BIOASSESSMENT OF STREAMS

6-8

SUBJECTS:
Biology, Ecology

TIME:
field trip or walk to a stream, then 2 class periods

MATERIALS:
magnifying glasses—one per student, if possible
2 buckets per team
2 hand nets for scooping stream debris
one clipboard & pencil per team
rubber boots for 2 people
student sheets

OBJECTIVES

The student will do the following:

1. Work as a team to gather organisms from a stream to evaluate if the water quality is excellent, good, or fair to poor.

BACKGROUND INFORMATION

The quality of streams can be determined by analyzing macroinvertebrates present. Macroinvertebrates are those organisms lacking a backbone that are visible to the naked eye. In freshwater streams, they include insects, crustaceans (crayfish and others), mollusks (clams and mussels), gastropods (snails), oligochaetes (worms), and others. In most streams and rivers, the larval insects dominate the macroinvertebrate community. These organisms provide an excellent tool for stream quality assessment work because they are restricted to their immediate habitat and cannot escape changes in water quality.

The problems affecting streams can be grouped into three general categories:

1. Physical – stream alterations such as reduced flow or temperature extremes, including excessive sediment input from erosion or construction which unfavorably alters riffle characteristics. The result of physical impacts to a stream range from a general reduction in the numbers of all organisms to a reduction in the diversity of taxa.
2. Organic Pollution and Enrichment – the introduction of large quantities of human and livestock wastes, as well as agricultural fertilizers. Mild organic enrichment usually results in a reduction in diversity, leaving a marked increase in the types and numbers of macroinvertebrates that feed directly on organic materials. Because of the organic enrichment, excessive blooms of algae and other aquatic plants provide a plentiful food supply, favoring algae and detritus feeders.
3. Toxicity – this includes chemical pollutants such as chlorine, acids, metals, pesticides, oil, and so forth. It is very difficult to generalize the effects of toxic compounds upon macroinvertebrates, since a number of the organisms vary in their tolerance to chemical pollutants. Generally speaking, however, a toxicity problem is usually the only condition that will render a stream totally devoid of macroinvertebrates.

Terms

detritus: loose fragments or grains that have been worn away from rock.

macroinvertebrates: organisms that are visible to the naked eye and lack a backbone.

taxa: one of the hierarchical categories into which organisms are classified.

ADVANCE PREPARATION

A. Either schedule a field trip or walk your class to a nearby stream or do the same activity as a classroom simulation, with 3 "streams" that have paper cut-out animals to be found and analyzed.

B. Divide the room into teams of about 10 students each with a team recorder for each group who will need a pencil, clipboard, and "Stream Quality Assessment Form."

C. Run off copies of the "Stream Quality Assessment Form," the "Macroinvertebrate Groups" form, and the "Bugs" sheets showing common stream macroinvertebrates.

D. Gather magnifying glasses for the class. The small ones tied around the neck like a necklace work very well.

E. Procure a couple of hand nets to gather stream debris. Procure 2 buckets per group.

F. Make sure those who will be in the stream wear rubber boots. Sometimes it is best for the teacher or a parent to get in the stream and do the actual gathering in the nets. Let the students go through the net contents and find the animals.

G. Contact an environmental scientist (if possible), for help in identifying the animals.

PROCEDURE

I. Setting the stage

A. Pour a glass of "mystery water" (made of sweetened tea) and tell the class this water was collected from a stream near a chemical plant. Ask if you have any volunteers to drink it. If there are no volunteers, drink the whole glass and brag about how delicious it tasted. Then pour a glass of "mystery water" (made of clear saltwater) and ask for a volunteer to taste it. Warn them that you are not sure where it came from and that they had better only take a sip. (One sip will not make anyone sick.)

B. Discuss the problem of determining water quality when the water has not been tested. Ask if the students can think of a way to determine water quality without a water testing kit.

II. Activity

A. Plan a trip to a nearby stream to bioassess the water quality. Each team should have an adult advisor, if possible, to help identify organisms. The "Macroinvertebrate Groups" form will help to identify organisms. Make sure one member of each team serves as a recorder with a clipboard, pencil, and "Stream Quality Assessment Form." Use the bottom half of the form to tally each animal discovered by a team member.

B. Only one or two people need to get into the stream (in the shallow parts, wearing rubber boots) and use nets to scoop up mud, leaf, and other stream debris. This is emptied out into a bucket in the center of each team, whose members go through it looking for organisms. As they find organisms, they identify them as belonging to group 1, 2, or 3 and are tallied by the team recorder.

C. This process lasts about 45 minutes. The goal is to find 100 organisms for each team, but stream assessment can be accomplished with fewer specimens. The teams do not bring specimens back to the school, although it is interesting to bring back a water specimen to view under the microscope.

D. After returning to school, the class analyzes and compares all team data. If many specimens (over 22) are found from Group 1, the stream is of excellent quality, since these organisms are pollution-intolerant. If there are few or no specimens from Group 1 and 2, and mostly specimens from Group 3, one can assume the stream quality is poor, with only pollution-tolerant organisms able to survive.

III. Follow-Up and Extension

A. Many opportunities exist to teach children about environmental issues after this activity. A few possibilities include cleaning up a poor quality stream, trying to find out the source of pollution and getting it stopped, and assessing other streams.

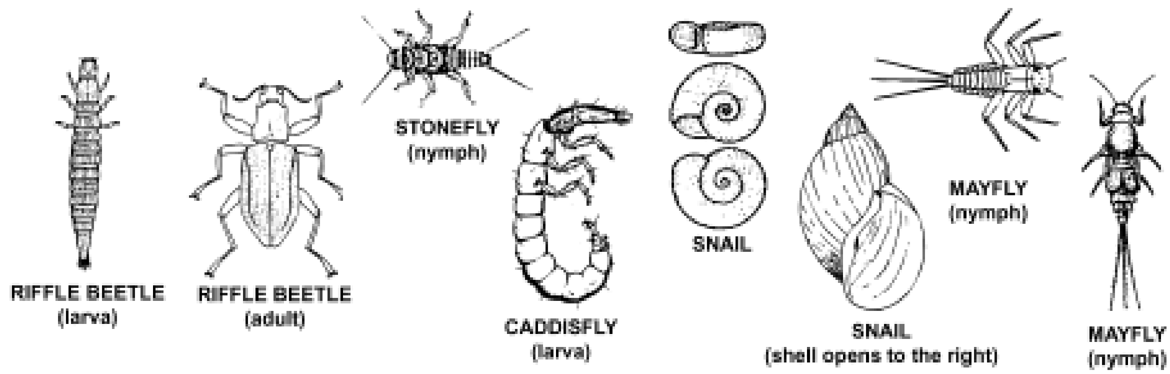
RESOURCES

Kentucky Water Watch. Biological Stream Assessment: http://www.state.ky.us/nrepc/water/introtxt.html

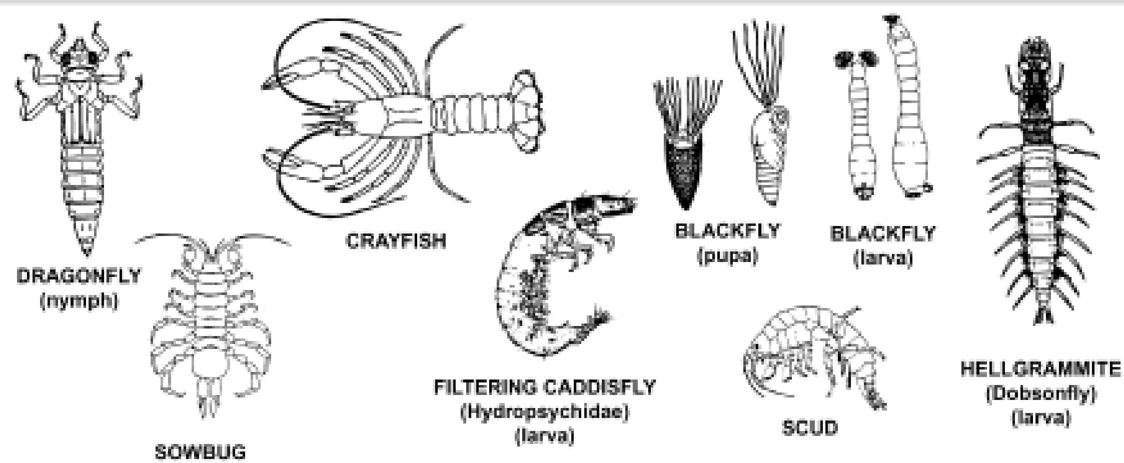
State Water Watch Organizations.

MACROINVERTEBRATE GROUPS
Beginner s Protocol PICTURE KEY

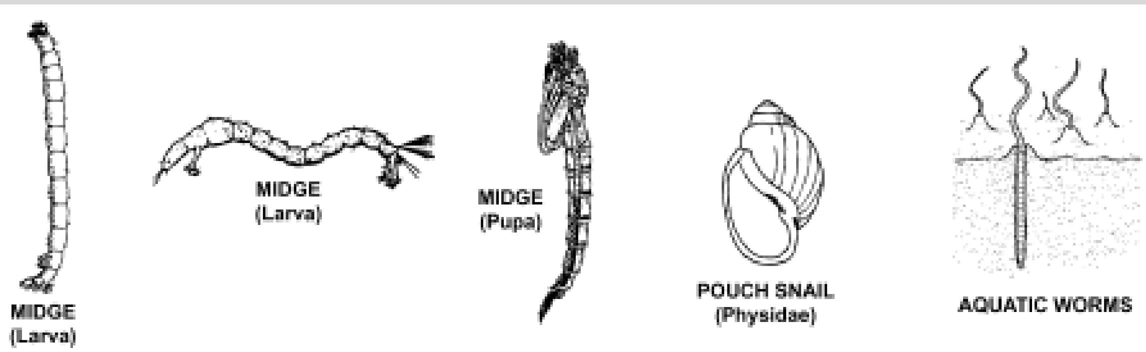
GROUP 1 *These organisms are generally pollution intolerant. Their dominance generally signifies* ***Excellent-Good Water Quality.***

