Uncertainty		9D/4							9D/4		9D/4,8
9E Reasoning									9E/1	9E/1	9E/1
11. COMMON THEMES											
11A Systems			11A/1,2,4	11A/1,2,4							11A/1,2,4
11B Models		11B/1			11B/1						
11C Constancy and Change		11C/4			11C/4	1C/4					11C/4
11D Scale											

Grades 9–12 Benchmarks for Science Literacy (continued)

	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
12. HABITS OF THE MIND											
12A Values and Attitudes	12A/2								12A/2	12A/2	12A/2
12B Computing and Estimation		12B/4,5			12B/1,2,4,5,7	12B/1					12B/1,4,5,6,7
12C Manipulations and Observations				12C/4		12C/1					12C/1,2,4
12D Communication Skills				12D/2					12D/6	12D/1	12D/1,6,7
12E Critical Response Skills										12E/1,2	12E/1,2,3

National Council of Teachers of Mathematics Standards

"Curriculum and Evaluation Standards for School Mathematics," NCTM, National Academy Press, 1991.

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS STANDARDS	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing & Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
NUMBER AND OPERATIONS											
Understand numbers, ways of representing numbers, relationships among numbers, and number systems											
Understand meanings of operations and how they relate to one another											
Compute fluently and make reasonable estimates					X	X	X				X
ALGEBRA											
Understand patterns, relations, and functions					X						
Analyze change in various contexts											X
Represent and analyze mathematical situations and structures using algebraic symbols											
Use mathematical models to represent and understand quantitative relationships		X			X		X		X		X
GEOMETRY											
Analyze characteristics and properties of two-and three dimensional geometric shapes and develop mathematical arguments about geometric relationships		X	X	X	X						
Specify locations and describe spatial relationships using coordinate geometry and other representational systems			X	X						X	X
Use visualization, spacial reasoning, and geometric modeling to solve problems			X	X						X	X
Apply transformations and use symmetry to analyze mathematical situations			X	X							
MEASUREMENT											
Understand measurable attributes of objects and the units, systems, and processes of measurement		X	X	X	X	X	X	X		X	X
Apply appropriate techniques, tools, and formulas to determine measurements		X			X	X	X	X			X

National Council of Teachers of Mathematics Standards (cont.)

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS STANDARDS Pesticide Spill Background and Scenario Activities	1 Reading product Labels	2 Toxicity Testing	3 Pump It Up: Part I	4 Pump it Up: Part II	5 Constructing & Analyzing Graphs	6 Using Paper Chromatography	7 Soil Texture	8 Soil Permeability	9 Decision Analysis	10 Siting Yoretown's Landfill	S Scenario
DATA ANALYSIS AND PROBABILITY											
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them		X				X	X	X		X	X
Select and use appropriate statistical methods to analyze data		X			X			X			X
Develop and evaluate inferences and predictions that are based on data		X			X	X		X		X	X
Understand and apply basic concepts of probability	X								X		X
PROBLEM SOLVING											
Build new mathematical knowledge through problem solving					X	X	X				
Solve problems that arise in math and other contexts		X				X	X	X		X	X
Apply and adapt a variety of appropriate strategies to solve problems						X	X	X			X
Monitor and reflect on the process of problem solving					X						
REASONING AND PROOF											
Make and investigate mathematical conjectures					X						
Recognize reasoning and proof as fundamental aspects of mathematics											
Develop and evaluate mathematical arguments and proofs											
Select and use types of reasoning and methods of proof						X				X	X

Social Studies Content Standards

"Curriculum Standards for Social Studies: Expectations of Excellence," National Council for Social Studies, 1994.

SOCIAL STUDIES CONTENT STANDARDS	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
NATIONAL SOCIAL STUDIES STANDARDS											
Science, Technology, and Society				X				X		X	X
Global connections					X						
People, Place and Environment							X	X		X	X
Individual Development and Identity	X										X
Production, Distribution, and Consumption	X				X						
OREGON CONTENT STANDARDS www.ODE.state.or.us											
Understand and use spatial concepts of geography										X	X
Interpret and evaluate information using complex geographic representations										X	X
Identify, research, and clarify an event, issue, problem, or phenomenon of significance to society											X
Gather, use, and evaluate researched information to support analysis and conclusions	X								X		X
Understand an event, issue, problem, or phenomenon from multiple perspectives									X	X	X
Identify and analyze characteristics, causes, and consequences of an event, issue, problem, or phenomenon		X			X						X
Identify, compare, and evaluate outcomes, responses, or solutions, then reach a supported conclusion	X	X							X	X	X
Understand how humans affect the physical environment							X	X	X		
Understand how physical characteristics in the environment and changes in the environment affect humans							X	X			X
Identify and analyze physical and human characteristics of places and regions, the processes that have shaped them, and their geographic significance					X		X	X			

Social Studies Content Standards (continued)

SOCIAL STUDIES CONTENT STANDARDS	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
OREGON CONTENT STANDARDS *continued*											
Understand, represent, and interpret chronological relationships in history				X							
Interpret and represent chronological relationships and patterns of change and continuity over time					X						
Understand and interpret events, issues, and developments in local history									X		
Understand how trade-offs and opportunity costs are decisions that can be measured in terms of costs and benefits	X								X	X	X

National Standards of Language Arts and English

"Standards for the English Language Arts," National Council of Teachers of English, 1996.

