4) Erosion & Runoff: Slip Slidin' Into the Bay

A Study of Soil & Water

Overview

Healthy soil is a very limited resource, and is the basis for successful and sustainable agriculture. Humans use land for many purposes, and some uses can result in excessive runoff and erosion. Students will study soil texture and characteristics, including permeability. They will investigate land use and its effect on runoff in their schoolyard. They will learn how to test for sediment, nutrients and other factors that affect water quality.

Learning Objectives

After completing this activity, students will be able to…

- Identify types of soil and their characteristics;
- Understand and be able to test for soil permeability;
- Understand the connections between land use and soil type, runoff and erosion; and
- Test water quality.

Unit Table of Contents

The table below lists the activities and documents in this unit and gives a brief description of the main ideas and the setting for each activity.

There are multiple activities for many learning phases of the unit. Teachers may choose to use one or more activities from any one phase.

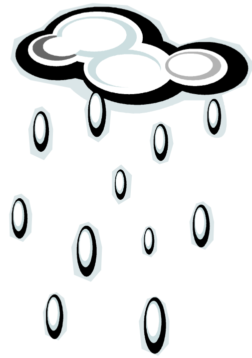
Continued on next page

Unit Table of Contents (continued)

Continued on next page

Student Introduction to Runoff & Erosion

The Earth is constantly shaped by nature. Humans can't really control what happens naturally, but there are many things we do that greatly increase:



- **RUNOFF** (water that runs off the land), and
- **EROSION** (when wind or water moves soil).

When we speed up RUNOFF and EROSION, it can harm our environment.

NATURAL erosion in the Grand Canyon

Erosion increased by **HUMAN ACTION** along the Potomac River

In this unit, you will learn about <u>runoff,</u> <u>erosion</u>, and <u>sedimentation</u>.

You will also learn what humans do to cause these problems and how we can improve them.

4.1 Apple Earth: How Big is Your Bite?

A Model to Demonstrate the Limitations of a Natural Resource: Arable Land

Overview

Using an apple as a model to represent the Earth, students will investigate the amount of the Earth's soil that is available for farming and providing food and fiber.

Lesson Characteristics

Use the table below for lesson planning purposes.

Time Required	15-30 minutes
Key Concepts/Terms	Natural resources: Renewable and Non-renewable, Arable (farmable) Soil, Fractions
Prerequisites	None
Setting	Indoors, Entire Class

Learning Objectives

After completing this activity, students will be able to…

- Understand our dependence on Earth's natural resources;
- Identify renewable and non-renewable resources; and
- Understand the scarcity of arable soil on Earth.

Materials Required

The following materials are required to complete this activity:

- 1 large apple (This needs to be round; do not use Red Delicious Apples)
- 1 paring knife (Can be plastic)

Background Information

Non-renewable natural resources, such as minerals and metals, are finite. Many resources, such as soil, can be renewed over time, but can also be depleted faster than they can be naturally replenished, making them, in effect, non-renewable. With population growth and technological advances, we are using our resources at an ever-increasing rate. Land for farming is a valuable resource that is becoming more and more scarce.

Continued on next page

Procedure

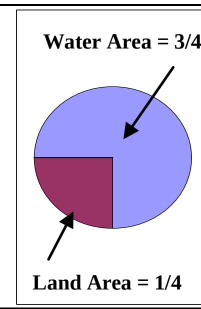
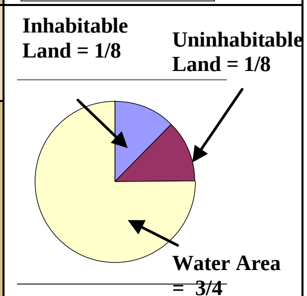
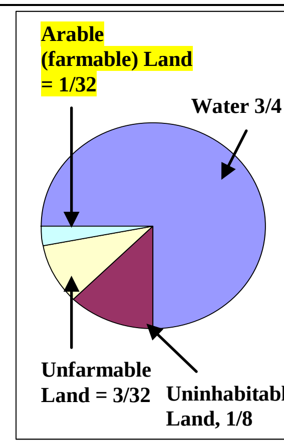
Follow the steps in the table below to conduct the activity. **Sentences in bold are suggestions for what teachers might say to students.** *Items in italics are possible student answers to questions.*

Phase	Step	Action
Engage	1	Ask students to brainstorm a list of natural resources. Write these on the board as they are mentioned.
	2	If they do not list "soil," ask them if they consider it a natural resource. Discuss the various ways we use soil, eventually focusing on our dependence on soil for most of the food and fiber we use.
	3	Ask students to categorize the natural resources they brainstormed into renewable and non-renewable. Some may be difficult to categorize, such as water. Ask students to defend their choices with well-reasoned arguments. Discuss why soil is actually non-renewable at our rate of use/loss.
Explore & Explain	4	Hold up the apple and explain that it is a model of the Earth. Ask students to hypothesize about the percentage of farmable/tillable soil available on Earth.

Continued on next page

Procedure (continued)

Phase	Step	Action
Explore & Explain	5	Follow the steps in the table below and discuss what the sections represent at each step with students.

Step	Cut Remaining Piece Into	What To Do With The Pieces	What The Pieces Represent	Graphs Of Available Land On Earth
A	4 equal pieces (Each section is **1/4** of the original apple.)	1 piece (1/4) – keep	Land area on Earth	
		3 pieces (3/4) – discard	World's waters	
B	2 equal pieces (Each new section is **1/8** of the original apple.)	1 piece (1/8) – keep	Land where people live.	
		1 piece (1/8) – discard	Land that is inhospitable to people (polar, desert, high mountains, etc.)	
C	4 equal pieces (Each new section is **1/32** of the original apple.)	1 piece (1/32) – keep	The section that is available for farming, with arable (farmable) soil.	
		3 pieces (3/32) – discard	Land that is not suitable for farming: too wet, rocky, cold, steep, poor soil, urban (cities, highways, schools, houses, parking lots, etc.)	
D	Peel the remaining **1/32** section	Keep the skin	This thin layer represents the very thin section of the earth's crust that we depend on for growing plants (less than 5 feet deep).	

Continued on next page

Procedure (continued)

Phase	Step	Action
Elaborate	6	You can extend this introductory activity to lead in to the following discussion points/topics: • **How do we use soil?** *For growing things, as a building material, as a building surface, etc.* • **How is soil made?** *Soil is made by weathering down of larger rocks into tiny pieces.* • **How do the demands we make as consumers affect soil usage?** *We demand specific produce, buildings, etc. that determine how soil is used.*

Vocabulary

The following terms are useful in this activity.

Term	Definition
Non-Renewable Resources	Resources that exist in limited supply and can't be replenished within the foreseeable future, including minerals and fossil fuels
Renewable Resources	Resources that can grow again and will last (as long as they are not overexploited); renewable resources include trees, fish, and crops, among other things. Renewable energy resources are geothermal, wind and sun.
Resource	A portion of the environment upon which people have placed or assigned value, and thus see as being available for use
Arable Soil	Land where the terrain is not too steep, and has adequate soil and rainfall, making it suitable for farming

4.2 Sweet Resources

Model of Natural Resource Limitations

Overview

Students will use an interactive model to investigate how natural resource depletion and waste increase with technological advances and population growth.

Lesson Planner

Use the table below for lesson planning purposes.

Time Required	45 – 60 minutes
Key Concepts/Terms	Natural Resources (Renewable and Non-renewable), Technology, Conservation, Waste
Prerequisites	None
Setting	Indoors/Outdoors, Whole Class

Learning Objectives

After completing this activity, students will be able to…

- Understand our connection to the environment and our dependence on Earth's natural resources;
- Identify renewable and non-renewable natural resources and their importance to society; and
- Compare and contrast agricultural changes and technological advancements over time.

Materials Required

The following materials are required to complete this activity…

- 2 pounds of M&M™ candies (or mixed beans)
- 6-7 flimsy paper plates
- napkins for each student

Continued on next page

Background Information

A ***Natural Resource*** is a portion of the environment upon which people have placed or assigned value. Natural resources fall into two categories: ***renewable*** and ***non-renewable***.

Why are natural resources in jeopardy?
Earth's non-renewable natural resources are finite, and many renewable resources are being used/depleted faster than they can be naturally replaced. Population growth and technological advances allow people to extract/harvest natural resources at a tremendous rate, often resulting in great waste.

Procedure

This activity is a simulation that will be conducted in three rounds, as outlined in the table below.

Round	Time Period	Common Tools in Use During This Period	Number of Volunteers Needed	M&M's™ are Collected Using…
1	Prehistoric	Spears, Clubs, Digging Stones	2	Index finger and Thumb of ONE hand
2	Colonial	Hand Shovels, Horse-drawn Plows, Dynamite	3	First 3 fingers & Thumb of ONE hand
3	Present Day	Bulldozers, Cars, Drills, Tractors	5-6	ONE entire hand

Follow the steps in the table below to conduct the activity. **Sentences in bold are suggestions for what teachers might say to students.** *Items in italics are possible student answers to questions.*

Phase	Step	Action
Engage	1	Have students form two concentric rings around a paper plate set on the floor. The inner ring of students can sit/kneel, which will allow the outer ring of students to view the activity as well.
	2	Ask students to define **NATURAL RESOURCES**.
	3	Have students brainstorm and identify **RENEWABLE** (ex: fish, wildlife, forests) and **NON-RENEWABLE NATURAL RESOURCES** (coal, oil, minerals, etc.).

Continued on next page

Procedure (continued)

Phase	Step	Action
Engage	4	Explain that the paper plate in the center of the circle is a model representing the Earth.
	5	Pour 1 pound of candies/beans onto the plate, and explain that they represent all of the earth's non-renewable natural resources. (The plate should be heaped full, almost overflowing.)
	6	Have students assign each color to represent a different non-renewable resource (ex. green = oil, brown = coal, etc.).
	7	Explain that the students will represent all the people on earth at different times in history.
Explore	8	Ask for the appropriate number of volunteers, as outlined on the preceding table.
	9	Discuss the tools of each time period with students.
	10	Explain what parts of the hand may be used to collect candies/beans during this round. This changes with each round to represent technological advances through time.
	11	Allow students to collect "resources" while you count for 3 seconds.
	12	Have students place the "resources" they collected on their napkin in front of them and return to their original positions. ***Note:*** Remind students not to eat any of the "resources" until the end of the activity.

Continued on next page

Procedure (continued)

Phase	Step	Action
Explore	13	Have students estimate the amount of waste they see, and compare it to the amount of resources that the volunteers obtained, as well as the amount remaining. Remind students that any "resources" that fell on the ground are waste and may not be collected or used.
	14	Compare the results of this round with any previous rounds.
Explain	15	Lead the class in a discussion of the following questions: • **What's left of the Earth's resources (candies/beans)? How will this affect the lives of future generations?** • **What do you think about all of the waste?** • **Considering our soil, what effect will severe loss/degradation have on our food supply? Will this affect the cost of food?** • **What would the earth look like if we continue to use our non-renewable resources at this rate?** • **What can we do to prevent resource depletion and conserve our remaining resources?** *(4 R's: rethink, reduce, reuse, recycle)* • **What about the students left in your group that didn't get any candy/beans? Is this fair? How does this resemble the use of resources on earth?** *Resources on the Earth are not distributed equally. Many countries do not have the access to natural resources that we in industrialized nations enjoy. This activity brings that point home for students, as not everyone in the class gets equal "resources."*
Elaborate	16	Have students research or discuss the function of various natural resources (renewable and non-renewable) in our economy. Examples could include: building on soil; burying garbage in soil; building with soil; etc.

Continued on next page

Procedure (continued)

Phase	Step	Action
Elaborate	17	Adapt the activity to represent **renewable** resources. With this version, start with ½ pound of M&M's, because whatever resource you choose will need to renew, so you need to save some of the original pound to account for this. An example for a variation could be the use of fishing and fishing harvests. • Fishing tools have changed over time, increasing our fish harvest. • In the case of this example, the teacher needs to "allow" the fish to reproduce annually. • The teacher will note the size of the population after a round, and AT MOST double the population for reproduction. • The total population of any round should not exceed the ½ pound used at the start of the activity.
Evaluate	18	Student understanding should be informally assessed throughout the discussion portions of the activity.

Continued on next page

Vocabulary

Understanding of the following terms is useful in this activity.