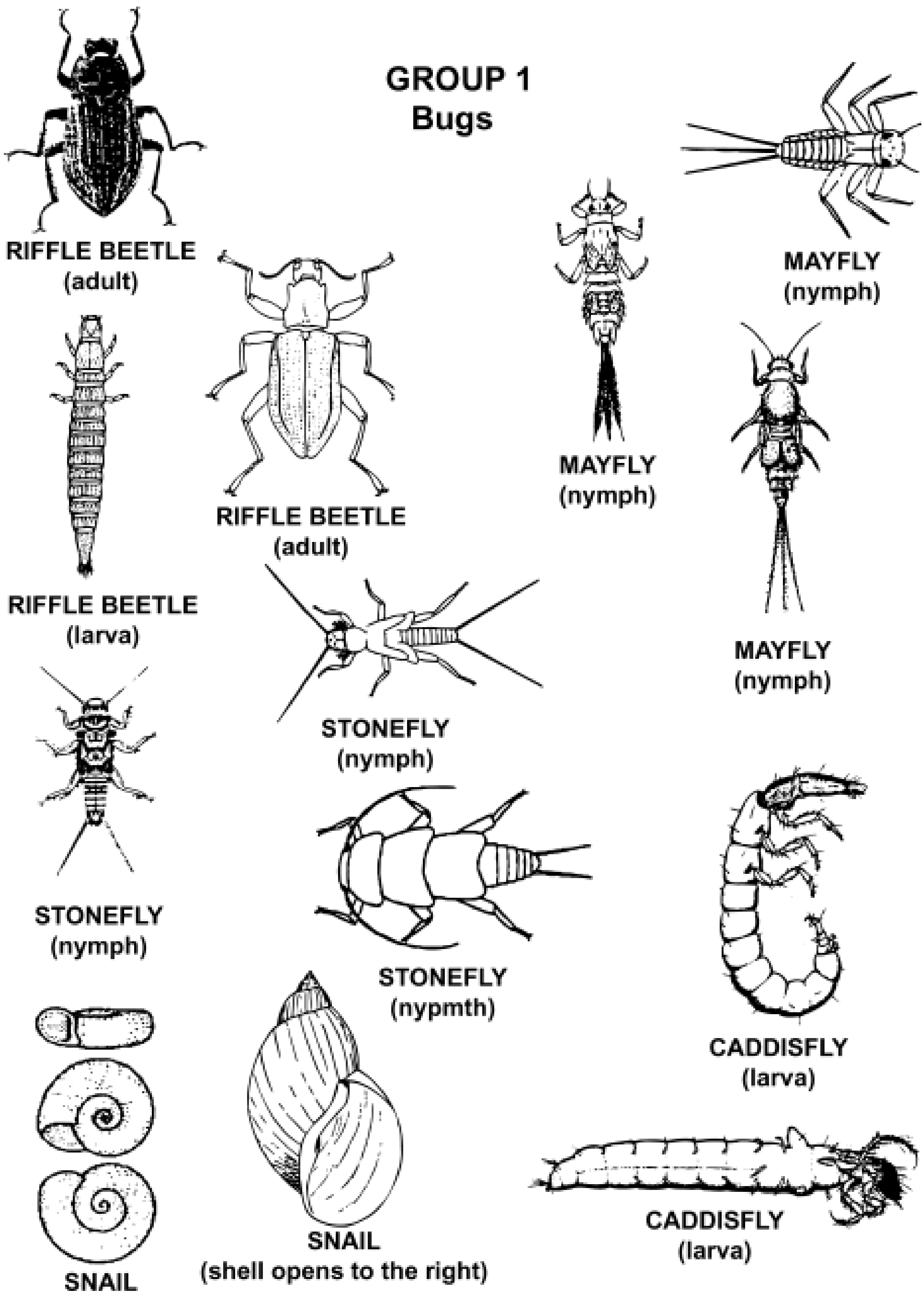


GROUP 2 *These organisms exist in a* ***Wide Range*** *of water quality conditions.*

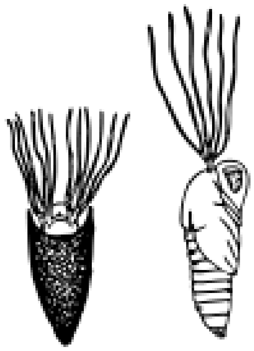


GROUP 3 *These organisms are generally tolerant of pollution. Their dominance generally signifies* ***Fair-Poor Water Quality.***

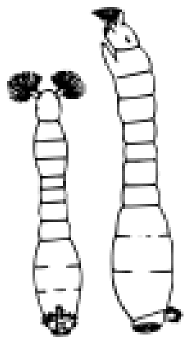



GROUP 1
Bugs
RIFFLE BEETLE
(adult)
MAYFLY
(nymph)
RIFFLE BEETLE
(adult)
MAYFLY
(nymph)
RIFFLE BEETLE
(larva)
MAYFLY
(nymph)
STONEFLY
(nymph)
STONEFLY
(nymph)
STONEFLY
(nypmth)
CADDISFLY
(larva)
CADDISFLY
(larva)
SNAIL
(shell opens to the right)
SNAIL

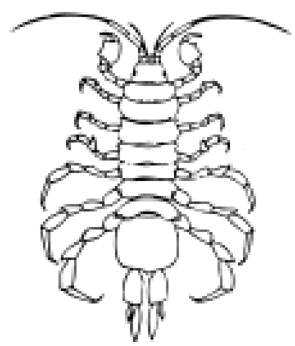
GROUP 2
Bugs



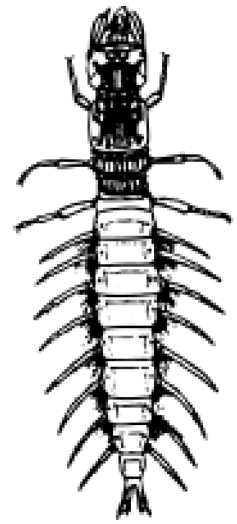
BLACKFLY
(pupa)



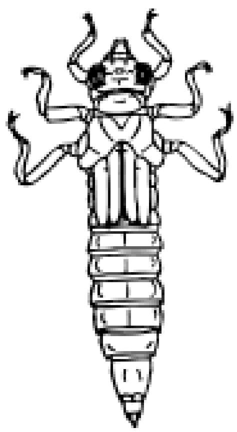
BLACKFLY
(larva)



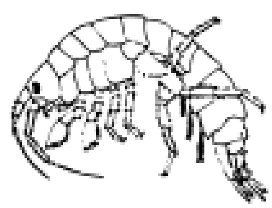
SOWBUG



HELLGRAMMITE
(Dobsonfly)
(larva)

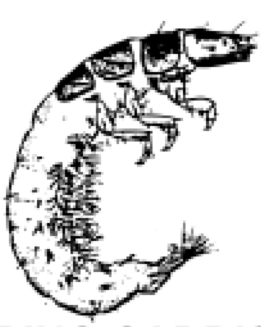


DRAGONFLY
(nymph)

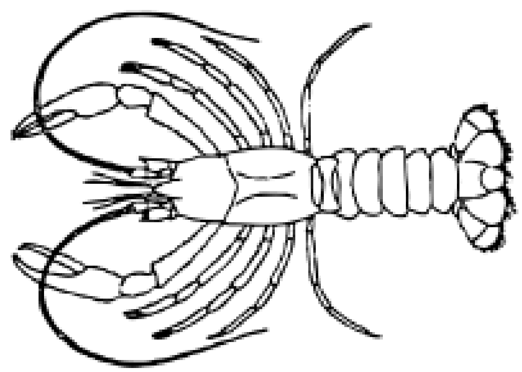


SCUD

SNIPE FLY
(larva)



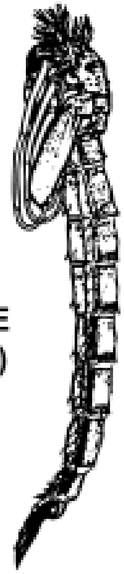
FILTERING CADDISFLY
(Hydropsychidae)
(larva)



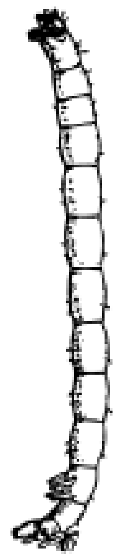
CRAYFISH

GROUP 3
Bugs

MIDGE
(Larva)



MIDGE
(Pupa)

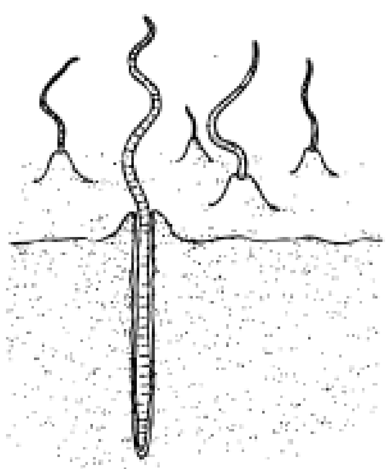


MIDGE
(Larva)

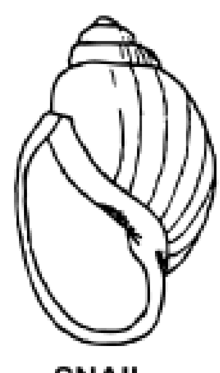
MIDGE
(Larva)

MIDGE
(Pupa)

MIDGE
(Pupa)



AQUATIC WORMS



SNAIL
(shell opens to the left)

STREAM QUALITY ASSESSMENT FORM

Monitoring Group

Name: ____________________ Stream Name: ______________

Site Location: __________________ Date:___________ Time (military):__________

County: _______________________ Town/City:_________________

• •

Organic Substrate Components: ____

Canopy Cover: open partly open partly shaded shaded

Streamside Vegetation type: ____

Turbidity: clear sightly turbid turbid opaque

Water Conditions (color, odor, bedgrowths, surface scum):_______________________

• •

Chemical Assessment

Please convert ½F to ½C (½C=[½F–32] x 5/9) & feet to centimeters (cm=ft x 30.48)

Air temp ½C:_________________ Water temp ½C:__________

Water depth (cm):______________ Secchi Depth (cm):_______

Alkalinity (mg/l):______________ Hardness (mg/l):__________

Dissolved Oxygen (mg/l):______ pH (SU):________________

Turbidity (JTU):_______________

• •

Width of Riffle:_______________

Bed Composition of Riffle (%):

Silt:_________

Sand:________

Gravel (1/4" -2"):___________

Cobbles (2"-10"):___________

Boulders (>10"):____________

CLEANING POINT SOURCE POLLUTION

6-8

SUBJECTS:
Chemistry, Ecology, Math

TIME:
50 minutes

MATERIALS:
clear plastic cups
medicine dropper
straw
spoon
motor oil
water
paper towels
student sheet

OBJECTIVES

The student will do the following:

1. Estimate the amount of pollution in a water sample.
2. Remove pollution from water using different methods.
3. Measure the pollution removed and calculate the percentage of pollution removed from each sample.
4. Analyze and discuss the most effective methods of cleaning pollution from water.