BACKGROUND AND SCENARIO ACTIVITIES	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
READING FOR PERSPECTIVE											
To build understanding of a variety of cultures through a wide range of print and nonprint texts							X	X			
To acquire new information			X	X			X	X	X	X	X
To respond to the needs and demands of society and the workplace			X					X	X	X	X
To read for personal fulfillment							X	X			
UNDERSTANDING THE HUMAN EXPERIENCE											
To understand the many dimensions of human experience through a wide range of literature							X	X			
EVALUATION STRATEGIES											
To apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts	X	X			X		X	X	X	X	X
To draw on prior experience, interactions with other readers and writers, previous knowledge of word meaning and other texts, word identification strategies, and understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics)	X	X					X	X	X	X	X
COMMUNICATION SKILLS											
To adjust use of spoken, written, and visual language (e.g., conventions, style, vocabulary)	X	X		X	X		X	X	X	X	X
To communicate effectively with a variety of audiences and for different purposes	X			X	X			X	X	X	X
COMMUNICATION STRATEGIES											
To employ a wide range of strategies in order to communicate with different audiences for a variety of purposes	X			X	X		X		X	X	

National Standards of Language Arts and English *(continued)*

BACKGROUND AND SCENARIO ACTIVITIES	1	2	3	4	5	6	7	8	9	10	S
Pesticide Spill Background and Scenario Activities	Reading Product Labels	Toxicity Testing	Pump It Up: Part I	Pump it Up: Part II	Constructing and Analyzing Graphs	Using Paper Chromatography	Soil Texture	Soil Permeability	Decision Analysis	Siting Yoretown's Landfill	Scenario
APPLYING KNOWLEDGE											
To create, critique, and discuss print and nonprint texts based on knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre	X	X			X		X	X	X	X	
EVALUATING DATA											
To conduct research on issues and interests by generating ideas and questions, and by posing problems		X			X		X	X	X	X	
To gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people)	X	X		X	X		X	X	X	X	
To communicate discoveries appropriate to purpose and audience	X	X		X	X		X	X	X	X	

MATERIALS LIST

Materials List

Quantity	Materials	Vendor
	Welcome to Hydroville - students work in groups of four	
Hydroville Science Journal		
1/student	Three-ringed binder with dividers and notebook paper	
Teamwork Skills		
1/group	10-foot diameter circle	
	Two coffee cans, one half-filled with popcorn	
	Three pieces of rope (7 feet long each)	
	One bicycle inner tube	
Pesticide Spill Video		
1	Pesticide Spill Scenario Video	Hydroville Curriculum Project, www.hydroville.org
1	TV and VCR or DVD player	
	Post-it Notes	
	Markers	
	Poster board or paper	

	Background Activities		
1	**Reading Household Product Labels - students work in pairs**		
	25-30	Examples of hazardous household products: oven and drain cleaners, pesticides (ant and wasp killer), solvents (thinner), adhesives (rubber cement, carpet glue), etc.	
	5	Examples of non-hazardous household products: toothpaste, shampoo, multi-purpose glue, etc.	
2	**Toxicity Testing-"Dose Makes the Poison" - students work in groups of three or four**		
	For Chemical Dilutions		
	1/group	Chemicals to be tested: salt, water-soluble plant fertilizer, insect repellent, window cleaner, coffee, all-purpose cleaner, vinegar	
	1/group	50 mL of chemical (in a 100 mL beaker)	
	6/group	50 mL beakers	
	1/group	25 mL graduated cylinder	
	1/group	10 mL graduated cylinder	
	1/group	100 mL distilled water	
	1/group	Eyedropper	
	Activity - Toxicity Testing on Seeds		
	6/group	Petri dishes or resealable plastic sandwich bags (heavy duty so that don't break)	
	6/group	Sheets 2-ply paper towel	
	6/group	Beakers containing 20 mL of solution of chemical to be tested (in concentrations 0% to 100%)	
	1 tsp/group	Radish seeds (60 seeds = 1 tsp)	
	1/group	Masking tape	
	1/group	Permanent marker	
	1/group	Safety glasses	
	1/group	Latex gloves	

Materials List (continued)

	Quantity	Materials	Vendor
3	**Pump It Up! - Part I: Analyzing Pumps - students work in pairs**		
		Examples of piston pumps: squirt guns, hand pumps, bike pumps, trigger pump sprayers, etc.	Bring from home
	1/group	Squirt gun or hand pump	
	1/group	Flathead screwdriver (for use as a prying tool)	
	1/group	Safety glasses	
	1/group	Beaker or dish tub filled with water (to test pump)	
	Class Materials on Tool Table		
		Assorted pumps (hand lotion bottles, bike pumps, spray bottles, etc.)	
		Paper towels	
		Disassembled squirt gun or hand pump with all the functional parts on display (optional)	
4	**Pump It Up! - Part II: Designing a Super Soaker - students work in groups of two or three**		
		Drill and 17/64" drill bit (for drilling holes in soda bottle lids)	
		Super Soaker-type squirt gun (for demonstration)	
	Activity		
	2/group	Tubing (shut-off) clamps	Fisher Scientific
	1/group	60cc syringe	Fisher Scientific
	1/group	1/8" Y-connector (fits 1/8" ID tubing)	Fisher Scientific or irrigation equipment
	3 feet/group	1/8" inner diameter vinyl tubing	Fisher Scientific or hardware store
	1/group	20-oz. plastic bottle (e.g. a Coke bottle) WITH LID	Bottling plant or students bring from home
	Class Materials on Tool Table		
		Scissors	
		Paper towels	
		Waterproof tape, duct tape, or electrical tape	
		Hot glue gun with glue sticks	
	Additional Supplies		
		Extra shut-off clamps	
		1/8" Y-connectors	Fisher Scientific or irrigation equipment
		Lids with two holes drilled	
		1/8" T-connectors (fits 1/8" ID tubing)	Fisher Scientific or irrigation equipment
		Various nozzles to attach to end of tubing	
5	**Constructing and Analyzing Graphs-Circumference and Diameter - students work in pairs**		
	1/group	Round objects	
		Rulers	
		Tape measures (or string)	
		Calculators	
		Calipers (optional)	

