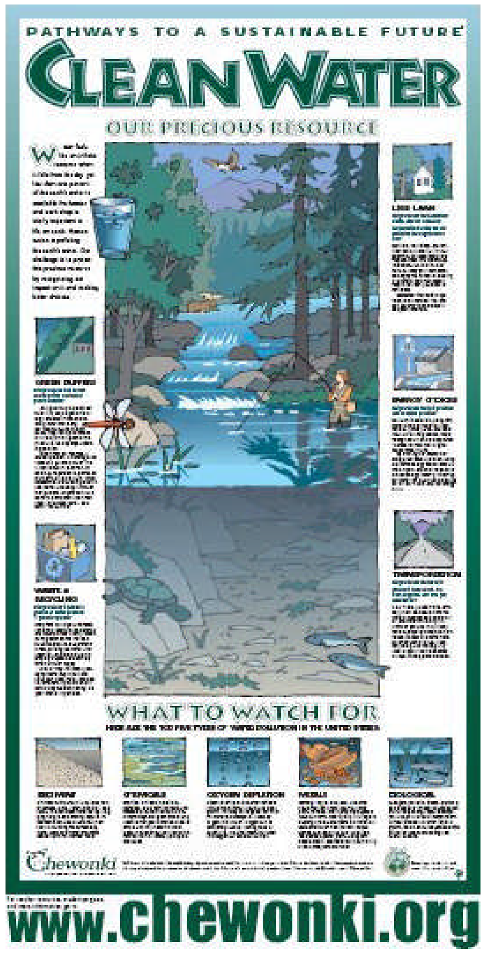
Clean Water Activities Module



The Chewonki Foundation
Wiscasset, ME

Pemaquid Watershed Association
Damariscotta, ME

INTRODUCTION

The Clean Water Activities is a collection of five lessons designed to augment the Clean Water Poster produced by The Chewonki Foundation. The lesson module and poster present a new "kit" of teaching tools for science classrooms and informal teaching forums. The lessons are geared towards upper-elementary-age through middle-school-age children and were developed, field-tested and reviewed by Midcoast Maine educators under the leadership of Tenley Wilder, Education Coordinator of the Pemaquid Watershed Association.

The goal of the lessons is to promote awareness, appreciation, understanding, and stewardship of water resources through the development and dissemination of classroom-ready teaching aids. The curriculum is available on the Internet for use by all water-related and environmental educators. The Clean Water Activities is an interdisciplinary environmental education module emphasizing the importance of caring for the future of the invaluable resource of water. As clean water is imperative to a healthy future for our world, we hope this curriculum and poster series instills a sense of responsibility and positive action in our young generation of water stewards.

The development of the learning activities was done largely through a synthesis of existing relevant learning activities, modified to pertain directly to the poster's content and refined to meet the current Maine Learning Results standards. The Less Lawn and Energy Choices activities were adapted from existing lessons that are part of the Project WET Curriculum and Project WILD Aquatic Education, whereas the Waste and Recycling, Green Buffers and Transportation activities were created exclusively by the Pemaquid Watershed Association. Although the text within the activities references Maine, the activities are designed to be transferable to a wide range of geographic locations.

The five activities included in this curriculum correspond to each of the five contextual areas highlighted on the Clean Water poster: Less Lawn, Green Buffers, Waste and Recycling, Energy Choices, and Transportation. Additionally, the activities were designed around behavioral learning objectives to promote critical thinking and problem-solving skills related to the pollution dimensions listed across the bottom of the poster (Sediment, Chemicals, Oxygen Depletion, Metals, Biological).

Each lesson includes a Navigation Bar that outlines the target audience of the activity, the time frame needed to complete the activity, and suggestions for other complementary lessons to be conducted before or after the current activity. These extension activities offer service-learning opportunities to integrate meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, encourage lifelong civic engagement, and strengthen communities for the common good.

A prerequisite for each activity is for students to have a basic understanding of a watershed and the movement of water through the hydrologic. The Clean Water Activities build upon these concepts so it is critical to have a good foundation in these areas before engaging students in the activities in this series. If further preparation is needed in these areas, please refer to Project WET activities ‘Branching Out’, ‘A Drop in the Bucket’, and/or ‘The Incredible Journey’.

The Clean Water Activities are available to educators through The Chewonki Foundation website (http://www.chewonki.org/pathways/pathways_cleanwater_poster.asp). Classroom teachers, environmental education specialists, park naturalists and others can adapt and integrate these activities to meet the needs of their curriculum, setting, time frame, and/or audience.

This program was developed by the Pemaquid Watershed Association, a nonprofit conservation organization serving the Pemaquid Peninsula in Maine (www.pemaquidwatershed.org). The Pathways to a Sustainable Future poster series project was funded by Poland Spring™ in recognition of their continued interest in the health of our natural resources.

Project Principals:
Tenley Wilder, Education Coordinator, Pemaquid Watershed Association
Donna Minnis Ph.D., Executive Director, Pemaquid Watershed Association
Peter Arnold, Coordinator, Pathways to a Sustainable Future, The Chewonki Foundation
Brendan Kober, Program Assistant, Pathways to a Sustainable Future, The Chewonki Foundation

Project Advisors:
Tracy Harkins, KIDS Consortium
Christine Smith, Maine Department of Environmental Protection

Waste and Recycling

As drops of water make the ocean, small steps can make a difference.

Navigation Bar

Target Audience:
Upper Elementary, Middle School

Subject Areas:
Earth Science, Mathematics/Reasoning

Duration:
Prep time: 15 minutes
Activity time: 45 minutes

Setting:
Classroom and computer lab

Skills:
Organizing (mapping); Gathering Information (observing, measuring); Analyzing (identifying components and relationships); Interpreting (generalizing and drawing conclusions); Applying (problem solving)

Charting the Course
A general understanding of what a watershed is should precede this activity, although it is not necessary to perform the activity. This lesson can be used as the introduction to the Clean Water series, or may be used as a stand alone lesson.

Vocabulary
✓ Ecological Footprint
✓ Reduce
✓ Reuse
✓ Recycle

Summary

Students monitor various aspects of their everyday actions (plastic waste production, food consumption and basic household activities), calculate their individual 'impact' on the world using an Internet model, and propose various ways to lessen their impact, specifically in regards to water conservation.

Objectives

At the conclusion of this activity, students will be able to:

- Identify the importance of clean water for all life
- Calculate their individual ecological footprint
- Identify different ways that pollution enters the water cycle through daily actions
- List 3 simple steps that each student can take to address issues of water conservation and environmental protection.

Materials

- Plastic waste from home
- Water Fact Sheet and (attached to lesson)
- Computer with Internet access
- Scale
- Writing materials

Making the Connection

Earth has a finite amount of fresh, usable water. Water is naturally recycled (collected, cleansed, and redistributed) through the hydrologic cycle. While humans have developed technology to aid in this process (filtration or treatment plants), factors such as drought, flood, population growth, contamination, etc. keep us from being able to adequately provide clean, usable water for all communities worldwide. We are using up and contaminating this limited resource faster than the hydrologic cycle, natural or assisted by man, can handle. Conservation and protection of water can ensure that supplies of freshwater will be available for everyone in the future.

Those of us who live in New England are fortunate as water is relatively plentiful and clean. As our population grows however, water conservation plays an increasingly important role in protecting the health of our state's lakes and streams and the safety of our drinking water supplies.

We can help safeguard our own health and the health of our neighbors by using less water. Water conservation improves septic system performance, which reduces the risk of groundwater contamination, and means less water gets diverted from streams. Water conservation also provides energy conservation savings, as less electricity is needed to heat, pump, and treat water. There are many other things we can do as well to ensure a 'clean water' future. Reusing plastic containers also can help conserve water and improve quality of the water, as less water will be needed to manufacture new plastics and less air pollution, the byproduct of manufacturing (including such things as chemicals, air pollution from coal, etc.), will be expelled.

Background

Water use is such an automatic and habitual daily activity that students often do not understand the consequences of its over-use. Seldom do they connect the water that comes out of a faucet to its sources in the natural world. The model that traces the dynamics of water is called the water cycle or the hydrologic cycle. The water cycle involves the path of water from when it falls in the form of rain or other precipitation on a watershed; to its travel as runoff that flows into streams, groundwater systems, lakes, reservoirs, estuaries and oceans; to its eventual return to the atmosphere through evaporation and evapotranspiration; to its formation into clouds; to its condensation in the form of precipitation as it again falls on a watershed in this continuing process. All forms of life on Earth are dependent upon and affected by this cyclical journey of water.

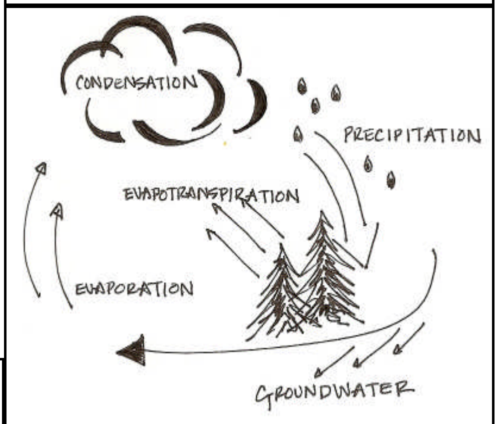
Procedure

***Warm up*- Student preparation before class:** Students should monitor their water use for five days prior to the in-class activity and record the results on the Student Water Worksheet (attached). Also, instruct students to be aware of the various products and services (packaged food? travel? etc.) they use or consume during the week. (Understanding their consumption habits will help when they calculate their ecological footprint.) As the warm up for the in-class activity, have students combine the data from their individual worksheets so that you have a total "water use" data table for the class. Have students calculate the gallons of water used by the students in just one week and list this on the classroom board. Have students read the Water Fact Sheet (attached) out loud. Were they surprised by any of these facts? Lead into the *Activity* by introducing the idea that what we observe as 'water use' is not the only way we deplete our clean water resource. What are some other activities we do every day that require water?