BACKGROUND INFORMATION

Point source pollution is pollution that is discharged from a single source, such as an oil tanker, water treatment plant, or a factory. Point source pollution is easily identified and can be traced to its source. It is often difficult to enforce cleanup of point source pollution, even when the source is identified. Point source pollution can also come from septic-tank systems, storage facilities for polluted waste, petroleum products stored underground, and runoff from landowners.

Organic chemicals are products composed of hydrocarbons originally found in ancient plants. A petroleum product, such as oil, can be accidentally released into the environment when collisions of tankers occur, when ships run aground, when facilities leak, or when petroleum products are not disposed of properly.

Sewage, radioactive and hazardous metals, medical wastes and all manner of dissolved solids contribute heavily to the pollution of our waterways. Of particular importance is mine waste because it is continuous, commercially important on a large scale, and involves pollution of water at several different points in processing. In coal mines in particular, sulfuric acid (H2S) is a problem. Coal is mineralized plant and animal matter that was not decomposed by microbes millions of years ago because it was in an oxygen-free environment. Without oxygen, microbes breathed sulfates instead and reduced them to sulfuric acid. This reaction is very inefficient, so these microbes were unable to decompose the carbon rich plant material. H2S is a natural and necessary part of coal deposits, but it is also a very strong acid. Poured onto soil, it causes aluminum and iron toxicity in crop plants and kills nitrogen fixing organisms, leading to crop deficiencies in nitrogen. The H2S that gets to the smelting stage of processing becomes gaseous H2SO4, the main ingredient in acid rain. Many other harmful minerals are present in the ores themselves so that even slurries of crushed rock may be harmful to the environment.

Many pieces of legislation have been put forth to eliminate point source pollution. The General Mining Law of 1872 says that miners who pollute canals that settlers rely upon must pay reparations for the damages they have caused. The Refuse Act of 1899 required a federal permit for the dumping of anything into navigable waters, and the Clean Water Act of 1972 regulated a new program of permits to replace the permits of the 1899 law with stricter more efficient enforcement.

Nonpoint source pollution is pollution generated from diffuse sources rather than one specific, identifiable source. The primary contributors to nonpoint source pollution include urban runoff, agriculture, silviculture, storm water, livestock waste, and raw domestic wastes. It may include contaminants such as sediment, bacteria, oil and oil-related chemicals, pesticides, heavy metals, and other toxic substances. Heavy rainfall often increases nonpoint source pollution by washing sediment, chemicals, and other contaminants from fields, towns, and cities into surface water areas and eventually into areas of possible groundwater recharge. Many federal, state, local agencies and groups have programs to help reduce nonpoint source pollution.

Terms

point source pollution: pollution that can be traced to a single point source, such as a pipe or culvert (e.g., industrial and wastewater treatment plant discharges).

nonpoint source pollution (NPS): pollution that cannot be traced to a single point, because it comes from many individual places or a widespread area (Example: urban and agricultural runoff).

hydrocarbons: a very large group of chemical compounds consisting primarily of carbon and hydrogen. The largest source of hydrocarbons is petroleum (crude oil).

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

ADVANCE PREPARATION

A. Set up three stations consisting of three different procedures for removing oil from water. **(Note: Oil may be added to each container by the teacher or by each group. The quantity of oil should be determined by the teacher. Each group must add the same amount of oil.)**

B. Place the following materials at the designated station:

Station 1:	Station 2 :	Station 3:
spoon	straw	medicine dropper
two clear plastic cups	two clear plastic cups	two clear plastic cups
student sheet	student sheet	student sheet
paper towels	paper towel	paper towel
motor oil	motor oil	motor oil

PROCEDURE

I. Setting the stage

A. Have students brainstorm the best ways to remove oil pollution from water. Have them research and discuss the oldest methods and compare them to newer methods used today.

B. Have students predict the most effective cleanup method of the three methods they will be using.

II. Activity

A. Station 1: You will have two minutes to perform the following activities:

1. Work with your group and estimate the pollution (oil) in each of the three samples. Enter your findings on the data table.

2. Have one member of the group use the spoon to try to remove all of the oil from the sample. Place the oil in an empty plastic cup.

3. Measure the amount of oil removed and calculate the percentage of pollutant removed from the sample with the spoon (old technology). Divide the amount of oil removed by the amount of water.

4. List any spills on the data chart.

5. Mark down any instances of habitat disturbance, such as water being removed with the cleanup.

B. Station 2: You will have two minutes to perform the following activities:

   1. Have another member of your group use the straw and try to remove all of the oil from the sample. Save the oil in an empty plastic cup.

   2. Measure the amount of oil removed and calculate the percentage of pollutants removed from the sample with this newer technology (straw). **Do not use your mouth!** Divide the amount of oil removed by the amount of water.

   3. Mark down any spills on the data chart.

   4. Mark down any instances of habitat disturbance, such as water being removed with the cleanup.

C. Station 3: You will have two minutes to perform the following activities:

   1. Have another member of your group use the medicine dropper and try to remove all of the oil from the sample with the dropper (newer technology).

   2. Measure the amount of oil removed and calculate the percentage of pollutant removed from the sample with the dropper. Divide the amount of oil removed by the amount of water.

   3. Mark down any spills on the data chart.

   4. Mark down any instances of habitat disturbance, such as water being removed with the cleanup.

D. Analyze the data collected from each group and discuss the most effective oil removal method. Brainstorm how cost-effective each method is on a global basis.

III. Follow-Up

A. Perform the same steps, but substitute various pollutants other than oil.

B. Have students research major oil spills in the world that are presently being cleaned and the methods by which they are being cleaned.

C. Have students discuss disposal alternatives for removed oil (Examples: burning, re-refining, coating surfaces for protection, use as fuel, etc.).

IV. Extensions

A. Secure a speaker from the Coast Guard or Environmental Protection Agency that has participated in a coastal cleanup.

B. Have students participate in a coastal cleanup, Earth Day activities, a clean campus organization, or other environmental activities.

RESOURCES

Arms, K. Environmental Science, Holt, Rinehart, and Winston, Austin, TX, 1996.

The Changing Definition of Point Source Pollution in the Clean Water Act of 1972: http://moby.ucdavis.edu/GAWS/161/2bravo/1.htm

Nonpoint Source Pollution: http://www.deq.state.la.us/owr/owrnps.html

Directions: Complete the data table for each of the three types of technology.

Technology	Original Cup Estimated mL Oil	Dump Cup % Oil Removed	Oil Spills While Cleaning Up	Water Removed Estimated mL Water
Spoon				
Straw				
Medicine Dropper				

Analysis and Conclusions

1. Which technology resulted in the most spills during cleanup?

2. Which technology caused the least disturbance of the habitat (removed the least water from the sample)?

3. Which technology would result in the highest fine?

4. Were the three technologies equally effective in helping you remove 50% of the pollution?

5. State a conclusion which relates to your original hypothesis.

COLIFORM BACTERIA AND OYSTERS

6-8

SUBJECTS:
Art,Geography, Microbiology, Math,

TIME:
50 minutes for experiments plus four observation days

MATERIALS:
film for camera
water samples from coastal areas
membrane filtration apparatus
hand-operated vacuum pump
MF-Endo broth in premeasured 2 mL ampuls (bio. supply co.)
absorbent media pads and gridded membrane filters
50- or 60-mm (about 2 inch) diameter petri dishes
1 mL plastic pipette
alcohol lamp
forceps
sterile or dechlorinated tap water
sterile glass or plastic petri dishes
1 mL plastic pipette
EMB (eosin-methylene-blue) agar-agar
Means Option B test materials
student sheets

OBJECTIVES

The student will do the following:

1. Explain why coliform tests are performed to aid in the protection of oyster reefs.
2. List three common sources from which coliform bacteria enter a body of water such as a bay or estuary.
3. Perform an experiment to measure the amount of coliform bacteria in a water sample from different areas of bays and estuaries.
4. Define and interpret verbal materials concerning the vocabulary used in the terms list.

BACKGROUND INFORMATION

Oyster farming in coastal areas is a valuable activity. The collection, processing, transporting, and selling of these oysters provide an income for many people. As is the case with fisheries, state laws regulate oystering. These laws are designed to protect the health of the consumer and the size of the oyster population.

Oysters are common bivalves that live in shallow estuarine waters. Their soft body tissue is enclosed by a two-part shell which is held together by a strong hinge. The shell of an oyster is usually attached to another oyster or some other hard object, forming clumps of oysters. Large areas covered with these clumps are called oyster reefs.

Oysters take in oxygen from the water by pumping water through their bodies and across their gills. During this process, tiny plants and animals are filtered from the water and are eaten by the oyster. The oyster cannot choose what is filtered from the water. Whatever is present in the water is filtered and taken into the oyster. Thus, any toxins or harmful microbes in the water are likely to be present in the oyster also.

State conservation, natural resources, and public health agencies are authorized to regulate the opening and closing of the oyster reefs. An open oyster reef is one from which you can legally collect oysters. A closed reef is off-limits to oyster collecting. Numerous tests and measurements are performed to provide information that will influence decisions to open or close the reefs. One of these tests measures the amount of a certain type of bacteria called coliform bacteria. These indicator bacteria are commonly found in the intestinal tract of many animals, including humans. They aid in digesting many foods that animals cannot digest alone. When animals defecate, some of the coliform bacteria in the intestinal tract are also passed. Although coliforms are relatively harmless, their quantity in the water is measured because it may be an indication that other harmful microbes are present. If these microbes are present in the water, they are probably also present in the oysters that live in that water.

Sewage outfalls are the most common causes of increased coliform levels. Although many environmental factors influence the closing of an oyster reef, an outfall located too close to a reef may be responsible for its permanent closing. The decision of where to put a new sewage outfall is always an intensely debated issue. Sometimes it is difficult to utilize one resource without affecting or destroying another. People are continually seeking better ways of using one resource without harming others.

In this activity, you will perform a test to measure the amount of coliform bacteria present in water samples taken from different areas. The tests actually used by state authorities are too difficult to be used in this case. Three quick and easy tests for measuring the amount of coliform are provided here.