Materials List (continued)

	Quantity	Materials	Vendor
6	**Using Paper Chromatography - students work in groups of three or four**		
	1/group	Strip of chromatography paper (1 cm x 16 cm) with crime scene ink	
	1/group	**A:** Sanford Sharpie permanent marker, fine point	Office supply store
		B: Paper Mate Write Bros. stick ballpoint pen, fine point	Office supply store
		C: Sanford Uni-Ball Vision Rollerball, micropoint	Office supply store
		D: Sanford Uni-Ball Vision waterproof, fine point	Office supply store
		E: Pentel Rolling Writer Rollerball, medium point	Office supply store
		F: Paper Mate Flexgrip Ultra, fine point	Office supply store
	1/student	Pencil	
		Ruler	
		Calculator	
		Safety glasses	
	4/group	Test tubes (20 mm x 150 mm) in a test tube rack or large plastic cup	
	3/group	Strips of chromatography paper (1 cm x 16 cm)	Fisher Scientific
	1/group	50 mL isopropyl alcohol	
	1/group	Non-permanent marking pen or wax pencil	
		Paper towels	
		Colored pencils	
7	**Soil Texture - students work in groups of two or three**		
	Demonstration		
		M&Ms® plain chocolate candies in three colors (brown, red, yellow)	
		250 mL beaker	
	Activity		
	1/group	Source of water (or wash bottle filled with water)	
		Aluminum pie plate or disposable plastic dinner plate	
		Resealable plastic sandwich bags or containers with lids	
		Permanent marker	
		Overhead transparency pen (optional)	
	Class Materials on Tool Table		
	500 grams/class	"Sand" - coarse sand (Industrial Quartz - 20 mesh)	Building supplies
	350 grams/class	"Silt" - fine sand (Industrial Quartz - 70 mesh)	Building supplies
	275 grams/class	Clay - powdered (Ball Clay Kentucky - OM4)	Ceramics supply store
		Balance (weighs up to 100 grams)	

Materials List (continued)

	Quantity	Materials	Vendor
8	**Soil Permeability - students work in groups of two or three**		
	Demonstration: Permeability of Clay		
	1/class	300 grams powdered clay (Ball Clay Kentucky - OM4)	Ceramics supply store
		Same materials listed for activity	
	Activity		
	1/group	Soil column: 4" (diameter) x 6" thin-walled PVC pipe	Hardware store or plumbing supplies
	4/group	Basket-style coffee filters	
		Duct tape or masking tape	
	1/group	800 or 1000 mL beaker	
		250 mL graduated cylinder	
		Ring stand with 4"ring	
		Non-permanent marker or pencil	
		Stopwatch or a wall clock with second hand	
	Class Materials on Tool Table		
		Balances (can weigh up to 300 grams)	
	300 grams/group	"Sand" - coarse sand (Industrial Quartz - 20 mesh)	Building supplies
	300 grams/group	"Silt" - fine sand (Industrial Quartz - 70 mesh)	Building supplies
		Buckets for disposal of waste water and soils	
9	**Decision Analysis**		
		None	
10	**Siting Yoretown's Landfill**		
		Rulers	

Materials List (continued)

	Data Collection		
	1	*Emergency Response Guide* (get most current available)	**JJ Keller & Assoc**
	Part I: Building a 3-D Model of the Spill Site - students work in their Southerville EnviroClean teams (4-6/team); each team builds one model		
		Paper cutter	
	13/team	11" X 11" copies of *Topographic Map of* Spill *Site* enlarged (150%) and photocopied on 11" X 17" paper	
	3/team	20" x 30" foam core or cardboard	
	2/team	Cardboard for cutting surface	
	1/team	Highlighters	
	2/team	Utility or Exacto® knives	Dollar store
		Multi-purpose glue	
		Scissors	
		Ruler	
		Colored markers or pencils	

	Data Analysis		
	Environmental Toxicologists - students work in groups of two or three		
		Colored markers	
		Poster board (for cue cards and visual props)	
		Video camera, tripod	
		Screen, backdrop material, or clear wall for filming	

Materials List (continued)

