LESSON 5 WATERSHEDS & WATER QUALITY

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People have divided lands by political boundaries, from property lines to international borders. Water defines nature's boundaries by dividing the earth into watersheds. The watershed concept is increasingly invoked by environmental planners and regulators; roadside signs call attention to these natural boundaries. People will increasingly be called upon to see themselves as citizens not only of a particular town or state, but of a certain watershed.

In the first activity, students create a model landscape and rain on it, observing the movement and accumulation of water. They then locate a community in the watershed and plan their town's water resources. MWRA operates a surface water system, drawing water not from aquifers through wells, but from water bodies on the surface, specifically, reservoirs. Thus it is important that consumers understand the watershed concept as it applies to their drinking water.

In order to assess the safety of water for human consumption, scientists must measure the levels of a variety of contaminants. The second and third activities in this lesson explore the units in which contaminants are measured: parts per million and parts per billion. They are intended to make students more conversant in the terminology that can help them make responsible decisions about their own health and become informed environmental citizens.

LESSON 5 WATERSHEDS & WATER QUALITY

ACTIVITY 5-1 WATERSHEDS

SUMMARY Students will build a model landscape and use it to investigate the flow of water over land.

CONTENT AREAS earth science, social studies

GOAL to understand the watershed concept

TIME one session

MATERIALS For each group:
- plastic or cardboard box
- white plastic trash bag
- spray bottle
- water with blue coloring
- newspaper
- paper towels
- items to represent buildings in landscape
- red food coloring

ADVANCE PREPARATION

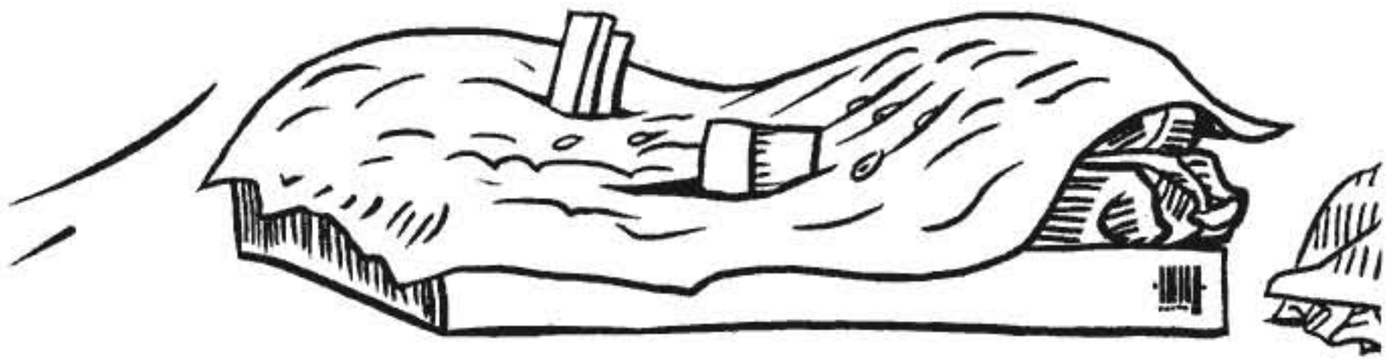
- Copy student pages.
- Create student groups.
- Fill spray bottles with blue water.
- Put student materials on table.
- Create "trash" for landfills by putting 2-3 drops of red food coloring on a small piece of paper towel and folding it into a small ball. It helps to let the first drop of food coloring dry before you add the second, and to allow all coloring to dry before folding the paper.

BACKGROUND INFORMATION

A watershed is the area of land which drains precipitation to a specific body of water. Watersheds vary in size. You might think of the Continental Divide as dividing two huge watersheds: the Atlantic Ocean Watershed and the Pacific Ocean Watershed. You also might think of the road in front of your school as belonging to the "watershed" of the local storm sewer. Ridges or divides are the higher areas of land that separate two watersheds.