Terms

bivalve: a mollusk that has two shells hinged together, such as the oyster, clam, or mussel.

coliforms: bacteria found in the intestinal tract of warm-blooded animals; used as indicators of fecal contamination in water.

defecate: to void excrement or waste through the anus.

estuarine: of an area where a river empties into an ocean; of a bay, influenced by the ocean tides, which has resulted in a mixture of saltwater and freshwater.

fishery: a place engaged in the occupation or industry of catching fish or taking seafood from bodies of water; a place where such an industry is conducted.

microbe: a microorganism; a very tiny and often harmful plant or animal.

sewage outfall: the point of sewage discharge, often from a pipe into a body of water, in turn called the outfall area.

ADVANCE PREPARATION

A. The teacher should be the one to collect appropriate water samples to be tested. Pictures should be taken of the various areas in which samples were collected. It is important that students can relate the samples to particular areas along the bay.

B. Make sure that the body of water from which you collect the samples is not heavily polluted. You do not want your students working with a water sample with harmful toxins or bacteria.

C. A special lab session should be given to show and explain how to use alcohol lamps and hand-operated vacuum pumps, as well as give instructions on how to sterilize equipment. Leave the lab set up for the experiments the following day.

D. Ask students during the prior weeks to look in the newspapers and magazine for articles concerning the oyster season's opening or closing.

PROCEDURE

I. Setting the stage

A. Pass out developed pictures of the different areas where the samples were taken. Ask students to try to identify the particular areas in a nearby bay or estuary.

B. Post all the pictures of each particular area together on different bulletin boards or showboards. Leave them out for students to look at during and after their experimenting.

C. Have an area map to plot the locations where samples were taken.

II. Activity

A. Light the alcohol lamp and sterilize the forceps by dipping them in alcohol and igniting by passing the tip through the flame.

B. Use the sterilized forceps to place a white absorbent media pad into a petri dish. Break an ampul of MF-Endo medium and pour the contents onto the absorbent pad. Close the petri dish.

C. Resterilize the forceps in the flame. Then use it to place a gridded membrane filter on the filter funnel. Close the apparatus.

D. Pour about 100 mL (the amount does not affect the outcome) of sterile or chlorine-free tap water into the funnel of the machine. The sterile water is used to dilute the test sample so coliforms (if present) will be distributed evenly on the filter and, therefore, be easier to count.

E. Pipette one mL of the "test sample water" (river or bay water) into the funnel of the apparatus. **Students should not put the pipette to their mouths.** The pipette will fill by capillary action if it is held vertically in the water, or a pipette bulb may be used.

F. Cover the apparatus and swirl it to mix the sterile dilution water and the one-mL test sample water.

G. Attach the hand pump to the equipment and filter the water. Sterilize the forceps. Then remove the filter and set it into the petri dish on top of the MF-Endo saturated pad. Close the petri dish.

H. Store the dish upside down in a dark place at room temperature. (Petri dishes are incubated in an inverted position to prevent condensation or moisture from falling on bacterial colonies: It causes them to "run together.")

I. Observe and describe the dishes each day for five days. Fill in the student data.

J. Counting the coliforms: Coliform colonies have a distinct metallic green sheen. Count only the obvious coliform colonies.

III. Follow-Up

A. The following is another convenient way to test for the "quantitative" presence of coliform bacteria without using an expensive membrane filtration kit.

1. Make up one or more sterile EMB agar-agar plates per group.

2. If you are using 100-mm sized petri dishes, pipette one mL of test sample (river or bay water) directly into the dish. Cover the dish and swirl the sample so the water covers as much agar as possible.

3. Store the petri dish upside down in a warm dark place at room temperature.

4. The presence of metallic green colonies is a positive test for coliform bacteria. Count the coliform colonies.

B. Due to crowding of the bacteria, it may be impossible to count all the colonies. Nevertheless, this experiment will give you a rough idea of the relative numbers of coliforms present in the water sample. Though relatively inaccurate, this procedure is fast, simple and very inexpensive. In addition, it requires a minimum amount of equipment. Even if you don't find coliforms, you will discover other kinds of bacteria, which in itself is interesting. A third simplified plate technique exists. Contact Alabama Water Watch for name, cost, and procedure.

C. Contact the local wastewater treatment plant. The plant operator might be willing to provide equipment or split a sample to verify students' results. The telephone and name can be gotten by calling the city hall, township hall, or village hall.

IV. Extensions

A. Take additional pictures of the results from the experiment and place the colony pictures with the correct photos taken from the different areas of the water you tested.

B. Have students correlate and graph the results of the experiments.

C. Students will then take the information and put it on the computer to send to their Conservation, Natural Resources, or Public Health agencies. Comparisons are requested from these departments.

RESOURCES

Biggs, A., Kapitka, C., and Lundgren, L., Biology: The Dynamics of Life, Glencoe, NT, 1995.

Cunningham, W. and Saigo, B., Environmental Science, Brown Publishers, Dubuque, IA, 1995.

STUDENT SHEET — COLIFORM BACTERIA AND OYSTERS

6-8

Directions:
Label each of the three petri dishes with the source of the water used.
Inoculate each dish with water, tape the lids on, and place it in a warm (not hot), dark place.
Draw and describe what is observed each day on each dish by filling in the information below.

Day 1 Date ___________________________

Inoculate three dishes with water from (1) _____________, (2)_____________, and (3) _______________.

Day 2 Date ___________________________

1

Description

2

Description

3

Description

Day 3 Date ___________________________

1

Description

2

Description

3

Description

Day 1 Date ____________________________

Inoculate three dishes with water from (1) ______________, (2)______________, and (3) ________________.

Day 2 Date ____________________________

1

2

3

Description

Description

Description

Day 3 Date ____________________________

1

2

3

Description

Description

Description

ALGAE GROWTH

6-8

SUBJECTS:
Biology, Botany, Math

TIME:
2 weeks

MATERIALS:
1-L soda bottles with labels
distilled water
three types of laundry or dishwashing detergents (two with and one without phosphate)
lawn fertilizer
graduated cylinder
pond water samples
microscope
student sheets
various algae

OBJECTIVES

The student will do the following:

1. Test the effects of common pollutants on algae growth in water.

2. Observe the growth of algae in a water sample.

BACKGROUND INFORMATION

Algae are simple plants. They generally do not have vascular tissue, and they do not show the high level of organ differentiation of the familiar, more complex plants. Most algae are photoautotrophic, which means that they can make their own food materials through photosynthesis by using sunlight, water, and carbon dioxide.

Algae are the chief food source for fish and for all other types of organisms that live in the water. They also contribute substantially to the store of oxygen on Earth. There are approximately 25,000 species of algae. The simplest algae consist of a single cell of protoplasm, a living jelly-like drop. No larger than three microns, the size of a large bacterium, it is visible only under a microscope. The most complex algae are the giant kelps of the ocean that may be 200 feet (60 meters) long.

Algae are found all over the Earth, in oceans, rivers, lakes, streams, ponds, and marshes. They sometimes accumulate on the sides of glass aquariums. Algae are found on leaves, especially in the tropics and subtropics, and on wood and stones in all parts of the world. Some live in or on higher forms of plants and animals. And some exist in places where few living things are able to survive. One or two species capable of tolerating temperatures of 176 degrees F (80 degrees C) dwell in and around hot springs. A small number live in the snow and ice of the Arctic and Antarctic regions.

Marine algae, such as the common seaweeds, are most noticeable on rocky coastlines. In northern temperate climates, they form an almost continuous film over the rocks. In the tropics they are found on the floors of lagoons. They are associated with coral reefs and island atolls. A few saltwater species of green algae secrete limestone that contributes to reef formation. In freshwater, algae are not noticeable unless the water is polluted.

All algae contain the green pigment chlorophyll. This substance makes it possible for algae to perform photosynthesis. Other pigments also are present, giving different algae the distinct colors that are used as a basis of classification.

Algae are of special interest because they include the most primitive forms of plants. They have no true roots, stems, or leaves, and they do not produce flowers or seeds, as higher plants do. Yet all other groups of plants may have evolved from algae.

Algal blooms are a serious consequence of human activities effect upon the water quality and temperature. When massive amounts of algae literally overtake an area of water due to excessive nutrients, it is considered an algal bloom. In addition to being unsightly and smelly, masses of blue-green algae can literally choke the life out of a lake or pond by depriving it of much needed oxygen. At first glance this may seem like something of a paradox: since blue-green algae undergo photosynthesis, they should produce more oxygen than they consume. However, after large concentrations of algae have built up, aerobic processes such as respiration and the decomposition of dead algal cells becomes increasingly significant. Under extreme conditions, a eutrophic lake or pond may be left entirely devoid of fish.

<u>Terms</u>

algae: any of a large group of simple plants that contain chlorophyll; are not divisible into roots, stems and leaves; do not produce seeds; and include the seaweeds and related freshwater and land plants.

nonpoint source pollution (NPS): pollution that cannot be traced to a single point, because it comes from many individual places or a widespread area (Example: urban and agricultural runoff).

non-vascular plant: a plant that does not have specialized tissue for transporting water, minerals, and food.

nitrates: used generically for materials containing this ion group made of nitrogen and oxygen (NO_3^-); sources include animal wastes and some fertilizers; can seep into groundwater; linked to human health problems, including "blue baby" syndrome (methemoglobinemia).

phosphate: used generically for materials containing a phosphate group (PO_4^{3-}); sources include some fertilizers and detergents; when wastewater containing phosphates is discharged into surface waters, these chemicals act as nutrient pollutants (causing overgrowth of aquatic plants).

ADVANCE PREPARATION

A. Collect soda bottles and place labels on them. Collect several water samples from ponds and other local sources.

   1. Label the bottles "A," "B," "C," "D," and "E."

B. List these figures and compute their corresponding percentages on the chalkboard: If we represent the Earth's entire supply of water as 1,000 mL, then 28 mL represents the total freshwater supply and the remaining 972 mL is saltwater that occurs primarily in oceans.

PROCEDURE

I. Setting the stage

A. Explain to the students the importance of unicellular algae to worldwide oxygen production. Have them observe some examples of various algae both with a magnifying glass and under a microscope.

B. Display several detergent and fertilizer containers. Notice on the list of ingredients whether or not they contain nitrates and phosphates and in what amounts.