Water Information Table[1]
(All values are approximate)

Flushing a toilet	3-5 gallons
Shaving and letting the water run	3 gallons
Showering	5 gallons/minute
Cooking three meals	8 gallons
Cleaning house	8 gallons
Washing dishes for three meals	10 gallons
Washing clothes	20-30 gallons
Watering the lawn	30-40 gallons
Taking a bath	30-40 gallons
Washing a car	30-40 gallons

Hydrologic Cycle



The Activity

Reduce and Reuse:

Student preparation before class: Ask the students to collect and save every piece of plastic waste produced in their homes (or by them alone) for two days. Have them bring these materials to school. (Note: caution the students to clean the plastics before bringing them to school so that they are free of food and drink remains. Also caution them about toxins such as ammonia, chlorine, bleach, etc, which may be in the containers. Containers should be emptied and rinsed completely.)

Have each student weigh their bag of plastic trash on the scale at the head of the classroom and record the weight on the board. Have students calculate the amount of water required to manufacture all the plastic they collected for just two days (24 gallons of water = the production of one pound of plastic.) How much water was used to produce the amount of plastic they used in a week? How about a year? Once the water has been used to make the plastic, chemicals have been added, and the water is no longer 'clean' or usable. This contamination is just from plastic manufacturing. Have students brainstorm other aspects of our every day life that might affect the quality of our water.

Recycle:

1) Draw the hydrologic cycle on the board. Ask students where the water that they use daily comes from. Do they collect rain water in cisterns? Do they have individual wells, or are they part of a community aquifer? Once the water had entered their home and they have 'used' it, ask students where it goes. Is the water that goes down the drain clean?

2.) Have students discuss if they think clean water is important. If so, why? What do we need water for? (Agriculture, hygiene, health, drinking, etc.) Looking back at the weekly use chart, how much of their daily needs are in some way connected to water?

3.) Using computers with an Internet connection, have students 'calculate' their ecological footprint using the Bobbie BigFoot Calculator activity. (http://www.kidsfootprint.org/index.html). Ask students to consider how their daily use of water impacts their footprint.

Wrap Up and Action

Have students brainstorm ideas that each one of us can do to reduce our use of water, from being more conscious of uses of water in our homes, to making different choices regarding the products we purchase. How can they reduce their footprint, which can in turn help conserve the quality and quantity of the water. Have each student choose one action that directly or indirectly helps conserve 'clean water' and rerun the BigFoot calculation for the entire class with the projected behavioral changes. Was the class able to make a difference? Do the students believe that they each can help protect our water for future generations?

Assessment

Have students:

- Draw and label the hydrologic cycle and identify areas in the cycle where humans can negatively affect the quality of the water.

- Have students write a story on "Breaking News: Water Use at Highest Levels Ever!" and include in the text ways that their readers can reduce their water use and actions they can take to protect the quality of our 'clean' water.

Extension

Students present their new understanding of the importance of clean water to a younger grade level or create a poster illustrating ways to conserve and protect 'clean water' to be hung at school.

Discuss how we use water beyond what is normally thought of as daily 'water use'. The production of plastic is not limited to the 24 gallons of water. Chemical are used to manufacture plastics. Coal is burned for energy to run the machines that manufacture the plastics. This coal enters the atmosphere and thus our aquatic and marine systems through precipitation. Can you think of other ways that we indirectly affect our 'clean water' resource? Research in depth how we, as consumers, contaminate our water–from our purchases (such as prepackaged foods) to our actions (letting water run down the drain while it heats up when you could put a watering can under the facet and use the 'wasted water' for your houseplants). Prepare a presentation for a parents visiting night that will help illustrate how parents, as the primary purchasers of your household, can help you make positive changes in your family's water consumption at home and work/school.

Because plastics are made from fossil fuels, you can think of them as another form of stored energy. Pound for pound, plastics contain as much energy as petroleum or natural gas, and much more energy than other types of garbage. This makes plastic an ideal fuel for waste-to-energy plants. Waste-to-energy plants burn garbage and use the heat energy released during combustion to make steam or electricity. They turn garbage into useful energy. Discuss the pros and cons of burning plastics or recycling them? Sometimes it takes more energy to make a product from recycled plastics than it does to make it from all-new materials. If that's the case, it may make more sense to burn the plastics at a waste-to-energy plant than to recycle them. Burning plastics can supply an abundant amount of energy, while reducing the cost of waste disposal and saving landfill space. However, harmful contaminants may be releases into the atmosphere while burning the plastic. Have students research waste-to-energy options and discuss the benefits and drawbacks of such a system in their town.

Read the following case study to students and open up a discussion about the complexity of recycling.

"A study by Canadian scientist Martin Hocking shows that making a paper cup uses as much petroleum or natural gas as a polystyrene cup. Plus, the paper cup uses wood pulp. The Canadian study said, "The paper cup consumes 12 times as much steam, 36 times as much electricity, and twice as much cooling water as the plastic cup." And because the paper cup uses more raw materials and energy, it also costs 2.5 times more than the plastic cup. But the paper cup will degrade, right? Probably not. Modern landfills are designed to inhibit degradation so that toxic wastes do not seep into the surrounding soil and groundwater. The paper cup will still be a paper cup 20 years from now."

Being educated about the materials and the process of waste management can help us, as consumers, make better choices. Arrange for the class to visit a landfill or waste yard and interview the men and women who work with your communities waste every day. Ask for their input on how the community could improve, as they will probably have the most hands-on experience with this problem.
Start a recycling program at home or school and spread the word about ways we can all help reduce our 'footprint'. Look for ways to reduce packaging waste: buy in bulk and reuse your glass, metal, and plastic containers. If you are unsure how to dispose of something, ask your town or city officials.

Have students research the company Terra Cycle. Considering the ideas of reduce, reuse, recycle, how does Terra Cycle put these three 'R's into practice. Partner with Terra Cycle and set up a box to collect bottles at your school.

Resources

[1]Energy Information Association for Kids. http://www.eia.doe.gov/kids/energyfacts/saving/recycling/solidwaste/plastics.html#paperorplastic

National Resources Defense Council. http://www.nrdc.org/cities/recycling/ften.asp

Project WET. 1996. Activities "Alice in Waterland." *Project WET*. Bozeman, Mt.: Council for Environmental Education.

TerraCycle. http://www.terracycle.net/

Student Water Worksheet

How many times/day you flush the toilet?	
How many times/day you let the water run while your parents shave (or brush your teeth)?	
How long do you take in the shower (in minutes)?	
How many meals do you eat at home?	
How many times during the week do you or your family clean the house?	
How many loads of laundry do you do per week?	
How often do you water the lawn?	
How many times a week do you take a bath?	

Water Fact Sheet

*Washing machines use about 15% of your house's water. Each wash cycle uses 32 to 59 gallons- as much as two showers.

*A standard shower head uses about 5-7 gallons of water per minute (gpm)- so even a 5-minute shower can consume 35 gallons!

*"Low-flow" shower heads help reduce water use by 50% or more. They typically cut the flow rate to 2.5 gpm- or less.

*Water pumping is one of the largest uses of electricity in the arid Western states. Every drop of water we conserve also saves electricity.

*Turn off the water faucet when brushing your teeth. This simple act can save 9 gallons of water every time you brush.

* The normal faucet flow is 3-5 gallons of water per minute (gpm). By attaching a low flow faucet aerator, you can reduce the flow by 50%. Incredibly, although the flow is reduced, it will seem stronger because air is mixed into the water as it leaves the tap.

*40% of the pure water you use in your house is flushed down the toilet.

*If a family of four takes 5-minute showers each day, they will use more than 700 gallons of water every week--the equivalent of a three-year supply of drinking water for one person.

Less Lawn

The grass is <u>not</u> always greener...

Navigation Bar

Target Audience:
Upper Elementary, Middle School

Subject Areas:
Earth Science, Social Studies, Reasoning/ Communications

Duration:
(Some preparation the week prior to activity required)
Prep time: 10 minutes
Activity time: 50 minutes

Setting:
Classroom and outdoors– access to perimeter of school campus

Skills:
Gathering information (observing, collecting); Analyzing (comparing, discussing); Interpreting (summarizing)

Charting the Course
Students should be familiar with the hydrologic cycle and how precipitation is a key part of this process. A general understanding of what a watershed is should precede this activity. This lesson can be used as part of the Clean Water series, supported by the Green Buffers activity, or may be used as a stand alone lesson.

Vocabulary
✓ Non-point source pollution
✓ Point source pollution

Summary

Students will investigate just how much water falls on their campus during a rain storm.

Objectives

At the conclusion of this activity students will be able to:

- List 3 forms of pollution from humans that can result from runoff from a rain storm.
- Define non-point source pollution
- List 3 reasons why people should monitor what they put on their lawns.

Materials

- Writing materials
- Calculator
- Trundle wheel (optional)
- Long piece of twine marked every yard
- Yard stick
- Rain gauge
- Local rainfall data (optional)

Making the Connection

Rainfall is one form of precipitation and one way that water re-enters aquatic ecosystems. As the rain falls on the surface of the earth, it doesn't just stop where it lands. Once rain falls upon a surface, water begins to move both laterally outward and vertically downward. Lateral movement is runoff and finds its way into streams, river, lakes, and eventually the ocean. Vertical movement seeps into the soil and porous rock and recharges groundwater supplies.

While the concept of the water cycle may be well understood, runoff from rainfall is a relatively abstract concept. Although we may notice and in fact get drenched from a rainstorm, we don't typically stop to wonder how much rain is falling. The volume of the water in a rainstorm is astounding.