Quantity	Materials	Vendor
Mechanical Engineers - students work in groups of two or three		
Spill Site Setup		
1/set-up	Masking tape	
	Tape measure or meter stick	
	Draw organizer (3" x 12") to represent ditch	
	500 mL colored water	
	250 mL graduated cylinder	
Transport Vehicle		
4/vehicle	Blue steel tacks (#4 - 7/16")	
1/vehicle	1" x 4" x 8" wood block (for base of vehicle)	Building supplies
1/vehicle	1/4" x 3/4" x 12" screen molding (can be used as a boom or crane)	Building supplies
1/vehicle	1/4" X 1 5/16" x 8" lattice	Building supplies
2/vehicle	1/4" x 6" wooden dowel (for wheel axles)	Building supplies
4/vehicle	Wood wheels with 1/4" hole	American Woodcrafters Supply Company
4/vehicle	Poly clamps (1/4"), "pillow block brackets" (to attach axles to base of vehicle)	Electrical supplies
	1/8" X 12" steel rod (optional)	Building supplies
	20' nylon string	Hardware store
Pump		
1/pump	60cc syringe	Fisher Scientific
	20cc syringe (optional)	Fisher Scientific
10 feet/pump	1/4" inner diameter vinyl tubing	Fisher Scientific or hardware store
	1/8" inner diameter vinyl tubing (optional)	Fisher Scientific or hardware store
1/pump	1/4" T-connector (fits 1/4" tubing)	Fisher Scientific or irrigation equipment
	1/8" T-connector (fits 1/8" tubing) (optional)	Fisher Scientific or irrigation equipment
2/pump	Tubing (shut-off) clamps	Fisher Scientific
1/pump	20 oz. plastic soda bottle (to hold 400 mL of pesticide)	
	Rubber stoppers (with one hole, two holes, or no hole)	
	Rubber bands	
Class Materials on Tool Table		
	Hammer	
	Hot glue gun and glue sticks	
	Scissors	
	Extra parts: washers, paper clips, staples, rubber bands, rubber stoppers, etc.	
	Leftover materials from Background Activity 4	
	Duct tape or masking tape	

Materials List (continued)

Quantity	Materials	Vendor
Analytical Chemists - students work in groups of two or three		
	3-D model of spill site	
	Rulers	
	Colored paper or Post-It® Notes	
	Toothpicks	
	Colored markers or pencils	
Soil Scientists - students work in groups of two or three		
	Calculators	
Soil Permeability Test		
125 grams/group	"Sand" - coarse sand (Industrial Quartz - 20 mesh)	Building supplies
120 grams/group	"Silt" - fine sand (Industrial Quartz - 70 mesh)	Building supplies
5 grams/group	Clay - powdered (Ball Clay Kentucky - OM4)	Ceramics supply store
	Balance that can weigh 5 - 250 grams	
1/group	Soil column: 4" (diameter) x 6" thin-walled PVC pipe	Hardware store or plumbing supplies
2/group	Basket-style coffee filters	
	Duct tape or masking tape	
1/group	800 or 1000 mL beakers	
1/group	250 mL graduated cylinder	
	Non-permanent marker	
	Stopwatch or a wall clock with second hand	
Pesticide Plume Demonstration - build one plume demo per class		
2/plume	1/4" x 12" x 12" Plexiglass	Glass supplies
2/plume	1/4" x 3/8" strips of thick, non-compressible foam (cut up blue foam pad for camping)	Foam supplies or outdoor sports store
6/plume	2" binder clips	Boise Cascade
	Clear packing tape	
1 Liter	"Silt" - fine sand (Industrial Quartz - 70 mesh)	
	Food coloring	
	Wash bottle	
1/plume	Transparency with 1" grid	
	Overhead transparency marker	

IV	**Data Synthesis**		
		Computers with PowerPoint	
		Blank transparencies and overhead pens	
		Flip chart paper or poster board	
		Colored markers and pencils	
V	**Solution Presentation**		
		Infocus projector, computer	
		Overhead projector	

GLOSSARY

Glossary

II, Pi: the ratio of the circumference of a circle to its diameter.

Absorption: a route of exposure: when a hazardous products come into contact with the skin or eyes and causes injuries; also known as "dermal" exposure.

Active compound: the component that kills, or otherwise controls, target pests in a pesticide product.

Acute toxicity: the ability of a substance to cause harm after a single exposure or dose during a short time, less than 24 hours.

Analyte: the sample constituent whose concentration is sought in a chemical analysis.

Analytical chemist: analytical chemists determine the structure, composition, and nature of substances by examining and identifying their various elements or compounds.

Analytical chemistry: the analysis of material samples to gain an understanding of their chemical composition, structure, and function.

Aquifer: an underground bed or layer of earth, gravel, or porous stone that yields significant or economic quantities of groundwater to wells and springs.

Bedrock: the solid rock underlying unconsolidated surface materials (as soil).

Boom: a) a floating device used to contain oil on a body of water; b) a piece of equipment used to apply pesticides from a tractor or truck.

Calibration curve: a method for determining the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration.

Caution: a signal word that is used on the warning labels of pesticides. "Caution" means that the product is slightly toxic and has an Oral LD_{50} of 500 to 5,000 mg/kg.

Chromatogram: the pattern of separated substances obtained by chromatography; detection in mobile phase versus time. A chromatogram has one or more peaks – the location of a peak on the time identifies the component, and the area under the peak provides a quantitative measure of that component.

Chromatography: a process in which a chemical mixture carried by a liquid or gas is separated into components as a result of differential distribution of the solutes as they flow around or over a stationary liquid or solid phase.

Chronic toxicity: the ability of a substance to cause harm after repeated exposures often at lower levels, over a longer time period (months to years).

Circumference: the perimeter of a circle.

Clay: a group of minerals present in soils usually less than 2 micrometers in diameter; flake or layered shape, affinity for water and tendency toward high plasticity.

Closed system: in pesticide application, when a pesticide is either injected or sprayed into the soil and then covered with tarps or packed down with a roller. Reduces exposure to people and applicator.

Concentration: quantity of a component in a mixture in a unit of volume or unit of mass of the mixture.

Glossary (continued)

Contour interval: the space between contour lines on a topographic map representing the difference in elevation.

Contour line: a line on a topographic map that tells the elevation.

Cost/benefit analysis: weighing the cost against the benefit to help make a decision.

