Restoring A Stream

Virginia SOL

- *Science* 6.7, LS.12
- *Social studies* CE.1, CE.3
- *Language arts* 6.6, 7.7, 7.8, 8.7
- *Technology* C/T8.1, C/T8.2

Objectives

- Research the importance of protecting and restoring streams
- Understand the accepted meaning of stream restoration
- Focus project on designing, establishing, and maintaining streamside forest buffers
- Identify a local stream habitat in need of protection and restoration
- Plan an action project to protect and restore the local stream habitat
- Seek technical assistance from local and state agencies and cooperation of landowners
- Work to return a waterway to former water quality and stability
- Use photos and journal records to document and share progress of restoration project
- Plan to measure success of project by monitoring the waterway following restoration work

Materials

- Planting bars or shovels
- Plants
- Bags or buckets for plants
- Water for the plants
- Survey tape to mark plants
- Wood stakes to mark planting area
- Tubes with nets to protect seedlings
- Camera and first aid kit

Safety & Regulations

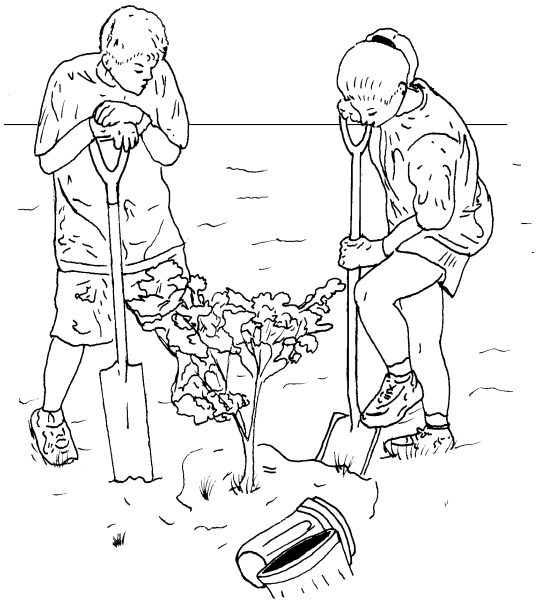
See Planning a Safe Trip in the Introduction section of this packet and Safety at the Stream at the end of this lesson. Adult chaperones will be needed for visits to the water site. See also the Riparian Planting Day Checklist handout for students.

Time Needed

This lesson is written as a long-term project.

What practical steps can we take to protect and restore the habitat at a local stream?

Protecting our water resources through restoration helps students understand watersheds as dynamic systems that are powerful, and at the same time fragile. Protecting even small streams is crucial for the Chesapeake Bay's recovery and the water quality in our own area. In addition to offering a meaningful field experience, this project activity supports SOL in different disciplines. The activity is intended for seventh grade Life Science. Sixth grade Science SOL 6.7 includes the health of ecosystems and major conservation, health, and safety issues associated with watersheds. Seventh grade SOL LS.12 specifically concerns relationships between ecosystem dynamics and human activity. This includes factors threatening and enhancing species survival and issues of water supply and waste management. Social Science SOL CE.1 and CE.3 for seventh grade include citizenship skills such as identifying problems and recommending solutions, and civic and social duties addressing community needs. In this lesson, students will learn about the stresses our aquatic ecosystems are under, and then plan and



participate in a streamside restoration project. They will monitor the results of their restoration project, and then document and share those results.

Virginia's growing population, accompanied by intensified residential and commercial development, is bringing increases in many land use activities that place increased stress on aquatic ecosystems from the smallest stream to the Chesapeake Bay. For example, as we increase the amount of impervious surfaces near our streams, including parking lots, roads, and rooftops, the volume and velocity of water directed into the streams increases. This tends to lead to increased soil erosion from the land surface around streams. Impervious surfaces are also the source of thermal pollution, as rainwater runs from a hot parking lot or rooftop, warming nearby streams.

This project will focus on restoring a stream through the planting of native trees and shrubs (available for purchase from the Virginia Department of Forestry). Planting vegetation by a waterway is a relatively easy and widely used tool for stream bank protection, particularly for small tributaries. In Virginia, some of our biggest water pollution issues are sedimentation and excess nutrients. As students will learn, a buffer planted alongside a stream or river will help reduce these problems while sustaining a healthy stream environment. For schools in coastal areas, the project can be modified so that students learn about the need to reintroduce submerged aquatic vegetation (SAV) into tidal rivers.

Time to Restore

Aldo Leopold, a forester, author, and preservationist who wrote about our ethical responsibilities in protecting natural areas, said, "The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to begin with." He, and many others today, believe in repairing the damage that has been done to the nation's aquatic resources: lakes, rivers, bays and wetlands. Chesapeake 2000, the latest Chesapeake Bay Agreement signed by Virginia and other states in the watershed, calls upon schools to help restore and protect streams and wetlands.

By successfully establishing a riparian buffer zone, students will accomplish a meaningful experience in water resource stewardship. Healthy rivers, bays, lakes, and even the smallest streams perform numerous environmental functions that are very valuable to plants, animals, and humans. Benefits can be economic, environmental, recreational, or aesthetic. The following list includes some of the specific benefits of riparian buffers.

- Providing shade and reducing water temperature in streams, improving habitat conditions for frogs, fish, salamanders, insect larvae, and other stream organisms.
- Providing habitat for wildlife. Shelter, food, and nesting sites for large and small animals can be found in riparian buffers. Buffers also act as corridors for animals to reach other areas of similar habitat.

- Providing organic material such as leaves and twigs, which are food for many of the animals living in a stream.
- Diminishing the impacts of floods. Riparian buffers slow and absorb floodwaters, reducing the likelihood of flooding downstream.
- Improving water quality by trapping and absorbing nutrients that are found in water running off of agricultural fields, lawns, golf courses, etc. These nutrients are then stored in the limbs, roots and leaves instead of entering the stream.
- Promoting sediment deposition, making water clearer.
- Helping recharge groundwater by providing pathways for water into groundwater aquifers.
- Providing pleasant areas for watching wildlife, such as birds, dragonflies, frogs, and butterflies.
- The root system of the riparian trees and scrubs helps to hold the bank soil together and increase overall bank stability by an interweaving network. Also, the plant stems and foliage slow stream flow, absorbing flow energy and decreasing the amount of erosion from the stream bank.

What is Stream Restoration?

According to the National Research Council, restoration means "the reestablishment of predisturbance aquatic functions and related physical, chemical, and biological character-istics." The Environmental Protection Agency has defined restoration as "the return of a degraded ecosystem to a close approximation of its remaining natural potential." There are many ways to restore a stream, river, or bay. These can include chemical adjustment of the water, reconstruction of physical conditions, biological manipulation, and reintroduction of native flora and fauna.

There are many benefits from carrying out stream restoration. Restoring aquatic ecosystems can reverse ecological damage before it is permanent and help maintain healthy populations of wild animals and native plants. Humans also benefit more directly when restoration improves streams for recreation and aesthetic enjoyment. Very often, there are economic benefits from acting quickly as this can then decrease future costs.