Runoff is the means by which many pollutants are picked up and find their way into moving waters, lakes, etc. Widespread sources of pollution such as garden insecticides, automobile emissions caked on parking lots, lead from paints and exhaust, etc., are washed by runoff into natural, aquatic ecosystems. Eventually, this water collects in channels such as streams and lakes and flows to the ocean.

Background

Contaminants whose entry point into the watershed is difficult to locate are classified as **non-point source pollutants**. Along with residential areas, agricultural fields and paved parking lots, school grounds can contribute non-point source pollutants. The schoolyard contributes **point source pollution** when the source of the pollution can be traced back to a specific location on the school grounds (e.g., sewer, ditch, pipe). Surface runoff flows over a school's grounds on its way to the collection site (river, pond, lake) and carries non-point source pollution as it travels, leaving the school grounds, and may carry soil, leaves and twigs; litter; oil and gasoline from parking lots; and fertilizer and pesticides from lawns.

While the root system of grass is advantageous to holding down soil, the depth of the root structure is often only as deep as the blades are tall. If the grass has formed a thick thatch layer, hardly any water can penetrate and all surface dirt and other stuff will be washed directly into nearby waterways just as quickly as if it were running over pavement. This can also happen when the ground is saturated with water due to heavy rains or snowmelt.

Procedure

Warm up-

The instructor should write the definitions of point source pollution and non-point source pollution on the board.

Provide students with a copy of the *Runoff Data Table* (attached) Ask: Based on the Runoff Data Table, which do you think absorbs more water, concrete or grass? Forests or residential areas? Why?

Point source pollution: *Pollutants discharged from any identifiable point.*

Non-point source pollution: *When pollution does not originate from one specific location .*

Runoff Data Table

Land Coverage	Average % Runoff
Forest	20
Grassland	10
Wetland	5
Residential	90
Agricultural	30

Ask: Why does a residential area indicate the highest level of runoff? (**Impervious** surfaces such as roads, sidewalks.) And, where would we most likely see the highest levels of pollutants such as litter, chemicals, or oil? (Residential) Which type of pollution, point or non-point source, would be found in a residential area? (Non-point source pollution as there is no one identifiable point of discharge.) Why? (Many of our daily activities result in putting small amounts of pollutants in our environment. Filling the lawn mower and spilling a little gasoline, throwing the gum wrapper out your window while you're in the car. Each small act can add up and create enough **non-point source pollution** to affect the natural world around us.) What problems could arise if water from a big rain storm runs quickly over surface material, gathering non-point source pollution? How might a quickly moving runoff from a big rain storm affect local water quality for either drinking or wildlife? And, how much water do you think qualifies a "big rain storm"?

The Activity

Collect *water in a rain gauge during the week leading up to the activity.* Once the area of the school grounds has been established, the next step is to determine the amount of rain that falls in the area. Three options are possible:

- Calculate the annual rainfall on the school grounds using information from your local resource agencies, e.g., weather bureau, soil conservation service, land trust or watershed association, local TV weatherpersons, local newspapers.
- Using a rain gauge measure the amount of rain over a period of time.
- Using a rain gauge, measure the amount of rain that falls during a given storm. Whichever method is chosen, the resulting data will provide the students with a value for the depth of rainfall on the surface of the land.

1.) Calculate the amount of land on your campus (teacher could provide this data or, time allowing, students could measure entire campus or a specific area such as the athletic field.

To begin, the students must determine the total area of the school ground. To do this, the length and width of the school ground must be measured. The students can use a length of twine (approximately 100 feet in length). For the purposes of this activity, the outer dimensions of the property will satisfy. There is no need to subtract the area of the buildings as it is assumed that rain falls upon them as well. The formula for calculating area is: Area = Length x Width or A = LW

Measure the twine every three feet with the yardstick and mark it with a black pen. If a trundle wheel is available, this may be convenient to use for measuring. (The school ground may be difficult to calculate as the perimeter may be irregularly shaped. Try not to get caught up in detailed exactness. A healthy approximation will suffice.)

> NOTE: A trundle wheel is a measuring device that operates a counter or clicks as it is rolled over the surface attached to a handle. Each revolution of the wheel represents one yard. Check to see if your school has one. City road crews often have them and may loan one to you for a few days.

2. With the depth of rainfall determined, and the area of the school ground measured, the next step is to calculate the volume of rainfall. For example, suppose the area of the school ground is 50,000 square feet and the rainfall during a spring storm brought three inches (.25 feet) then the volume of rain would be: 50,000 square feet x .25 feet = 12,500 cubic feet of rain. The volume of rainfall during that one storm is 12,500 cubic feet!

3. The measurements and calculations in this activity are intended to impress upon students that there are remarkable volumes of water moving through the water cycle even during short periods of time and in relatively small locations. All the water that students measure eventually finds its way to a wildlife habitat. A major issue of concern is how humans affect the quality and quantity of water that eventually reaches aquatic systems.

4. Once the concept of the volume of rainfall during a rainstorm is undertstood- not just the 1-2" projection students may hear on the Nightly News- gather students for a 10 minute round table discussion about the advantages or disadvantages of a nice, green lawn. (Some pros: excellent playing area for sports, cleanly appearance, good to sit on and eat your lunch. Some cons: constant mowing to keep 'neat', pesticides to control bugs, weed killers to ward of dandelions, fertilizers to keep grass green, watering during dry spells.) Help students make the connection between their calculated rainfall and what fertilizers are being used to keep their campus 'pretty'. If there was less lawn, would there be as great a need for fertilizers or pesticides? What do they think happens when rain washes over the campus? Have students name some potential pollutants which runoff might come in contact? What are some of the positive and negative effects that the water may have on the environment at various points on its journey.

Consider and discuss the following:

- With what kind of potential pollutants does the water from rainfall come in contact with on your school campus?
- Where is the location of the nearest wildlife habitat that receives the school's runoff?

Assessment

Have students:

- Name 3 human activities that have affected the quality of runoff
- Explain the difference between point source pollution and non-point source pollution, giving 1 example of each.
- Design a flyer describing steps individuals and communities can take to prevent surface water contamination and explaining why we should monitor what we put on our lawns.

Extension

(The *Buffers* learning activity will build upon the concepts presented in this lesson and may be used as an extension of the above activity.)

The metric system is considered the standard for scientific measurements. Introduce the metric system to your students and have them complete the activity with metric units.

100 feet = 30.48 meters
3 feet = 1 yard = .9114 meters
Square feet x .0929 = square meters
Inches x 2.54 = centimeters
Feet x .3048 = meters

Use Google Earth (http://earth.google.com/) to expand your geographic area and calculate the amount of rainfall in your town.

Work with your local soil and water conservation district and land owners to prevent or eliminate non-point sources of pollution such as erosion from roads and agricultural fields and organize local residents to explore the use of alternatives; require the use of catch basins, wide ditches, hay bales and storm water retention basins where appropriate.

There are many ways to improve the quality of water and our landscapes at the same time. Creative landscaping that requires fewer nutrients and chemicals and appreciating a natural environment are important steps to combating water pollution. Read Landscapes for Maine: Adding a Rain Garden to your Landscape from the University of Maine Extension Program, select a site on your campus, and design a rain garden to help 1.) improve the quality of water that seeps into the ground and 2.) decrease the quantity of water that flows over the campus as runoff.

Calculate the total area of the school playing fields. Then figure how long it takes to mow the grass. Beyond fertilizer and pesticide use, how is mowing degrading our environment? While maintaining good sports fields, is it possible to reduce the impact we have on our environment by using different chemicals or using a different method of lawn care? At first thought, lawn care might not seem like a major contributor to pollution. The U.S. Environmental Protection Agency, however, estimates that 17 million gallons of fuel are spilled each year just in refueling small engines—more than the Exxon Valdez spilled in the Gulf of Alaska accident in 1989—and that 10 percent of all air pollution is caused by our nation's 89 million small engines. In fact, one hour of operating a gas-powered mower generates as much pollution as driving a new car for eleven hours!

Thought-Provoking Facts

- Metals and solvents from industrial work can pollute rivers and lakes. These are poisonous to many forms of aquatic life and may slow their development, make them infertile or even result in death.
- Pesticides are used in farming to control weeds, insects and fungi. Run-offs of these pesticides can cause water pollution and poison aquatic life. Subsequently, birds, humans and other animals may be poisoned if they eat infected fish.
- Petroleum is another form of chemical pollutant that usually contaminates water through oil spills when a ship ruptures. Oil spills usually have only a localized affect on wildlife but can spread for miles. The oil can cause the death of many fish and stick to the feathers of seabirds causing them to lose the ability to fly.
- On the positive side, much of runoff is uncontaminated. Runoff waters are necessary to renew many aquatic habitats that are dependent upon inflow for continuity. The inflow prevents lakes from shrinking due to evaporation and it prevents streams from going below minimum flow levels. Inflow thus helps support aquatic life. Without runoff, aquatic habitats would suffer. And clearly, uncontaminated runoff is preferable to contaminated runoff!

Resources:

Environmental Protection Agency. http://www.epa.gov/glnpo/greenacres/toolkit/chap2.html

Project WET. 1996. Activities "Color Me a Watershed," "Rainy Day Hike," and "A-maze-ing Water," "Poison Pump." *Project WET*. Bozeman, MT.: Council for Environmental Education.

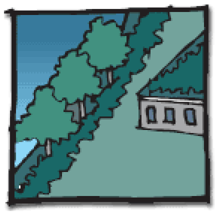
Project WILD. 1992. Activities "Where Does Water Run Off After School?" *Aquatic Project WILD*. Bethesda, MD.: Western Regional Environmental Education Council.

Runoff Data Table

Land Coverage	Average % Runoff
Forest	20
Grassland	10
Wetland	5
Residential	90
Agricultural	30

Green Buffers

Put buffers to work to reduce erosion!