Corrosive: a product that can burn or destroy living tissue, such as skin or eyes, or by chemical action, e.g., drain cleaner, oven cleaner, lye.

Danger: a signal word that is used on the warning labels of pesticides. "Danger" means that the product is highly toxic/corrosive and has an Oral LD_{50} of 0 to 50 mg/kg.

Dependent variable: a mathematical variable whose value is determined by that of one or more other variables in a function.

D.E.Q. (Department of Environmental Quality): a regulatory agency responsible for protecting and enhancing a state's water and air quality, for cleaning up spills and releases of hazardous materials, and for managing the proper disposal of hazardous and solid wastes.

Diameter: the length of a straight line through the center of an object.

Dose: the measured quantity of a chemical that enters the body.

Dose response: how the amount of a substance affects a particular response, such as a skin rash, liver tumors, cancer, or death. The dose-response relationship is based on data collected from experimental animal, human clinical, or cell studies.

Dose-response curve: used to show the relationship between the amount of a drug or other chemical to the degree of response produced, such as enzyme activity, heart rate, or death. This response is measured by the percentage of the exposed population that shows the defined effect. If that effect is death, such a curve may be used to estimate an LD_{50} value.

D.O.T. placard: the U.S. Department of Transportation (D.O.T.) requires the use of hazardous materials placards when shipping hazardous materials cargo and dangerous goods in the United States.

Duration: duration of exposure can be acute or chronic. Acute exposure is once or twice in a short period of time, such as a week or less. Chronic exposure is long-term or lifetime exposure and spans at least 10 percent of a lifetime. For humans, this is considered 7 or more years.

Environmental toxicologist: a person who conducts research, tests, and experiments to measure toxins in the environment. They do field work to collect samples, run toxicity tests, enter and interpret data, write reports, and present findings.

Federal Hazardous Substances Act (FHSA): regulated by the U.S. Consumer and Safety Product Commission, FHSA requires precautionary labeling on hazardous household product containers to help consumers safely store and use those products.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA): gives the U.S. EPA control of pesticide distribution, sale, and use. It also requires users (farmers, utility companies, and others) to register when purchasing pesticides.

Glossary (continued)

Flammable: any liquid, solid, or the contents of an aerosol can that is capable of burning or causing a fire.

Frequency: refers to the number of times a person is exposed and the time between exposures.

Fumes: tiny particles trapped in vapor in a gas stream.

Fumigant: pesticides that are injected or incorporated into soil before planting, and form a gas which permeates the soil and kills soil-borne pests, such as insects, microorganisms, weeds, and nematodes.

Gas chromatography (GC): chromatography in which the sample mixture is vaporized and injected into a stream of carrier gas (as nitrogen or helium) moving through a column containing a stationary phase, and is separated into its component compounds according to their affinity for the stationary phase.

Groundwater: the water that is pumped and treated from aquifers (natural reservoirs below the earth's surface).

Half-life: the time required for a pollutant to lose one-half of its original concentration. For example, the half-life of DDT in the environment is 15 years.

HazMat Team: a Hazardous Materials (HazMat) Response Team protects public health and safety and the environment. The HazMat Team intervenes in chemical, biological, and radiological accidents.

Hazardous: involving or exposing one to risk or danger (as of loss or harm); a substance is hazardous if it may cause substantial personal injury or illness.

Hazardous substance: may cause personal injury or substantial illness during customary and reasonable handling or use, including ingestion by children.

Impermeable: the property of a material or soil that does not allow, or allows only with great difficulty, the movement or passage of water.

Independent variable: a mathematical variable whose value is specified first and determines the value of one or more other values in an expression or function.

Individual susceptibility: how the body responds to chemical exposure depends on the individual. Certain populations are generally more sensitive, including the young, old, and those with compromised immune systems. Gender, genetic make-up, and prior chemical exposure are also factors.

Ingestion: a route of exposure; eating or drinking hazardous substances or contaminated foods and water and absorbing these substances through the gastrointestinal tract.

Inhalation: a route of exposure; breathing in gases, vapors, and sprays that are absorbed through the lungs and enter the bloodstream.

Inlet nozzle: an opening for intake that allows water from a reservoir to enter into a pump cylinder.

Irritant: a product that is not corrosive but causes injury to the area of the body that it comes into contact with after immediate, prolonged, or repeated contact.

Glossary (continued)

Landfill: disposal sites for solid wastes spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day. Landfill operation is subject to a permit system and to technical control procedures in compliance.

Landfill liner: materials placed in the bottom and sides of sanitary landfills to minimize the chance of release of hazardous substances into the environment.

LC_{50} (Lethal Concentration 50): used to measure the concentration of a hazard in air, such as gases and vapors. The units are in mass of hazard per volume of air, e.g., mg/m^3.

Leachate: the liquid that forms when water percolates (moves) through any permeable material, such as soil.

LD_{50} (Lethal Dose 50): the dose at which 50% of the test animals (usually rats and mice) are expected to die.

Level B personal protection: worn when protection is necessary but a lesser level of skin protection is needed. Equipment includes air tank, hooded chemical-resistant clothing, coveralls, chemical-resistant gloves and boots, hard hat, and face shield.

Line of best-fit: a line drawn on a scatter plot to estimate the relationship between two sets of data.

Loam: a soil composed of equal amounts of sand, silt, and clay. Loams are gritty, plastic when moist, and retain water easily.

Manifest: papers required to be carried in a truck that give information about the load it is carrying.