Term	Definition
Conservation	Using natural resources in ways that assure their continuing availability to future generations; the wise and intelligent use or protection of natural resources
Non-renewable Resources	Resources that exist in limited quantities and can't be replenished by natural processes within the foreseeable future, including minerals and fossil fuels
Renewable Resources	Resources that can be grown again or exist in an unlimited supply. (***Examples***: trees, fish, crops, wind energy, solar energy)
Resource	Something that people value and use.
Technology	The tools, machines, and methods used to accomplish tasks.

4.3 Soil Study

An Outdoor Activity to See How Soil Structure and Texture Impact Runoff

Overview

Soil varies greatly in composition from place to place. Soil characteristics determine its use in agriculture, and how water flows through the watershed. Runoff and erosion can be increased by our land use choices, and are directly related to soil characteristics.

Lesson Planner

Use the table below for lesson planning purposes.

Time Required	1 -2 hours
Key Concepts/Terms	Soil Structure, Permeability, Runoff, Erosion, Sedimentation, Watershed
Prerequisites	***Activity 2.6: Mapping Your Surroundings***; Understanding of Watersheds and the Water Cycle or equivalent
Setting	Classroom and Outdoors, Small Group

Learning Objectives

After completing this activity, students will be able to…

- Identify the main components of soil;
- Rate soil types for permeability; and
- Understand how soil type and land use affect runoff and erosion.

Materials Required

The following materials are required/suggested for this activity:

- ***Schoolyard Habitat Project Guide***, U.S. Fish and Wildlife Service (http://www.fws.gov/ChesapeakeBay/schoolyd.htm)
- Soil samples: garden soil (loam), sand, silt or clay, peat or fine compost
- Small trowel to dig up soil samples,
- Water
- Soil permeability testing kit:
  - – Can with both ends removed,
  - – 100 mL measure,
  - – Stopwatch

Continued on next page

Background Information

What is Soil?
Soil is a complex material -- a mixture of broken down rocks, decayed organic material, air and water. An ideal soil for agriculture might be:

45% mineral   5% organic   25% air   25% water

Soils vary greatly, both in composition and structure. These differences determine what can be grown, where we can safely build, and even where we can create landfills to dump our garbage.

How Soil Forms

- **Rocks** are broken apart by the freezing and thawing of water in pore spaces or cracks; chemical weathering by water; fracturing by other rocks; or invading plant roots.
- Layers of finely ground rocks or **sediment** are transported by wind, water or glaciers.
- As plants and animals die, their decomposed bodies add **organic** matter to the soil.
- Small animals living in the soil turn and **aerate** it, and further break down organic matter, making the soil more fertile.
- Plant roots absorb **water**, and hold soil in place.

Why We Have Different Soil Types
Four main factors that affect the type of soil formed are:

- the length of time a soil has been forming,
- the type of rock (chemical composition) in the parent material,
- climate, and
- topography.

How Topography Relates to Soil Type
Some examples of the effect of topography are:

- Hillsides tend to have shallow soils, since fine particles and organic matter wash downhill.
- Depressions tend to collect fine clay particles and organic material, and thus, are poorly drained.
- The floodplain areas along a river are sandy soils maintained by periodic deposition.
- Wetlands have highly organic, waterlogged soils with little mineral content.

Procedure Follow the steps in the table below to conduct the activity.

Phase	Step	Action
Engage	1	Compare Types of Soils (Classroom) • Allow students to examine samples of sand, loam, and silt or clay. • Use chart on page 104 of the ***Schoolyard Habitat Project Guide*** to explain relative sizes of particles, and how the greater the particle, the larger the air spaces; hence, more room for water to penetrate. Thus, clay soils, with the finest particles, drain very slowly and can even form impenetrable layers. Sand drains very quickly. • Loam is a mixture of particle sizes, and usually contains decayed organic matter, which makes it fertile and very good for growing plants.
Explore	2	Determining Soil Texture (Classroom) • Complete the Soil Texture Chart (on page 41 of the ***Schoolyard Habitat Project Guide on the TI Flash Drive)***, using each of your different soil samples.
	3	Looking at Topography (Outdoors) Outdoors in the schoolyard, allow students to explore with the following guidelines, recording their data in journal or map form *(refer to **Journaling** and **Mapping Your Surroundings**):* • Look at the topography: identify high and low areas. • Observe water flow patterns. Where does water go during a heavy rainstorm? • Look at surfaces to see which **do** or **do not** look like they would absorb runoff. Based upon student observations, choose several sites to test, looking for sites that will vary in permeability. Ask students to predict which site will drain the fastest. At each site, determine soil texture (Step 2, above) and perform Permeability test (Step 4, below).

Continued on next page

Procedure (continued)

Phase	Step	Action
Explore	4	Testing Soil For Permeability (Outdoors) a) Place the can on the soil to be tested, and gently twist and push until about 1 inch is in the ground. b) Measure 100 mL of water. c) Pour the water all at once into the can and use the stopwatch to time how long it takes for the water to disappear. d) Record the results in seconds. If water is still present after two minutes, stop timing and record the surface as **IMPERVIOUS**. e) The times will correlate inversely to permeability; the shorter the time, the more permeable the soil.
Explain	5	Analyzing Results (Classroom) In groups, ask students to compare their data and compile a group map or sketch which shows the following: • Areas of high and low elevation in the schoolyard • Flow patterns for rainwater • Testing sites and results: permeability and soil texture **Student Assignment** **Based upon your observations and analysis, write a description of how rainwater travels through the schoolyard, including:** • **Where it sinks into the ground.** • **Where it travels fastest over the surface.** • **What might be carried with it.** • **Where it ends up after it leaves the schoolyard.** • **How land use (buildings, parking, playgrounds, etc.) impacts this water flow.**

Continued on next page

Procedure (continued)

Phase	Step	Action
Elaborate	6	Testing the Conclusions Choose a rainy day, and use the results of Step 5 to test the accuracy of the analysis by going outside and observing actual water flow.
Evaluate	7	Performance Evaluation map or journal data, written analysis

Vocabulary

Understanding of the following terms is useful in this activity.

Term	Definition
Impervious	A surface that does not allow water to soak in, such as asphalt
Land Use	The type of activity conducted on a specific piece of land, with emphasis on how it impacts runoff and erosion
Permeability	The rate at which water passes through soil; high permeability means rainwater quickly soaks into the ground
Runoff	Rainfall that does not soak into the soil, but flows into surface waters, often carrying sediment and pollutants
Sediment	Material eroded from preexisting rock that is transported by water and wind into stream beds
Topography	Surface features such as mountains, rivers and roads

4.4 Great Terrain Robbery

A Model of Land Use and its Effects on Runoff & Erosion

Overview

Students will investigate the rate of runoff and erosion on different land surfaces.

Lesson Planner

Use the table below for lesson planning purposes.

Grade Level(s)	3– 6
Time Required	**Preparation**: 1 hour **Experiment**: 30 minutes
Key Concepts/Terms	Water Cycle; Watershed; Erosion & Runoff; Soil Conservation; Water Quality; Scientific Method
Prerequisites	Watershed, Water Cycle, Scientific Method
Setting	Outdoors/Indoors with a large table, Whole Class

Learning Objectives

After completing this activity, students will be able to…

- Explain the effect of land use on runoff, erosion, and water quality.

Materials Required

The following materials are required for this activity:

- 3 dishpans notched in one end, with spouts attached (see the illustration of the experiment setup below)
- Soil for all the bins (the same amount and type)
- Soil cover materials: mulch and grass sod
- One watering can per dishpan of soil (each one needs to be the same size watering can, with the same type of spout on each one)
- 1 liter measuring containers
- A large-mouthed collection vessel for the runoff from each dishpan – these should be identical in size and shape and clear
- A prop for each dishpan (2x4's work well for this. All the bins need to be at the same slope.)

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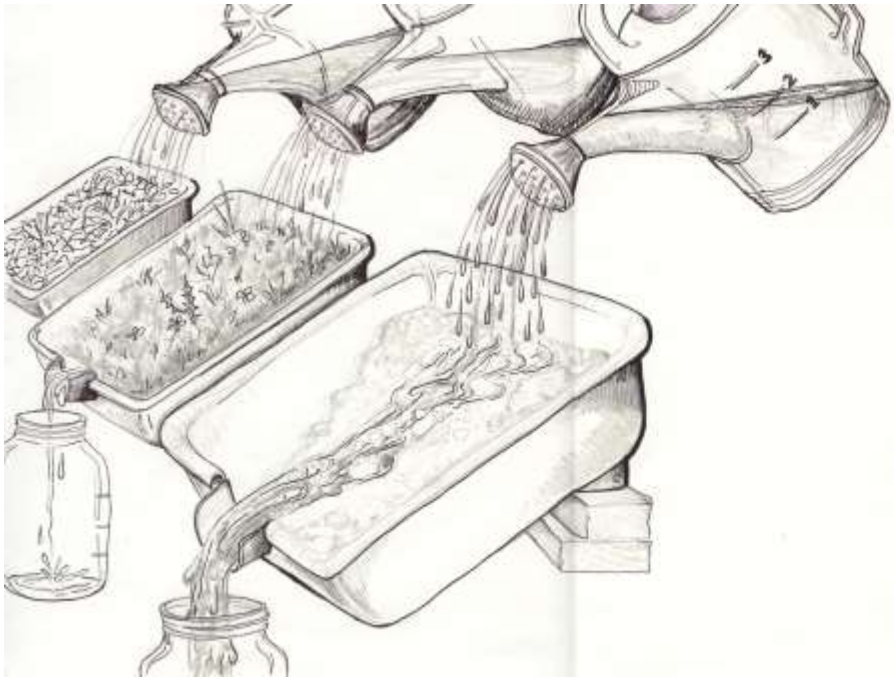
Experiment Set-Up Diagram



Background Information

Soil as a Natural Resource

Soil can be considered a non-renewable natural resource because the formation of new soil is a very slow process. In temperate areas like the Chesapeake Bay watershed, it takes two hundred to one thousand years, depending on soil and climate type, to renew just one vertical inch of topsoil.

What is the Problem?

During farming and building activities, the plant material that covers, protects and holds the soil in place is disrupted, removed, or paved-over. When soil is left uncovered, it is more easily moved by wind and water, which is called **erosion**. Erosion often moves soil into creeks, rivers, and bays, a process called **sedimentation,** which decreases water quality and disrupts aquatic life. Worldwide, soil is eroding on farmland at seven to two hundred times the natural rate of soil renewal.

As more land is covered by impermeable surfaces such as pavement or asphalt, water cannot soak into the soil and runoff increases. Water moves more quickly over impermeable surfaces, and this fast water has more power to carry sediments, pollutants and trash into the nearest waterway.

Continued on next page

Procedure

Follow the steps in the table below to conduct the activity. **Sentences in bold are suggestions for what teachers might say to students.** *Items in italics are possible student answers to questions.*

Phase	Step	Action
Engage	1	Prepare 3 bins of the same size, as depicted in the ***Experiment Set-Up Diagram***, pg. 4-20. The bins should each have the same amount and type of soil (constants in the experiment), but vary in the surface covering (independent variable). The soil coverings for the three bins should be: a) Mulch, b) Grass sod, and c) No cover.
	2	Place prepared soil bins in a central location so all students can view the surfaces. Bins should all be raised at the back (the end away from the runoff spout) the same height, so that the slope is the same for all of them (see ***Experiment Set-Up Diagram***, pg. 4-20).
Engage	3	**Say: "Where have you seen real life examples of ground that looks like each of these bins?"** *Answers will vary, but may include:* • *Mulch is found on flower beds, gardens, new roadcuts, lawns, and playgrounds.* • *Grass sod is found in lawns, parks, road sides, school yards, and playing fields.* • *Exposed soil is seen on farms/gardens before crops are planted, next to roads, under playground swings, and construction sites.* • *Impermeable surfaces are found on roofs, sidewalks, cement areas, roads, and parking lots.*
	4	**"Why is soil important to us?"** *Soil is needed for food production, used for building surfaces, provides homes for animals, supports plants, etc.*
Explore	5	**"We are going to conduct an experiment about water runoff and soil erosion** (review these terms with students, if necessary)**. These soil bins are models to demonstrate what happens to different land surfaces when it rains."**

Continued on next page

Procedure (continued)

<table>
<tr><th>Phase</th><th>Step</th><th>Action</th></tr>
<tr><td rowspan="3">Explore</td><td>6</td><td>“What are the parts of a well-designed experiment?”

Use the table below to lead students to identify the parts of the experimental design.