Of course, there are also methods to prevent damage or pollution in the first place. For example, in farming areas, fences can be installed to keep livestock out of streams and reduce bank erosion and fecal contamination.

LESSON INTRODUCTION

Researching the importance of protecting and restoring streams...

Before undertaking a restoration project, students will need to carry out some research of their own into the importance of protecting and restoring streams. Lead the students so that they come to understand the accepted meaning of restoration and the benefits that are gained from restoration. Students can research information in each of the following areas.

- The importance of rivers and smaller streams
- The importance of the Chesapeake Bay

- The riverine-riparian ecosystem
- The critical role riparian stream buffers play in protecting water quality
- Stresses on rivers and streams
- Threats to the health of aquatic ecosystems
- Benefits from restoration

After the students have completed their general research, focus them on carrying out a riparian buffer planting project. Provide the students with some background information on how to carry out a planting project, and some of the specific benefits that can be achieved by this type of restoration.

Identifying a local stream habitat in need of protection and restoration...

You will need to work with students to identify a suitable local site that is in need of protection and restoration. Possible sites might include any of the following.

- An eroding stream bank
- A park with a stream needing more riparian buffer
- Soon-to-be-developed agricultural land

ACTIVITY PROCEDURES

Planning the action project...

Goals need to be set for the stream protection and restoration project. Middle school students will need considerable help and guidance with this, and you should work together with the students to establish appropriate, achievable goals. The U.S. Environmental Protection Agency's Office of Wetlands, Oceans, and Watersheds has developed several principles for carrying out a successful aquatic restoration project. Possible general goals include the following.

- Preserving and protecting aquatic resources.
- Restoring ecological integrity.
- Restoring natural structure.
- Restoring natural function.
- Addressing ongoing causes of degradation.

The goals that are chosen should have as local a focus as possible, in order to make the project relevant and meaningful for the students. Your goals must also be clear, achievable, and measurable. More specific goals might include the following.

- Decreasing a pollution problem. For example, the project could be designed to decrease the amount of erosion in an area or decrease the amount of nutrients entering the water.
- Increasing the wildlife population in an area, or at least stopping a decline.
- Restoring a wildlife habitat.

The school restoration project could be part of a bigger effort. The U.S. Department of Agriculture and other agencies encourage the public to think in terms of an entire stream corridor or stream valley. While a school or school class might work in just one small area, this might easily be part of a wider effort to

restore a relatively large ecosystem. You should make contact with your local Soil and Water Conservation District (SWCD) office to learn if any larger plan exists that includes the local stream you have identified for your project. You should seek whatever assistance might available from the local SWCD office to help the students carrying out a project. Other agencies that you can contact for help include local Extension offices, the Department of Forestry, and the Department of Game and Inland Fisheries. The Virginia Department of Environmental Quality has educational specialists who welcome opportunities to help schools with this type of project. Local and state agencies can provide help with designing project plans, and they may also be able to provide supplies or suggest sources of funding. To find phone numbers for these and other conservation contacts in your watershed, see the "Yellow Pages" that were compiled by the Virginia Department of Conservation and Recreation (*www.dcr.state.va.us/sw/wsheds.htm#contacts*).

Carrying out the riparian planting project...

To carry out their project, students need to gather plants and planting equipment. The plants chosen should be native plants that are suited to a streamside environment. Select plants that prefer moist to very wet soil and that can withstand occasional flooding. Virginia's Department of Forestry (DOF) has several riparian buffer packs of trees for sale including such trees as oaks, hazelnut, hackberry, buttonbush, ash, mulberry, locust, dogwood, cherry, persimmon, sycamore, and others. Call your nearest DOF office to learn if trees can be donated to your project, and also if they have planting bars or shovels you can borrow. DOF can also give you advice on how far apart the tree seedlings should be planted.

If you are planting bare-root seedlings (which are only as thick as a pencil), students can use a planting bar which creates a narrow slit in the dirt. Working in teams of two or three, students can quickly plant dozens of these small trees. Bare-root seedlings must be kept moist until planting. If the plants are in pots with a root ball, shovels will be needed to dig larger holes. If time and budget allow, you may want to protect the seedlings by placing tubes around the young plants. When this is not possible, planting a larger number of seedlings is advised. Other equipment that will be needed for planting is listed at the beginning of this lesson. As you plan your restoration project, you may want to refer to the Pennsylvania Stream ReLeaf Forest Buffer Toolkit (see web address at end of this lesson). After planting, the area may need to be marked to protect the seedlings from accidental mowing.

When making visits to the planting site, be sure to follow all school field trip procedures. Adult chaperones will be needed. Also, refer to the Planning a Safe Trip information in the Introduction section of this packet and the Safety at the Stream information at the end of this lesson. At the end of the lesson there is also a Riparian Planting Day Checklist for students.

A measure of the success of a restoration project can be obtained by water quality monitoring. Ideally, monitoring should be carried out before, during, and after the restoration project. Tests to carry out could include temperature, turbidity, dissolved oxygen, nitrogen, and records of observed wildlife. See the Water Quality Monitoring chapter and the Evaluating a Stream lesson in this section for more information.

Documenting and sharing progress of the project...

Have students record and document the progress of the restoration project by taking photos and writing journals. If digital cameras are available, photographs taken can be imported into typed journals.

Project results can be shared by having students create posters for the classroom, school, and neighborhood. Students could also create and distribute newsletters or brochures. You might choose to have students use computer technology and practice skills from the Virginia Computer/Technology Standards of Learning. Using advanced publishing to produce page layouts would support SOL C/T8.1, and developing web pages to share project results would support SOL C/T8.2.

QUESTIONS

- What is meant by stream restoration?
- What are some steps that can be taken to restore a stream habitat?
- Which trees and shrubs are best for planting beside streams?
- How does the health of our stream site compare with other streams nearby?
- What are some general benefits of restoring a stream site?
- What are some specific benefits of creating a riparian buffer zone?
- How successful was our stream restoration project?
- Which of our project goals were achieved successfully?
- How do you imagine our stream site will be five years from now?

ASSESSMENTS

- Research reports on stream restoration and benefits from stream restoration.
- Journals documenting the stream restoration project. Digital camera photos can be incorporated into typed journals.
- Posters, newsletters, or brochures to share information about the stream restoration project.