Mechanical engineer: a person who applies engineering principles to design products or systems, such as instruments, controls, robots, engines, machines, and mechanical, thermal, hydraulic, or heat transfer systems.

Metam sodium: a broad spectrum soil fumigant that can be used to treat soils before planting to control nematodes, weeds, and fungi used on fruit and vegetable crops.

mg/kg: a common dose measurement that stands for milligram of substance per kilogram of body weight.

Mineral: a solid, homogeneous, crystalline chemical element or compound that results from the inorganic processes of nature.

MITC: methyl isocyanate is a gas formed when the pesticide metam sodium is used. MITC is the active ingredient that permeates the soil and kills soil-borne pests, such as insects, microorganisms, weeds, and nematodes.

Mixture: a sample of matter consisting of more than one pure substance with properties that do not vary within the sample.

Mobile phase: the chemical that moves in the technique of chromatography; for example, the alcohol in paper chromatography or helium in gas chromatography.

Molecule: the smallest particle of a substance that retains all the properties of the substance and is composed of two or more atoms.

NOEL (No Observed Effect Level): the dose at which no effect of the type under study is observed. The Acceptable Daily Intake (ADI) for the pesticide is then set at one one-hundredth (1/100) of the NOEL.

Nozzle: a short tube with a taper or constriction used (as on a hose) to speed up or direct a flow of fluid.

Objective: expressing or dealing with facts or conditions as perceived without distortion by personal feelings, prejudices, or interpretations.

One-way flow valve: any of numerous mechanical devices by which the flow of liquid or gas may be started, stopped, or regulated by a movable part that opens and shuts.

Organic matter: consists of plant and animal material that is in the process of decomposing.

Outlet nozzle: releases pressurized water or liquid through a smaller opening that allows it to flow in a concentrated stream.

Paper chromatography: chromatography that uses paper strips or sheets as the adsorbent stationary phase through which a solution flows.

Parts per billion (ppb): unit of concentration; one ppb represents one microgram of something per liter of water (ug/L), or one microgram of something per kilogram of soil (ug/kg). 1 in 1,000,000,000.

Parts per million (ppm): Unit of concentration; one ppm is equivalent to one milligram of something per liter of water (mg/L) or 1 milligram of something per kilogram of soil (mg/kg); 1 in 1,000,000.

Permeability: refers to the rate at which water and air move through the subsoil. The permeability of a soil is estimated by determining the texture, density, and structure of the soil, i.e., size and shape of the pores in the rock.

Pesticide: a substance or a mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Piston: a sliding piece moved by or moving against fluid pressure that usually consists of a short cylinder fitting within a cylindrical vessel, along which the cylinder moves back and forth.

Plume: a visible or measurable discharge of a contaminant from a given point of origin. Can be visible or thermal in water or in the air, e.g., a plume of smoke.

Poison: a signal word that is used on the warning labels of pesticides. It refers to products that are highly toxic, with an Oral LD_{50} of 0 to 50 mg/kg.

Pore space: the space between soil particles.

Porosity: the volume of open or pore space in soil. Porosity determines the soils water-holding capacity.

Positive-displacement pump: a device that is able to move a measured quantity of liquid by trapping the liquid in a fixed space, raising the pressure, and then delivering it to a piston-cylinder, gear, etc.

Glossary (continued)

Pressure: the application of force to something by something else in direct contact with it.

Public service announcement (PSA): a free "community-interest advertisement" aired on television or radio as part of a public awareness campaign to inform or educate the public.

Pump cylinder: a chamber in a pump from which the piston expels the fluid.

Qualitative analysis: chemical analysis designed to identify the components of a substance or mixture.

Quality check: using a known value to check a standard curve.

Quantitative analysis: chemical analysis designed to determine the amounts or proportions of the components of a substance.

Remediation: cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site.

Reservoir: a) a part of an apparatus in which a liquid is held; b) a lake used to store water for community use.

Retention factor (Rf): a ratio of the distance traveled by a chemical component to the distance traveled by the mobile phase (the solvent).

Risk: a measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

Risk assessment: qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

Route of exposure: the avenue by which a chemical comes into contact with an organism, e.g., inhalation, ingestion, dermal contact (absorption), or injection.

Sand: a loose, granular material that results from the disintegration of rocks; consists of particles smaller than gravel but coarser than silt.

Saturate: to treat, furnish, or charge with something to the point where no more can be absorbed, dissolved, or retained.

Scatter plot: a scatter plot, also called a scatter diagram or a scattergram; a basic graphic tool that illustrates the relationship between two variables. The dots on the scatter plot represent data points.

Signal words: the words used on product and pesticide labels to indicate level of toxicity – Danger, Warning, and Caution.

Silt: silt particles fall between 1⁄256 and 1⁄16 mm (3.9 to 62.5 µm), larger than clay but smaller than sand. Silt is produced by the mechanical weathering of rock, as opposed to the chemical weathering that results in clays.

Slope: the average rate of change of a line.

Soil porosity: the percentage of the total volume of rock or soil that consists of open spaces. The space between particles is called pore space.

Glossary (continued)

Soil scientist: a person who investigates soils as primary natural resources at the surface of the earth, including the study of soil formation and classification, soil biology (study of soil organisms), soil chemistry, and soil physics.

Soil texture: the relative proportions of the various soil components in a soil as described by the classes of soil texture.

Soluble: capable of being dissolved; in this case, the characteristic of soil minerals that leads them to be carried away in solution by water (see Leaching).

Spring: mechanism that controls the piston by moving it back and forth, increasing or decreasing the volume.