<table>
<tr><th>For this Experiment the…</th><th>Is…</th></tr>
<tr><td>Independent Variable</td><td>• Soil Cover</td></tr>
<tr><td>Dependent Variable</td><td>• Amount of Runoff
• Clarity of Runoff</td></tr>
<tr><td>Constants</td><td>• Bin size, shape, material, slope
• Soil amount and type
• Water amount, type and temperature
• Watering can/applicator type
• Water application (speed, height, same start time)
• Runoff collection jar type, size, shape</td></tr>
</table>
</td></tr>
<tr><td>7</td><td>“We are going to model a rainstorm and catch the runoff in the jars. The jars represent the river.”</td></tr>
<tr><td>8</td><td>“We need to make some hypotheses before we run our experiment.”

Ask students the following questions to formulate hypotheses. Students do not need to all agree.

• “Which land surface will have the most runoff?”
• “Which land surface will have the least runoff?”
• “Which land surface will have the most erosion?”
• “Which land surface will have the least amount of erosion?”</td></tr>
</table>

Continued on next page

Procedure (continued)

<table>
<tr><th>Phase</th><th>Step</th><th>Action</th></tr>
<tr><td rowspan="4">Explore</td><td>9</td><td>Assign student jobs as follows:
<table>
<tr><th>Job</th><th># of Students Needed</th><th>Location of Students</th></tr>
<tr><td>Measuring water</td><td>3</td><td>A flat surface</td></tr>
<tr><td>Pouring water</td><td>3</td><td>Above the top of the bin slope</td></tr>
<tr><td>Catching runoff</td><td>3</td><td>At the base of the bin slope, holding the collection jar under the lip of the spout.</td></tr>
</table></td></tr>
<tr><td>10</td><td>“We need to make sure that all rain-makers start the rain at the same time. Ready, set, go!”

Students simultaneously pour water at the same rate.</td></tr>
<tr><td>11</td><td>“We need to make some observations about the amount of runoff and erosion on each land type.

“Which bin had the most runoff?” Uncovered soil (This is measured by the volume of water collected in the runoff collection jar.)
“Which bin had the least runoff?” Grass Sod
“Which bin had the most erosion, as demonstrated by water clarity?” Uncovered soil
“Which bin had the least erosion, as demonstrated by water clarity?” Grass Sod
</td></tr>
<tr><td>12</td><td>“So how do our results compare with our hypotheses?”</td></tr>
</table>

Continued on next page

Procedure (continued)

Phase	Step	Action
Explain	13	**"How can we explain the results?"** *Student answers should include:* • *Grass and other plants slow the water down, so it cannot move as much soil as it can on bare earth.* • *Roots of the plants open up channels for the water to soak into the soil, so there is less runoff.*
	14	**"Why is erosion a problem?"** *Student answers should include:* • *The top soil layer is important for growing food, and takes a long time to form.* • *Soil isn't good in our waterways because it blocks the sun so plants cannot photosynthesize, which disrupts food webs; smothers gills and eggs; etc.*
	15	**"How can erosion and runoff be slowed or prevented?"** *Protecting/covering the soil with vegetation, or mulch if vegetation is not possible, will help slow/prevent runoff and erosion.*
Elaborate	16	Take a schoolyard "field trip" and have students explore water pathways to discover areas of runoff and erosion. This would be particularly effective on a rainy day!
Evaluate	17	***Designing a Schoolyard***, pg. 4-71

Continued on next page

Vocabulary

Understanding of the following terms is useful in this activity.

Term	Definition
Erosion	The movement of soil by water or wind
Runoff	Water that is not absorbed into the ground and flows over the land, often carrying sediments or pollutants
Infiltration	In the water cycle, water moving into the pores or spaces between soil particles
Impermeable	Not allowing passage of water to the ground beneath; examples of impermeable surfaces include cement and blacktop
Mulch	Straw, wood chips, leaves, or other material spread over the soil as protection; these also control weeds and reduce water evaporation from the soil

4.5 Does Your Soil Perc?

An Indoor Activity to Analyze Soil Permeability

Overview

In this activity, students will predict and test the permeability of different types of soils, and relate the composition of the different soil types and the permeability to land use implications.

Lesson Planner

Use the table below for lesson planning purposes.

Time Required	1.5 hours
Key Concepts/Terms	Permeability, Runoff and Erosion, Soil Types, Organic Matter
Prerequisites	Understanding of the water cycle
Setting	Indoors (though this activity deals with water and soil, so the area should be suitable for such), Small groups

Learning Objectives

After completing this activity, students will be able to…

- Classify soils as clay, sand or loam based on soil characteristics;
- Explain why different soil types have different permeabilities; and
- Explain the implications of a given soil type permeability on land use.

Materials Required

The following materials are required, **PER GROUP**, to complete this activity…

- 6 plastic soda bottles (2 liter)
- Permanent marker
- Scissors
- Ruler/measuring tape
- 3 rubber bands
- 3 small squares of cotton or ladies stockings
- Three soil samples: sand, clay, and loam
  (To locate appropriate soils for this activity, try shoreline (sandy soil), construction site/farm (clay), and woodlands/hedgerows (loam).)
- 1 measuring vessel
- Water
- Magnifying glass (You may want each group to have a couple of these.)
- Student data sheets (one per student)

Continued on next page

Background Information

What is Soil?
Soil is a mixture of weathered rocks, decayed organic material, air and water. An ideal soil composition might be:

- 45% mineral
- 5% organic material
- 25% air
- 25% water

Soil Characteristics
Different soils have different characteristics, which determine how water flows on and through them, what plants can grow in them, and how we can use them. The soils used in this activity are sand, clay and loam (a fairly even combination of sand, silt, and clay).

The table below shows important characteristics of soils.

Soil Characteristic	How it is Measured	Why It is Important
Particle Size/Texture	Soils are classified from largest particle size (gravel) to smallest (clay), as in this diagram: Gravel ↓ Sand ↓ Silt ↓ Clay Soils are usually composed of a mixture of particles.	The larger the soil particle size, the more quickly and easily water can travel through the soil. Too large particles = water travels right through soil, so none is retained for plant use. Too small particles = water moves too slowly through the soil, or not at all, which creates runoff problems.
Organic Component	Very dark soils = rich in organic material; pale soils = low in organic material.	Organic matter comes from previously living organisms. This returns nutrients to the soil that are necessary for plant growth.
Permeability	This is measured by recording the rate of water absorption. Does it runoff, or sink in too quickly?	Runoff causes erosion problems, and moves trash and other pollutants throughout the watershed. Water that moves down through the soil too quickly is not available for later use by plants.

Continued on next page

Procedure

Follow the steps in the table below to conduct the activity. **Sentences in bold are suggestions for what teachers might say to students.** *Items in italics are possible student answers to questions.*

Phase	Step	Action
Engage	1	Place sand, clay, and loam in piles for students to observe. **"Take a look at the three soil samples in front of you. In what environments have you seen soils like these? What was growing there?"** *Student answers might include playground, construction site, beach, yard, farm, woodland, and the plants associated with each.*
	2	For each of the soil types, have students make observations and complete ***Student Sheets, Part A,*** *pg.4-32*.
	3	**"We need to make hypotheses about which soil would be best for plant growth. What do you think? Why do you think this is the best one? Write your hypothesis in Part B."** *Accept all hypotheses, but encourage students to support their suggestions with some rationale.*
Explore	4	Follow the directions on the ***Student Sheets***, ***Part C, D and E,*** pg. 4-34.

Continued on next page

Procedure (continued)

Phase	Step	Action
Explain	5	***Student Worksheet, Part F. Analyzing Data*** Discuss student answers to the following questions, from Part F: • **Which soil took the longest to begin dripping water?** *(Clay)* • **Which took the least amount of time?** *(Sand)* • **Which soil took the longest to stop dripping?** *(Clay)* • **Which one stopped dripping the fastest?** *(Sand)* • **Did this support our hypotheses?** • **How do our results relate to our observations about the soil properties at the beginning of this activity?** *In the clay soil, which has the finest particles, the water moved the most slowly. This is because the tiny particles fit very closely together, and there isn't much room between them, so water moves very slowly.* *In the sand, which felt the most coarse, the particles don't fit together as closely, so the water moves through these larger spaces much more quickly.* *In the loam, which has sand, silt, clay, and organic matter, the water did not rush right through, but it didn't move too slowly either, because it has all different sized particles, and so it has many different sized pores between them.*

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Procedure (continued)

Phase	Step	Action
Elaborate	6	***<u>Student Worksheet, Part G. Applying Results to Real World Situations</u>*** Discuss student answers to the following questions from Part G: • **If you were a farmer, how would the different soils affect your ability to grow crops?** *If you had very sandy soil, the water would move very quickly through it, so it would not hold water for plant use. If you had a lot of clay in your soil, water would not sink into the ground very easily, but would run off the land, so there would be erosion, and your plants still wouldn't be getting enough water down at the roots. Loam is the desirable soil for plant growth.* • **Imagine you are a homeowner and you want to plant a vegetable garden. One part of your property is loose sandy soil; another part is compacted clay; another is leafy brown soil. Which section of your property would you choose for your garden and why?** *Students should choose the loam, because it has organic nutrients for plants, and the water can percolate into the ground, unlike the clay, but it is retained and available for plant use, unlike the sand.* • **Other than gardening or farming, why would soil percolation be important?** *Flood control; erosion;, sedimentation in water bodies which affects photosynthesis of aquatic plants, and thus the rest of the components in the food web for the area.*
	7	Have students design and conduct an experiment to test their hypotheses regarding the best soil for gardening by planting seeds of the same plant in different soils, while controlling all other variables (light, water, time, etc.).

Continued on next page

Procedure (continued)

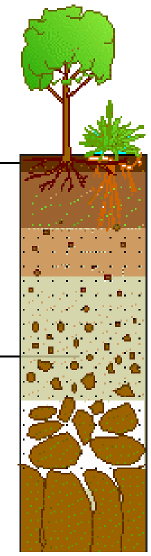
Phase	Step	Action
Evaluate	8	Review student data and answers on the Student Worksheets.

Vocabulary

Understanding of the following terms is useful in this activity.

Term	Definition
Erosion	The movement of soil by wind, water, or chemical agents.
Loam	A mixture of sand, silt, clay and organic material.
Organic Material	Material from once living organisms.
Percolation	Water moving through a permeable material
Runoff	Precipitation that flows off the land into bodies or water, rather than soaking into the ground.

Student Sheets -- Does Your Soil Perc?



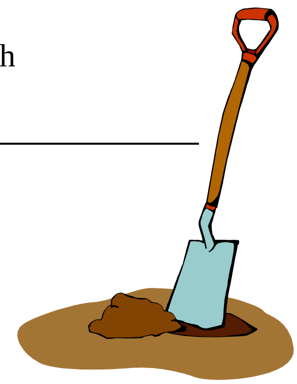
Overview

During this activity, you will test three different types of soil to find out how water travels through each, and why different soils are better for some uses than others.

Objectives

By the end of this activity, you should be able to:

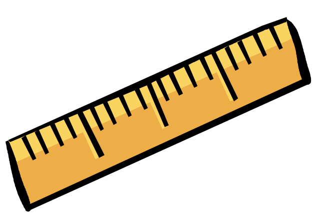
- Explain the different characteristics of three soil types: sand, clay, and loam;
- Explain why water travels at different rates through different types of soils; and
- Explain which soils are better suited to various land uses, such as farming/gardening.

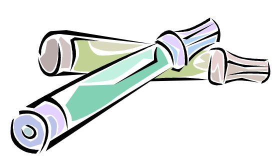


Materials

For this activity, your group needs to have:

- 6 soda bottles (2 liter)
- 3 small squares of cotton or ladies stockings
- Three soil samples: sand, clay, and loam
- Permanent marker
- Scissors
- Ruler/measuring tape
- 3 rubber bands
- Student data sheets (one per student)
- 1 measuring container
- Water
- Magnifying glass
- Stopwatch





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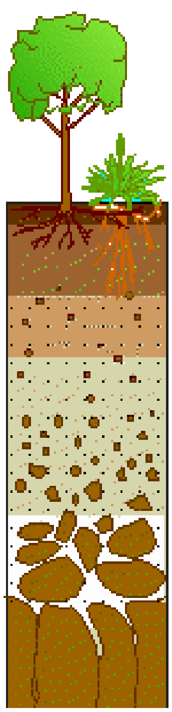
Part A. Examining Your Soils

Examine all three soil types and record your observations in the table below.