EXTENSIONS

- Instead of planting a streamside buffer, schools in coastal areas might want to focus on the issue of submerged aquatic vegetation, and undertake a project to help restore underwater beds of grasses. Like streamside trees and shrubs, submerged aquatic vegetation reduces shoreline erosion and provides animals with food and habitat. Contact the Alliance for the Chesapeake Bay for school project ideas. The Chesapeake Bay Foundation (CBF) has several restoration projects for schools, including restoration of underwater sea grass beds, oysters, oyster reefs, and shad. CBF also offers restoration field trips for students and teachers, as well as assistance in building large-scale community restoration projects.
- To raise awareness about the importance of forest buffers along Chesapeake Bay tributaries, the Virginia Department of Forestry, the Alliance for the Chesapeake Bay and other groups coordinate native tree seed collection throughout Virginia's Chesapeake Bay watershed. Acorns and other seeds are then used to grow seedlings to be planted along our rivers and streams to provide habitat, stabilize our riverbanks, and protect water quality. Contact your local Department of Forestry office or the Alliance for the Chesapeake Bay for details.
- Visit an area farm where the farmer has added best management practices that include riparian buffer plantings. Contact your local U.S. Department of Agriculture or Soil & Water Conservation District office to ask for their assistance in setting up such a field trip.

RESOURCES

For the teacher...

- *Alliance for the Chesapeake Bay www.acb-online.org*
- Chesapeake Bay Foundation *www.cbf.org*

  Restoration projects: *www.cbf.org/site/PageServer?pagename=edu_educators_restoration_index*
- Ecological Restoration. Munro, J. W. (1999). *The Volunteer Monitor, 11*(1), 1–5.
- *Give Water a Hand. www.uwex.edu/erc/gwah*

  A national watershed education program designed to involve young people in local environmental service projects. A program of the University of Wisconsin - Environmental Resources Center.
- Humpty Dumpty. *Project WET*.
- Learning Science Through Restoration. Martin, J. (1999). *The Volunteer Monitor, 11*(1), 22.
- *Pennsylvania Department of Environmental Protection www.dep.state.pa.us*

Pennsylvania Stream ReLeaf Forest Buffer Toolkit: *www.dep.state.pa.us/dep/deputate/watermgt/WC/Subjects/StreamReLeaf.htm*

The Pennsylvania Stream ReLeaf Forest Buffer Toolkit is one of the best resources on line as you plan your restoration project.

- U.S. Environmental Protection Agency *www.epa.gov*

  EPA River Corridor and Wetland Restoration: *www.epa.gov/owow/wetlands/restore*

  Free single copies of Document EPA 841-F-00-003 Principles for the Ecological Restoration of Aquatic Resources (2000) are available from the web site or by calling 1-800-490-9198.

- Protecting Our Watersheds. Earth Force GREEN.

- Restoration Resources. (1999). The Volunteer Monitor, 11(1), 20–21.

- Riparian Retreat. Aquatic Project WILD.

- Virginia Department of Forestry *www.dof.state.va.us*

  Riparian buffer information: *www.dof.state.va.us/rfb/rfb-intro.shtml*

  Resources for teachers: *www.dof.state.va.us/coned/index.shtml*

STUDENT HANDOUT

Riparian Planting Day Checklist

Safety at the Stream

(Some of these ideas from the "Stream Sense" activity by Project WET.)

For the teacher...

- Make sure the stream site is safe for students. Check the stream depth, velocity, and temperature. Also, check for walking conditions, litter, potentially dangerous wildlife, and poisonous plants.
- Bring a first aid kit on the trip.
- Define the boundaries for your visit. Make sure students understand that staying within these boundaries protects both them and wildlife.
- Locate a place where students can wash hands after the visit.

For the students...

- Stay with group members at all times.
- Wear old shoes or boots because they will likely get wet and muddy. Keep shoes on at all times to protect feet from harm.
- Stay in the designated area, and do not go near or into the water except to collect water samples.
- Do not touch any wildlife that you find or taste any water or plants.
- Learn what poison ivy and poison oak look like, and avoid these plants.
- Do not eat any food without first carefully washing your hands.

Student Handout

Riparian Planting Checklist for Students

Equipment and Materials for the Planting

- Planting bars or shovels
- Plants
- Bags or buckets for the plants
- Water for the plants
- Survey tape to mark plants
- Wood stakes to mark planting area
- Tubes to protect seedlings
- Nets to place on top of tubes

Clothes to Wear

Make sure you wear proper clothes for the planting. Remember it might be colder by the water.

- Gloves and sturdy shoes or boots
- Hat (for shade or warmth)
- Long pants that can get dirty
- Dress in layers for warmth – long pants, turtleneck, sweater, jacket, windbreaker, and hat
- Bring wool or waterproof clothes for wet weather
- Bring additional warm clothes with you

Other Items to Bring

- Drinks (1 quart)
- Bag lunch and snacks
- Sunscreen
- Sunglasses
- Change of clothes in case of getting wet
- Camera to document planting

Safety During the Planting

- Stay with your group members at all times.
- Do not go near or into the water.
- Keep your shoes on at all times to protect your feet from harm.
- Do not touch any wildlife that you find or taste any water or plants.
- Learn what poison ivy and poison oak look like, and avoid these plants.
- Do not eat any food without first carefully washing your hands.

NOTES

Plants: Nature's Filters

Students perform a demonstration of how plants in wetlands and riparian buffers can remove pollution from water.

Level(s): 6-7

Subject(s): Life Science; Earth Science

Virginia SOLs: 6.5 a,f,g; 6.7 a,c,d,f; 6.9 a,c; LS4 a; LS7 a; LS12 e

Objectives: Students will be able to explain the role plants in wetlands and riparian buffers play in protecting water quality

Materials:
For each student group:
1. beaker or jar
2. food coloring (other than green)
3, 1 fresh celery stalk with leaves
4. water
5. knife
6. masking tape (to label beakers)

Estimated Time:
1st session: 15 - 20 minutes
2nd session : 45 minutes

Background Information: *Riparian Buffers*, p. 20; *Wetlands*, p.25.
Plants in wetlands and riparian buffers play many roles in protecting water quality. Some pollutants are converted to less toxic forms by plants while others may remain in the plant and re-enter the environment when the plant dies. The ability of plants to remove pollutants is limited, and cannot replace efforts to reduce the amount of pollution we release into the environment.

Preparation:
Fill each beaker two-thirds full of water and add a few drops of food coloring.

Activity Procedure:
1st Session
1. Discuss with students the roles that plants play in protecting water quality in riparian buffers and wetlands. Tell them they will perform a demonstration of how plants can take in pollutants, removing them from the water.

2. Divide the students into groups of 2-3. Give each group a set of materials. Tell them that the color in the water represents some form of pollution such as heavy metals or nutrients.

3. Have students cut off the bottom half inch of the celery stalks and place them in the water. Each group should use a piece of masking tape to write a label identifying their beaker. Place the beakers someplace where they can be observed during the day.

2nd Session

1. Have students retrieve their beakers and observe the color of the celery.

2. Have students cut the celery stalk and observe the cross-section to see where the dye is present inside the stalk. Have the students draw the cross section.

3. If the teacher wishes, this is also an opportunity to review or discuss transpiration in plants and the role of *phloem* and *xylem*.