ACTIVITY 5-1 WATERSHEDS

Reservoir water is collected from watersheds. The precipitation lands on the ground and is "shed" to tributaries that lead to the reservoir. Both meanings of the word "shed" apply to the definition of watershed. Water is "shed" from the land, and a watershed is like a storage area ("shed") for water. Watershed boundaries help water suppliers estimate how much water will drain to the reservoir. The boundaries also help us understand of what type of waste can end up in the reservoir. Pollution that occurs inside the watershed boundary may have an effect on the quality of water. Soil acts as a filter for pollution, but once the contamination reaches a tributary it will travel pretty quickly to the reservoir.



TEACHER PROCEDURE

1. Tell students they are going to build a model landscape that will help them understand watersheds.
2. Give each group a set of materials.
3. Each group should create a landscape by putting the crumpled newspaper in the bottom of the box, and then placing the plastic bag over the top of the newspaper. Tell them to make sure that the edges of the plastic bag stay outside the box.

PART A - Getting to know your landscape

4. Ask students to describe the type of land formations they see in their landscapes (hills, mountains, valleys). Ask them to predict what will happen when they spray water over the landscape.
5. The bottle of water represents rain. The students should rain over their landscapes for about one minute. (You may want each student in the group to take ten sprays).
6. While spraying, each group should make four observations about what they see happening in the landscape. They should record these on their **Student Recording Page**.
7. Ask each group to explain one of their observations to the class. Someone may mention that the inclines have water drops clinging to them. Ask the rest of the class if they have the same observation.
8. Students will now try to follow the path of water over their landscape. Tell them to choose one drop of water and predict where that drop will flow when it begins to move. Students should test this prediction by gently spraying water over the drop so that it becomes heavy enough to move. They should do this process several times. The idea is for the students to get to know the landscape. Remind students to predict carefully before they see where the water flows.

9. Ask students to record on their **Student Recording Page** how this landscape is different from the real earth. Have students share some of those answers with the class. Eventually someone will say that the real earth is covered with soil and so water gets absorbed. Give each group two pieces of paper towel* to place over the landscape to act as soil.

10. Students should spray over the landscape again and observe how it acts differently with the "soil" on it. Students should answer question 3 on the **Student Recording Page**.

PART B - Developing a community in your landscape

11. Tell students they are going to plan a community for their landscape. They will need to include a water supply and a landfill.

12. You will give each group something to represent the buildings in the community (small game pieces, building toys, coins). You will also give each group a small piece of paper towel with red food coloring rolled up to represent the landfill. They should place these in the landscape.

13. When they have chosen the locations for those three items (buildings, landfill, reservoir) they should have a rainstorm over their landscape. The "pollution" in the landfill will start to leak out. Some students will find that the landfill contaminated their drinking water supply.

PART C - Discussing the activity

14. Lead a class discussion on the changes students might make to their community design.

15. Some teachers might want to do the activity again after a day or two to see if students can use the information they learned to avoid polluting the water supply.

* Some guidance on paper towels: White is best. Highly absorbant (better quality towel) is better. Push towel gently to conform to shape of hill.

ACTIVITY 5-1 WATERSHEDS

INTRODUCTION

In this activity you will create a model landscape and discover how rain travels over the land.

PROCEDURE

1. Create a landscape using a box, a plastic bag, and newspaper. Once you have completed the model, try not to touch the plastic bag because it will change the shape of your landscape.

2. You will use your spray bottle to "rain" over the landscape at various times during the activity. You will observe and record your observations.

Part A- **Getting to know your landscape**

3. The bottle of water represents rain. You should rain over your landscape for about one minute.

4. While spraying, make four observations about what you see happening in the landscape. Record these on your **Student Recording Page**.

5. Now you will now try to follow the path of water over the landscape. Choose one drop of water and predict where that drop will flow when it begins to move. Test this prediction by gently spraying water over the drop so that it becomes heavy enough to move. Do this process several times. Remember to predict carefully before spraying any water.