Navigation Bar

Target Audience:
Upper Elementary, Middle School

Subject Areas:
Earth Science, Mathematics

Duration:
Prep time: 15 minutes
Activity time: 45 minutes

Setting:
Classroom and school campus

Skills:
Organizing (mapping); Gathering Information (observing, measuring); Analyzing (identifying components and relationships); Interpreting (generalizing and drawing conclusions); Applying (problem solving)

Charting the Course:
A general understanding of what a watershed is should precede this activity. This lesson can be used as part of the Clean Water series, especially supported by the Less Lawn Activity, or it may be used as a stand alone lesson.

Vocabulary:
✓ Best Management Practice (BMP)
✓ Erosion
✓ Impervious surface
✓ Non-point source pollution (NPS)
✓ Oxygen Depletion
✓ Riparian buffer
✓ Vegetation

Summary

Students conduct experiments to observe how water is absorbed into the ground and learn how pollutants, such as excess fertilizer, can be filtered — and soil erosion prevented by — vegetation.

Objectives

At the conclusion of this activity, students will be able to:

- Compare and contrast the ability of different types of ground surfaces to absorb water.
- Describe how nutrient and pollutant runoff and erosion threaten aquatic systems.
- Identify 2 Best Management Practices that can be used to reduce nutrient and pollutant runoff and erosion.

Materials

- Map of school grounds from Less Lawn Activity (optional)
- 3 large cylinders (e.g. V8 cans with the tops and bottoms removed; please cover the edges with a strip of duct tape for safety). Each cylinder should be marked with a circumference line using permanent marker two inches from the bottom edge.
- 3 stop watches
- 3 1-quart jugs of water
- 3 hammers
- 3 2 ft x 2 ft boards
- 3 soil testing kits (from your local soil conservation group or hardware/garden store)
- Writing materials and paper

Making the Connection

Riparian buffers (referred to in this lesson as buffers) are the single most effective protection for our water resources in Maine. These strips of grass, shrubs and/or trees along the banks of rivers and streams filter polluted runoff and provide a transition zone directly between human land use and the water. Buffers are also complex ecosystems that provide habitat and improve the stream communities they shelter. Naturally occuring riparian buffers have been lost in many places over the years. Restoring them is an important step toward improved water quality, riverbank stability, wildlife abundance and diversity, and aesthetics. Landowners, town road agents, local governments, farmers, and conservation organizations can all help restore and protect buffers which, in turn, restore and protect the quality of our waterways.

Excess water that runs off lawns, adjacent roads and sidewalks during rain storms can pick up sediment (soil), toxins (pesticides and metals), and nutrients (fertilizers) that may have been applied to the landscape. These three pollutants can impact the health of local waterways and, ultimately, a larger area such as the Gulf of Maine. By observing how **vegetation** absorbs water, students can think about the services that buffers provide and why these services might be important. Understanding how vegetation affects water's movement through a site promotes student appreciation of the relationship between water quality and landscape.

Background

As it flows over and through soil, water filters through spaces among particles and around plant roots and vegetative matter. This process slows the movement of water. Vegetation helps hold soil in place. When vegetation is removed (by human or natural causes), soil particles are more likely to be dislodged and carried away by water. Excess toxins, nutrients, and other pollution will also travel more quickly without a vegetative filter to slow the flow of runoff.

Soil being worn away from the earth's surface, carried by water, is a natural, ongoing process called **erosion**. When soil and organic matter are carried by water from one location to another, the destination site may be enriched. However, the effects of erosion are not always desirable. Erosion of topsoil decreases the fertility of soil, and sediment build-up in streams and lakes can be detrimental to aquatic ecosystems.

To reduce erosion and other water problems, **Best Management Practices** (BMPs) are used. Watershed managers rely on BMPs that reduce erosion and **non-point source**

pollution problems. BMPs that prevent erosion include: landscaping areas to promote plant cover; replanting areas cleared by logging; monitoring water that enters and leaves disturbed areas; building terraces, catch basins, and natural filters to mitigate sediment deposition in lakes, streams, and other waterways; and leaving a naturally vegetated or landscaped buffer in riparian areas.

Procedure

Warm up- what happens when pollutants enter an aquatic system?

A major environmental concern is how humans affect the water quality and quantity that reaches streams, rivers, lakes oceans, or our drinking water supply. Many students may be aware that chemicals such as nitrogen and phosphorus are used in fertilizers to help plants grow. Nitrogen and phosphorus are natural elements and vital to many ecosystems. However, too much of either of these chemicals can have a detrimental effect.

A bowl of cereal provides a clear analogy. Ask students how much sugar they like to spoon onto their breakfast in the morning. A spoonful? Maybe three if they can get away with it? Ask students if they would want to eat that bowl of cereal with 20 spoonfuls of sugar. While sugar, in small quantities, may make your breakfast tasty, an exorbitant amount would make the meal unappetizing.

Fertilizer works in a similar manner. A little nitrogen and phosphorus, two main components of fertilizer, can help terrestrial and aquatic plants thrive. Too much, however, can run off the land into a lake and cause large amounts of algae to grow. Large algal blooms can cover the water's surface. The algae die after they have used all the nutrients. Once dead, they sink to the bottom where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water. Once the oxygen is gone (**oxygen depletion**), many aquatic plants and animals die.

Other pollutants besides excess nitrogen and phosphorous can affect our aquatic systems. Soil, or sediment, is recognized as the biggest pollutant of all. Sediment is swept from roads and construction areas during rain storms. The sediment eventually finds its way into aquatic systems and covers the rocky bottom with a layer of dirt. Fish use rocky bottoms to make nests and lay eggs, so if the rocks are covered with dirt, fish are not able to find a suitable nesting site and won't reproduce. Garbage is also carried with fast moving water from a rain storm and can litter aquatic systems, harming plants, fish, birds and animals.

Have students discuss where the water from the rainfall goes when it leaves their school campus. Are there places on campus that seem to become saturated and soggy after a big storm? Is there any evidence of erosion? Think about how much water might be absorbed by the different surfaces on the school grounds? A dry, dusty lot or a parking lot are some examples of hard, **impervious surfaces** where water may not be easily absorbed. Ask students if they think some surfaces might absorb water (**permeable surfaces**) better than others (i.e. areas covered with grasses and plants, sandy soil, etc.)? With what pollutants might water runoff come in contact (i.e. oil from school buses, fertilizers, pesticides, cleaning products, trash)? Identify as many sources of potential contamination as possible on your school grounds. Remember that *soil* is considered one of the greatest causes of water pollution so any exposed dirt would be considered a pollutant.

The Activity

Identify places on campus that could be modified to reduce pollution that ends up in waterways.

1. Divide students into three groups to test the absorption rate of three sites, preferably sites that are landscaped or planted differently. Allow each team to decide which sites to test, but guide their decisions to include:
   a) an area of high pedestrian traffic with little or no vegetation
   b) a well manicured area at the foot of a slope, and
   c) an area with overgrown or natural, diverse vegetation, ideally a place that is not frequently fertilized.

2. Have students sketch their campus, including buildings, playing fields, parking lots, etc., or use your drawing from the *Less Lawn* activity and add in various features and structures. Mark the sites on the map where each group has chosen to conduct their permeability tests.

3. At each site, a team member should pound the V8 can into the ground to the 2-inch mark. This should be done by placing a board over the top of the can (to distribute the weight) and hammering on the board to push the can into the ground.

4. At each site, have the team pour the 1 gallon of water into the can.

5. Have each team use the stop watch to time how long it takes for all the water to be absorbed. Convert the time from minutes and seconds to just seconds and record this in your table. (Students may either create their own table, time allowing, as an activity in data collection and math theory, or may use the Sample Table attached to this activity.)

6. While two group members are monitoring the water absorption, the other group members should test nitrogen and phosphorous (as a representation of the nutrient/ fertilizer levels in the soil) at that site. Follow the directions on the soil test kit. Record these numbers in your table.

7. The team members that finish first (or if the group is larger, have the remaining students) should take notes of the characteristics of their site. Is their test site on a slope? Above/ below what? Is the area shaded? What is on the surface of the ground? Grass, leaves, mulch, etc.? Is there any litter or visible pollutants like oil spills around?

Wrap up and action

When students have completed their site testing, gather the class together and combine the findings in a table. Have students discuss why there might be differences in absorption rates or differences in nitrogen and phosphorous levels at the different sites. Do certain areas absorb water better? Do certain areas filter nitrogen and phosphorous better? Remind students how nitrogen and phosphorous can be good as fertilizers in moderation, but that an excess of these chemicals may enter an aquatic ecosystems and disrupt the balance of life in that system.

If more nitrogen and phosphorus was measured in the soils in areas of diverse vegetation, where do students think the nitrogen and phosphorus is going in the test sites that have poor vegetation? (Your local aquatic system!) From the table, the students should be able to determine that areas with permeable soil, natural vegetation (as opposed to landscaped beds) and a variety of plant, shrubs, etc. are best at absorbing a significant amount of water in a short time while also filtering out excess chemicals. Reveal that such landscaping, natural or planned, are called **buffers**! Buffers slow down the flow of water and filter out sediment, toxins, and nutrients that could reach aquatic systems while reducing erosion by holding soil in place.

Sample Table To Record Data

	Start Time	End Time	Nitrogen (N)	Phosphorus (K)	Notes/ Describe Your Site
Site 1					
Site 2					
Site 3					

Assessment

Have students :

- Explain how the school campus fits into the local watershed and how the current landscaping/types of ground surfaces on campus may positively or negatively affect the nearby aquatic ecosystems by how well they absorb water.
- Give 1 example of a problem that results from too much sediment, toxin, or nutrient runoff.
- Look at the map of their campus and determine where the highest rate of runoff might be. Name two BMPs that would help slow the flow of water and filter it before it enters an aquatic ecosystem?

Extension

Is there anything that is currently being done to reduce or eliminate excess nutrients and soil from entering your local waterways? Ask students to think about the possible benefits of buffers and native vegetation in regards to slowing down the speed at which runoff flows through your school grounds. Please see the *Less Lawn* activity for a continuation of this topic.