Data Table 1. Soil Appearance				
Soil Type	**Where You've Seen It Before**	**Color**	**Texture (How it feels)**	**Observations Under the Magnifying Glass**
SAND				
CLAY				
LOAM				

Part B. Your Hypotheses



Before conducting an experiment, you need to make one or more hypotheses about what you think will happen. Answer the following questions with your hypotheses.

1. Through which soil will water run the fastest? ______________________
2. Through which soil will water run the slowest? ______________________

Explain why you chose your answers to Questions 1 & 2.

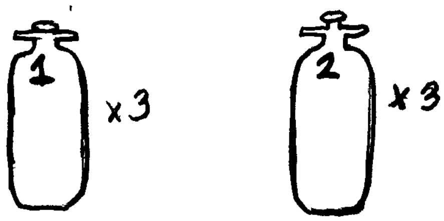
Continued on next page

Part C. Setting Up Your Experiment

Make three identical percolation containers using the following steps:

1. Remove any labels from the bottles.

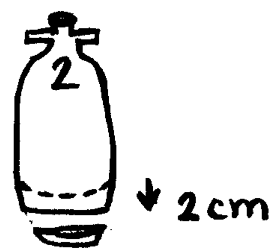
2. Label three of the bottles, near the necks, #1. Label the other three bottles #2.



3. **<u>For all #2 Bottles</u>**

   a. Remove the caps and bases from all #2 bottles.

   b. Starting from the hip of the bottle, on all #2's, measure down 2cm and mark this point with a marker.



   c. Cut off this portion (the bottom of the bottle) with scissors. (Check with your teacher first, as this may be easiest if he/she makes the first cut using an Exacto™ knife.)

   d. Cover the cap opening on the #2 bottles with the cloth/stocking, and secure it with a rubber band.

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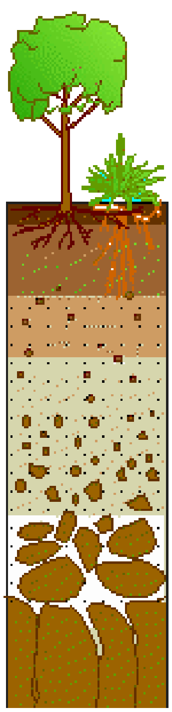
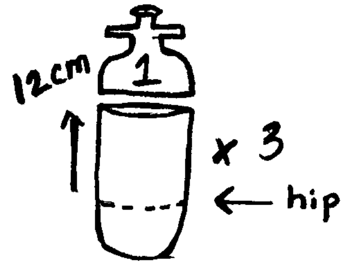


Part C. Setting Up Your Experiment (continued)

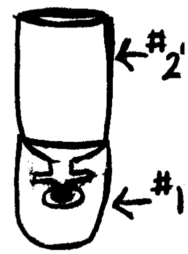
4. **For all #1 Bottles**

   a. Starting from the hip of the bottle, measure up 12 cm and mark this point with a marker.

   b. Cut off this portion with scissors, and dispose of the top section.



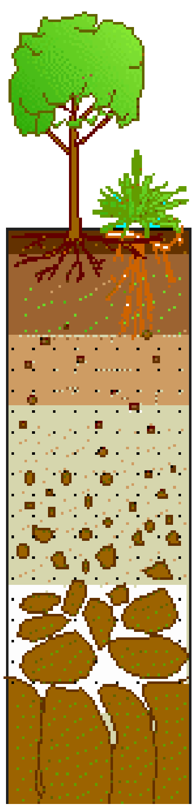
   c. Invert a #2 bottle into each #1 bottle. You now have 3 sets.



5. Label one set SAND, the next CLAY, and the last set LOAM.

6. Measure out 400 ml of sand and carefully pour it into the containers marked SAND.

7. Repeat Step 6 for CLAY and LOAM.



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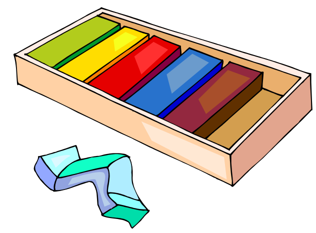
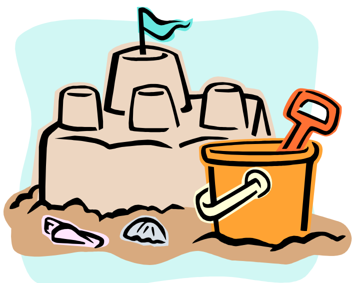
Part D. Run the Experiment

Conduct the experiment following the procedure listed below.



1. Measure out 200 ml of water.
2. Pour the water into the SAND container, and start the stopwatch.
3. Observe the following and record your observations in the data table in ***Part E***:
    a. Measure how long it takes the water to BEGIN dripping through the sand.
    b. Measure how long it takes the water to STOP dripping completely.
    c. Measure how much water (volume) came through the soil after it has stopped dripping completely.



4. Repeat Steps 1-3 for CLAY, and then for LOAM.

Part E. Collect Your Data

Record your observations from Part D in the data table below.

Data Table 2. Percolation Test Results

Soil Type	Amount of Time fore Water to BEGIN dripping (Minutes, Seconds)	Amount of Time for Water to STOP dripping (Minutes, Seconds)	Amount of Water that dripped through (mL)
SAND			
CLAY			
LOAM			

Continued on next page

Part F. Analyze Your Data

To analyze your data, answer the following questions.

1. Which soil took the longest to begin dripping water? _______________
2. Which soil took the shortest amount of time to begin dripping water?

   ____

3. Why do you think this happened this way? (Hint: Think back to your observations about the soils in ***Part A***.)

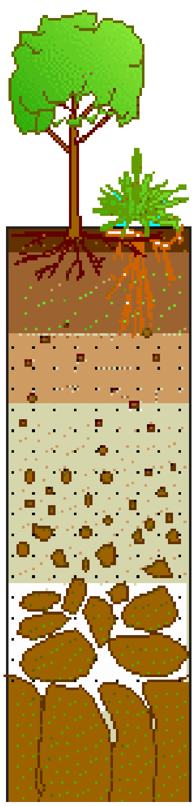
   ____

   ____

   ____

   ____

   ____



4. Which soil took the longest to stop dripping? _____________
5. Which soil took the shortest amount of time to stop dripping?

   ____

6. Why do you think this happened this way? (Hint: Think back to your observations about the soils in *Part A*.)

   ____

   ____

   ____

   ____

Continued on next page

Part F. Analyze Your Data (continued)

7. Which soil had the MOST water drip through? ____________

8. Which soil had the LEAST water drip through? ___________

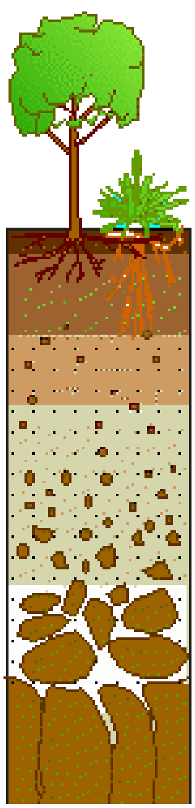
9. Did the results support your hypotheses? Explain.

Part G. Applying Your Results to Real-World Situations

What effect do different soils and percolation (water flow through the soil) have in the real world? To apply what you have learned to real-life situations, answer the following questions.

1. If you were a farmer, how would the different soils affect your ability to grow crops?

2. Imagine you are a homeowner and you want to plant a vegetable garden. One part of your property is loose sandy soil; one part is compacted clay; and one part is leafy brown soil. Which section would you choose for your garden? Explain why your choice is best.



3. Other than gardening or farming, why would soil percolation (the ability of water to travel through the soil) be important?

4.6 Sediment: Choking the Life Out of the Bay*

A Model of Sedimentation in the Chesapeake Bay

* Reprinted with permission, from the Chesapeake Bay Foundation

Overview

Students will construct a model bay and use it to study how sedimentation affects aquatic life.

Lesson Characteristics

Use the table below for lesson planning purposes.

Time Required	45 minutes
Key Concepts/Terms	Sedimentation, Erosion, Runoff, Watershed, Habitat
Prerequisites	Understanding of the water cycle and watershed concepts
Setting	Indoors/Outdoors, Small Groups of up to 5 students

Learning Objectives

After completing this activity, students will be able to…

- Explain how sedimentation affects aquatic habitats and the organisms that live there.

Materials Required

The following materials are required for EACH GROUP to complete this activity:

- 2 clear jars (same size and type)
- 2 plastic aquarium plants/pieces of real plants
- 1 cup of soil (yard or potting soil; do NOT use humus)
- Dried lima and/or kidney beans
- Macaroni/spaghetti noodles

- ***Optional Additions:***
    - Styrofoam trays
    - Scissors
    - String
    - Paper Clips

Continued on next page

Background Information

Why Excess Sediment is a Problem in Aquatic Habitats

Sediment has many adverse effects on aquatic life, including:

- Blocking sunlight from submerged aquatic vegetation (SAV), which results in plant loss (This decreases the amount of dissolved oxygen (DO) in the water for other living things, as well as removing valuable habitat and food for bay animals.);
- Clogging fish gills;
- Smothering eggs, macroinvertebrates, and bottom-dwelling organisms like oysters; and
- Filling in of gravel beds necessary for fish spawning and macroinvertebrate habitat.

Additionally, sediment does not break down like many other pollutants, so it is a problem that recurs with each rainstorm, as it gets stirred up into the water column.

How Does Excess Sediment Get Into Aquatic Habitats?

Erosion is a natural process where sediment is moved by wind/water. Unfortunately, human land use choices have accelerated this natural process. Natural groundcover slows the water, and the roots of plants hold the soil, lessening the erosion. Less vegetation and natural ground cover means more erosion, because water cannot penetrate the impervious surfaces of roads, rooftops, sidewalks, etc. and exposed soils are easily moved. For further information on how land use choices affect erosion, see ***The Great Terrain Robbery***, pg. 19.

Continued on next page

Procedure

Follow the steps in the table below to conduct the activity.

Phase	Step	Action
Engage	1	Brainstorm with students to create lists of: • Animals and plants that live in the Chesapeake Bay (You could also choose to model your local river/stream instead.). For a list of possible organisms, refer to ***Activity 5.8: Ecosystem Food Web Mural.*** • Sources of sediment in our water bodies
	2	Distribute the ***Student Sheets – Sediment: Choking the Life Out of the Bay*** and activity materials to student groups.
Explore	3	Follow the instructions on the ***Student Sheet*** as a teacher-led or self-directed activity. Students may need assistance with new vocabulary words.
Explain	4	Discuss students' answers to the questions on the ***Student Sheet.***
Elaborate	5	• Create a journal entry on how sediment would affect one animal of your choice. This could be a story or just an explanatory paragraph. How might sediment interrupt the food chain of which your animal is a part? Include illustrations, etc. • Examine data regarding SAV distribution changes in the Chesapeake Bay to see how sedimentation has affected these habitats over time. • Take a trip to a local stream, river, or bay to examine the sedimentation present.
Evaluate	6	Use the ***Student Sheet*** for evaluation.

Continued on next page

Vocabulary

The following terms are useful in this activity.

Term	Definition
Erosion	Movement of soil by wind/water
Runoff	Water that is not absorbed into the ground, but runs off the land into a river, stream, etc.
SAV	Submerged (completely underwater) aquatic vegetation
Sediment	Soil that is deposited by water, wind or glaciers
Spawning	The process of laying and fertilizing eggs

References

State of the Bay Annual Report by the Chesapeake Bay Foundation, Philip Merrill Environmental Center, 6 Herndon Avenue, Annapolis, MD 21403. 410.268.8816. www.cbf.org/Document.Doc?id=2289.

Student Sheets for SEDIMENT: Choking the Life Out of the Bay

Introduction

When wind or water hits bare soil, it breaks it up, and takes it downhill to the nearest river, stream or bay. This is **EROSION.** In this activity, you are going to make a model Chesapeake Bay. You will figure out how **SEDIMENT** (soil) in the water affects things that live there.

Objectives

After completing this activity, you should be able to:

- Give 3 examples of how SEDIMENT in water harms organisms that live there.

Materials

Your group should have:

- 2 clear jars, with lids (same size/type)
- Equal amounts of water for each jar, above
- 2 plastic plants
- Soil (1 cup)
- Dried beans
- Noodles

Note: You may have extra items, which your teacher will explain.

Procedure

Follow the steps below to complete the activity.