6. Record on your **Student Recording Page** how this landscape is different from the real earth.

Part B- **Developing a community in your landscape**

7. You are going to plan a community for your landscape. You should decide the placement of buildings, the reservoir, and the landfill.

8. When you have chosen the locations for those three items you should have a rainstorm over the landscape. On your **Student Recording Page** describe what happens after you have the rainstorm.

NAME _____

DATE _____

STUDENT RECORDING PAGE

1. Record four observations about spraying water over your landscape.

2. How is this landscape different from the real earth?

3. What happened after you sprayed water over your community?

4. What changes might you make to the design of your community if you did this activity again?

ACTIVITY 5-2 PARTS PER MILLION & PARTS PER BILLION

SUMMARY

Students will create several different concentrations of solutions with food coloring.

CONTENT AREAS

physical science, math

GOAL

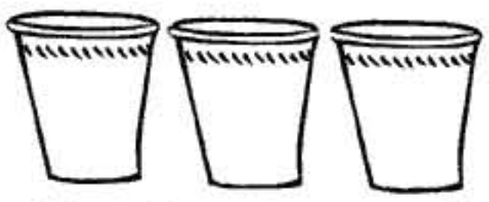
to demonstrate concentrations that are used to measure water quality

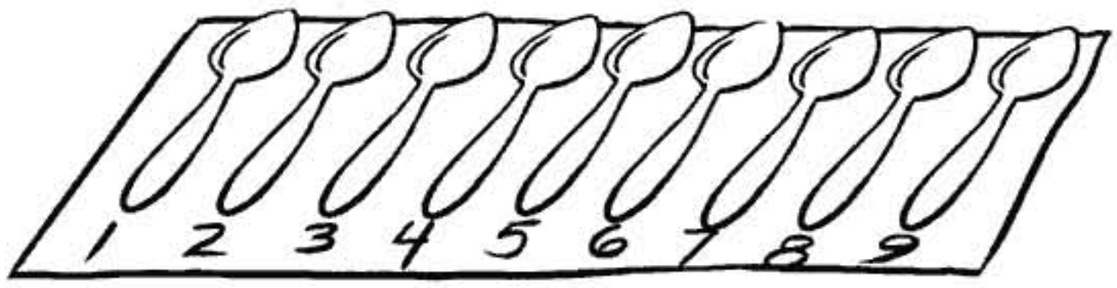
TIME

one session

MATERIALS

For each group:
- toothpicks
- 3-4 droppers
- 9 white plastic spoons
- 4 cups of water for diluting and rinsing
- red food coloring





ADVANCE PREPARATION

- Copy students pages.
- Create student groups.
- Prepare materials.

BACKGROUND INFORMATION

Concentrations of such materials as chemical pollutants and minerals are usually expressed in units of "parts per million" (ppm) or "parts per billion" (ppb.) For example, chemical fertilizers contain nitrates, a chemical which can be dangerous to infants below the age of six months even in quantities as small as 10 ppm. Water suppliers are required to test for and report findings for many substances which might be found in the water.

Following are some more familiar terms to help students understand ppm/ppb:

1. If a CD sells one million copies, than a single CD is one part in a million.
2. Thirty seconds is about one part per million of an entire year.
3. If an average bathtub is twenty-five gallons, two drops of water is one part per million of the water in the tub.

ACTIVITY 5-2 PARTS PER MILLION AND PARTS PER BILLION

TEACHER PROCEDURE

1. Distribute materials to student groups.

2. Have each group line up the nine spoons side-by-side on the table in front of them with a piece of paper in front of the row. They should number the paper from 1 to 9 in front of the spoons.