4. Discuss how the process they have observed could remove pollutants from water.

Assessment Opportunities:

Ask:

1. How do wetlands help to purify water?
2. Is the water in the beaker still "polluted"? Why or why not?
3. Where does the water go after uptake into the plant?
4. What happens to the pollutants?
5. Why can't we dump all of our waste water into wetlands?

Extensions:

1. Discuss what kinds of plants are found in wetlands.
2. What is the difference between a pond, a wetland, a marsh and a swamp? Discuss how the words we use affect the way we think about things.

from **Discover wetlands: A curriculum guide**, pp.65-73

Riparian Buffers

Adapted from the ***Riparian Buffer Modification & Mitigation Guidance Manual***
DCR web site: http://www.cblad.virginia.gov/ripbuffstat.cfm

Land adjacent to a stream, river, wetland or pond is referred to as a riparian area. If the riparian area has tree and other plant cover, it functions as a buffer, or protective area, and can minimize the impacts of human activity on the water. Vegetated riparian buffers, especially forested buffers, improve water quality, help manage stormwater and floodwater management, stabilize stream banks and shorelines, maintain lower water temperatures, provide wildlife habitat, and absorb of pollutants in the air. The wider the buffer is, the more effective it is. In Virginia, a buffer width of 100-feet has been deemed sufficient to protect water quality through the removal of sediment and nutrients.

Protection from Erosion and Sediment Pollution

In general, the greatest sources of sediment are row crop agricultural fields and construction activities. Livestock that are permitted to enter streams can cause bank destabilization and erosion, adding sediment to the water in a stream. Some lumbering practices can also cause sediment to flow into streams, especially when a site is clear-cut or forest roads are poorly maintained.

Sediment that reaches surface waters is a pollutant that can harm aquatic plants and animals. Riparian buffers help to reduce stream sedimentation in several ways. A buffer may keep farm fields, construction or logging far enough back from the water feature that the disturbance does not directly affect the banks. Buffers can also reduce the speed and amount of stormwater runoff that causes erosion and carries sediment to streams by allowing more water to enter the ground. The vegetation, roots, and leaf litter can trap sediment from surface runoff before it reaches the water. The vegetation, particularly their roots, helps stabilize stream banks, and also provide woody debris within the stream that helps trap sediment. During floods, the buffer moderates the velocity of the storm flow that surges onto the floodplain, reducing erosion, and allowing the sediment to settle out and be deposited on land.

Nutrient and Chemical Control

Plant nutrients such as phosphorus and nitrogen and chemicals such as pesticides and herbicides can reduce water quality and damage habitat. Although there are natural sources of nitrogen and phosphorus, human activity has greatly increased the amount of nutrients reaching ground and surface waters, often leading to algae blooms. In rural areas, agriculture is generally the leading contributor of nutrients, from row crops and livestock operations, but residential lawn fertilization and on-site sewage systems also contribute a significant amount of nutrients and pathogens. In urban areas the runoff from lawns and impervious areas are the principles sources of nutrients. Pesticides and herbicides, like fertilizer, are applied to agricultural fields and residential lawns. These chemicals can harm or kill aquatic organisms.

Riparian buffers can have a significant impact on the removal of nitrogen, especially if they have a mix of plants including trees, shrubs and tall native grasses. Most nitrogen enters the buffer dissolved in the ground water. Trees, shrubs and tall native grasses that have significant deep roots extending into the sub-surface waters can remove nitrogen. Nitrogen can also be used by some soil microbes or adsorbed by soil particles in the buffer. Most phosphorous that is carried by runoff is bound to particles of sediment rather than dissolved in water. For this reason

plants in buffers are not able to take in much phosphorous. Still, a riparian buffer can keep phosphorus-producing activity away from the stream, and can prevent particles carrying phosphorous from reaching the stream. Riparian buffers help minimize pesticide problems by keeping pesticide application away from the water feature, preventing direct contamination and reducing the risk of drift. They can reduce the amount of toxins in surface runoff as well. Many pesticides and herbicides are retained in the buffer to decompose over time

Other Contaminants

Other contaminants such as bacteria and viruses, and heavy metals, can also harm aquatic systems. Animal and human waste can supply pathogens and organic matter to surface water. Heavy metals are usually associated with transportation systems and industrial activities, and can enter systems through surface runoff from urban areas. Buffers can trap waste from surface waters, preventing it from reaching water features. Many heavy metals can be bound to soil particles and remain in the buffer. As with nitrogen and phosphorus, the dense vegetative cover and litter layers encourage infiltration of pesticides. The dense root biomass and layers of organic matter support a rich soil capable of transforming dissolved chemicals through enhanced microbial activity.

Hydrologic Benefits

Another important function of the riparian buffer is to slow the rate of stormwater runoff, increasing the potential for infiltration. The recharging of the ground water is important for maintaining wells and supplying the baseflow waters that feed streams. The vegetation is important for maintaining a uniform flow of water through the buffer, allowing longer detention times for pollutant transformation or removal. A uniform flow also helps protect stream and shoreline banks from erosion. During floods, the trunks, stems, twigs, and woody debris within the forested buffers provide a further advantage by slowing the speed of water flow through the floodplain. This reduction in the speed of water flow helps to encourage the settling of sediment and associated contaminants.

Habitat Benefits

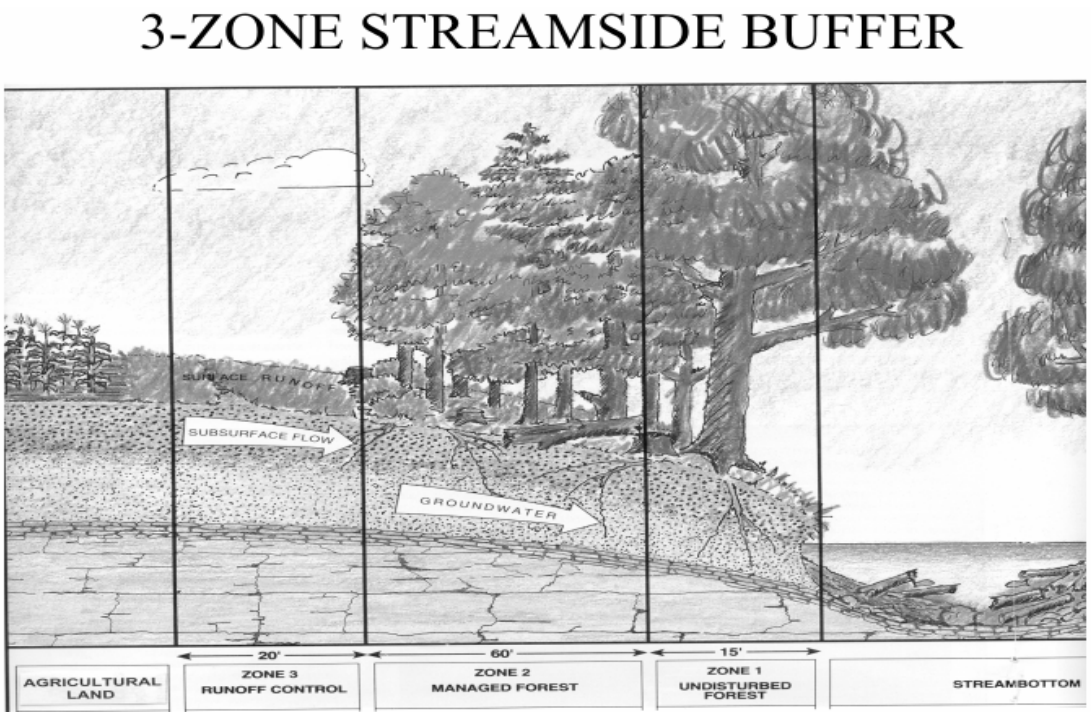
A forested buffer improves habitat for animals by providing food, shade, and woody debris or snags for shelter. On land, the habitat benefits from the availability of water, the abundant food supplied by riparian vegetation and the variety of cover provided by trees and shrubs to support numerous organisms. Certain microorganisms and invertebrates at the bottom of the food chain require high quality water to survive. Microorganisms that form the bottom of the food chain break down the leaves, twigs, fruits, nuts, flowers and insects that fall into the stream from a forested buffer. The invertebrates that depend on organic debris and microorganisms are in turn important sources of food for fish. The vegetation in a buffer also supports a healthy insect population, which provides food for fish. Streams and rivers provide habitat for smaller fish which depend on the insects and debris falling from the riparian area, for food.