1. Describe 3 ways you think SEDIMENT in the water affects the plants and animals that live in the Chesapeake Bay.

Continued on next page

Making Models of the Chesapeake Bay

2. Put the same amount of water in each jar.
3. Put one plastic plant in each jar.
4. Look at the other items you have to work with (beans, noodles, etc.). These items are going to represent things that live in the Chesapeake Bay. Decide what animals or plants each one looks like. Put equal numbers of each item in each jar. List the items you included, and what animal/plant they represent in the table below:

Object You Used	Organism that It Represents

5. In the space below, draw a picture of each of your "Bays." Label the organisms you are representing in each of your jars.

Continued on next page

6. Add a handful of soil to **ONE** of your jars. Cap and shake the jar.

7. Let the jars sit for 5 minutes. While you are waiting, complete Steps 8-11.

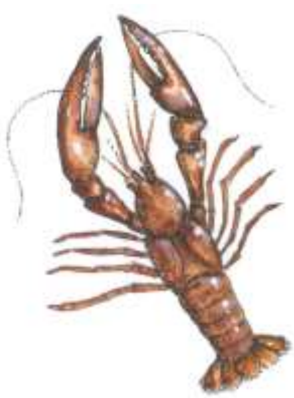
8. Compare the two jars. What differences do you notice? List at least four differences here.

9. Through which jar could sunlight pass most easily? Which organism(s) in your jar would need sunlight most? Explain why.

10. Read the following paragraph from the book <u>Turning the Tide</u>, and answer Question 11.

    "Sediment pollutes by smothering fish eggs, by tearing at fragile gills of young fish, and by covering gravel bottoms that are prime habitats for spawning fish and aquatic insects. Further downriver, it may cover oyster beds. Sediment also clouds the water, blocking sunlight needed to grow the submerged grass that is critical habitat in streams and the bay (Horton & Eichbaum, 1990)."

11. Describe two ways you think the submerged grass in the paragraph above is important to animals living in the Bay.



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Student Sheets for SEDIMENT: Choking the Life Out of the Bay, Continued

12. After the five minutes is over, study the two jars again. In the space below, draw and label your two jars again. Show any changes that happened during the five minutes.

13. Think about what you saw in the model and what you read in the paragraph. Use what you've learned to fill out the table below.

Think about:

- How sediment floating in the water affects things that live there.
- How sediment sitting on the bottom affects things that live there.
- How sediment affects the food chain in the water.

Bay Organism	Effect of Sediment

4.7 Water Quality Testing

Looking at the Health of a Stream

Overview

Students will learn to conduct and interpret water quality tests to assess the health of a stream or river. They will test for:

- **Dissolved Oxygen**, which is essential for all aquatic plant and animal life;
- **pH**, which determines if the water is acidic, basic or neutral;
- **Turbidity**, which is a measure of the cloudiness of the water; and
- **Nitrates** & **Phosphates**, nutrients essential for aquatic plants in small quantities but harmful if overabundant.

These tests may be practiced in the classroom, and then conducted in the field to determine the health of a local stream.

Lesson Characteristics

Use the table below for lesson planning purposes.

Time Required	Testing Time: 2 hours
Key Concepts/Terms	Turbidity, Water Quality, Nitrates, Phosphates, pH, Dissolved Oxygen
Prerequisites	None
Setting	Indoors/Outdoors, Small Group

Learning Objectives

After completing this activity, students will be able to…

- Test water for levels of dissolved oxygen, pH, turbidity, nitrates and phosphates;
- Explain the importance of, and acceptable limits for, each of the water test parameters; and
- Determine the relative health of a body of water based upon their test results.

Continued on next page

Materials Required

The following materials are required for this activity:

Note: There are several options for water testing kits. Each kit will have its own set of testing directions.

Item	Quantity	Per
Safety Goggles	One	Student
Water Quality Test Kits for: • Dissolved Oxygen • pH • Nitrates • Phosphates • Turbidity	One	Group (You can rotate the tests between groups)
Student Information Sheets, pgs.53-57, for each Water Quality Test parameter you are covering.	One Set	Group
Rinse Bottles of clear water for cleaning equipment.	One	Group
Waste bottles to collect used samples.	One	Group
Student Data Sheets, pg. 58	One	Student
Water Sample for testing (This can be from a local stream or a classroom fish tank.)	One	Group

Background Information

Why Should We Care About Clean Water?
(reprinted, with permission, from *Bridging the Watershed*, Alice Ferguson Foundation)

Most forms of life on Earth require clean water and cannot survive without it. Though the supply used to be plentiful, the situation changed over time so that, by the 1970's, at least 65% of the water tested in U.S. waterways was unsafe for fishing and swimming because of pollution. The U.S. Congress was so concerned that it passed the Clean Water Act in 1972. The goal of the act was to provide all Americans with waterways safe enough for swimming and fishing. With the act, we rejected some old ideas and practices that led to widespread water pollution, decided to clean up the pollution already present, and made a commitment to keep the waterways clean using good resource management practices.

Continued on next page

Background Information (continued)

Today, only about 33% of this nation's waters are considered unsafe for fishing and swimming. That's some improvement, but not enough, and many of those "safe" areas are now threatened by new sources of pollution. Most of the pollution we've been able to eliminate is from traceable sources like a factory or a sewage treatment plant. This type of pollution is called "point source pollution" because we can point to one place – one point—as the source of the problem. Unfortunately, most of the really damaging pollution is untraceable because it comes from multiple sources, reaching the waterways in runoff. When it rains, whatever is on the land washes into rivers, lakes and oceans. Wetlands, stream corridors, and coastal areas are especially vulnerable to this type of pollution, called "non-point source pollution." It's a deadly combination of substances, including various pollutants from urban and suburban streets and parking lots; fertilizers and pesticides from lawns and farms; and other substances from forestry, ranching, and mining operations—essentially many of the different ways we use the land. All these runoff pollutants threaten environmental balance as well as human health. Every year, there are more warnings for people not to swim at certain beaches or eat certain fish or shellfish because of pollution. New threats to health arise as a consequence of new or continued pollution.

The United States recognized the connection between land use and clean water as an environmental crisis. In 1992, the General Assembly of the United Nations invited all countries on Earth to a conference in Brazil to discuss the problem. The leaders at this conference understood that all of us in the rapidly rising world population are trying to improve our standard of living. As we do so, we destroy the environment at an alarming rate. We clear land for new housing, transportation, growing food, and manufacturing, and we pollute. This disrupts many natural cycles like the water cycle, food chains, and the oxygen and carbon dioxide cycles. Clearing land also reduces the supply of clean water for all organisms on Earth. The conference participants addressed the global question of how to allow for development while maintaining the natural ecosystems. They knew about the "interconnectedness" of all life on Earth and agreed that development must be balanced by environmental protection. They understood that if we fail to do this, there would soon be nothing left to develop. Humans cannot survive if the delicate balance of ecosystems on Earth is destroyed.

Many great leaders have understood the importance of maintaining the quality of our land and waters, not just for ourselves in the "here and now," but for future generations of humankind as well as all of Earth's life forms.

Continued on next page

Background Information (continued)

Theodore Roosevelt once said:
"*The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased and not impaired in value.*"

How Can We Measure Water Quality?

The National Sanitation Foundation created a standard index, called the Water Quality Index (WQI) that can be used to compare water quality over time, water quality from different segments of the same river, and water quality of different rivers. Each water parameter is rated on a scale from 1 to 100, with 100 indicating an excellent level for that parameter.

What Does Each Water Quality Parameter Mean?

See ***Student Background Information Sheets***, pgs. 4-53 through 4-57 for specific information on each test parameter.

Procedure

Follow the steps in the table below to conduct the activity.

Phase	Step	Action
Engage	1	Conduct the activity, ***Sediment: Choking the Life Out of the Bay***, pg. 4-39. This demonstrates the effects of erosion and sedimentation and introduces several of the water quality parameters students will be testing during this field study.
Explore	2	Have students look at and smell the water sample to be tested to form a hypothesis regarding the water quality. They should rate it on a scale from 0 to 100 (with 100 being excellent).
	3	Assign water parameters to student groups. Each group may do one test and then share results with the class, or each group may do all of the tests, dividing tasks within each group. Modify the ***Student Data Sheet***, pg. 4-58, to fit. The parameters to be tested are: • Dissolved Oxygen • pH • Turbidity • Nitrates • Phosphates

Continued on next page

Procedure (continued)

Phase	Step	Action
Explore	4	Distribute ***Student Background Sheets***, pgs. 4-53 through 4-57, for use as references regarding the parameters being tested.
	5	Introduce test procedures through demonstration, or distribute tests and instructions for a self-guided activity.
	6	Distribute testing materials (including rinse and waste bottles).
	7	Demonstrate/explain rinse and water disposal methods. Labware should be rinsed before and after using with the rinse water. All rinse and tested water should go in the waste container to be disposed of properly.
	8	Have students conduct the tests as assigned and record their data on their ***Student Data Sheets***.
Explain	9	When every group has finished, introduce the concept of Q values: a. Distribute ***Q Value Sheets***, pg. 4-59 b. Explain that these Q values are a way of comparing very different measurements and giving each one a grade. c. Show students how to use the Q value graph to find their score for a particular test: i. Find the test reading on the X-axis (horizontal). ii. Draw a vertical line up into the graph until you intersect the graph line. iii. Draw a horizontal line from this point on the graph to the Y-axis (vertical). iv. The number where your line intersects the Y-axis is your score for that test.
	10	Have students compare the water quality rating with their original hypothesis. Were the results what they expected?

Continued on next page

Procedure (continued)

Phase	Step	Action
Elaborate	11	• Take students to a body of water, such as a stream near the school, and conduct the water tests to determine the health of the stream. • Adopt a local stream to monitor and test it several times throughout the year.
Evaluate	12	Use ***Student Data Sheets*** for evaluation.

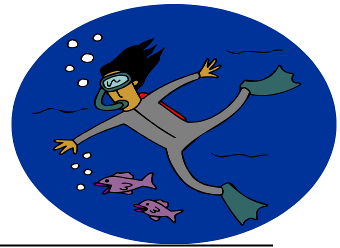
Vocabulary

The following terms are useful in this activity.

Term	Definition
Dissolved Oxygen	Oxygen in a gas form in water
pH	A measure of the acidity/basicity of a substance
Nitrate	The form of nitrogen which is necessary for the growth of living things.
Phosphate	The form of phosphorus necessary for plant growth and reproduction
Turbidity	A measure of the cloudiness of the water

Water Quality Parameter Fact Sheet:
DISSOLVED OXYGEN (DO)

Student Background Information



Importance of DO

Healthy water has to have enough dissolved oxygen (DO) so things can live there. Fish, invertebrates, plants and aerobic bacteria all need oxygen, just like we do.

Sources of Dissolved Oxygen

Most of the DO in water comes from the **atmosphere**. Oxygen in the air mixes into water at the surface. This happens because of rain, wind, waves, and currents. Faster moving water has more DO than slower water. This is because when it splashes over rocks it touches the air more than slower water.

Plants that live in the water also make DO during photosynthesis. The more plant life in the water, the more DO it has.

So What is the Problem?

Low DO levels are caused by:

- **Low Temperature:** Warm water holds less oxygen than cold water. DO levels rise and fall during different seasons and times of day because the water warms or cools.
- **Low Light Level:** All plants need light to produce oxygen, so if there isn't a lot of light, there isn't a lot of DO. This happens on cloudy days, at night, or when the water is too cloudy for light reach plants.

How is DO Measured?

We measure DO in one of two ways:

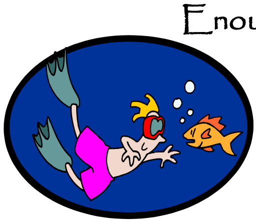
- in **milligrams** of oxygen **per liter** of water **(mg/L)** or
- in **parts per million (ppm).**

We then change those measurements to **percent (%) saturation**. This is a measure of the percentage of oxygen in the water compared to the maximum it could possibly hold. Remember that temperature affects how much DO water can possibly hold.

How Much is Enough?

Different aquatic animals need different amounts of dissolved oxygen. Some, like a catfish, can live with very low levels. Others, like trout, need much higher DO.

A rule of thumb is 5 ppm as a minimum for aquatic life.