II. Activities

A. Pour 900 mL distilled water into each of the five bottles.

   1. Add 90 mL pond water to Bottle A.

   2. Add 90 mL pond water and 15 mL detergent # 1 to Bottle B.

   3. Add 90 mL pond water and 15 mL detergent # 2 to Bottle C.

   4. Add 90 mL pond water and 15 mL detergent # 3 to Bottle D.

   5. Add 90 mL pond water and 15 mL fertilizer to Bottle E.

B. Ask students to make predictions as to what they think will occur.

C. Set the uncovered bottles in a well-lighted place for about two weeks, ensuring that each bottle receives an equal amount of light each day.

D. Have students compare and record their observations on the student sheet. Take note of any algae growth that they notice.

III. Follow-Up

A. Have the students write up the lab activity by completing the student sheet.

B. Have students list and draw several different types of algae that may be present.

C. Have students locate several different types of detergents used in their home and list the phosphate and nitrate content of each.

D. What are the environmental implications of algae blooms to lakes and streams? Which are most severely affected? Why?

IV. Extensions

A. Look up algae blooms that occur when fire algae reproduce rapidly. Have students investigate how these blooms affect the animals in the water.

B. Have students go the supermarket and take notes on which detergents contain phosphates (list amount) and those that do not.

C. Contact a local nursery and find alternatives to processed fertilizers. How are they better for the environment?

D. Use a microscope to examine the microorganisms found in each bottle.

RESOURCES

Algal Bloom: http://pasture.ecn.purdue.edu/agen521/epadir/wetlands/algal_bloom.html

Introduction to Algae: http://www.botany.uwc.ac.za/presents/algae1/index.html

Compton's New Media, Inc., Compton's Interactive Encyclopedia, 1995.

Directions: Complete the following information about your investigation.

1. Problem Statement

____

____

____

2. Procedure (number the steps you performed)

a.

b.

3. Data collected

Bottle	Contents	Amt	Amt Phosphate	Amt Nitrate	Algae Growth After 4 Days	After 8 Days	After 12 Days
A	distilled water pond water	900 mL 90 mL	0	0			
B							
C							
D							
E							

4. Data Analysis

a. Which bottle had the smallest amount of algal growth? ______________________________

b. Which bottle had the largest amount of algal growth? _______________________________

c. Which detergent produced results most similar to the fertilizer? ______________________

Tentative Conclusions

a. What effect does the amount of phosphate and nitrate have on algal growth?

b. List all of the things you and people in your home can do to keep phosphates and nitrates from entering the water.

SMALL FRYE

6-8

SUBJECTS:
Art, Microbiology

TIME:
2 class periods

MATERIALS:
one gallon jar of pond water
18 hand lenses
one microscope for every team of two students
pens
pencils
3 packs assorted colors of poster paper
kite string or fishing line
75 plastic straws
35 wire coat hangers
teacher sheet
student sheet

OBJECTIVES

The student will do the following:

1. Identify various forms of microscopic life that live in water.

2. Compare the relationship of various aquatic plants and animals.

BACKGROUND INFORMATION

When Robert Hooke and Anton Van Leeuwenhoek, inventors of the microscope, observed the small world of ponds and streams, they were amazed to find life forms. It was obvious that thousands of small organisms lived in water. Microorganisms, both plants and animals, are essential in the food supplies of fish, aquatic birds, amphibians, and mammals—yes, even humans.

Microorganisms can be divided into the following categories:

Bacteria: Bacteria are single-cell microbes that grow in nearly every environment on Earth. They are used to study diseases and produce antibiotics, to ferment foods, to make chemical solvents, and in many other applications.

Protozoans: Protozoans are small single-cell microbes. They are frequently observed as actively moving organisms when impure water is viewed under a microscope. Protozoans cause a number of widespread human illnesses, such as malaria, and thus can present a threat to public health.

Algae: These are organisms that carry out photosynthesis in order to produce the energy they need to grow.

Fungi: These are well-known organisms, such as mushrooms and bread mold, that lack chlorophyll. Fungi usually derive food and energy from parasitic growth on dead organisms.

Viruses: Viruses are the smallest form of replicating microbes. Viruses are never free-living; they must enter living cells in order to grow. Thus, they are considered by most microbiologists to be nonliving. There is an infectious virus for almost every known kind of cell. Viruses are visible only with the most powerful microscopes, namely electron microscopes.

One way to eliminate microorganisms from water supplies is to add chlorine. Adding chlorine to drinking water virtually eliminates waterborne diseases, such as cholera, by destroying these disease-causing microorganisms.

Microorganism's habitats may be as large as an ocean or smaller than a grain of sand. The ubiquity or extreme prevalence of microorganisms is due to the following characteristics and abilities:

1. Small size allows for easy dispersal.
2. Energy conversion is not restricted to aerobic condition, they survive and thrive in anaerobic conditions (without oxygen).
3. Extreme metabolic versatility, they can utilize a broader range of nutrients than eukaryotes; unique ability to fix atmospheric nitrogen.
4. Tolerate unfavorable environmental conditions.

Terms

microorganisms: organisms too small to be seen with the unaided eye, including bacteria, protozoans, yeasts, viruses, and algae.

pond: an enclosed body of water usually smaller than a lake.

food web: the connections among everything organisms in a location eat and are in turn eaten by.

food chain: a succession of organisms in a community that constitutes a feeding order in which food energy is transferred from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member.

habitat: the arrangement of food, water, shelter, and space suitable to an organism's needs.

ADVANCE PREPARATION

A. Introduce students to the term "microorganisms." Ask them to list what they have heard, learned, or read about these microorganisms.

B. Ask students to write a one-page essay of what life would be like if they were microscopic.

PROCEDURE

I. Setting the stage

A. Students will take a field trip to an environmental center or area in their neighboor or town to observe life in a pond or view a video or film about pond life.

B. Have students share their observations with other members of the class, either orally or in writing.

II. Activity

A. The teacher will collect pond water samples and furnish each team with one tablespoon of the water sample. Samples are to be taken from within the container and not just at the surface. Students are to examine the water with microscopes and hand lenses.

B. Students are to draw or make sketches of the microorganisms they observe.

C. After they have sketched several organisms, they are to select a favorite life form from which to construct a microorganism mobile.

III. Follow-Up

A. Invite a laboratory technician who works for a water or wastewater treatment plant that uses microorganisms to break down wastes into harmless substances.

B. Have the students collect samples of pond water from various ponds and observe the microorganisms.

IV. Extensions

A. Have a contest for the best constructed "Microorganism Mobile."

B. Read aloud stories written by the students about their life as a microscopic organism.

C. Have pictures of common microorganisms that are found in pond water and have students identify their sketches with the pictures.

RESOURCES

Aquatic Project Wild, 1987. P.O. Box 18060, Boulder, CO 80308-8060. (303) 444-2390.

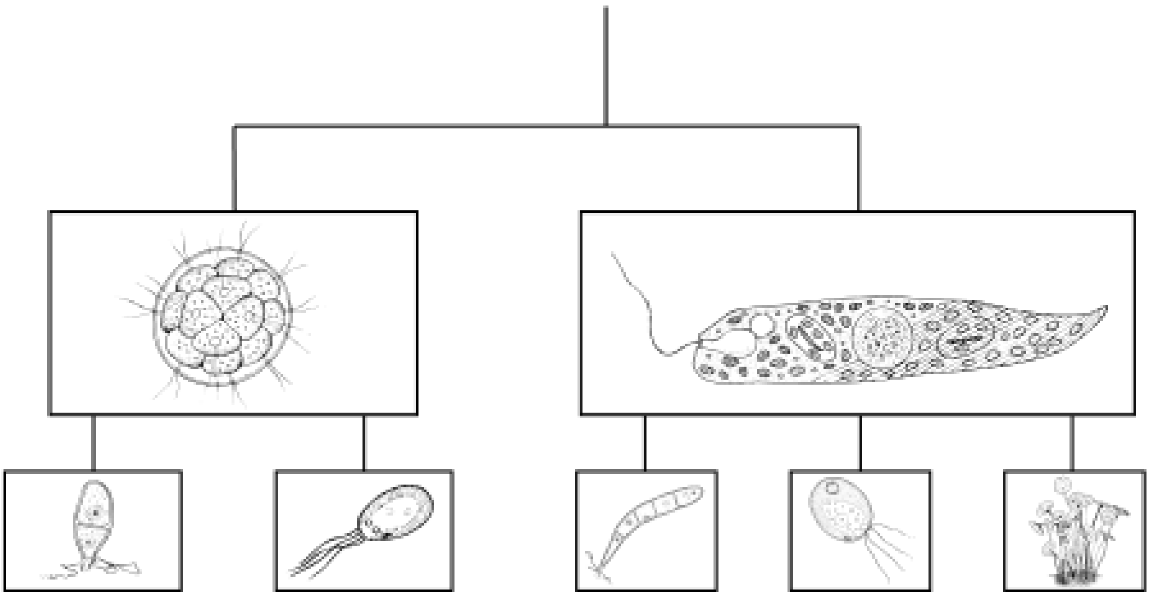
Compton's Interactive Encyclopedia. Compton's NewMedia, Inc., 1994, 1995.

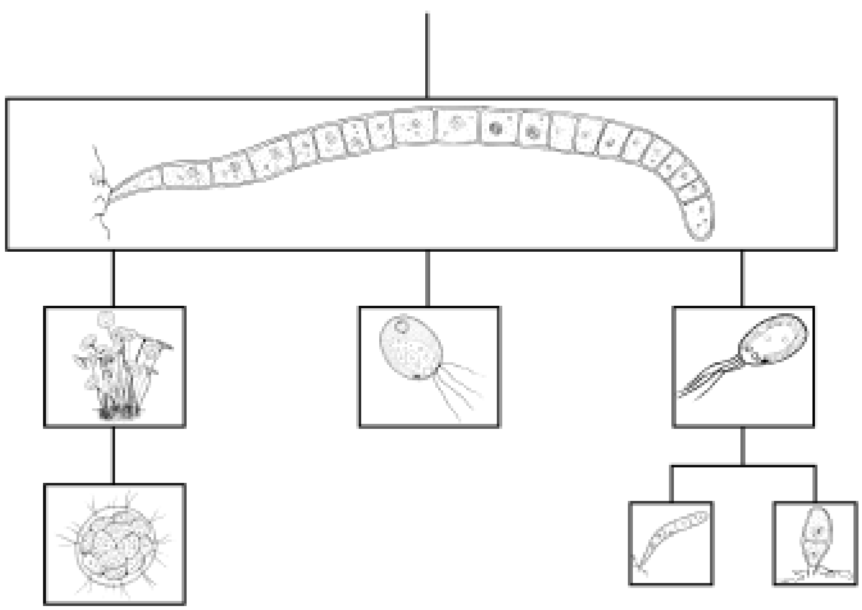
Eliminating Microbes from Water: http://c3.org/curriculum/bbc5.html

Life Science, Grade 7, Prentice Hall, 1991.