Design a buffer project with a “Buffer Fund” of $1000, keeping in mind that the project should encompass a 3-year scope to make sure the plantings are well established. Work with the maintenance and school administrators to create a buffer on your campus. Work with your classmates to design a fundraiser to raise the $1000 for your project. With the help of a local nursery or landscape professional, research native plants in your area by noting what is growing around your campus in the areas that have not been formally landscaped, as these will be the best types of plants suited to your locale and climate. Consider how your ‘Buffer Fund’ could be best put to use for plantings, maintenance, other landscaping features (such as boulders) should such be useful to help slow runoff, etc..

Resources:

Find helpful hints and tools for building your buffer on the Chewonki *Pathways to a Sustainable Future* website. http://www.chewonki.org/pathways/pathways_cleanwater_poster.asp

EPA. 2006. Activity “Superfund for Students and Teachers, Soil Soakers.” http://www.epa.gov/superfund/students/clas_act/fall/soakers.htm

Project WET. 1996. Activities “Rainy Day Hike,” “Branching Out!” and “Just Passing Through.” *Project WET*. Bozeman, Mt.: Council for Environmental Education.

Transportation

Roads carry speeding cars – and speeding water, too!

Navigation Bar

Target Audience:
Upper Elementary, Middle School

Subject Areas:
Earth Science, Social Studies, Reasoning/ Communications

Duration:
Prep time: 15 minutes
Activity time: 50 minutes

Setting:
Classroom and outdoor area

Skills:
Analyzing (identifying components and relationships); Interpreting (generalizing and drawing conclusions); Applying (problem solving)

Charting the Course
A general understanding of what a watershed is should precede this activity, although it is not necessary to perform the activity. This lesson can be used as part of the Clean Water series, especially supported by the Waste and Recycling activity, or may be used as a stand alone lesson.

Vocabulary
✓ Impervious surface
✓ Non-point source pollution
✓ Peak flow
✓ Urban runoff

Summary

Students interpret graphs to explain cause-and-effect relationships and compare runoff in urban and non-urban areas.

Objectives

At the conclusion of this activity, students will be able to:

- Define urban runoff
- Define non-point source pollution and list 3 sources of contamination in urban runoff
- Site 2 reasons why flow rates might differ in urban and rural waterways
- Explain which size culverts might better able to handle a peak flow in an urban area and why

Materials

- 2 Cafeteria trays
- Various sponges
- 2 containers with an equal volume of water
- 2 plastic dish pans
- A measuring cup
- Flow vs. Time graph of two imaginary streams
- Student worksheets and Answer Key
- Paper cups
- Drinking water
- Cocktail straws
- Standard drinking straws

Making the Connection

Remember the hydrologic cycle from *Waste and Recycling*? In this lesson, we are going to focus on the precipitation component of that cycle. When water falls from the sky in the form of rain, sleet or snow, it can end up traveling many different paths before it returns to the atmosphere during transpiration. Water percolates down through the soil and ends up as groundwater. As precipitation soaks into the soil, it is drawn up through plant roots and released back into the atmosphere. Water can also flow over the surface of the land into a local body of water like Pemaquid Lake in Maine. When this surface flow occurs in urbanized areas, with water flowing over streets, parking lots, construction areas, and golf courses, it is called **urban runoff.** Human-caused sources of overland water flow, such as sprinklers, are also included in the definition of urban runoff. Heavy rain storms cause large quantities of water to flow into natural systems such as lakes, and, often, the water flows in at a faster rate than the natural system can handle, carrying with it the contaminants it picked up along the way. Rainwater can become severely contaminated in the process of flowing across the urban landscape. This usually results in flooding, which can have disastrous results in urban areas. Some of the contaminants that are picked up by runoff include:

- Motor oil (dripping cars, dumping of used motor oil)
- Antifreeze or coolant (dripping cars, dumping of used antifreeze or coolant)
- Other automobile fluids and greases
- Rubber dust from tires
- Pet wastes
- Fertilizers and pesticides
- Paints and thinners (disposed of improperly or dumped down a storm drain)
- Dirt from construction sites or unpaved roads
- Leaching of pollutants from Industrial yards
- Litter

Background

There are several important differences between runoff in an urban setting and runoff in a rural setting. In an urban area, cement, asphalt, and other impervious surfaces (surfaces that are not permeable) cover more land area. Water that would soak into the ground in an area with fields and forests cannot soak into city pavement and literally "runs off" the paved surfaces. Also, because pavement moves water efficiently, urban flows tend to move much faster, peak sooner, and have more scouring power than rural flows. So not only are more contaminants (such as pesticides, fertilizers, oil, and grease) found in urban areas, but the rapidly moving water is more capable of picking up contaminants and washing them into a nearby water body.

One of the major factors contributing to urban runoff pollution is simple ignorance of storm water systems and storm drains. Storm drains, the metal grates seen along curbs and in streets, do not lead to water treatment plants. Storm drains and culverts are designed to drain rainwater off the streets and put the water as quickly as possible into local lakes or rivers to prevent flooding. This complex system of underground pipes is an essential part urban planning. Culverts, the pipes that divert surface water, also help maintain safe roads. By diverting the water, soil beneath the road and the pavement surface are not as frequently washed away during a big storm. The excess water from a rain storm flows through the path of least resistance. In this activity, students will study flow rates in a man-made concrete river system (or underground storm water pipes as pertinent to your region) and in a natural river.

Procedure

Warm up-

Ask students to think about what happens during a large rainstorm. Do little "rivers" form in their yards? Is there a lot of water running down their driveways to the street? Where do they think all that water goes?

Set up two cafeteria trays. On one, place a series of sponges at random, explaining that these represent a porous surface such as one might find in a field or forested area. The other tray will represent an urban area with impervious surfaces. The hard plastic tray is non-porous, as are pavement and sidewalks. Prop the trays at an angle to represent a slight hill.

(Important: Have two dish pans ready at the bottom of each tray to catch the water as it flows off the trays!) Pour two containers of water of equal measure, one on each tray. What happened on the urban tray? The rural tray? Have students measure the water that flowed off of each tray and discuss which locale might experience more flooding in a real rain storm and why.

Has your town experienced any floods in the recent past? Ask students to share what they know about floods and storm drains with their fellow classmates.

The Activity

Indoor Component

1) Place students in small working groups.
2) Distribute copies of the Flow vs. Time graph or enlarge and post it so that all students can see it. The graph compares runoff data from two imaginary streams that are similar in size, location, and amount of rainfall during a storm. The two creeks differ only in their surroundings. Countryside Stream flows in a forested or natural area, and City Stream is an underground storm drain that flows through an urban area.
3) Next, distribute a student worksheet to each group. Explain that when a stream is carrying the greatest amount of water it has "peaked." Ask groups to complete worksheets using information from the Flow vs. Time graph.

Outdoor Component- *with the differences between a rural area and an urban area demonstrated through the Flow vs. Time worksheet and graph, it is time to take a closer look at an urban area.*

4) In each group, designate a 'straw-blower'. The straws will represent two sizes of culverts that are currently being used in your town. The designated student will take a large sip of water, place the standard straw to their lips and blow the water through it. Repeat this step with the cocktail straw. What happens? Have the students report to the entire class their groups' results. (The water should have flowed quickly through the standard straws while the cocktail straws may either have caused sore cheeks from trying to push the water through the small straw- or the water may have 'found a path of lesser resistance' and escaped through the lips, bypassing the straw altogether... a "flood"!)

5) Continue this step if you have time or use it as an extension.) Climate change brings a new element to the picture. Experts have predicted that climate change will bring heavier and more frequent rainfall patterns throughout the northeastern United States. The current diameter of culverts may not be able to handle the increase flow during peak rates. Have students discuss what might happen if a culvert is not big enough to handle a peak flow and fails. (The road may wash out for miles!) In Keene, New Hampshire, a group of conservationists, scientists and students considering this possible problem were suddenly forced to face the issue in 2004 when many of their culverts were not able to handle the peak flow and many roads were destroyed. Have students discuss how in an urban area, with a high peak flow due to urban runoff, certain culverts might be more effective than others. If they were on an urban planning board, would they recommend a narrow diameter culvert or a wide diameter culvert to be installed under the roads?

Assessment

Have students :

- Define urban runoff
- Have students write a haiku poem that defines non-point source pollution and includes three sources of contamination in urban runoff
- Site two reasons why flow rates might differ in urban and rural waterways
- Explain which size culverts, might better able to handle a peak flow in an urban area and why

Extension

Set up a mock town meeting with the students divided up into different interest groups, including construction workers, Department of Transportation officials, a town planning board, a conservation association, and commuters. Weigh the costs and benefits of replacing none, some, or all the culverts in your town in anticipation of a heavy rainfall.

Students may choose to work with town officials to monitor flow rates in local culverts and determine if preventive action by replacing the culvert with a larger pipe is cost effective. (Have students consider the alternative cost of replacing an entire, washed out roadway.)

Have students complete the storm drain stenciling activity Water Actions from Project Wet™ to help educate others about runoff, protecting our natural aquatic systems, and reducing the contaminants that reach our lakes and streams.

Current Maine Events in the News! This Could Be You!

KITTERY STUDENTS STENCIL STORM DRAINS TO RAISE AWARENESS

With the help of the Spruce Creek Association students from Traip Academy and Shapleigh Middle School will be stenciling the phrase "Keep it Clean – Drains to Creek" on area storm drains in an effort to educate the public and raise awareness regarding stormwater and the path it takes to receiving water bodies -- in this case, Spruce Creek and the Piscataqua River. It is a common misconception that stormwater, which is rain that does not soak into the ground, is treated at the local wastewater treatment plant, but in fact stormwater is not treated. Stormwater runoff can consist of oil, gasoline, chemicals, and litter, as well as sediment and organic matter, such as leaves and lawn clippings. This overload of pollutants has a negative impact on aquatic life and the overall nature and recreational appeal of the water body.