3. As students do this activity they should fill out the blank spaces on the **ppm/ppb Data Sheet.**

4. Tell each group to place 10 drops of food coloring into spoon #1. The concentration in the first spoon is one part per ten because there is one part red dye for every 10 parts water. (Food dye comes in a one:ten dilution.) On the board show students how to write one part in ten as a fraction. (1/10)

5. Tell students to place one drop from spoon # 1 into spoon #2, return the rest to spoon #1, and rinse the dropper in clean water.

6. Using a clean dropper, students should add 9 drops of water to spoon #2 and stir the solution with a toothpick. Rinse the dropper. Ask students "what is the concentration of the solution in spoon #2." (One part in 100, or 1/100)

7. Transfer 1 drop of the solution from spoon #2 to spoon #3. Rinse the dropper with water. Add nine drops of clean water to the spoon and stir the solution with a toothpick. Rinse the dropper with clean water. Ask students the concentration of this solution. (One part in 1,000 or 1/1000.)

8. Tell students to transfer 1 drop of the solution in spoon #3 to spoon #4. Rinse the dropper with clean water. Add nine drops of water to spoon #4 and stir.

9. Continue through all nine spoons. You can guide students through the whole activity or have them complete the process with the remaining spoons on their own.

10. Review the **ppm/ppb Data Sheet** and the conclusion questions with the class.

11. Some students may be so focused on getting the right number of drops each time that they miss the point of the activity. You may want to do it a second time so that students can think more about the concentrations.

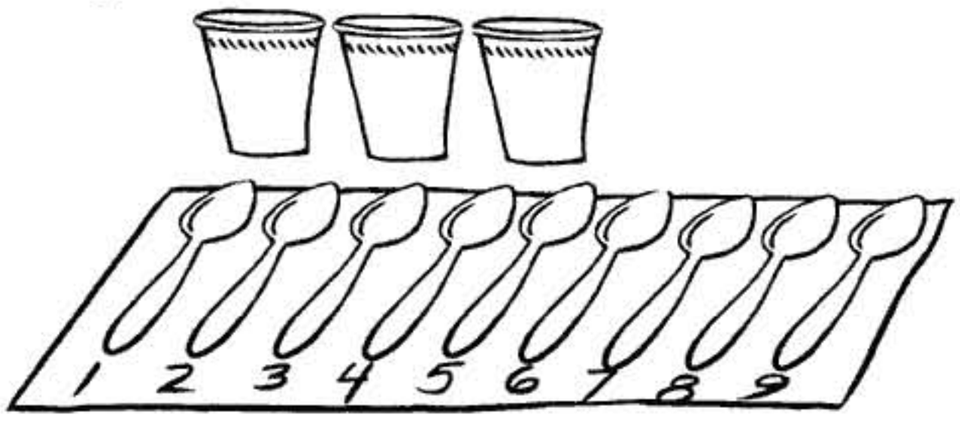
ACTIVITY 5-2 PARTS PER MILLION & PARTS PER BILLION

INTRODUCTION

Concentrations of materials in water are usually expressed in units of "parts per million" (ppm) or "parts per billion" (ppb.) For example, lead in the water can be harmful at levels above 15 ppb. Water suppliers are required to test for and report findings for many substances which might be found in the water.

MATERIAL

- tooth picks
- 3-4 droppers
- 9 white plastic spoons
- 4 cups of water for diluting and rinsing
- red food coloring



PROCEDURE

1. Line up the nine spoons side-by-side. Place a piece of paper in front of the row. Number the paper from 1 to 9.

2. Record your numbers and observations on the **ppm/ppb Data Sheet** as you do this activity.

3. Place 10 drops of food coloring into spoon #1. The concentration in the first spoon is one part per ten because there is one part red dye for every 10 parts water.

4. Place one drop from spoon # 1 into spoon #2.

5. Using a clean dropper, add 9 drops of water to spoon #2 and stir the solution. Rinse the dropper.

6. Transfer 1 drop of the solution from spoon #2 to spoon #3. Rinse the dropper with clean water. Add nine drops of clean water and stir the solution with a toothpick.