Trees dropping large woody debris into a stream promote a variety of habitat for a variety of aquatic organisms. Large logs help create pools, riffles, or still backwaters that function as places for fish to rest and juveniles to seek shelter. They supply cover from overhead predators and sunning spots for reptiles and amphibians. Logs also provide surface habitats for invertebrates to colonize. Woody debris can capture twigs, leaves, and other organic food items, such as seeds, or provide surface areas for invertebrates to colonize.

The canopy of a forested buffer has a direct affect on the light and temperature of the stream water. The amount of light that reaches the stream is important for the rate of plant and algae growth. Sunlight hitting a stream raises the water temperature. A higher temperature can increase decomposition, decrease the amount of oxygen in the water and increase the amount of nutrients released from suspended sediments. The higher temperature and greater amount of light can encourage the growth of algae and parasitic bacteria while creating an environment that supports a less diverse community. Higher temperatures will prevent some species from thriving and stress others beyond survival.

The complex plant community of a natural buffer provides water, food and shelter for both permanent and migrating species. The availability of food from seeds, fruits, buds and twigs to insects and small mammals makes the buffer an important source of food. The variety and complexity of wooded buffers supplies numerous opportunities for shelter for birds and small animals. Riparian areas provide corridors of habitat within agricultural settings and may provide the only natural areas in urban landscapes.

Riparian buffers benefit everyone by protecting water quality, maintaining stream health, reducing flood damage and erosion, and by providing good habitat for a wide range of animals and plants. They also improve local air quality by removing pollutants from the air. In addition, these stream corridors, when surrounded by a healthy plant cover, improve the landscape and serve as ideal places for recreational activities such as walking, bicycling, picnicking, fishing, swimming and bird watching.



Wetlands: Our Natural Purification System

Students perform an experiment on how the sediments in wetlands help to filter pollutants out of surface water before entering the groundwater.

Level(s): 6-8

Subject(s): Life Science, Earth Science, Physical Science

Virginia SOLs: 6.5 b,e,g; 6.7 a,d,f; 6.9 a,c; LS7 a,c; LS10 b; LS12 e; PS2 b,c,f

Objectives:
Students will be able to explain the role sediments in wetlands play in removing pollution from water.

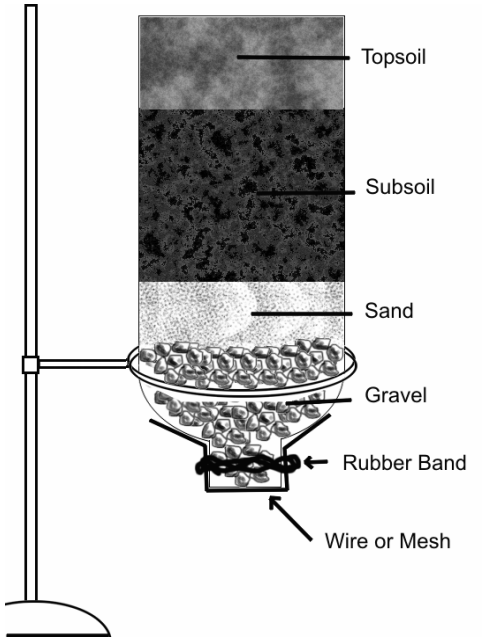
Materials:
1. 5 used one-liter plastic bottles with the bottoms cut off
2. 5 three-inch squares of wire screen or plastic mesh
3. 5 ring stands
4. rich topsoil (with organic material)
5. subsoil
6. sand
7. small gravel or pebbles
8. 300 ml of water mixed with 100 ml of **vinegar**
9. 400 ml of water mixed with 3 tablespoons of **baking soda**
10. 300 ml of water mixed with 100 ml of **rubbing alcohol**
11. 400 ml of water mixed with 1 teaspoon of **red food coloring**
12. 400 ml of water mixed with 3 tablespoons of pulverized **charcoal briquettes**
13. 3 tablespoons each of **talcum powder**, **leaf mulch** (oregano can be used), fine ground **black pepper** (see *Note* for Activity Procedure Step #4 below).
14. litmus paper (for pH test)
15. 5 500 ml beakers or jars
16. 5 pieces of cloth (for filtering water discarded down the drain)
17. rubber bands

Estimated Time: 45-50 minutes

Background Information: *Wetlands***,** p.25.
Sediments in wetlands filter out pollutants as they seep down to the groundwater. Some of these pollutants may be converted to less harmful forms through the action of bacteria, and others may remain in sediments until disturbed by some action such as dredging, draining or development of a wetland.

Preparation:
Have the materials ready for students to assemble at five stations. Each station will have one of the pollutant solutions (# 8-13 above).

Activity Procedure:



1. Divide the students into five groups, assign each group to a station and have them set up the filter system as shown in the diagram on the right.

2. Tell the students that there is a water sample at each station that has been contaminated by a pollutant. Have the students observe, smell and test the pH of each "pollutant" (no tasting) and record their observations before they begin. Ask them to record their prediction of what they think will be the result when they pour their polluted water through the filter system.

3. Next, each team slowly pours its contaminated water through the filter, catching the flow out the bottom. Have the students repeat their examination of the liquid, recording their observations. Students should discard the outflow by filtering it through a piece of cloth when they pour it down the drain.