Students from both Traip Academy and Shapleigh Middle School in Kittery will be stenciling storm drains on Wednesday, May 30th and on Thursday May 31st. Juniors and seniors from Traip Academy will stencil storm drains near the River from 12:30 a.m. to 2:00 p.m. on Wednesday as a part of their "Coastal Resources" classes. Students in the "Environmental Sciences" class will then stencil in Admiralty Village on Thursday. Also, sixth graders from Shapleigh Middle School will be stenciling storm drains in the parking lots of the Kittery Trading Post and the Tanger Outlet Center stores, located on Route 1 in Kittery, on Wednesday, May 30th from 2:00 to 4:00 p.m. as a school volunteer activity.

Storm Drain stenciling is a popular, nationwide, public awareness initiative arising from the result of new stormwater regulations. Recently, 28 communities in Maine have become subject to the Phase II Stormwater Regulatory Program, which regulates stormwater discharge from small municipalities. Part of the regulation requires the use of public education to raise awareness concerning stormwater pollution while at the same time promoting ways the public can help reduce it. The Town of Kittery is subject to the new regulation.

What's the Flow? Answer Key

1. 75 ft^3 2. 320ft^3 3. about 2 a.m. Sunday 4. about 8 a.m. Sunday

5. City Stream experienced a rapid flooding as water fell on paved areas; it wasn't absorbed into the ground and ran off. Countryside Stream peaked at a slower rate as the water was absorbed and slowed by vegetation. Trees soaked up the water, absorbing the impact of rain on the ground, and their roots provided passageways for water to sink into the ground.

6. The vegetation and ground in the Countryside Stream area absorbed the water. The paved areas around City Stream did not.

7. Countryside stream because there would be less risk of flooding.

8. With Countryside Stream, more rainfall was absorbed by the soil and vegetation, which keep dribbling out their supply after the storm itself has ended, like a sponge. This makes for a more gradual drop-off in the streamflow.

9. Oil, fertilizer, pesticides, detergent, animal wastes, etc.

Resources:

Earth Observatory. http://earthobservatory.nasa.gov/Newsroom/MediaAlerts/2005/2005101120687.html

New Hampshire Office of Energy and Planning. http://www.nh.gov/oep/newsletters/Flood_Lines_V1_I2_Spring07.pdf

Spruce Creek Association. http://www.sprucecreekassociation.org/stencil.html

St. Johns River Water Management District. http://sjr.state.fl.us/education/

What's the Flow?

1. How much water was Countryside Stream carrying when it peaked? _______________

2. How much water was City Stream carrying when it peaked? ________________________

3. When did Countryside Stream peak? ____

4. When did City Stream peak? ____

5. Why did one stream peak before the other?

____

____

6. Why did one stream peak lower than the other?

____

____

7. If you were going to build your home near a stream, which would you rather live by? (Think about the possibilities of flooding and also the pleasures of living near trees and wild-life.)

____

____

8. Why did the water level in Countryside Stream go down slower than in City Stream?

____

____

9. What else besides water gets washed into storm drains and streams as runoff when rain hits city streets?

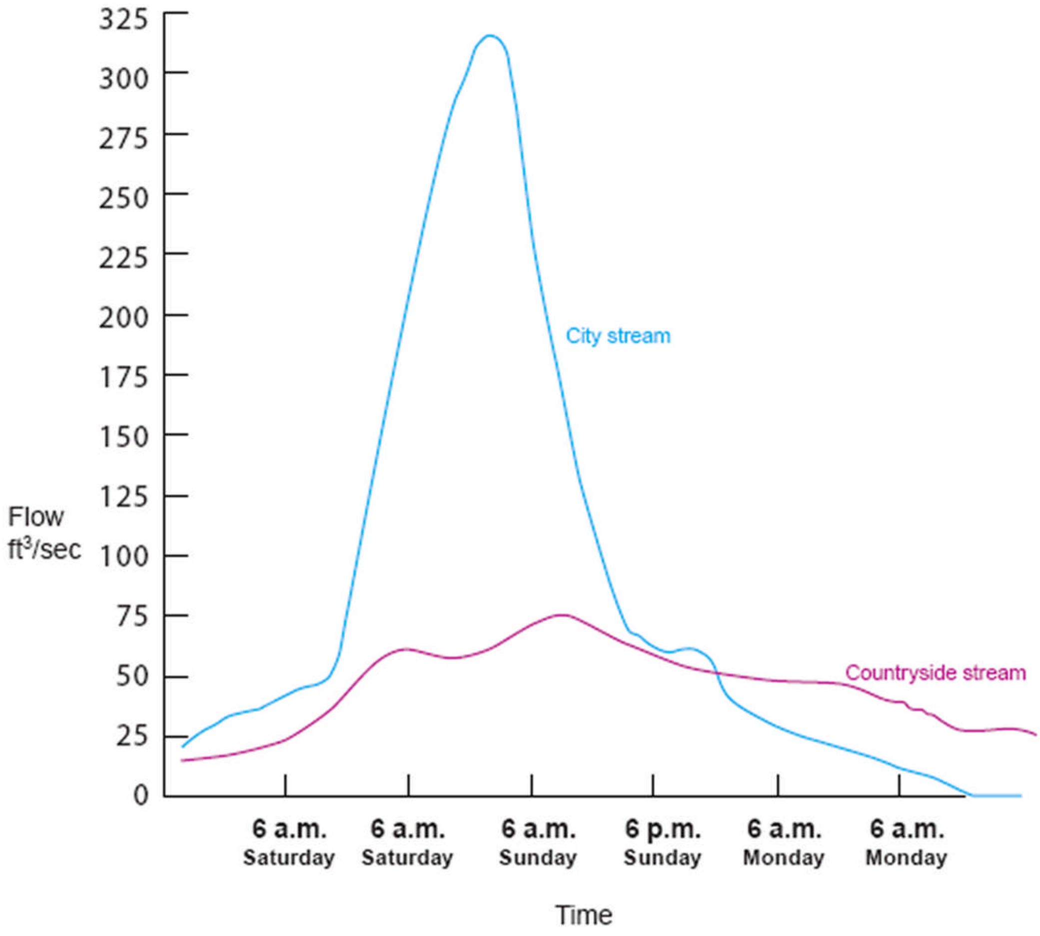
____

____

____

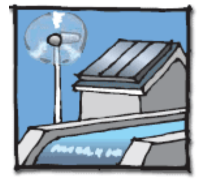
Flow Chart

The Transportation of Water through Waterways in Different Locales



Energy Choices

Tracking a Toxin: From Fuel to Air to Water to Wildlife to Us



Navigation Bar

Target Audience:
Upper Elementary, Middle School

Subject Areas:
Earth Science, Social Studies, Reasoning/ Communications

Duration:
Prep time: 10 minutes
Activity time: 50 minutes

Setting: Classroom

Skills:
Gathering information (observing, collecting); Analyzing (comparing, discussing); Interpreting (summarizing); Critical Thinking (awareness of the connections within our environment)

Charting the Course:
Prerequisite Knowledge: Students should understand what a fossil fuel is and what some of the alternatives are (e.g., solar, wind). Students also should have a basic understanding that burning fossil fuels causes gases, such as CO_2, to get caught in the atmosphere, which results in air pollution. Use this lesson as part of the Clean Water series, or it may be used as a stand-alone lesson.

A general understanding of the hydrologic cycle should precede this activity.

Vocabulary:
✓ Fossil Fuel
✓ Bioaccumulation
✓ Ecosystem

Summary

Bioaccumulation of heavy metals in our aquatic ecosystems is a big problem. Reducing our reliance on fossil fuels can reduce health risks to wildlife and humans. How? Read on to make the connections!

Objectives

At the conclusion of this activity, students will be able to:

- Describe at least 1 process by which a heavy metal pollutant can get from coal into our waterways.
- Summarize the process of bioaccumulation in an aquatic food chain.

Materials

- 10 very small containers (1-2 oz)
- 5 small containers (4-5 oz)
- 3 medium containers (~8 oz)
- 1 clear container (able to hold about 7-8 cups of water)
- 36 small beads of uniform size (or something similar) in 3 distinct colors: 20 in one color; 10 in the second color, and 6 in the third color.
- A map of your state showing waterways (a state highway map will usually work)
- Paper and drawing instruments
- 3 handouts (attached)

Making the Connection

Fossil fuels (oil, natural gas, coal) are burned at power plants and in homes in order to create energy that we use everyday for light and heat. When fossil fuels are burned, gases are released into the Earth's atmosphere; if too many of these gases enter the atmosphere, our air becomes polluted. This pollution then falls to the earth with precipitation. So, by only using the energy that we need and not wasting energy, we reduce the amount of air pollution, which in turn reduces water pollution, too!

Some toxic chemicals **bioaccumulate** in wildlife. Scientists discovered this phenomenon when they noticed that the levels of certain chemicals in some animals' bodies were significantly higher than in the surrounding environment. Many types of chemicals are stored in fat tissues and thus are eliminated by animals far more slowly than they are consumed. Over its lifetime, an animal will gather and store toxic chemicals at levels far above those in its environment. These levels were highest at the top of food chains. Because this bioaccumulation happens at each successive level of a food chain, the more links there are in a food chain, the higher the levels of toxic chemicals. Predators, such as polar bears, eagles, and people, are at the top of long food chains and sometimes accumulate concentrations of toxic chemicals in their bodies hundreds of times greater than those in the surrounding environment. Bioaccumulation in humans can lead to serious health risks, including cancer.