7. Transfer 1 drop of the solution in spoon #3 to spoon #4. Rinse the dropper with clean water. Use a clean dropper to add nine drops of water. Stir with a toothpick.

8. Complete the process with the remaining spoons.

9. Compete the **ppb/ppb Data Sheet** and the conclusion questions.

NAME _____

DATE _____

ppm/ppb DATA SHEET

Spoon number	1	2	3	4	5	6	7	8	9
Solution color									

Spoon number	1	2	3	4	5	6	7	8	9
Solution concen-tration									

CONCLUSION

1. What was the concentration of the solution when it first appeared colorless?

2. Do you think there is any food coloring present in the diluted solution even though it is colorless? Explain.

3. What would remain in the spoons if all the water evaporated?

4. What would have happened if you had not used clean water to rinse your dropper?

ACTIVITY 5-3 CONCENTRATIONS

SUMMARY

Students will play a dice game about water quality and watersheds.

CONTENT AREAS

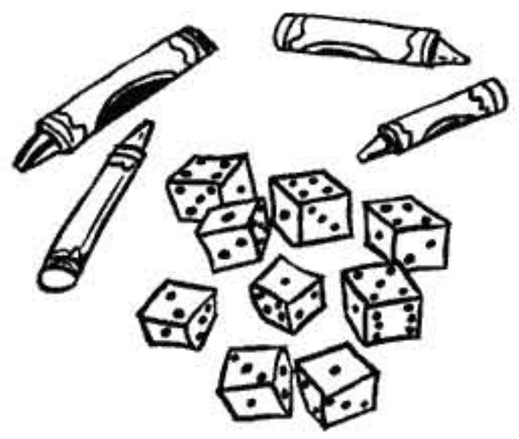
earth science, math

GOAL

to understand some of the factors that affect water quality

TIME

one session



MATERIALS

For each group:
- pair of dice

For each student:
- copy of thousand dot paper
- four different colored markers, crayons, or pencils

ADVANCE PREPARATION

- Copy student pages.
- Create student groups.