Water Quality Parameter Fact Sheet – pH

Student Background Information

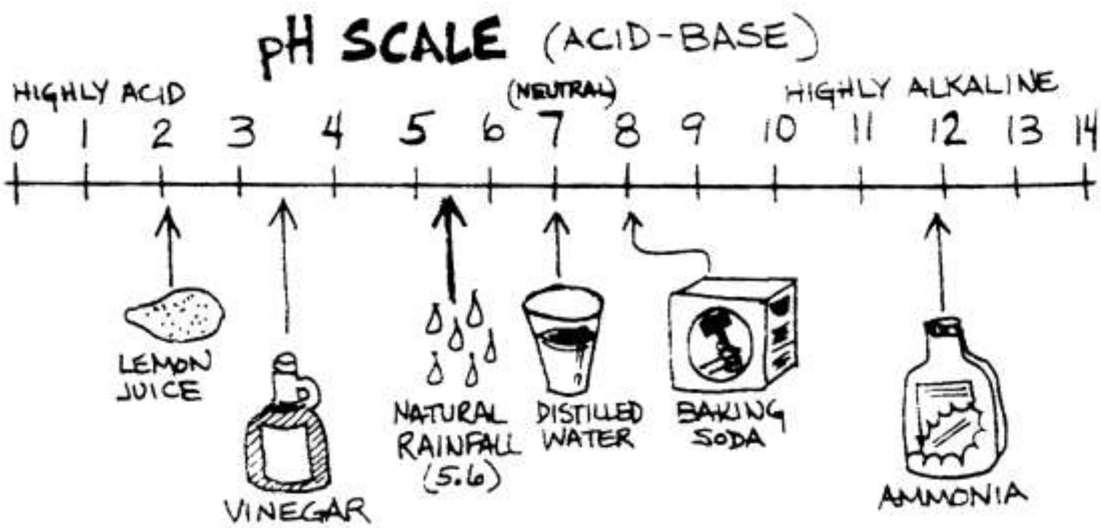
What is pH?

pH is a measure of how acidic or basic something is. Lemon juice is very acidic, and ammonia is very basic. Animals and plants can live in water that is in the middle, not too acidic or too basic.

How is pH Measured?

pH is measured on a scale from 0 – 14. There are no units of measurement. 7.0 is considered neutral. Less than 7.0 is acidic. Closer to 0 means more acidic. The opposite is true for basic substances. Higher than 7.0 is basic and the higher numbers mean more basic.

A sample scale is shown with common items below:



What is a Good pH for Water Quality?

Aquatic organisms can usually survive in water with a pH between **6.5 and 8.5.**

What Causes pH Problems in Our Water?

Many things can change the pH of water. Some of these are:

- Acid rain,
- Minerals from rocks,
- Melting snow,
- Heavy precipitation, and
- Accidental spills, runoff from the land, and when sewers overflow.

Water Quality Parameter Fact Sheet –PHOSPHATES

Student Background Information

What is Phosphate?

All living things need **phosphate**, which is a natural chemical. Naturally most water has very little phosphate. Underwater plants compete for these phosphates. So, how fast plants can grow and reproduce depends on how much phosphate they can get.

What is the Problem?

Here is what happens when there is **too much phosphate:**

Tiny green plants called algae use the phosphate and reproduce quickly. This is called an "**algae bloom**," which means that the water is covered with algae, and…

1. No sunlight can reach plants on the bottom, so they die. Fewer plants = less Dissolved Oxygen in the water.
2. When the algae have used all of this phosphate and there isn't any more, they begin to die off.
3. Bacteria decompose these dying plants and use all of the dissolved oxygen in the water.
4. This means fish and other animals in the water don't have enough oxygen. They suffocate, and the whole aquatic ecosystem collapses.

Causes of Too Much Phosphate

The most common reasons that too much phosphate gets in our water are:

- People put too much **fertilizer** on their lawns or farm crops;
- People use **detergents** with extra phosphate in them; and
- Some companies release **industrial wastes** into the water.

Units of Measurement

Phosphates are measured in **mg/L.** This stands for **milligrams** of phosphate **per liter** of water.

What is a Good Level for Phosphates?

In natural bodies of water, a phosphate level of 1.0 mg/L is considered excellent.

In water with levels of 2-3 mg/L, there is more plant growth and algal blooms.

Levels of 4.0 mg/L and higher usually have an algal bloom.

Water Quality Parameter Fact Sheet – NITRATES

Student Background Information

What are Nitrates?

Nitrate is a form of **Nitrogen,** a natural chemical that all plants and animals need to grow.

In nature, there is much more nitrogen than phosphorus. Nitrogen is most commonly found in the **atmosphere**. In fact, it makes up about 79% of the air we breathe. This kind of nitrogen is useless to both plants and animals.

In order for plants to be able to get nitrogen, it has to be changed to **nitrate** by organisms like bacteria that live on the roots of some plants. This puts nitrate in the soil so plants can get it. Animals get it by eating those plants.

Nitrate Sources

Nitrates are in all plant and animal bodies. Nitrates get returned to the soil when these bodies die and decompose (rot). Those nitrates are then used as fertilizer for new plants. This is called the nitrogen cycle.

What's the Problem?

Small amounts of nitrate are necessary for plants and algae to grow in water. Too much nitrate in water, combined with too much phosphate, can cause an algae bloom. This means that:

1. The tiny green algae reproduce very quickly and completely cover a pond, stream or river.
2. When the algae uses up all of the nitrates and phosphates, they start to die.
3. Bacteria decompose the dead plants and use up all of the Dissolved Oxygen.
4. So, an algae bloom takes out so much dissolved oxygen from the water that fish and other animals can't breathe. They suffocate, and the whole aquatic ecosystem collapses.

Causes of Too Much Nitrate

High Nitrate levels are caused by:

- People use too much **fertilizer** on their lawns or agricultural fields. This washes off into nearby streams or rivers when it rains.
- This runoff can also carry **animal wastes**, or manure, into streams as well.

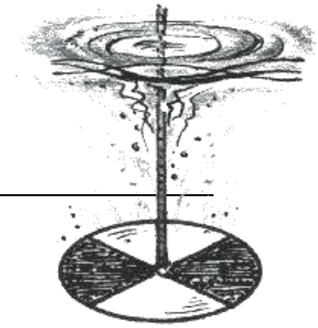
Measurement

Nitrates are measured in **mg/L**, which means **milligrams** of nitrate **per liter** of water.

How Much is Too Much?

Normally, stream or river water has a nitrate level of 2.0 mg/L or less. Water with nitrate levels above 4.4 mg/L is unsafe for drinking.

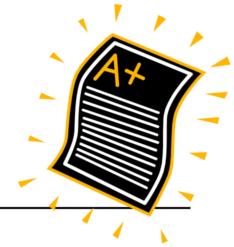
Water Quality Parameter Fact Sheet – TURBIDITY



Student Background Information

What is Turbidity?	Turbidity is a measure of the how cloudy water is. The more tiny pieces of sediment (soil) and other material floating in the water, the cloudier it is.
When is it a Problem?	Underwater plants need light to make food (photosynthesis). When water is cloudy or "**turbid,**" less light can reach plants that live in it. When there is A LOT of turbidity, all these tiny pieces floating in the water can **clog fish gills.** This makes it hard for them to breathe. The particles in the water can also **smother fish eggs and other organisms in the water**. Turbidity can also **increase water temperature** because the particles floating in the water soak up heat. Warmer water means **less dissolved oxygen (DO)** for plants and animals that live there because warm water holds less oxygen than cold water.
Causes of Too Much Turbidity	Erosion is when wind or water move soil. This is a natural process that forms land such as the Grand Canyon. Unfortunately, many human activities speed up erosion. This puts too much soil into our rivers and streams (SEDIMENTATION). **Causes of increased erosion can include:** • Construction of new homes, schools or businesses. This can remove trees and leave large areas of open soil that wash away when it rains. • When farms fields are left open with no plants after a harvest. • Cutting of forests for lumber, paper, etc. This can leave soil open to rain and snowmelt.
Units of Measurement	**Turbidity is measured in Jackson Turbidity Units, or JTU's.**
How Much is Too Much?	**In a stream, you don't want the turbidity to be higher than 40 JTU's because it can harm the gills of fish.** **Drinking water should have a turbidity of less than 5 JTU's.**

Student Data Sheet of Water Quality Testing



Hypothesis   My hypothesis about the quality of this water is ____________________

(Give a score from 0 (very bad) to 100 (excellent).)

	Group 1		Group 2		Group 3		Group 4		Group 5		
WATER QUALITY PARAMETER	Test Result	Q-Value	Test Result	Q-Value	Test Result	Q-Value	Test Result	Q-Value	Test Result	Q-Value	Average Q-Value
Dissolved Oxygen											
pH											
Phosphates											
Nitrates											
Turbidity											
Average Q-Value											

Average Q Value of All Tests = ____

What is your conclusion about the quality of this water? __________________________

____

Q Values

A Means of Weighting Water Quality Test Values

Overview

140 different scientists "graded" water quality from 0 (worst) to 100 (best) for each of the tests you did.

To see how this works, let's look at pH. The best pH for living things in a stream is about 7.4; so on the pH test a result of 7.4 gets was given a grade of 100 (best). As pH scores get lower or higher than this, the grade gets lower, because fewer things can live in that water.

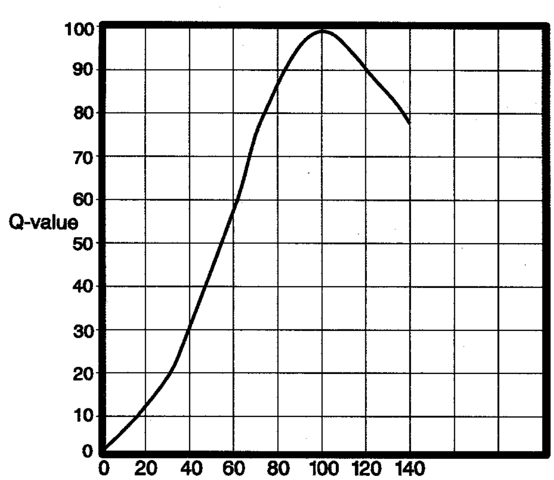
The scores from each scientist were averaged and a graph was made for each test. You'll use these graphs to give your water a "grade," called a Q-value, for each test.

Calculating Q Values

Calculate Q-values for each parameter as follows:

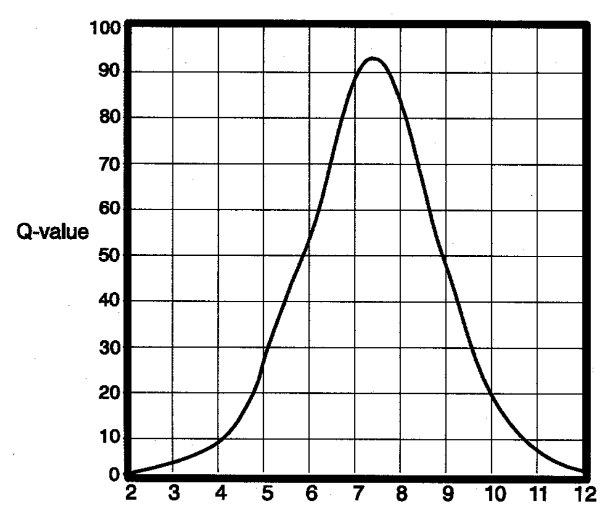
a. Find the weighting curve graph for your test.
b. Mark your test result with a pencil on the X-axis (horizontal) of the weighting curve graph.
c. Draw a vertical line from that point to the weighting curve. Then draw a line from the intersection point on the curve to the Y-axis (vertical) of the graph. The point where your line intersects the Y-axis is the Q-value for your test result.