4. First have students record their prediction of how many 400 ml containers of clear water will have to run through the system before they can no longer detect the pollutant. Then have the students flush the system of pollutant by pouring 400 ml amounts of clear water through it. Test and record descriptions of the outflow. Repeat the process with clear water until the pollutant cannot be detected in the outflow. ***Note*:** The group using the charcoal mixture will probably find that all of the charcoal is eliminated the first time through. Have them repeat the process with some other particles, such as talcum powder, soil, ground leaf mulch, and/or ground black pepper and report any differences)

5. Discuss how the results of each experiment might apply to different types of pollution.

Assessment Opportunities:
Have students explain the role sediments play in removing pollution from water.

Extensions:
1. Try the experiment with a stronger solution of each contaminant.
2. Have students locate wetlands nearest the school on a topographic map. Locate the source of water for the wetland and determine what types of pollution might be fond there. Visit the wetland and test the water and sediments there for pollution,
3. Follow up with *Plants: Nature's Filters*

from **Discover wetlands: A curriculum guide** pp.65-73

Wetlands

Wetlands are a prime natural resource and include such areas as swamps, bogs and coastal marshes. These are areas that have standing water at least part of the year. Wetlands are usually identified by the presence of certain types of soils and vegetation that are associated with wet or damp conditions. Many wetlands are transitional areas located between dry lands and deeper aquatic systems like rivers and lakes.

All of these damp areas have tremendous importance in terms of productivity. Wetlands provide feeding, spawning, and nursery grounds for finfish and shellfish. They provide habitat for about half of all endangered species of plants and animals.

Wetlands lessen global warming by locking up huge amounts of carbon in peat rather than allowing CO_2 to be released in the atmosphere. They also clean the water by absorbing and filtering pollutants. Some pollutants are converted to less toxic forms by plants, while others may remain in the plant and re-enter the environment when the plant dies.

Wetlands also play a role in preventing the erosion of shore lines, and they provide a buffer against storm tides. They absorb large quantities of water, preventing or lessening the effects of flooding, and they may serve as “holding” tanks to recharge wells and aquifers.

Some wetlands develop in low-lying areas where water drains and collects. Others border salt or fresh bodies of water, such as oceans, rivers, or ponds, while still others are isolated in forests and urban areas. As transitional zones between upland and aquatic systems, wetlands often support both terrestrial and aquatic species, contributing to the local and regional diversity of plants and animals.

Two hundred years ago, the United States had 220 million acres of wetlands. Now we have less than 100 million acres. As of 1996, the loss was around 300,000 acres each year. Half of the Florida Everglades is gone; half of Connecticut’s coastal wetlands and 2/3 of the prairie potholes are gone. California has only 9% of its wetlands remaining, Iowa 11%, and Indiana and Missouri 13%.

Functions Of Wetlands

1. Wetlands provide habitats for fish, wildlife and plants. They are critical to the survival of a wide variety of organisms. They also provide food, water, or cover for many species.

2. Wetlands provide critical habitats for endangered species. A number of rare and threatened species depend on wetlands for their survival.

3. Wetlands provide flood control and protection. Some wetlands store flood waters or water that collects in isolated depressions. Wetland plants can help to slow the speed of flood waters to protect nearby properties.

4. Wetlands improve water quality serving as excellent water filters to remove nutrients, wastes, and sediment from runoff water before they reach an open body of water. These nutrients, wastes and sediment may cause algae blooms or decrease the volume of a lake, pond, or river.

5. Wetlands provide shoreline erosion control. Those located between rivers and high ground to help to buffer shorelines against erosion. Wetland plants strengthen the sediment by binding soil with their roots. They also dampen wave action.

6. Wetlands reduce storm damage by serving as buffers between the winds and waves of storms and the coastal areas. Property located behind wetlands along shorelines and large lakes often fares much better during storms than unprotected areas.

7. Wetlands facilitate groundwater recharge. As the water moves slowly through the wetlands, some will seep down into aquifers below.

8. Wetlands provide a variety of natural products. These range from fish, shellfish, and wildlife to timber, berries, and wild rice.

9. Wetlands provide areas for recreation, rest, and enjoyment. Hunting, boating, and fishing are allowed in many wetland areas. Artists and photographers enjoy capturing the beauty of wetlands in their crafts. Tourists and visitors often find peace and appreciation for these natural areas.

10. Wetlands facilitate education and research. Although much is known about the functions of wetlands, researchers are still studying these environments and the species that thrive there in an attempt to discover more fully the benefits that they bring to humans.

Terms

bog: freshwater marsh with build-up of peat and high acidity that typically supports mosses adapted to acidic soil conditions (particularly, sphagnum); many are located in colder regions

bottomlands: lowlands along streams and rivers that are typically flooded **cypress**

domes: small, depressional swamps, typically with tall cypress trees at center, characterized by subsurface hardpan overlain by organic matter

estuary: a marine ecosystem where freshwater enters the ocean. The term usually describes regions near the mouths of rivers, and includes bays, lagoons, sounds, and marshes.

forested wetland: wetland dominated by trees. "Trees" (for the purpose of this definition) are defined as woody vegetation with diameter greater than 3 inches at breast height (approx. 4 feet from ground level).

freshwater marsh: a wetland frequently or continually inundated by freshwater, characterized by emergent herbaceous vegetation

mangrove swamps: tropical, wet, coastal areas dominated by mangroves (trees). Mangroves have extensive root systems which form a dense thicket, providing cover for aquatic life.

prairie potholes: shallow, marsh-like ponds which serve as primary breeding grounds for ducks and migratory birds found in North Dakota, South Dakota, Minnesota, and Canada

runoff: water (originating as precipitation) that flows across the surface of the land rather than soaking in; eventually enters a waterbody; may pick up and carry a variety of pollutants

salt marsh: estuary habitat submerged at high tide, but protected from direct wave action, and overgrown by salt-tolerant herbaceous vegetation; aquatic grasslands (coastal "prairies") affected by changing tides, temperatures, and salinity

swamp: wetland dominated by shrubs and trees

Adapted from the U.S. Environmental Protection Agency **Water Sourcebook**
http://www.epa.gov/safewater/kids/wsb/index.html#9-12

Invisible Passengers

Students perform an experiment to investigate the characteristics of sediment in water. They will also discuss the effects of various types of pollution on aquatic organisms.

Level(s): 6-8

Subject(s): Physical Science, Life Science, Earth Science

Virginia SOLs: 6.5 a, c, f; 6.7 a, c, f; 6.9 a, c LS.4 a, b, c; LS.10 c, LS.11 b; LS.12 e PS.1 l; PS.2 b, c, d

Objectives:

1. Students will be able to identify and describe a variety of natural and introduced materials that are found in river waters
2. Students will be able to explain some of the effects of erosion on water quality
3. Students will be able to understand that water pollution can have a harmful effect on aquatic organisms, even if the pollution is not visible.

Materials:

1. 25 quart-size jars (with lids)
2. water
3. clay/silt
4. sand
5. small gravel/pebbles
6. five liquids which can be identified by odor (e.g. vinegar, ammonia, vanilla extract, bleach, perfume)
7. table salt
8. measuring cups or graduated cylinders

Estimated Time: 45 – 60 minutes

Background Information: *Major Pollutants of Fresh Water,* p.103.