Microorganisms in Their Natural Environment: http://www.towson.edu/~wubah/miceco/natural_envts.html

Directions: Draw the organisms you observe in the pond water.





SURFACE FREEZING

6-8

SUBJECTS:
Chemistry, Math

TIME:
50 minutes

MATERIALS:
clear plastic soda container
ice cube trays
water
blue and yellow dye
scissors
colored pencils
graph paper
stapler
student sheet

OBJECTIVES

The student will do the following:

1. Create a moving picture of the circulation of water in a pond thawing after a winter freeze.

2. Explain the impact of surface freezing on the life of a pond.

BACKGROUND INFORMATION

The surface of a body of water receives adequate sunlight to sustain a diverse population of organisms. The region of water which receives this sunlight is known as the littoral zone. Autotropic organisms cannot, however, survive in zones inaccessible to sunlight. This zone, known as the benthic zone, is host to other types of organisms called heterotrophs. In addition, organisms that die will sink to the bottom and decompose, replenishing the pond with nutrients.

As the air temperature decreases and falls below zero degrees Celsius, the freezing point of water, the surface water will begin to freeze. Sustained below-freezing temperatures will allow the pond or lake to maintain a blanket of ice at its surface. Life at the surface will decrease due to the lack of adequate sunlight, and competition for food will increase among heterotrophs. As the surface ice begins to melt in the springtime, this colder, denser water will sink to the bottom. As it does, it creates a convection current in the pond which will carry the nutrients resting on the bottom to other zones in the pond, including the littoral zone. After the surface ice has completely melted, the littoral zone, as well as other zones, will once again contain a diverse population of life.

Terms

autotroph: an organism that can make its own food (usually using sunlight).

benthic zone: the lower region of a body of water including the bottom.

convection current: the transfer of heat by the mass movement of heated particles.

heterotroph: an organism that is not capable of making its own food.

littoral zone: region in a body of water that sunlight penetrates.

ADVANCE PREPARATION

A. Have each student bring an empty one- or two-liter plastic soda container.

B. Prepare colored ice cubes (blue in color).

C. Run off a student sheet for each student.

D. Remove the label and clean the inside of the container.

E. Cut off the top portion of the container.

PROCEDURE

I. Setting the stage

A. Discuss the background information to be sure the students understand the terms.

B. Explain the behavior of water in its three states.

II. Activity

A. Gather the materials.

1. Fill the container three-fourths full with hot water.

2. Add a few drops of yellow dye to the container and let stand for several minutes or until the water is no longer circulating.

3. Place one colored ice cube in the container and observe.

4. Have students write down observations as the ice is melting.

5. Have the students use the student sheet to make a precise drawing of the appearance of the container every 30 seconds until the ice has completely melted. (Be sure to instruct them to note the position and size of the ice over time in their drawing, as well as the color of the water in the rest of the container.)

6. Color the drawings with the proper colors and place the sheets in the proper sequence and staple together.

III. Follow-Up

A. Have the students observe the moving picture of their experiment and compare it to others in the class. Have them explain the similarities and differences between their results.

B. Have the students write up this activity in proper scientific form including a purpose, materials, procedure, results, and conclusion.

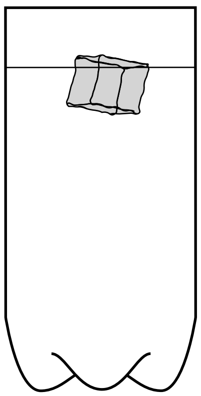
IV. Extension

A. Use real samples of pond water (obtaining both bottom sediments and water) and compare the quantity of organisms in each zone before and after melting a top layer. Use a microscope to observe and draw the organisms and graph results.

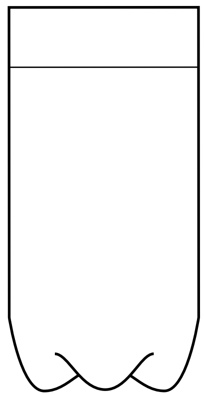
RESOURCE

Robson, P. and Seller, M., Encyclopedia of Science Projects, Shooting Star Press Inc., New York, 1994.

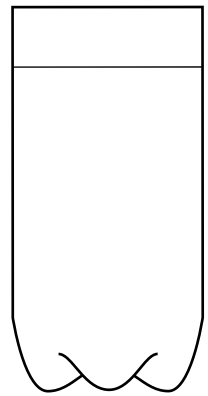
SURFACE FREEZING



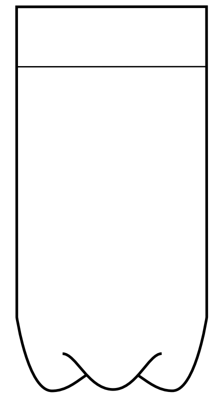
Time 0 Min.



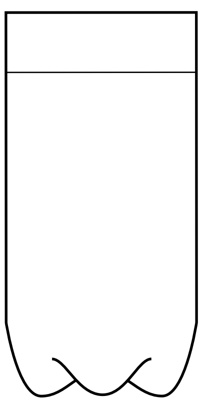
Time 30 Sec./.5 Min.



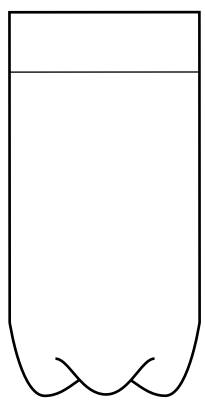
Time 1 Min.



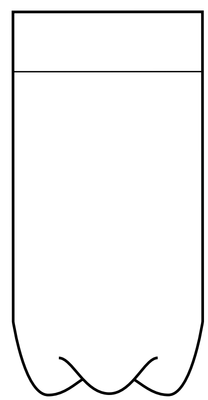
Time 1.5 Min.



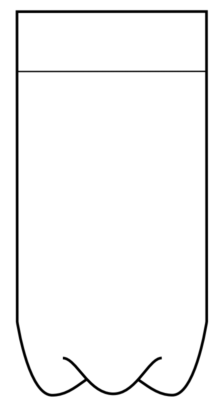
Time 2.0 Min.



Time 2.5 Min.



Time 3.0 Min.



Time 3.5 Min.

SURFACE TENSION

6-8

SUBJECTS:
Chemistry, Language Arts, Physical Science

TIME:
50 minutes

MATERIALS:
petri dish
container of water
loop of thread
dishwashing detergent
toothpicks
list of vocabulary words for follow-up activity
student sheet

OBJECTIVES:

The students will do the following:

1. Explain the concept of surface tension.

2. Identify the process by which surface tension can be broken by the addition of detergents.

BACKGROUND INFORMATION

The tendency of a liquid to form a relatively tough "skin" or film on its surface is known as surface tension. Surface tension is caused by the attraction between the molecules of the liquid; it is surface tension that causes water molecules to stick together and to form droplets. The surface tension that holds drops together makes it difficult for the water to penetrate or "wet" fabrics or skin; consequently, many soaps or detergents contain "wetting" agents designed to reduce surface tension and to increase fabric penetration by water.

If you could see molecules of water and how they act, you would notice that each water molecule electrically attracts its neighbors. Each has two hydrogen atoms and one oxygen atom, H_20. The extraordinary stickiness of water is due to the two hydrogen atoms, which are arranged on one side of the molecule and are attracted to the oxygen atoms of other nearby water molecules in a phenomenon known as "hydrogen bonding." (If the molecules of a liquid did not attract one another, then the constant thermal agitation of the molecules would cause the liquid to instantly boil or evaporate.)

Hydrogen atoms have single electrons which tend to spend a lot of their time "inside" the water molecule, toward the oxygen atom, leaving their outsides naked, or positively charged. The oxygen atom has eight electrons, and often a majority of them are around on the side away from the hydrogen atoms, making this face of the atom negatively charged. Since opposite charges attract, it is no surprise that the hydrogen atoms of one water molecule like to point toward the oxygen atoms of other molecules. Of course in the liquid state, the molecules have too much energy to become locked into a fixed pattern; nevertheless, the numerous temporary "hydrogen bonds" between molecules make water an extraordinarily sticky fluid.

Within the water, at least a few molecules away from the surface, every molecule is engaged in a tug of war with its neighbors on every side. For every "up" pull there is a "down" pull, and for every "left" pull there is a "right" pull, and so on, so that any given molecule feels no net force at all. At the surface things are different. There is no up pull for every down pull, since of course there is no liquid above the surface; thus the surface molecules tend to be pulled back into the liquid. It takes work to pull a molecule up to the surface. If the surface is stretched - as when you blow up a bubble - it becomes larger in area, and more molecules are dragged from within the liquid to become part of this increased area. This "stretchy skin" effect is called surface tension. Surface tension plays an important role in the way liquids behave. If you fill a glass with water, you will be able to add water above the rim of the glass because of surface tension.

You can float a paper clip on the surface of a glass of water. Before you try this you should know that it helps if the paper clip is a little greasy, so the water doesn't stick to it. Place the paper clip on a fork and lower it slowly onto the water. The paper clip is supported by the surface-tension skin of the water.

The water strider is an insect that hunts its prey on the surface of still water; it has widely spaced feet rather like the pads of a lunar lander. The skin-like surface of the water is depressed under the water strider's feet.

Terms

surface tension: the elastic-like force in a body, especially a liquid, tending to minimize, or constrict, the area of the surface.

polar: of or relating to a pole of a magnet.

adhesion: the molecular attraction exerted between the surfaces of bodies in contact.

cohesion: the force of attraction between the molecules in a mass.

polarity: the quality or condition inherent in a body that exhibits opposite properties or powers in opposite parts or directions or that exhibits contrasted properties or powers in contrasted parts or directions.

positive charge: of, being, or relating to electricity of a kind that is produced in a glass rod rubbed with silk.

negative charge: of, being, or relating to electricity of which the electron is the unit and which is produced in a hard rubber rod which has been rubbed with wool.