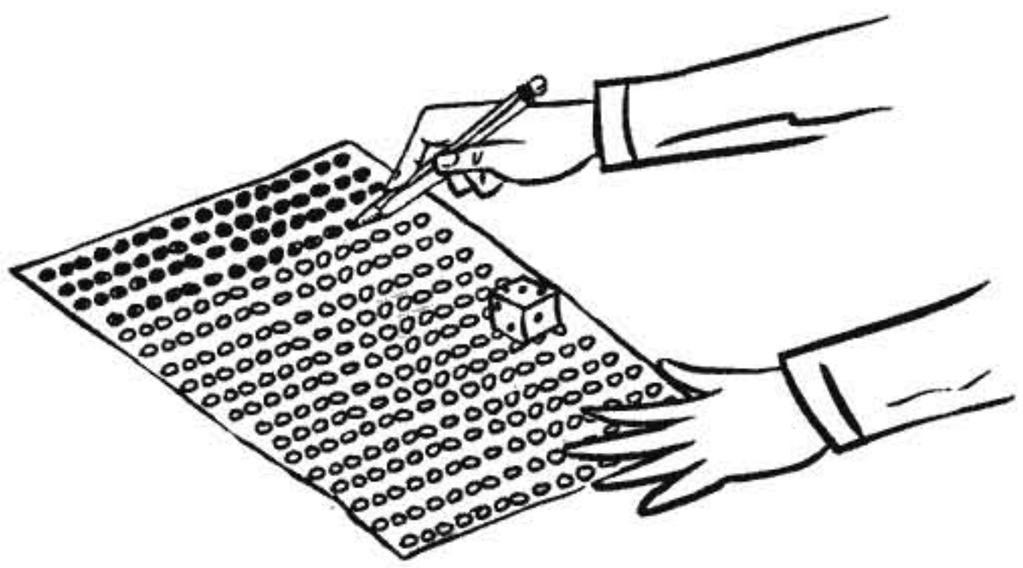
BACKGROUND INFORMATION

Contaminants in drinking water are measured by their concentrations; usually in parts per million (ppm) or parts per billion (ppb). You can relate this to percent (which means "per one hundred.") For example, 1 percent means one part per hundred. The maximum contaminant level for lead is 15 ppb. This number means 15 parts of lead for every billion parts of water. Scientists, through research, determined that continued exposure to lead levels higher than 15 ppb could be harmful. Scientists have set standards for all the contaminants listed. Water suppliers must test for the contaminants and report their results. There are many factors that affect water quality. This activity will help students realize some of these factors and also them help them understand how contaminants are measured.

TEACHER PROCEDURE

1. Give each student one copy of the **Thousand Dots Page** and four different colored pencils, markers, or pens.
2. Give each group a copy of the **Dice Directions**.
3. Students will take turns rolling the dice. After each roll they should find the number on the **Dice Directions** that corresponds to the number they rolled. Then they color in the correct number of dots with the correct color. On the board put the maximum contaminant levels as follows:

▪ contaminant blue	10 parts per thousand
▪ contaminant red	8 parts per thousand
▪ contaminant purple	7 parts per thousand
▪ contaminant green	12 parts per thousand



4. The objective is to end up with as few dots colored in as possible. The game ends once each person has had twelve turns.
5. Follow up the game with a class discussion on factors that affect drinking water quality.

ACTIVITY 5-3 CONCENTRATIONS

INTRODUCTION

Contaminants in drinking water are measured in concentrations. Concentration is the measure of the amount of contaminant in the total volume of water. Some contaminants are so strong that the allowable levels are in parts per millon or parts per billion. For example, the rule for lead in drinking water is fifteen parts per billion (15 ppb). The Safe Drinking Water Act (passed in 1974) requires water suppliers to limit contaminants in water supplies to certain levels.

PROCEDURE

In this game you will imagine you are monitoring a water supply. We will use levels in parts per thousand (because we can't fit a million dots on one page.) Contamination is represented by four different colored dots. The objective of the game is to keep your water supply with the lowest possible levels of contaminants (the fewest dots colored in).

Each player will have a piece of paper with one thousand dots on it and four different colored pencils, markers, or pens. On your paper each dot represents one part per thousand. Each color represents a different contaminant.

The first player should roll the dice and then follow the **Dice Directions** to determine how many dots to color in. For example, if you rolled a 3, you would follow the directions for number 3, and color 2 dots blue. The second player will then take a turn by rolling the dice and following the dice directions. Go around the group twelve times. The objective is to end up with as few dots colored in as possible.

The regulations for the maximum contaminant levels are as follows:

- contaminant blue 10 parts per thousand
- contaminant red 8 parts per thousand
- contaminant purple 7 parts per thousand
- contaminant green 12 parts per thousand

DICE DIRECTIONS

After you roll the dice, follow the directions for the number.

2. Erosion control on the logging roads has been improved. Don't color any dots.

3. A town in your watershed decided to lift restrictions on development. Color 2 dots blue.

4. Your hazardous waste collection day was very successful! Don't color any dots.

5. The local middle school collected several thousand used batteries and brought them to the proper disposal site. Don't color in any dots.

6. Outdated Septic systems found to be leaking during rainy weather. Color 3 dots green.

7. Your town's planning board voted to allow development of a new shopping area near a wetland. Color 2 dots purple.

8. A factory in your watershed did not pretreat its wastewater. Color 2 dots red.

9. New and improved street sweepers that vacuum particles were purchased by your town. Don't color any dots.

10. A plan to reduce the use of road salt was accepted by your town council. Don't color any dots.

11. A farm in your watershed has decided to increase their use of pesticides. Color 3 dots purple.

12. The local sewer line was leaking for several hours. Color 3 dots green.

THOUSAND DOTS PAGE