Preparation:

1. Provide containers with clay, sand and gravel
2. Provide a source of water
3. Prepare and number 5 jars with water and enough of an odorous liquid for it to be identified by smell

Introduction:

1. Discuss with the class how stormwater runoff can cause erosion on the land and carry silt into streams and rivers.
2. Discuss how high flows after storm events can cause erosion of stream banks and the bottom of the stream channel
3. Discuss what effects the two processes above can have on the water quality of streams, and on the aquatic life living in those streams.
4. Explain that the students will be simulating high water flows in a stream or river and investigate the properties of various substances in the water.

Activity Procedure:

1. Divide the class into 5 groups. Distribute 4 jars to each group. (Remind the students to use caution as the jars are breakable.)

2. Have the students fill each of the 4 jars half full with water. Add a cup of silt or clay to the first jar, a cup of sand to the second jar, a cup of gravel to the third. In the final jar add one-third cup of each: silt, sand and gravel. Give the contents time to settle.
3. Tell the students they will be shaking the jars observing them as the contents settle. Have them record predictions regarding:
   a. which will settle the fastest
   b. which will settle the slowest
   c. which will be easiest to stir up after it settles with only a slight motion
4. Advise the students to make sure that the lids are tightly fastened onto the jars. Then ask them to shake all the jars vigorously for 5 or 10 seconds. Have them set all the jars on their desks at the same time and record their observations of the three factors above.
5. Invite the students to devise a method to determine the following:
   a. flood time or rapid flow behavior of the water (rapid motion)
   b. low water or slow flow (gentle or no motion)
6. Discuss what behavior you have when rapid flow is followed by slow flow in each jar (silt seldom settles).
7. Have students predict if any change will occur when a teaspoon of salt is added to the mixtures in each jar, and then observe the result. (The salt dissolves and created little or no visible effect.). Discuss how salt might get into the water (natural minerals in stream beds, agricultural practices such as irrigation, road salt for snow.)
8. Ask students if they think they have a good sense of smell. Invite them to see if they can detect a difference in odor between sand silt and gravel and the mixture of all three. Invite them to describe the odors detected.
9. Tell the students that biologists believe that many fish use their sense of "smell" in different ways. Some use sensitivity to "odors" for feeding a migrating to spawning habitats. Tell the students they are going to see how many odors they can accurately detect in the water. Ask them to write the numbers 1-5 on a piece of paper.
10. Pass out one of the prepared and numbered jars to each group. Ask them to open them carefully pass the jar to everyone in the group. They are to record the jar number and the odor or "passenger in the water" they think they can detect. Once the jar has been passed among all the members of the group, trade the jar with another group. Repeat until all the jars have been sampled by all the students in the class and the lists are complete.
11. Discuss the possible effects of each of these conditions on living things in the rivers. Have them think of "invisible" substances that could be in the water, and what harmful effects these could have on aquatic organisms living in the water or on people who drink the water, swim in it or eat food taken from the water. Emphasize that the natural inhabitants of the water have adapted to the stream or river environment, but that when theses conditions change, they can a harmful effect on them. Discuss how changes in land use can introduce various kinds of pollution to the stream or river environment.

Possible Follow Up:

1. Test various samples of water for nutrients such as nitrates or phosphates and discuss their effects on water quality.

Adapted from **Rivers at Risk**, pp. 30-31

Major Pollutants of Fresh Water

Cause of Pollution	Consequences of Pollution
Organic Matter and Fertilizers • Sewage from cities and towns • Livestock waste from farms • Pet waste • Fertilizers used on farms, lawns, gardens, golf courses and parks	Increased levels of nitrates and phosphates cause growth of algae and bacteria, which use up the dissolved oxygen in the water that fish and other creatures need for survival.
Sediments • Natural erosion of hills and river banks • Construction sites • Farms • Waste products from mines	Many creatures require a rocky bottom on which to lay their eggs, which becomes unavailable when covered in sediment. Fish and other creature's eggs can also be buried in silt. Food becomes harder to see and gills can become clogged with silt. Water temperature increases when the sun's heat is absorbed by darker sediment, causing oxygen levels to decrease. Sediment in water also prevents the sunlight from reaching plants on the bottom.
Toxic Waste • Industrial areas: petrochemical products, solvents, heavy metals and minerals • Cars: motor oil, coolant, brake fluid, metal particles (copper, zinc and cadmium from brake lining and tire wear) • Diesel exhaust: chromium, mercury, copper, zinc	Poisoning of fish and other water organisms. Illness in humans. Some toxic waste is associated with cancer or leukemia, which can be fatal.
Pesticides, Fungicides, Herbicides • Used on farms, lawns, gardens, golf courses and parks	Can be poisonous to aquatic organisms and to humans. Some chemicals build up over time in organisms, becoming more concentrated in the bodies of animals near the top of the food chain, such as fish, which may be consumed by humans.
Disease-Carrying Organisms • Bacteria found in sewage • Mosquitoes	Illness in humans caused by bacteria. Spread of diseases such as Malaria and West Nile Virus by mosquitoes.

Muddying the Waters

Students investigate the behavior of sediment in water, and discuss how sediment can affect waterways and the creatures that live in them.

Level(s): 6, 7

Subject(s): life science, earth science

Virginia SOLs: 6.1 h,i; 6.5 c,g; 6.7 a,f; LS4 a, b, c; LS 12 b,d,e;

Objectives:
Students will be able to:
1. summarize the effects of sediment on water quality.
2. describe the behavior of sediment in water.
3. list methods for preventing sediment from entering waterways.

Materials:
For each student group:
- one clean jar with lid
- scissors
- rulers
- white paper
- clear tape
- 50 ml of soil (from schoolyard)
- stirrer
- tap water
- graduated cylinder or measuring cup
- stopwatch or wristwatch with second hand

For each student:
- *Student Experiment Sheet*
- *Student Data Sheet*

Estimated Time: two 50-minute sessions

Background Information: *Water Pollution: Sediment*, p.109.

Preparation:
1. For each jar cut a 2-inch wide strip of white paper the approximate height of the jar.
2. Divide each strip lengthwise into 3 zones of the same size and label the zones: "A" at the top, "B" in the center and "C" at the bottom.
3. Attach each strip to the jar vertically with the letters facing inward so that the students can look through the jar from one side and see the strip and its labels on the opposite side.

Activity Procedure:

Session One
1. Define and discuss *sediment*, if you have not already done so in previous activities. Explain that when soil and other particles are eroded from the land, they are often carried into waterways.

2. Distribute the *Student Experiment Sheet* and *Student Data Sheet* to each student. Explain how the sheets are to be used, and ensure that the students understand the experiment procedures.
3. Have students complete the "hypothesis" section of the *Student Experiment Sheet*. When they are done, ask students to share their predictions with the class.
4. Divide the class into groups of 3-4 and give each group the materials for the experiment (i.e. jar, soil, stirrer, measuring cup and stopwatch). Instruct students to perform the experiment procedures, and explain that each group member should complete his or her own Student Data Sheet (with help from group members).