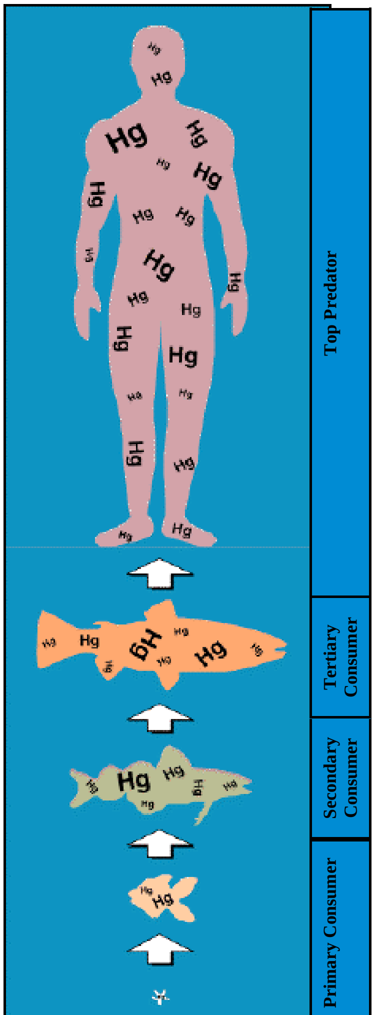
The plants and animals in an **ecosystem** are dependent upon each other for food energy, oxygen, nutrients, and the other building blocks of life. When one group of organisms within an ecosystem is affected by pollution, whether it is bioaccumulation or another form, all other organisms are affected.

Background

Students might not readily make the connection between air pollution from fossil fuels as harmful to our water. This activity will help not only draw that connection but lead students to think about bioaccumulation in the wildlife that are part of aquatic ecosystems.

Air pollution contributes substantially to water pollution. Pollutants like mercury, sulfur dioxide, nitric oxides, and ammonia deposit out of the air and then cause problems like mercury contamination in fish, acidification of lakes, and eutrophication (nutrient pollution). Most of the air pollution that affects water comes from coal-fired power plants and the tailpipes of our vehicles, though some also comes from industrial emissions.

Mercury is a silvery, liquid metal at room temperature and is often referred to as one of the "heavy metals." Like water, mercury can evaporate and become airborne. Because it is an element, mercury does not break down into less toxic substances. Once mercury escapes to the environment, it circulates in and out of the atmosphere until it ends up in the bottoms of lakes and oceans. Mercury can be found as the elemental metal or in a wide variety of organic and inorganic compounds. Depending on its chemical form, mercury may travel long distances before it falls to earth with precipitation or dust.



Mercury (Hg) Bioaccumulation in Humans
University of Wisconsin Extension[2]

Bioaccumulation in Fish and Humans
Bacteria and chemical reactions in lakes and wetlands can change mercury into a much more toxic form known as methylmercury. Fish become contaminated with methylmercury in two ways: by absorbing it and by eating plankton and smaller fish that have absorbed it. Mercury continually builds up in a fish's bodies for as long as the fish is exposed to it. Fish that eat other fish become the most highly contaminated due to bioaccumulation. Thus, the largest fish tend to be the most contaminated.

When people eat contaminated fish, the methylmercury can remain in their bodies for a long time. If they eat fish containing methylmercury faster than their bodies can get discharge it, the methylmercury accumulates in their bodies and can be toxic. For this reason, many states have fish consumption advisories to inform people about how many meals of fish they can safely eat over a period of time.

Where Does Mercury Come From?
Mercury is a naturally occurring element. Mercury ore, known as cinnabar, is mined in Spain, Algeria, Kyrgyzstan and China. Mercury is also a byproduct of gold and zinc mining. Mercury enters the environment from:

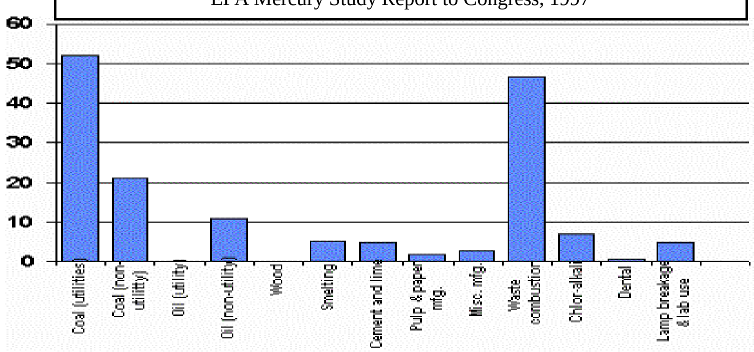
- Natural sources such as volcanoes and the weathering of rocks
- Our intentional uses of mercury
- Our unintentional releases of mercury from burning fossil fuels and smelting metals

Mercury's Environmental Effects
Fish are the main source of food for many birds and other animals, and mercury can seriously damage the health of these species. Loons, eagles, bears, otters, mink, kingfishers and ospreys eat large quantities of fish. Recent research in Minnesota indicates that the following environmental effects are occurring:

- Loons are accumulating so much mercury that it may be affecting their ability to reproduce;
- Elevated levels of mercury have been found in mink and otters;
- Walleye reproduction may be impaired by the fish's exposure to mercury. (University of Minnesota[1])

Similar effects are being documented for other fish and fish-eating species around the United States and Canada. Has there always been mercury contamination, or is this a recent problem? This is a difficult question to answer, in part because of a lack of adequately preserved fish specimens of preindustrial age to compare against contemporary samples. However, several lines of evidence from recent studies on Wisconsin lakes suggest that increased emissions to the atmosphere, and subsequent higher deposition rates to lakes, likely translate into higher mercury levels in fish. (University of Wisconsin Extension[2])

1994-95 U.S. Mercury Emissions (in tons)
EPA Mercury Study Report to Congress, 1997



Procedure

Warm Up

Provide some background information concerning the characteristics and origins of mercury. Ask students to count how may appliances, lights, computers, etc. are on in just their classroom. Estimate how many 'things' are on in the whole school. Where does the energy come from to keep the classroom lit and powered? Explain that in 2005, 50% of the country's energy came from burning coal. Before starting this activity, students should have a basic understanding that burning fossil fuels causes gases, such as carbon dioxide, to get caught in the atmosphere, which results in air pollution. This process also released mercury! Ask students if they are aware of air pollution in the area; does smog appear in the area? Are there factories where the air smells bad and it's harder to breathe?

As you start the activity, help students make the connection that the majority of mercury enters lakes, streams, rivers, and oceans from the atmosphere via precipitation. It is important to understand why mercury is in the atmosphere because once we understand the causes, we can concentrate on controlling the sources.

Hand out both the EPA graph illustrating the U.S. Mercury Emissions and the diagram of the mercury cycle.

The Activity

1. Fill all the containers 1/3 full with water.
2. Use the beads to represent mercury. Put 2 beads of the first color in each of the 10 very small (1-2 oz.), 2 beads of the second color in the 5 small containers (4-5 oz), and 2 beads of the third color in the 3 medium containers (8 oz).
3. Using the mercury cycle diagram as a guide, have the students label the 10 very small cups as the micro-organisms, the 5 small cups as the animal that eats the microorganisms (small fish, insects, etc.), the medium cups would be the animal that eats the small ones and the clear container will represent a top predator.
4. Have the students help you with the demonstration and put the food chain and bioaccumulation into action. First the 10 very small containers (they are being eaten by the primary consumer) are poured into the small containers. Some of the beads/beans may stay in the each container as you pour, which is okay because it represents the mercury that is excreted by the animal (i.e., not 100% of the mercury accumulates). Now the small containers will be "eaten" by the medium or secondary consumer. Finally, the medium cups are "eaten" by the top predator (tertiary consumer). Discuss what just happened with special emphasis on the number of beads. How much of the mercury was accumulated by the top predator relative to how much was in the earlier links in the food chain?
5. Hand out the *Bioaccumulation in Humans* chart and discuss how the chart illustrates what has been demonstrated in the activity.

Assessment

Have students :

- Explain how mercury, although released into the atmosphere by burning fossil fuels, how does it end up in a pond? (Precipitation)
- Describe how they can reduce the amount of Mercury through simple daily actions. (Turn off lights, etc. to reduce energy consumption which will in turn reduce energy production.)
- Draw a diagram or picture showing the movement of mercury from a coal-burning factory to their fish sticks dinner. You may give students a scrambled list of the following words as a hint:

Air	Algae
Clouds	Big Fish
Rain	Human
Small Fish	Pond
Aquatic Insects	Factory Chimney

Extension

Since air pollution can lead to water pollution, and the single best thing a person can do to reduce air pollution is to use less fossil-fuel-derived energy, have students make a poster for the school about conserving energy and how this can, in turn, help keep our water resources clean.

Work with your school administration to reduce the overall energy consumption of the school. By disconnecting soda machines and turning off unnecessary lights at night, your school will use less energy. This in turn could result in less mercury entering our atmosphere because energy suppliers will not need to produce as much energy.

Visit the Chewonki website and check out the Renewable Energy poster for more lessons and insight into the world of energy.