ADVANCE PREPARATION

A. Place petri dishes, containers of water, loops of thread, and small containers of detergents at each lab station.

B. Prepare the list of words for use in the follow-up activity.

PROCEDURE

I. Setting the stage

A. Students will perform the activity before it is discussed. This activity is best discussed *after* students have manipulated the thread in the water and observed the results.

B. Students are reminded to make careful observations about the loop of thread during each step of this activity.

II. Activity

A. Have students fill the petri dish about half full of water. The petri dish is more visible placed on a white sheet of paper. Place the loop of thread on the surface of the water. The thread will float, but have an irregular shape. Students will observe and make inferences about the shape of the loop.

B. Students will touch the surface of the water within the loop with the end of a clean toothpick. The thread should move slightly, but not change shape. Students will observe the floating loop and discuss how surface tension is responsible for supporting the thread.

C. Students will next dip the end of the toothpick into the dishwashing detergent and carefully place a drop of soap inside the loop of thread by touching the toothpick to the surface of the water.

D. Students will describe what happened when the drop of dishwashing soap was placed inside the loop of thread. Have them speculate about what would happen if the drop of detergent were placed outside the loop of thread rather than inside the loop of thread.

III. Follow-Up

A. Students will explain what happened to the loop of thread and why it happened using the following terms in the explanation. All terms must be used and can be used more than once.

bound	circle	surface tension
cohesion	polar	positive charge
lowers	higher	negative charge
attractive forces	strong	adhesion
polarity		

B. Have the students highlight or circle all of the above words used in their explanation.

IV. Extensions

A. Research different types of detergents. Compare results obtained when these detergents are placed into the loop.

B. Double the amount of detergent to observe if there is a noticeable difference in the loop of thread.

C. Change the temperature of the water for each group to determine if thermal pollution is a factor in surface tension.

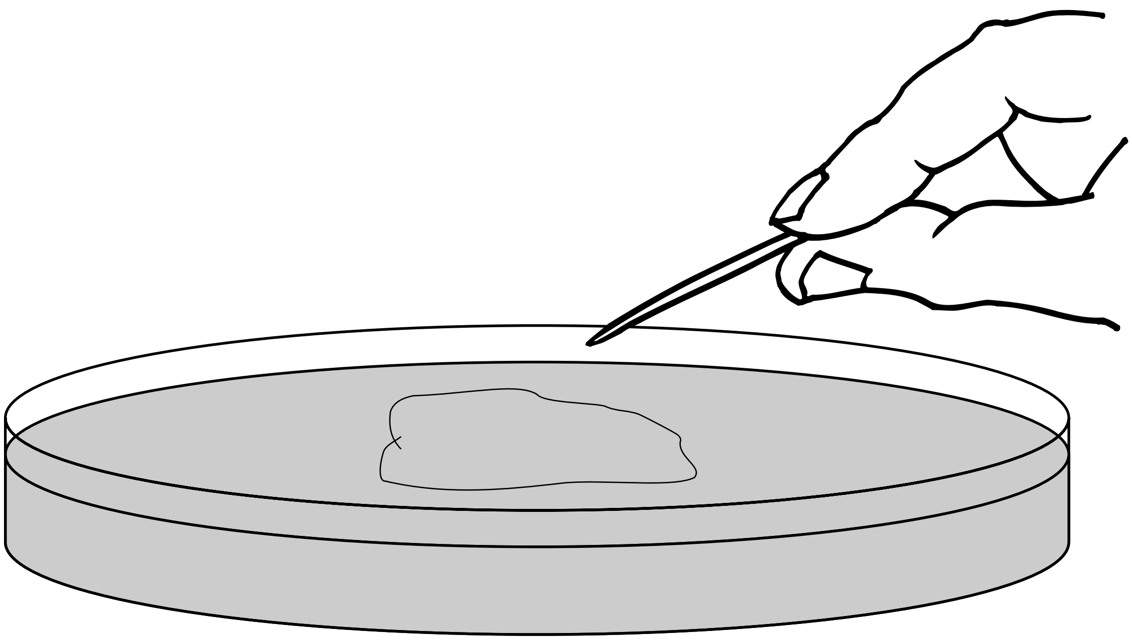
D. Prepare a wall data chart for groups to observe over a period of time. Refer to the data collected and review as other clean-up concepts are discussed.

RESOURCE

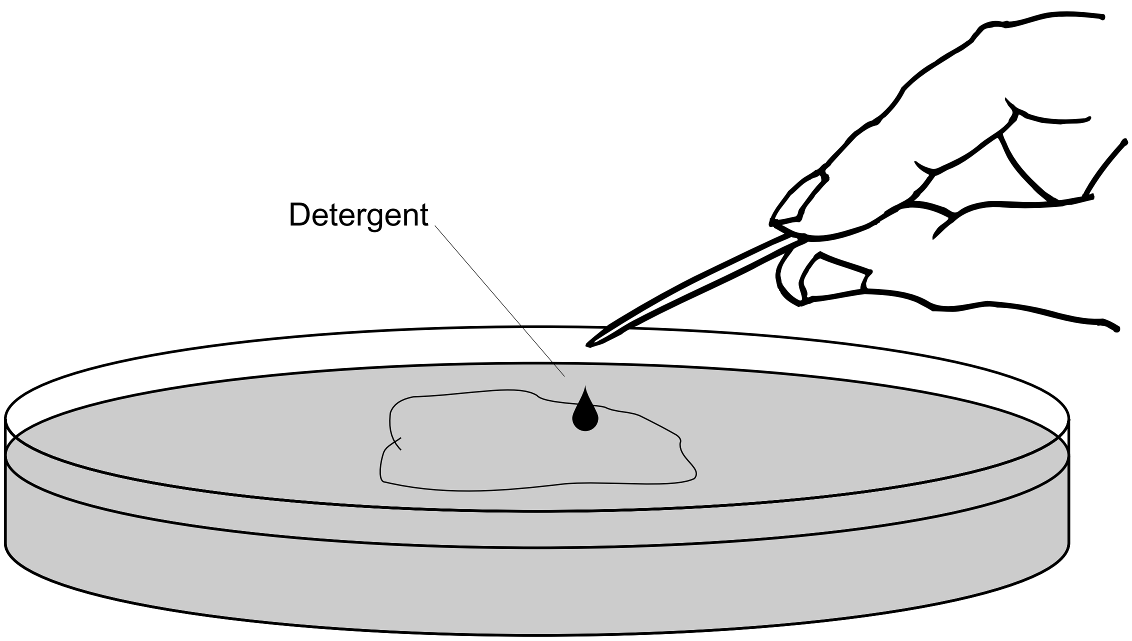
Robson, P. and Seller, M., Encyclopedia of Science Projects, Shooting Star Press, London, 1994.

Surface Tension, WQA: http://www.wqa.org/WQIS/Glossary/surftens.htm

http://www.whitman.edu/Departments/Biology/classes/B111/Modules/Water/Cohesion.html



Gently touch surface of water with a clean toothpick and observe



Place one drop of detergent inside the loop of thread and observe

RUNOFF

6-8

SUBJECT:
Biology, Geology

TIME:
1-2 class periods

MATERIALS:
county map / state map of your area
student notebooks
plastic box or pan at least one foot by two feet
sandbox sand, enough to fill half the box
two 250 mL cups
65 mL chocolate syrup
one 20 cm by 20 cm square of sod or several smaller grass plugs
a metric measuring cup
water
bucket or pot
teacher sheet

OBJECTIVES

The students will do the following:

1. Define surface water, runoff, drainage basin, permeable, and impermeable.
2. Identify factors affecting runoff in a drainage basin.
3. Perform an experiment on drainage basins.

BACKGROUND INFORMATION

Water found above the ground is called surface water. That is because it is located or seen on the Earth's surface. Oceans and rivers are examples of natural surface water bodies. Most surface water bodies are natural; however, there are many bodies of surface water that are made artificially.

The area where water drains off the land into a river or lake is called a drainage basin. Water that drains off the land into the basin is called runoff. Many things determine the runoff in a drainage basin. Water moves slowly along flat land or a gently sloping hill. When the water moves more slowly, it can evaporate or soak into the ground. A steep slope will cause water to flow more quickly into a surface water body. That is why drainage basins with steep slopes often flood.

Vegetation such as plants, trees, and grass help slow the water flowing through a basin. Trees and other plants also help to hold water on or above the ground. By doing so, they allow the water time to soak into the ground or to evaporate. Different kinds of soil have differing abilities to hold water. Water moves more quickly and easily through layers of sand and gravel than through clay. This is because clay is not as permeable as sand or gravel. Permeability is how fast water can flow through an object. Because clay particles fit tightly together, water does not flow through clay very easily. Clay is said to be impermeable. The next time it rains, watch what happens to the water running off the sidewalk or street near your home, then watch the water that falls on ground covered with trees, grass, or other plants. Notice which type of surface has the faster-flowing water. Rainwater that runs off a paved surface and does not soak into the ground is called storm water runoff. This water usually flows into the nearest body of water.

<u>Terms</u>

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration. It is stored in streams, lakes, rivers, ponds, wetlands, oceans, and reservoirs.

drainage basin: an area drained by a main river and its tributaries.

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

permeable: passable; allowing fluid to penetrate or pass through it.

impermeable: impassable; not permitting the passage of a fluid through it.

storm water runoff: surface water runoff that flows into storm sewers or surface waters.

ADVANCE PREPARATION

A. Study the background information so it may be presented to the class in an organized manner.

B. Write the vocabulary words on the board so the students may view the words that will be covered in this lesson.

C. Have materials ready for the experiment.

PROCEDURE

I. Setting the stage

A. Have materials set out on a table in the front of the room. Tell the students that they will be learning about surface water and will be performing an interesting experiment.

II. Activity

A. Discuss the background information with the students.

B. Ask the following questions:

1. What is water above the ground called?
2. What makes water drain from one area to another?
3. What does permeable mean?
4. Through what soils does water move quickly?
5. Why does water move slowly through clay?
6. What does storm water runoff mean?
7. Name some examples of things storm water can pick up as it travels over land.
8. Where might storm water runoff go in rural areas?