Session Two

1. Direct students to consult their completed *Student Data Sheets* and complete the "Conclusions" section of the *Student Experiment Sheet*.
2. When students have completed the *Student Experiment Sheet*, discuss the experiment, and ask students to share their results. Ask students to share their "Conclusions" from the *Student Experiment Sheet*. In addition, discuss the following questions:
   - What are some ways that people can help reduce the amount of sediment entering waterways?
   - What can we do to educate others in our school and community about the effects of sediment on the water quality and aquatic life of local waterways?

Assessment Opportunities:

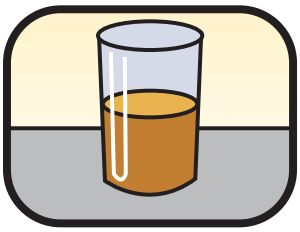
Have students:

1. summarize the effects of sediment on water quality
2. describe the behavior of sediment in water
3. list methods for preventing sediment from entering waterways

Extensions:

1. Have students design experiments comparing how long various types or mixtures of soil remain in suspension, including different mixtures of clay, sand and organic debris. What conclusions can they draw from the results?
2. Have the class participate in the planting of a riparian buffer.

Adapted from **Lessons from the Bay**



Muddying the Waters

Student Experiment Sheet

Name _____

Question: How does sediment affect water quality?

Prediction:

I predict the sediment will

___ sink to the bottom.

___ float on the top.

___ completely dissolve.

___ be suspended in the water.

I predict the sediment will

___ not change the clarity of the water.

___ change the clarity of the water. In what way?

_____

Procedures:

1. Fill your jar with 500ml of tap water.
2. Add 50 ml of soil.
3. Use your stirrer to mix the contents of the jar completely.
4. Put the lid back on the jar.
5. Shake the jar well.
6. After 1 minute, 5 minutes, and 10 minutes:
   a. Observe the clarity of the water in each zone. Record the level of clarity (*clear*, *somewhat clear*, *somewhat cloudy*, *cloudy*, or *very cloudy*) on the data sheet.
   b. Draw a detailed picture of the jar in the boxes on the data sheet.

Conclusions:

1. Were your predictions correct or incorrect? Explain.

_____

_____

_____

2. What actually happened? Did the sediment sink, float, dissolve, or suspend in the water? Describe what happened.

_____

_____

_____

3. How did time affect the clarity of the water in each zone?

_____

_____

_____

4. How do you think sediment might affect fish and other aquatic life? Will the impact be different depending on where the organisms live?

_____

_____

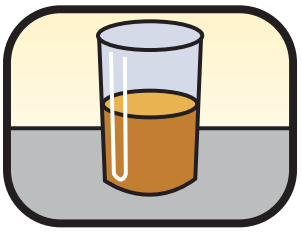
_____

5. Based on what you have observed, could sediment in the Bay eventually change it physically? If so, explain how.

_____

_____

_____



Muddying the Waters

Student Data Sheet

Name _____

		Zone A	Zone B	Zone C
1 minute	Clarity			
	Picture			
5 minutes	Clarity			
	Picture			
10 minutes	Clarity			
	Picture			

Water Pollution: Sediment

Sediment, small particles of soil and other materials, is one of the most damaging pollution of waterways and bodies of water such as the Chesapeake Bay. When stormwater runoff causes soil erosion, it carries sediment into the water. Natural erosion may be increased 4 to 8 times by agricultural development and 10 to 50 times by careless construction.

Sediment fills stream channels, harbors and reservoirs. When suspended in the water, sediment prevents sunlight from reaching underwater vegetation. Suspended sediment can also clog the gills of fish. And makes it harder for them to find food. As sediment settles to the bottom, it can smother the organisms that live there. It can also cover the rocks on the bottom of waterways, which is where many aquatic creatures lay their eggs.

Sediment can best be reduced by erosion-control measures. Hay bales and filter cloths can be used to keep exposed soil from reaching nearby waterways. Seeding and mulching can establish vegetation that will hold soil in place. Vegetated buffer zones along waterways filter sediment from runoff before it reaches the water.

Erosion: Rubbing the Earth the Wrong Way

Students perform an experiment to determine how water volume and velocity affect soil erosion.

Level(s): 6-8

Subject(s): Life Science, Earth Science

Virginia SOLs: 6.5 c,g; 6.7 a,f; 6.9 a,c; LS4 a,b,c; PS1 b,k,m

Objectives:
Students will be able to explain how
1. water volume and velocity affect the erosion of soil.
2. sediment in water affects aquatic organisms.
3. erosion can be prevented.

Materials:
For all students.
1. Copies of the article *Water Pollution: Sediment*
2. Copies of the handout *Erosion*: *Student Data Sheet*
3. (optional) clipboards

For each group
1. enough sand or sandy soil to build a mound 2 feet high
2. enough clay soil to build a mound 2 feet high
3. eye dropper
4. graduated cylinder
5. step ladder (or other means of pouring water from a height of 6 feet)

Estimated Time: 50 minutes

Background Information: *Water Pollution: Sediment*, p.109.

Preparation: Arrange for materials and a suitable outdoor location

Activity Procedure:
1. Have students discuss what they know of erosion and its effect on water quality.
2. Describe the experiment that you will be having the students perform. Ask them to predict what they think the results will be.
3. Divide the students into groups of 4 or 5.
4. Have each group build two mounds of soil – each 2 feet high – one from sandy soil and one from clay soil.
5. Drop 10 drops of water from an eye dropper from a height of one foot onto both mounds of soil. Have students observe and record any marks made by the water, taking notes on their data sheet.
6. Repeat the process from six feet.

7. Pour 4 oz. of water onto each mound from one foot and then six feet, taking notes and sketching any changes to each mound.
8. Pour 16 oz. of water onto each mound from the two heights, recording the results.
9. Discuss and compare results back in class. Have students compare their results to their initial predictions. Ask students to suggest conclusions about soil erosion as it relates to type of soil and volume and velocity if rainfall, based on their observations.
10. Hand out *Water Pollution: Sediment* for homework or to read in class and discuss the article afterwards.

Assessment Opportunities:

Ask students

1. What three factors account for the amount and rate of soil erosion?
2. What are three ways soil erosion can be controlled?
3. What are three ways in which sediment is harmful to aquatic organisms?

Extensions:

1. Have students locate places around the school (or in their own neighborhood) where erosion has occurred. They should sketch the erosion and suggest ways the erosion at each location could be prevented. If digital cameras are available, have students take photographs.
2. Have students suggest ways that the previous experiment could be improved to make it more accurate or informative. (each test should use a dry mound, the rate at which water is poured should be standardized)

Adapted from **Action for a Cleaner Tomorrow,** pp.153-154.