Dissolved Oxygen



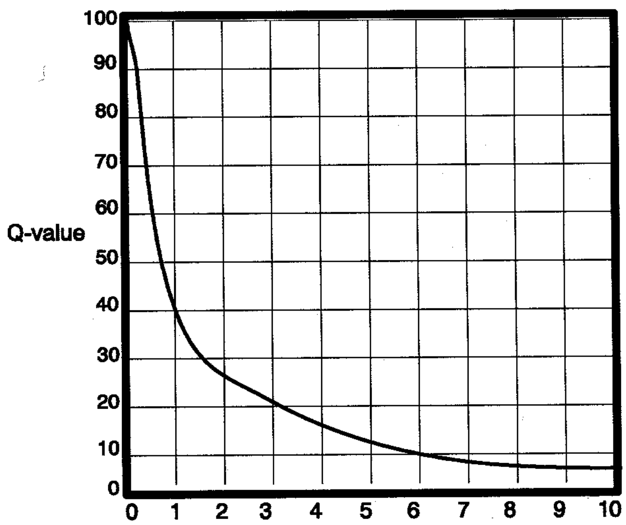
Dissolved Oxygen: % saturation
Note: Q = 50.0 if DO% saturation >140.0

pH



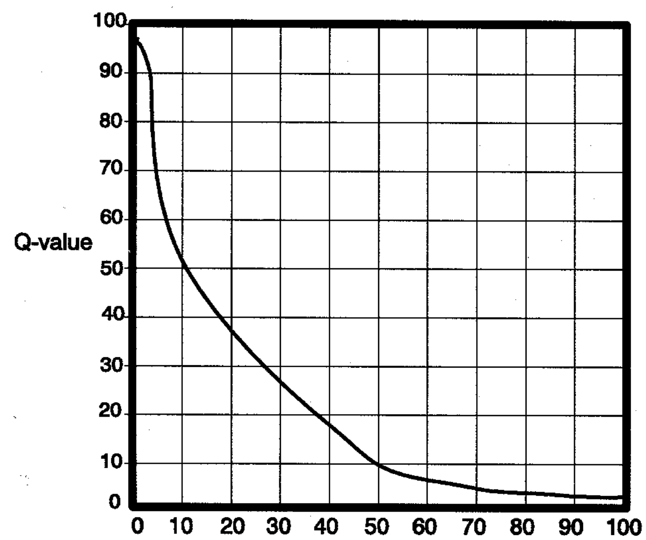
pH: units
Note: Q = 0.0 if pH < 2.0 or if pH > 12.0

Orthophosphates



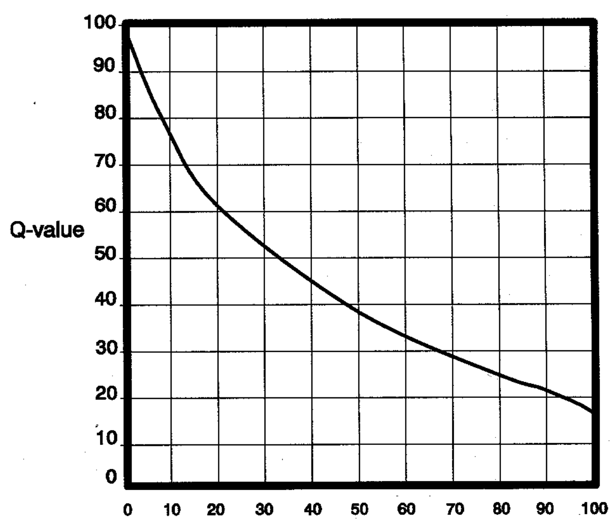
Orthophosphate: mg/L
Note: Q = 2.0 if orthophosphate > 10.0

Nitrates



Nitrate: mg/L
Note: Q = 1.0 if Nitrate > 100.0

Turbidity



Turbidity: JTU
Note: Q = 5.0 if Turbidity > 100.0

4.8 Wetland Metaphors*

*Adapted with permission from Project WILD.

Overview

Using ordinary household objects, students will be asked to identify how these objects represent the natural functions of wetlands. Students will understand the form and function of wetlands in clear and concrete terms that relate to their lives.

Lesson Planner

Use the table below for lesson planning purposes.

Time Required	15-30 minutes
Key Concepts/Terms	Wetlands, Habitat, Biodiversity, Erosion/Runoff, Water Quality
Prerequisites	Basic Understanding of: Energy Cycle: Food Chains/ Food Webs; Runoff & Erosion; and Wetlands
Setting	Outdoors/Indoors, Small Group

Learning Objectives

After completing this activity, students will be able to…

- Make observations to describe and classify characteristics of wetlands;
- Understand the importance of wetlands; and
- Understand how people are connected to the local watershed.

Materials Required

The following materials are required, per group, to complete this activity…

- Backpack or small bag (pillow case) to carry your Wetland Metaphor Kit (see ***Background Information***, pg. 4-62, for a list of possible materials to include in your kit.)
- ***Optional***: journals, binoculars, cameras

Continued on next page

Background Information

Wetlands have many values and functions, as detailed in the table below, which describes the function and suggests metaphoric objects to include in your Wetland Metaphor Kit.

Wetland Function/Value	Why This is Important	Suggested Metaphoric Object
Food for Animals	Wetlands have great soil for plant growth, and support a lot of biodiversity (many different living things). This provides a variety of food choices for animals, so the habitat can support a larger variety of animals in turn. More biodiversity = healthier ecosystem with many food web connections.	Mini cereal box
Breeding Grounds	Wetlands are wonderful nurseries, with many options for shelter of eggs/young of animal species.	Toy Baby Bottle/Miniature of a Baby Carriage
Filter	Water slows down when it enters wetlands, which allows sediments and trash items to settle out, keeping them from entering our water bodies.	Coffee Filter
Flood Control	Wetland soils can absorb large quantities of water, and so control flooding.	Sponge
Pollution Control	When water slows in wetlands, it allows plants to trap and neutralize pollutants like sewage waste and toxic substances.	Antacid Bottle
Migratory Resting Place	Wetlands act as a resting place for migratory animals, providing temporary water, food and shelter.	Pillow or Miniature Bed
Mixing of Nutrients	Wetlands mix nutrients and oxygen into water.	Egg beater/Wisk
Environmental Cleanser	Wetlands clean our water by removing, litter, sediments and toxins.	Soap

Continued on next page

Procedure

Follow the steps in the table below to conduct the activity.

Phase	Step	Action
Engage	1	**<u>Option A.</u> On-site at a Wetland** Ask students to make observations about the wetland using the senses of sight, hearing, and smell. After a brief reflective period, discuss student impressions. **<u>Option B</u>. In the Classroom** Have students make as many observations as possible while viewing a video of a wetland, particularly sight and hearing observations. Use the narrator's dialogue to guide discussion of wetland smells.
Explore	2	Have students compare their observations to something they have seen, heard or smelled elsewhere. Use an example to guide them, such as: "*This wetland smells like wet grass*," or "*The moving grasses look like waves on the ocean.*"
	3	**Pass out one metaphoric object** from your Wetland Metaphors Kit, to each pair of students. Tell students that these objects represent something that wetlands do for us or for other organisms. Give students an example to use as a guide. You may choose any of the objects to keep for your example.
Explain	4	Give students a few minutes to discuss their objects, and then share their thoughts with the group. Encourage students to build on what others have said.
	5	Expand student appreciation for wetlands by explaining how humans use them: recreation, beauty, environmental quality, nature study, etc.
Elaborate	6	• Conduct the activity, ***Activity 5.8 Ecosystem Food Web Mural***, ***Unit 5,*** and create a web of the links in a wetland habitat. • Investigate local, county, state and federal regulations and laws regarding wetland use.

Continued on next page

Procedure (continued)

Phase	Step	Action
Evaluate	7	• Have students draw a diagram of the wetland, and label it to explain the wetland functions and values they have learned. • Evaluate student performance on ***Activity 5.8 Ecosystem Food Web Mural.*** • Have students select five organisms and describe how wetlands are important to each.

References

Aquatic Project WILD, 1992. Western Regional Environmental Education Council. Houston, TX.

4.9 Bernie's Toes

Analyzing Water Quality Data

Overview

Students will analyze authentic data on water quality and human population growth over the past 60 years to determine patterns and causal relationships.

Lesson Characteristics

Use the table below for lesson planning purposes.

Time Required	30 minutes
Key Concepts/Terms	Runoff & Erosion, Water Quality, Land Use
Prerequisites	Water Cycle, Watersheds, Water Quality Parameters, Land Use
Setting	Indoors, Individual/Student Pairs

Learning Objectives

After completing this activity, students will be able to…

- Recognize that increased human population and land use result in decreased water clarity; and
- Demonstrate understanding of how various land uses affect water quality.

Materials Required

The following materials are required for this activity:

- ***Student Sheet -- Bernie's Toes***, pg. 68

Background Information

See ***Student Sheet – Bernie's Toes.***

Continued on next page

Procedure

Follow the steps in the table below to conduct the activity. **Sentences in bold are suggestions for what teachers might say to students.** *Items in italics are possible student answers to questions.*

Phase	Step	Action
Engage	1	Read the introductory paragraph on the ***Student Sheet – Bernie's Toes***, pg. 4-68.
Explore	2	Have students complete the ***Student Worksheet***, either as a teacher-directed class activity, or as an individual self-directed activity..
Explain	3	Lead a class discussion regarding the answers to the questions on the ***Student Worksheet***: **Describe the changes in visibility from 1940 to 1999.** *Visibility decreases from 1940 through 1989. After 1989, the visibility starts to improve.* **Describe the changes to the human population in the Patuxent River Watershed from 1940 to 1999.** *The population in the Patuxent River Watershed increases steadily over the time period.* **Compare the two graphs. It would seem likely that as population increases, visibility would continue to decrease. Did that happen in this case? Explain.** *The visibility decreased until 1980 and then began to improve, even though the population continued to increase at that point.* **What are some possible causes of decreased visibility relating to human actions as the population increased? What are some possible reasons that the visibility improved from 1980 to 1999?** *Students should be able to suggest plausible land use decisions and human actions that would increase erosion & runoff, and so decrease visibility. Possible answers include: more construction, removal of forests, pollution.* *From 1980 to 1999, perhaps the increase in visibility resulted from increasing efforts to clean up the water. Student answers should reflect something plausible along these lines. Accept all reasonable answers.*

Continued on next page

Procedure (continued)

Phase	Step	Action
Elaborate	4	• Conduct the summative activity for this unit, ***Design a Schoolyard,*** pg. 4-68. • Research newspaper articles to find the latest data for Bernie Fowler's wade-in. • Research online to find current data on the state of the Patuxent river and Chesapeake Bay.
Evaluate	5	Use the ***Student Sheet*** for evaluation.

Resources

Compare how Bernie did in the 2015 Wade-In:
http://www.chesapeakebay.net/blog/post/bernie_fowler_measures_a_sneaker_index_of_44.5_inches_at_annual_wade_in

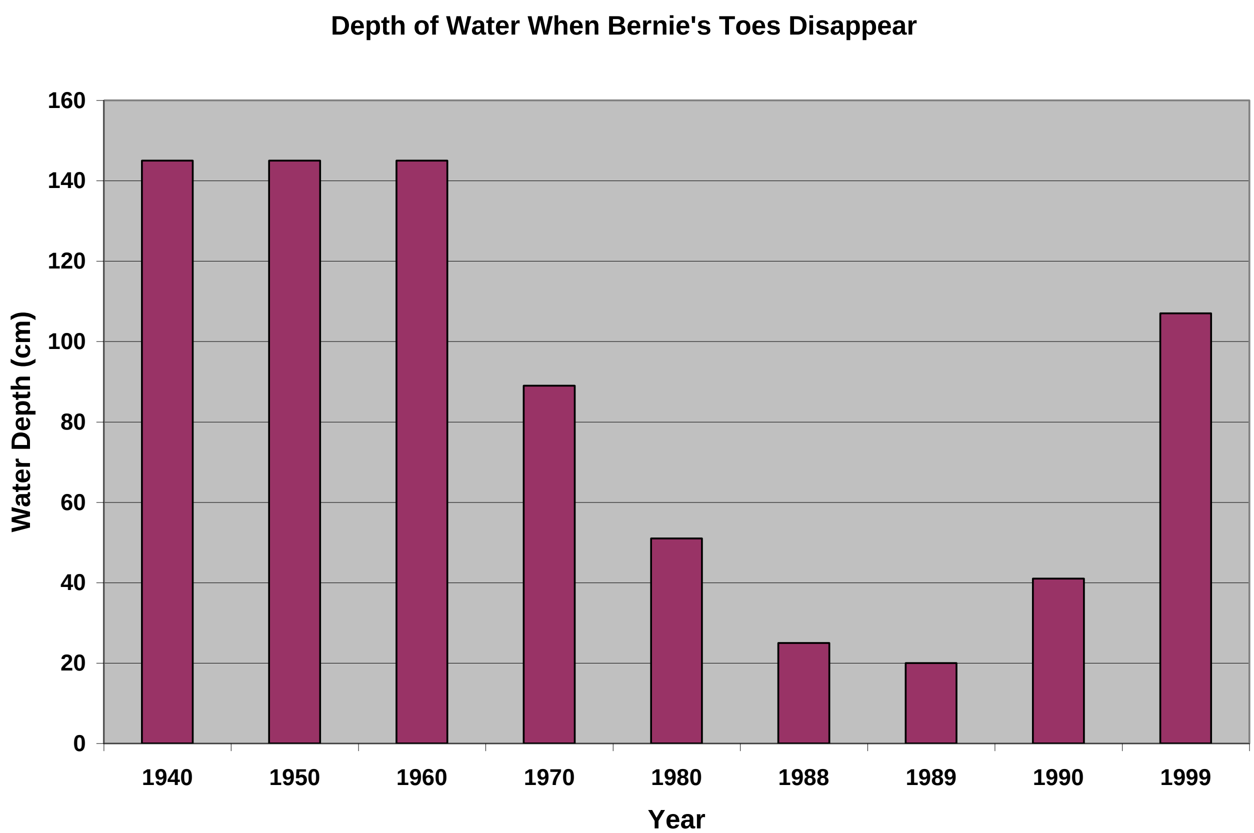
Use NOAA's Chesapeake Bay Interpretive Buoy System real-time data to determine: What would Bernie's sneaker index be today? www.buoybay.org/site/public/

Student Sheet -- Bernie's Toes

In the 1940's there was a young boy named Bernie Fowler who lived near the Patuxent River. He liked to swim, crab and fish in the river. He really liked to walk into the water and catch tasty soft-shelled crabs. These crabs hide in the thick grasses that grow under the water. As he got older he saw changes in the river. There weren't as many crabs. Also, it was harder each year to see his toes under the water because it was getting cloudier. Bernie started to write down how far he could go and still see his toes. In 1940 he could see his toes as deep as 145 centimeters (57 inches). By 1999, Bernie could only get to 107 centimeters (42 inches) and still see his toes. When Bernie grew up he became a Maryland State Senator. He still walks out in the water to measure how clear it is every year, and you can read about it in the newspapers.