Resources:

Biodiversity Research Institute, www. briloon.org

Energy Information Administration, www.eia.doe.gov/fuelelectric.html

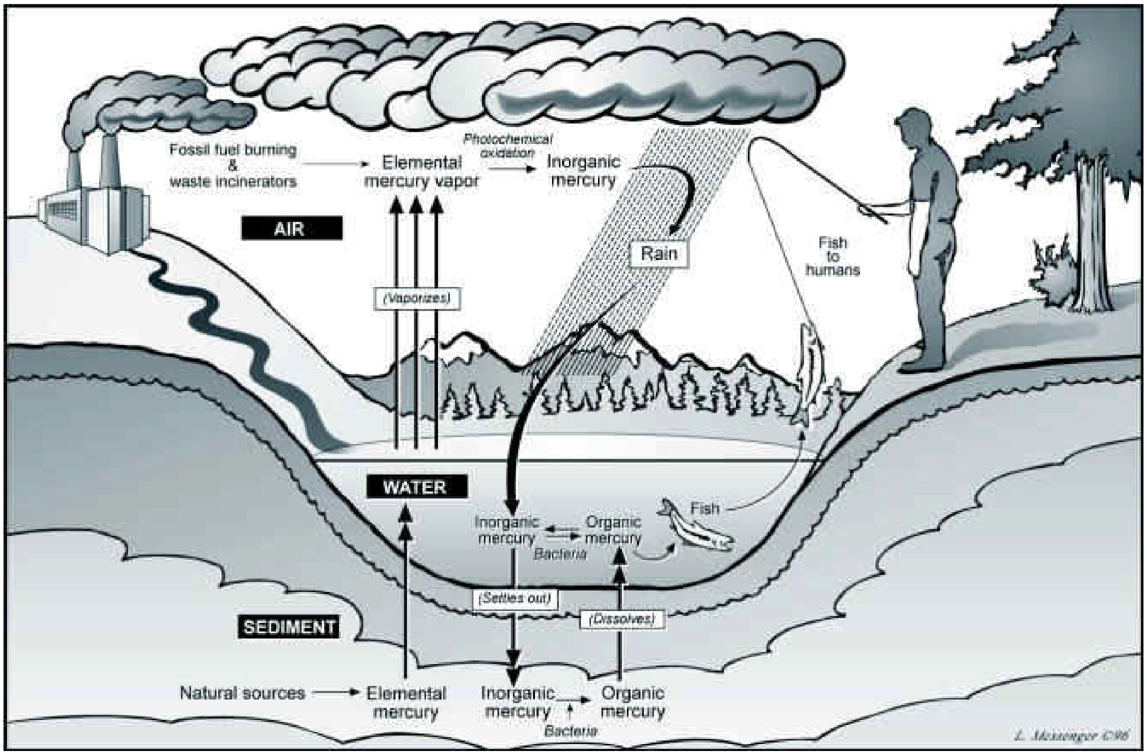
Environmental Protection Agency. http://www.epa.gov/mercury/, http://www.epa.gov/mercury/report.htm

US Geological Survey. http://toxics.usgs.gov/definitions/biomagnification.html, http://wi.water.usgs.gov/pubs/FS-216-95/

[1]University of Minnesota; Environmental and Occupational Health. http://www1.umn.edu/eoh/hazards/hazardssite/mercury/mercriskassess.html

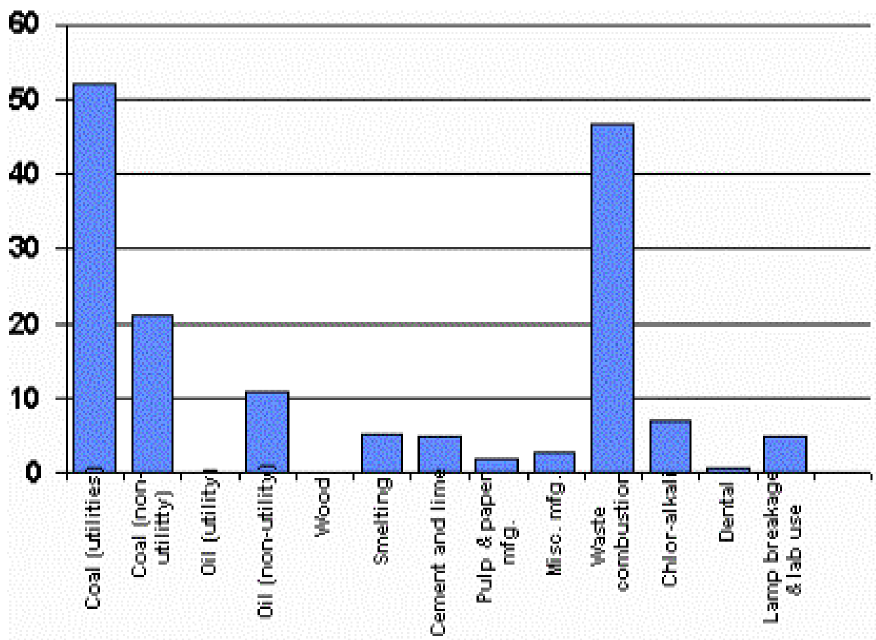
[2]University of Wisconsin Extensions. http://www.mercuryinschools.uwex.edu/curriculum/hg_in_env.htm

The Mercury Cycle



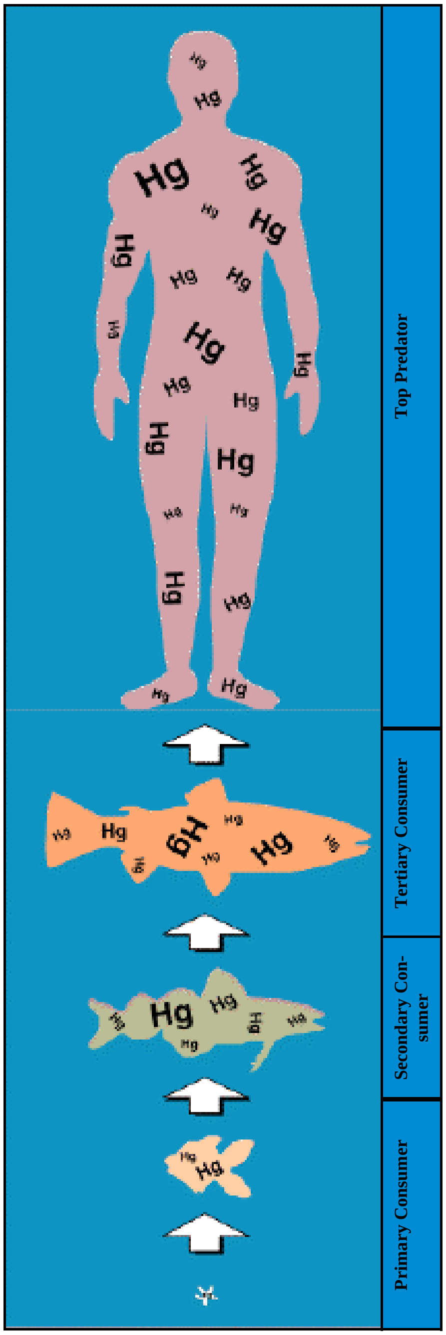
University of Wisconsin Extension.
http://www.mercuryinschools.uwex.edu/curriculum/hg_in_env.htm

1994-95 U.S. Emissions
(in tons)



Courtesy of the U.S. Environmental Protection Agency's Mercury Study Report to Congress, 1997

Mercury (Hg)
Bioaccumulation in Humans



University of Wisconsin Extension[2]

GLOSSARY

Best Management Practices
Methods adapted by resources users designed to mitigate harm to the environment that might result from their activities.

Bioaccumulation
The accumulation of a substance, such as a toxic chemical, in various tissues of a living organism.

Buffer
An area managed to reduce the impact of adjacent land use.

Collection Site
A stream, lake, reservoir, or other body of water fed by water drained from a watershed.

Conservation
The use of water-saving methods to reduce the amount of water needed for homes, lawns, farming, and industry, and thus increasing water supplies for optimum long-term economic and social benefits.

Contaminant
Any substance that when added to water (or another substance) makes it impure and unfit for consumption or use.

Ecological Footprint
Something which has permanently damaged or had a negative impression the environment; the impact of humans on ecosystems created by their overuse of land, water, and other natural resources.

Ecosystem
A community of living organisms and their interrelated physical and chemical environment; also, a land area within a climate.

Erosion
The wearing down or washing away of the soil and land surface by the action of water, wind or ice.

Flood
Any relatively high streamflow overtopping the natural or artificial banks of a stream.

Fossil Fuel
Fossil fuels are hydrocarbons found within the top layer of the earth's crust. They are a non-renewable resource because they take millions of years to form and reserves are

being depleted much faster than new ones are being formed. Petroleum and coal are a few examples of fossil fuels.

Impervious Surface
A surface that water does not pass through.

Non-point source pollution
Widespread overland runoff containing pollutants; the contamination does not originate from one specific location, and pollution discharges over a wide land area.

Oxygen Depletion
Is a phenomenon that occurs in aquatic environments as dissolved oxygen (**DO**; molecular oxygen dissolved in the water) becomes reduced in concentration to a point detrimental to aquatic organisms living in the system.

Peak Flow
In relation to a rain storm, when water is flowing at its fastest rate at its highest level relative to the land.

Permeable
Capable of transmitting water (e.g., porous rock, sediment, or soil).

Point source pollution
Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types.

Pollution
An alteration in the character or quality of the environment, or any of its components, that renders it less suited for certain uses. The alteration of the physical, chemical, or biological properties of water by the introduction of any substance that renders the water harmful to use.

Riparian Buffer
Land areas directly influence by a body of water; usually have visible vegetation or other physical characteristics showing this water influence. Stream banks, lake borders, and marshes are typical riparian areas.

Runoff
Precipitation that flows overland to surface streams, rivers and lakes.

Sediment
Fragmented organic or inorganic material derived from the weathering of soil, alluvial, and rock materials; removed by erosion and transported by water, wind, ice, and gravity.

Soil
The top layer of Earth's surface, containing unconsolidated rock and mineral particles mixed with organic material.

Storm drain
Constructed opening in a road system through which runoff from the road surface flows into an underground sewer system.

Vegetation
Ground cover provided by plants, and is, by far, the most abundant biotic element of the earth,

Wastewater
Water that contains unwanted materials from homes, businesses, and industries; a mixture of water and dissolved or suspended substances.

Water cycle
The paths water takes through its various states-vapors, liquid, and solid-as it moves throughout Earth's systems (oceans, atmosphere, ground water, streams, etc.). Also known as the hydrologic cycle.

Watershed
The land area from which surface runoff drains into a stream channel, lake, reservoir, or other body of water; also called a drainage basin.