Stakeholder: an individual or group with an interest in the success of an organization in delivering intended results and maintaining the viability of the organization's products, services, or programs.

Standard: something set up and established as a rule for the measure of quantity, weight, extent, value, or quality.

Stationary phase: a substance that shows different affinities for different components in a sample mixture in a separation of the mixture by chromatography. The mobile phase (a solution containing the sample) flows over or through the stationary phase to effect the separation.

Strong sensitizer: a product that can cause an allergic reaction or hypersensitivity on normal living tissue upon repeated uses of the same substance. For example: dyes, oils, soap, cosmetics and perfume, insecticides, etc.

Subjective: modified or affected by personal views, experience, or background.

Superfund: the program that funds and carries out EPA solid-waste emergency and long-term removal and remedial activities.

Super soaker: a pump-action water gun. The user pumps a handle on the gun, which pressurizes air in a reservoir. When the user then operates a piston-like trigger, the pressurized air ejects water from a separate water tank, resulting in a strong stream of water that can reach as far as 50 ft (15 m).

Terrain: the physical features of a tract of land.

Topographic map: a map showing the terrain relief of the ground elevation, usually through either contour lines or spot elevations.

Topography: the configuration of a surface including its relief and the position of its natural and human-made features.

TD_{50} (Toxic Dose 50): the dose at which 50% of the population tested shows a toxic effect (cancer, liver or kidney disease, birth defects, etc.).

Toxic: a product that can cause long-term effects such as cancer, birth defects, or neurotoxicity (toxic to nerves). Examples: brake fluids, fungicides, insecticides, fertilizers, rat poison, antifreeze.

Glossary (continued)

Toxicity: the degree to which a substance or mixture of substances can harm humans or animals. Acute toxicity involves harmful effects in an organism through a single or short-term exposure. Chronic toxicity is the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure sometimes lasting for the entire life of the exposed organism.

Toxicology: a science that deals with poisons and their effects and with the problems involved (such as clinical, industrial, or legal).

Trend line: a line of best-fit for plotted points indicating a statistical trend.

Trigger: a lever pressed by the finger to release or activate a mechanism.

Unknown: a) a symbol (as x, y, or z) in a mathematical equation representing an unknown quantity; b) a specimen (as of bacteria or mixed chemicals) required to be identified as an exercise in appropriate laboratory techniques.

Vacuum: a space in which the pressure is significantly lower than atmospheric pressure.

Valve: any of numerous mechanical devices by which the flow of liquid, gas, or loose material in bulk may be started, stopped, or regulated by a movable part that opens, shuts, or partially obstructs one or more ports or passageways.

Vapor: the gas given off by substances that are solids or liquids at ordinary atmospheric pressure and temperatures.

Volatile: any substance that evaporates readily.

Volume: the measure of the amount of space inside of a solid figure, like a cube, ball, cylinder, or pyramid. The length x width x height is measured to get cubic units (e.g., cm^3).

Warning: a signal word that is used on the warning labels of pesticides. "Warning" means that the product is moderately toxic and has an Oral LD_{50} of 50 to 500 mg/kg.

Water intake: a large pipe that draws raw water out of a river, lake, or reservoir. Once it is treated, it is used for drinking water.

Water soluble: capable of being dissolved in water. If a substance is water soluble, it can very readily disperse through the environment.

Water-holding capacity: amount of water a soil can hold before becoming saturated.

SCORING GUIDES

Scoring Guide

Name ______________________________

Date _________________ Period ______

Team Presentation Scoring Guide

Team number ________ **Evaluator** ___________________________________

Circle the number that best reflects the team's performance:
1 = needs improvement, 3 = meets expectations, 5 = exceeds expectations
Add specific feedback for the team under each item.

Organization

1. Introduction included hypothesis and overview of key points. 1 2 3 4 5
2. Navigated the audience clearly through key points to conclusion. 1 2 3 4 5
3. Strong conclusion, summarizing information. 1 2 3 4 5

Content – Solution and Visual Aids

4. Plan meets guidelines and cost effectiveness. 1 2 3 4 5
5. Graphs, charts, posters are correct, easy to read and understand, well designed. 1 2 3 4 5
6. Key points supported by data presented. 1 2 3 4 5

Adaptation to Audience

7. Adapted message to audience's values, beliefs, and fears. 1 2 3 4 5
8. Maintained positive, natural tone. 1 2 3 4 5

Delivery

9. Used appropriate language, eye contact, interaction with the audience. 1 2 3 4 5
10. Dynamic team effort, supportive and encouraging, all members involved. 1 2 3 4 5

What did you like best about this presentation?

What suggestions can you give that might be useful for future presentations?

Scoring Guide

Name ______________________________

Date __________________ Period ______

Team Member
Team Evaluation Scoring Guide

Team number ________ **Member's name** ______________________________

Circle the number that best reflects your team's performance:
1 = strongly disagree, 5 = strongly agree

Goals

1.	We achieved our goals and were successful.	1	2	3	4	5
2.	I was pleased with our presentation.	1	2	3	4	5

Task Sharing

3.	Tasks were distributed fairly among members.	1	2	3	4	5
4.	Members helped each other and discussed tasks.	1	2	3	4	5

Communication

5.	Communication among members was clear, positive, and frequent.	1	2	3	4	5
6.	Members listened to each other.	1	2	3	4	5

Problem Solving

7.	We clarified issues, listened, restated positions, and reached consensus.	1	2	3	4	5

Group Spirit

8.	Each member enjoyed being a part of this team.	1	2	3	4	5
9.	We respected each other.	1	2	3	4	5

What recommendations would you make to improve your group's working as a team?