Part A. Water Visibility Data

1. Study the graph below. This shows the how deep Bernie could go and still see his toes from 1940-1999.



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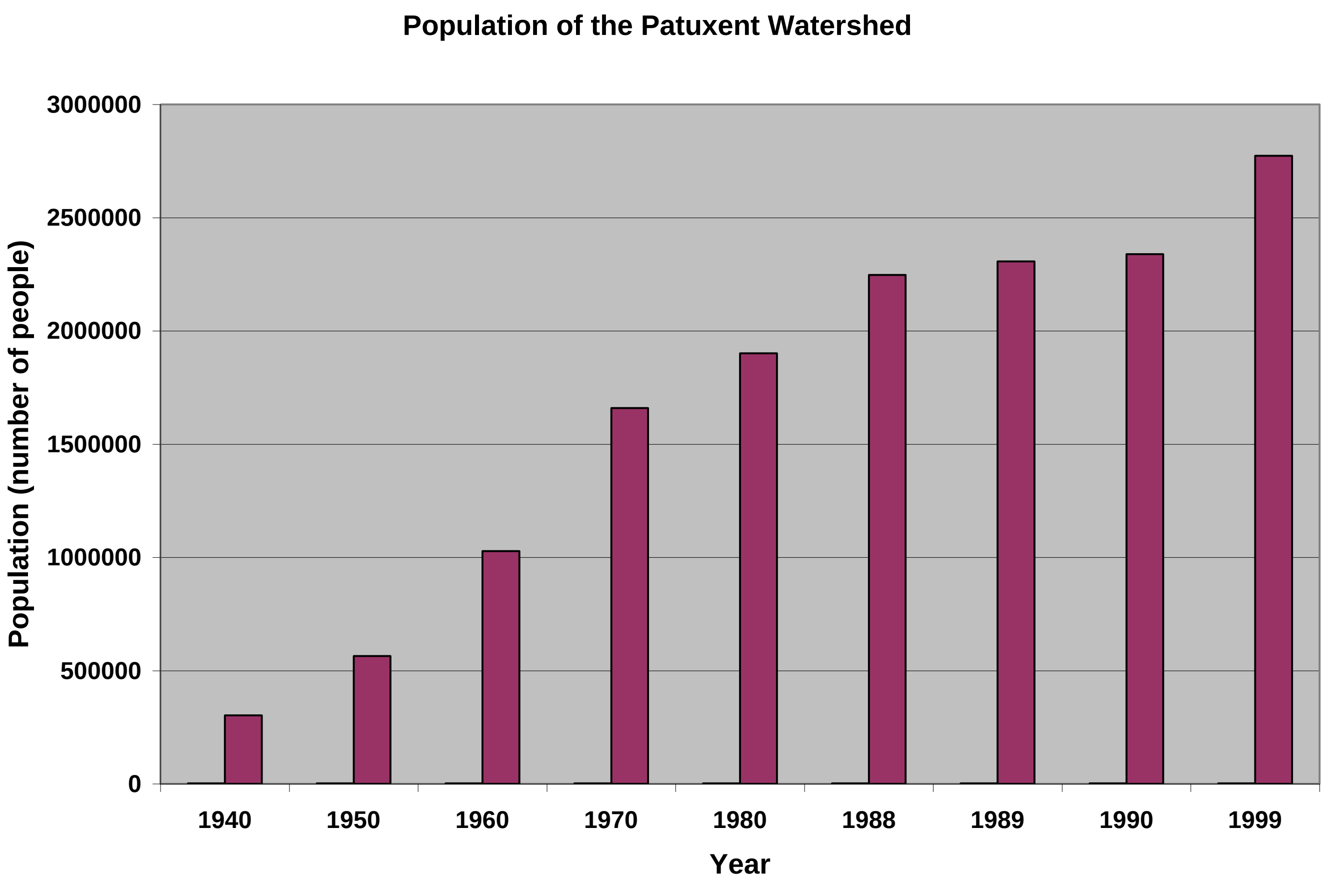
2. Using what you learned from the graph, describe how the water changed from 1940 to 1999.

Part B. Human Population Data

3. Study the graph below. It shows how many people have lived in the Patuxent watershed from 1940 to 1999.



4. Describe how the human population changed from 1940 to 1999 in the Patuxent River watershed.

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Part C. Putting It All Together

5. Compare the two graphs. How does the population change relate to the change in the water? Explain why you think this is so.

6. Think about what you have learned so far in this unit. In the space below list two things humans have done that probably caused the water to get cloudier. For each one explain **WHY** you think each cause is likely.

7. Explain why you think it got easier to see in the water after 1980.

4.10 Designing a Schoolyard

Summative Activity for Erosion & Runoff Unit

Overview

In this activity students will design a plan for a schoolyard that minimizes erosion and runoff. Use this activity to assess student mastery of material from the unit on Runoff & Erosion.

Lesson Characteristics

Use the table below for lesson planning purposes.

Time Required	1 hour
Key Concepts/Terms	Runoff, Erosion, Sedimentation, Water Quality, Land Use
Prerequisites	Students should understand all of the key concepts, above, as this is a summative activity for the entire unit.
Setting	Indoors, Pairs/Small Group

Learning Objectives

After completing this activity, students will be able to…

- Demonstrate understanding of how runoff, erosion, sedimentation relate to various land use decisions; and
- Demonstrate understanding of the relationships between runoff, erosion, sedimentation and water quality.

Materials Required

The following materials are required for this activity.

- Graph Paper
- Pencils/Markers

Procedure

Follow the steps in the table below to conduct the activity.

Phase	Step	Action
Engage	1	Review the concepts of runoff, erosion and sedimentation.
	2	Review mapping skills.
Explore	3	Pass out graph paper to student groups/pairs.
	4	Establish a scale, such as 10 feet = one square on the graph paper. ***Note:*** Students may have difficulty estimating the size of the area of a building or driveway. Give them the appropriate dimensions of the school buildings and any other large features to make it easier to get started. You should also practice this yourself beforehand, so that it will all fit on one sheet of graph paper.
	5	Hand out the ***Student Sheet – Design a Schoolyard***, pg. 4-74, and explain their task.
	6	Allow 20-30 minutes to devise and complete their plan.
Explain	7	Have students create a written or oral explanation of the impact of each feature on their plan. *Possible Student Plan Features:* • *Lessen runoff by altering gutters to put water in a rain garden or storage vessel.* • *Change impervious surfacing, like parking lots, to a more permeable material, or divert the runoff to sediment pond, rain garden, etc.* • *Cover the hard-packed surface of the playground with mulch to reduce runoff & erosion.* • *Plant buffer areas around streams to lessen sedimentation.*

Continued on next page

Procedure (continued)

Phase	Step	Action
Elaborate	8	Compare student plans with the actual plan for your schoolyard.
Evaluate	9	Performance Assessment Student schoolyard design plans. Assessment should focus on the following points: • Does the plan include all of the required features? • Is the plan drawn approximately to scale? • Does each part of the plan have a way to reduce runoff?

Student Sheet – Design a Schoolyard

Introduction

RUNOFF, EROSION and **SEDIMENTATION** happen when water runs off the land, rather than sinking in. This water picks up soil, trash and other pollutants. These are carried downhill to the nearest stream or river. To stop this we have to slow water down. Then sediment and pollutants can drop out or sink into the ground.

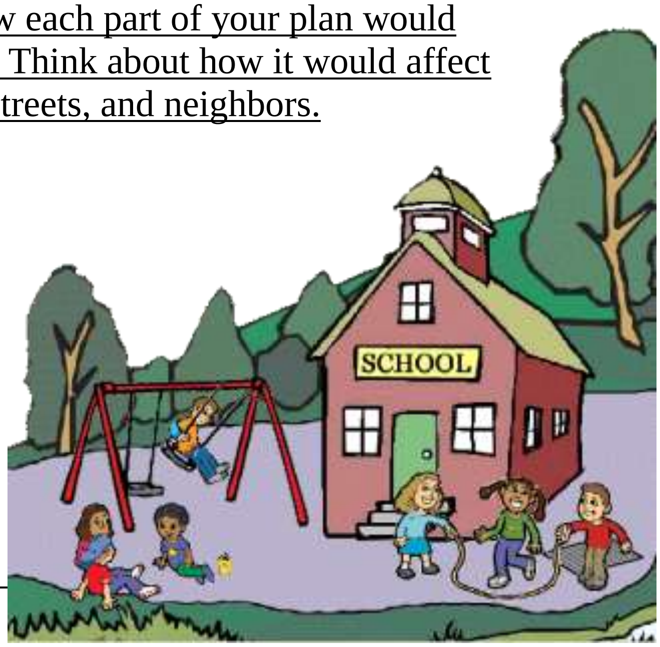
Your Assignment

Design a schoolyard that will cause as little damage to the environment as possible. Think about how water from rain and melting snow moves around your schoolyard. Can you limit runoff, erosion and sedimentation? Think about all the different ways people use your school property. How do these help or hurt the environment?

Your plan must include:

- The School Building
- Driveway
- Parking Lot
- Playground
- A Stream Along One Side of the Property

<u>You must explain how each part of your plan would affect the environment. Think about how it would affect the stream, streets, and neighbors.</u>



Overview

This section provides teachers with suggested Websites, books, videos and organization contact information regarding erosion and runoff.

Books

Conner, Susan L. & Lloyd A. Freeman. 2000. **Drinking Water Quality : Taking Responsibility Coloring Book** Waterworks Pub.
DESCRIPTION: *32 page coloring book that tells the story of drinking water, how it gets dirty and what it takes to get it clean again.* (Elementary reading level) ISBN: 0966252020

Stille, Darlene R.. 2005. **Erosion: How Land Forms, How It Changes** Compass Point Books
DESCRIPTION: *information about erosion by water, wind, and glacier and discusses the pros/cons of attempting to control erosion*. (Elementary reading level) ISBN: 0756508541

Websites

LaMotte: *leading company in water, soil and air quality testing equipment and services*
www.lamotte.com/environmental_education_monitoring.html/

Real Trees 4 Kids: *good general information about soil on this kid friendly tree farming Website*
www.realtrees4kids.org/ninetwelve/soil.htm

EPA's Planet Protectors Club :
www.epa.gov/wastes/education/kids/index.htm

AFF website—Kids' Zone: *Ways of a Watershed and The Water Cycle at*
fergusonfoundation.org/hard-bargain-farm/activities-lessons-links/

Agencies/ Organizations

Project WET: *nonprofit water education program for educators and children*
www.projectwet.org

International Erosion Control Association: *provides education, resource information and business opportunities for professionals in the erosion and sediment control industry.*
www.ieca.org

Maryland Department of Planning: *promotes growth that fosters vibrant, livable communities, preserves and protects the environment, and makes efficient use of State resources.*
www.mdp.state.md.us/