Scoring Guide

Name ______________________

Date ______________ Period ______

Press Release or Newspaper Article Scoring Guide

Author's Name ______________________

Evaluator ______________________

Circle the number that best reflects the team's performance:
1 = needs improvement, 3 = meets expectations, 5 = exceeds expectations
Add specific feedback for the author under each item.

Document Design/Style

1. Strong visual appeal: clear design with white space and text. 1 2 3 4 5
2. Easy to navigate: clear structure. 1 2 3 4 5
3. Interesting, engaging, strong voice. 1 2 3 4 5

Content

4. Thesis or focus plus key points introduced early. 1 2 3 4 5
5. Clear direction, flows naturally. 1 2 3 4 5
6. Concise statements in active voice. 1 2 3 4 5
7. Sentence variety, vivid language and terms. 1 2 3 4 5
8. Conclusion synthesizes key points. 1 2 3 4 5

Mechanics

9. Correct punctuation. 1 2 3 4 5
10. Correct spelling. 1 2 3 4 5

The strength of this piece was:

For further revision, consider:

Presentation Rubrics

Presenter ______________________ **Evaluator** ______________________

Please use the following ratings to provide feedback to the presenters. Circle the rating for the team presentation under the title of each category. Provide comments to support your evaluation.

Category/ Ratings	Solution	Teamwork	Communication	Visual Aids	Overall Presentation
Very successful	Plan offers more than one solution. Meets guidelines and cost effectiveness.	Team effort clearly comes across. Supportive and encouraging. All participants active in presentation.	Able to provide detailed answers to most questions. Language is appropriate, good audience interaction.	Graphs, charts, poster are clear, coherent, and effective.	Clear, interesting, and understandable.
Successful	Plan includes removal of pesticide, cost-benefit analysis. Meets environmental and regulatory guidelines.	Evidence of team work, all participants had a role in the presentation.	Answers questions with some detail. Language appropriate, addresses audience.	Information is clearly displayed, with only minor inconsistencies.	Clear, interesting, with only minor details left out.
Somewhat successful	Plan is somewhat incomplete, minor omissions.	Most of team involved, some more than others.	Answers questions with yes or no, but little detail. Refers to notes but makes eye contact with audience.	Displayed but lacks precision or detail.	Able to describe a plan, left out details.
Not yet successful	Plan is unclear or poorly described, major errors.	Not all team members involved.	Reads from notes, rarely looks up. Unable to answer questions clearly or at all.	Visuals are confusing, careless, or inappropriate.	Presentation short and incomplete.

1. What did you like best about this presentation?

2. What suggestions can you give that might be useful for future presentations?

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Group Communication Rubrics

Presenter ______________________ **Evaluator** ______________________ **Score** ______

Directions: Scores range from 1 to 5 with 1, 3, and 5 defined. Circle the score under the appropriate category.

Category/ Score	Goals or Task	Delegation: Task Sharing	Communication	Problem Solving	Group Spirit
5	We achieved our goal and were highly successful; product quality was excellent.	Tasks were shared eagerly; members helped each other often and discussed tasks.	Communication was clear, upbeat, and frequent; team listened to each other.	We clarified issues, listened, restated positions, and reached consensus.	Each member enjoyed being a part of this team; we respected each other.
4					
3	Task was close to being finished. Some aspects were hastily done.	Work was not evenly distributed. Some teammates worked harder than others.	Some confusion existed about job roles. Arguing and some "put-downs" occurred.	Some issues were not dealt with directly; compromise was not easy.	Some members unsure of what they learned; aware that product could be improved.
2					
1	Task not completed or "thrown together."	Team often at cross purposes; team members occasionally "made work" for each other.	Very little dialog between members. Team fragmented and uncommunicative.	We were not able to solve our important problems as a group.	Our group was at odds with each other. It wasn't "fun" to be working together.

Remarks

Score

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Self-directed Learner Rubrics

Presenter____________________ Evaluator ____________________ Score ______

Directions: Scores range from 1 to 6 with 1, 3, and 5 defined. Circle the score under the appropriate category.

Category/ Score	Goal Orientation	Organization	Use of Time	Use of Resources
6				
5	The student can set clear goals and structure his/her efforts. He/she is aware of his/her strengths and weaknesses, and can act accordingly.	Student keeps track of assignments and scores. Work is organized and accessible.	Student self-schedules. Can stay on task during work time and is a model for other students. Work is turned in on the due date.	When unsure of her/his methods or knowledge, the student gets help from the appropriate source (teacher, peers).
4				
3	The student has a sense for what she/he wants, but may not always be able to act on her/his goals. He/she is learning to assess his/her strengths and weaknesses.	Student misplaces work occasionally and may not be aware of progress. Work can be disorganized and is not always available.	Scheduling of work is partial. Assignments are late at times. Student's off-task time may affect self or others.	The student uses information sources ineffectively or has difficulty getting help.
2				
1	The student has difficulty clarifying and acting on his/her goals. He/she does not try or know how to reflect on his/her efforts.	Student does not keep assignments and scores or does not do them. Notebooks are disorganized, misplaced, or not kept.	Assignments are seldom completed on due date. A majority of the student's time is off-task and little work gets done in class.	The student will sit idle instead of trying to obtain help or look up the information. Has difficulty defining his or her needs and acting on them.
Remarks				
Score				

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