C. Have the students perform the following experiment.

1. Fill the box or pan half full of sand. Diagonally, from the top corner of the box to the bottom corner, make a surface water (river) channel. Scoop sand from the middle of the box up onto the sides to form river banks. Make a steep slope on one side of the river and a gentle slope on the other side.
2. Place the sod square or several grass plugs on the side with a gentle slope. This represents wetlands vegetation.
3. Place bucket or pot under opening.
4. Position one student on each side of the “river” holding the 8-ounce cups of water. These students will make it “rain” on the river. Very slowly and at the same time, have one student pour water on the sandy side, while the other pours water on the grassy area. Observe which runoff flows faster and drains into the “river” first.

D. Repeat Step C, using 65 mL of chocolate syrup. The syrup represents storm water pollution. Observe what happens.

E. Repeat Step C, again, pouring 125 mL of water on the syrup. Observe what happens.

F. Ask the following questions:

1. Which side of the river had the fastest runoff?

2. What effect did the grass or sod have on storm water runoff? On pollution?

3. Did you see anything in this experiment that would help you decide whether the sand is permeable or impermeable? If so, what?

4. List several things that determine the speed of runoff in a drainage basis.

III. Follow-Up

A. Have the students list examples of surface water bodies in their county and state. Let your students see how many water bodies they can name before posting the maps.

B. Have the students determine where the school's storm water runoff drains.

1. Are there steep or gentle slopes around the school yard?

2. What types of pollution would this storm water pick up as it drains from the school yard?

IV. Extensions

A. Ask students to find out the average rainfall for their city or county.

B. Have students bring in various types of soil and design their own experiments to test which soils are permeable or impermeable.

C. Have students do research in the library to locate information on how to make a rain gauge.

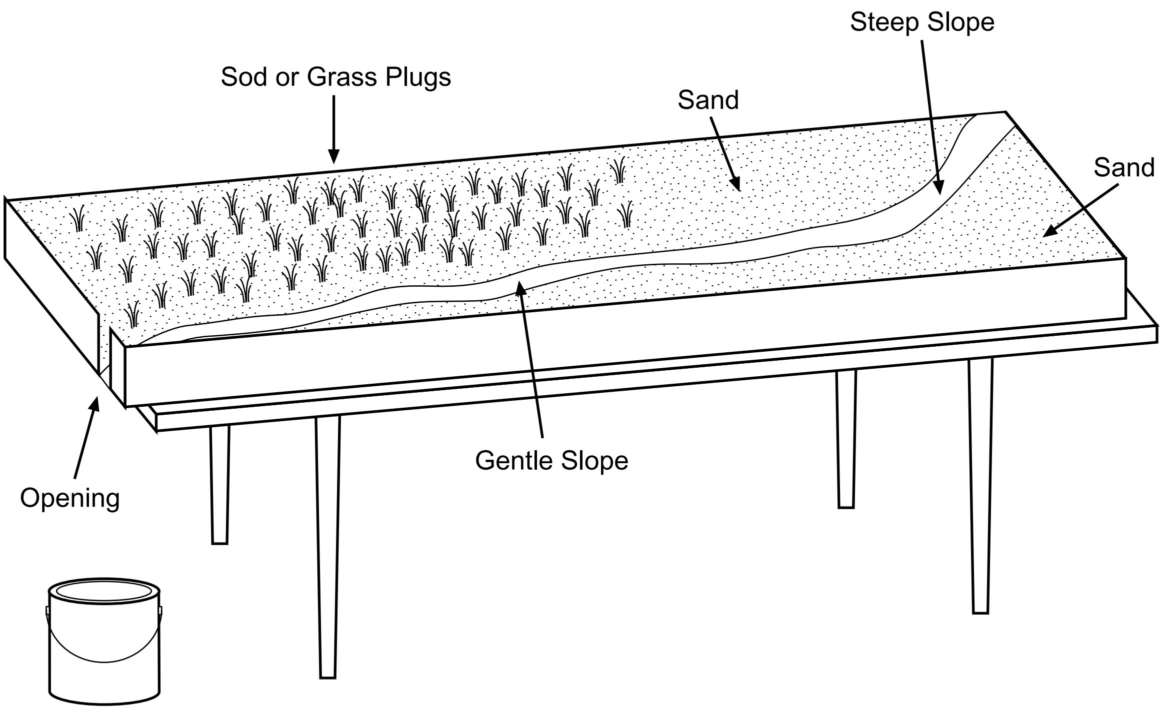
1. Help students make their own rain gauges and have them keep track of rainfall amounts for one month in their waterways notebook.

2. Have them design a bar graph to show rainfall totals. Have students do this at home and then compare their findings with others in their class. Sometimes it will rain on one side of the street and not on the other.

D. Contact the local office of the Natural Resources Conservation Service (formerly known as the Soil Conservation Service, or SCS) to request a guest speaker on the "soil profile" of your area. Ask the SCS representative for more information and experiments on soil types.

RESOURCE

Johnson, C., Waterways: A Water Resource Curriculum, St. John's River Management District, Jacksonville, FL, 1991.


Steep Slope
Sod or Grass Plugs
Sand
Sand
Opening
Gentle Slope

THE SHRINKING ANTACID

6-8

SUBJECTS:
Chemistry, Earth Science

TIME:
20 minutes

MATERIALS: (for each group)
small clear cup
l tablespoon
white vinegar
antacid tablet containing calcium carbonate
student sheets

OBJECTIVES

The student will do the following:

1. Define acid rain.
2. Explain what causes acid rain.
3. State various substances found in acid rain.
4. Describe the effects of vinegar on antacid tablets.

BACKGROUND INFORMATION

Normal rain has a pH of between 5.6 and 6.0, whereas acid rain has a pH between 2.0 and 5.6. Acid rain leads to several detrimental effects in the ecosystem. A very highly publicized problem is the effect of acid rain on trees. Conifers appear to be particularly affected, with needles dropping off and seedlings failing to produce new trees. The acid also reacts with many nutrients the trees need, such as calcium, magnesium, and potassium. The trees then starve, which makes them much more susceptible to other forms of damage, such as being blown down or breaking under the weight of snow.

Acid rain also causes lakes and rivers to become acidic, causing fish populations to decline. Short-term increases in acid levels kill many fish, but the greatest threat is from long-term increases. A long-term increase stops the fish from reproducing. The extra acid also frees toxic metals, especially aluminum, that were previously held in rocks. This metal can prevent fish from breathing. Single-celled plants and algae in lakes also suffer from increased acid levels, with numbers dropping off quickly once the pH goes below 5. By the time the pH gets down to 4.5, almost no life is sustainable.

Many toxic metals are held in the ground in compounds. However, acid rain can break down some of these compounds, freeing the metals and washing them into water sources such as rivers. As the water becomes more acidic, it can also react with lead and copper water pipes, contaminating drinking water supplies. Too much copper can cause diarrhea in young children and can damage livers and kidneys in adults and children.

Terms

acid rain (or acid precipitation): rain with a pH of less than 5.6; results from atmospheric moisture mixing with sulphur and nitrogen oxides emitted from burning fossil fuels or from volcanic activity; may cause damage to crops, forests, wildlife habitats, aquatic life, as well as damage to buildings, monuments, and car finishes.

calcium carbonate: a powder occurring in nature in various forms, as calcite, chalk, and limestone, which is used in polishes and the manufacture of lime and cement.

pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

pollution: contaminants in the air, water, or soil that cause harm to human health or the environment.

ADVANCE PREPARATION

A. Divide the class into groups of three.

B. Gather enough materials for each group.

PROCEDURE

I. Setting the stage

A. Show the students some calcium carbonate tablets.

B. Ask them to guess what they are.

C. Tell them what they are and explain to them that these substances are found in many different kinds of rocks.

II. Activity

A. Give each group a cup with an antacid tablet in it.

B. Ask them to pour 15 mL vinegar over the antacid tablet.

C. Ask the students to observe the antacid and vinegar for about 5 minutes.

D. Tell the students to record the action between the vinegar and the antacid tablet.

E. Ask the students to answer the following questions:

1. What happened to the antacid tablet?

2. How can this experiment relate to the effects of acid rain in various areas?

3. What causes acid rain?

4. What measures can we take to prevent or stop acid rain?

5. Why is acid rain such an important topic to study?

III. Follow-Up

A. Ask the students to write a report on the effects of acid rain on the environment.

B. Ask the students to draw or cut out pictures from a magazine showing the effects of acid rain.

C. Ask the students to do research and write a paper about acid rain.

IV. Extensions

A. Have the students use other substances that will act on the antacid tablet.

B. Have the students research and plot various areas on a geographic map that have problems with acid rain.

RESOURCES

Tippens, Tobin, Instructional Strategies for Teaching Science, Macmillan, New York, 1994.

Cable, Charles, Dale Rice, Kenneth Walla, and Elaine Murray, Earth Science, Prentice Hall, New Jersey, 1991.

http://nis.accel.worc.k12.ma.us/www/projects/WeatherWeb/acidrain.html

Directions – Record your observations at the specified times and answer the questions.

Time	Add 15 mL vinegar to antacid in cup
1 minute	
1.5 minutes	
2 minutes	
2.5 minutes	
3 minutes	
3.5 minutes	
4 minutes	
4.5 minutes	
5 minutes	

1. What happened to the antacid tablet?

2. How can this experiment relate to the effects of acid rain in various areas?

3. What causes acid rain?

4. What measures can we take to prevent or stop acid rain?

USING TOPOGRAPHIC MAPS AND DATA TABLES TO DETERMINE SURFACE WATER QUALITY

6-8

SUBJECTS:
Ecology, Geography

TIME:
2 class periods

MATERIALS:
topographic or relief map of watershed area
student sheet

OBJECTIVES

The student will do the following:

1. Describe the physical features of land areas surrounding area waters.

2. Distinguish drainage areas that will flow into existing bodies of water.

3. Analyze data obtained from a sampling of surface waters.

BACKGROUND INFORMATION

A watershed is a drainage area that includes all the rivers, streams, and sloping land which flow into a specific body of water. A watershed is impacted by activities that occur within the specific sloping area. Pollution from industries and individuals can affect the quality of water in a watershed. Other activities that can damage a watershed include farming, construction, and industrial activities.

Water monitoring sites can be established along watershed drainage areas to determine the quality of the water entering the downstream body of water. Data can be collected and analyzed at various sites along the drainage areas. Downstream impact can be determined by measuring the dissolved oxygen content, pH of the water, turbidity, and the biological diversity of organisms located in the drainage areas. By analyzing these parameters, students can compare information from several monitoring sites and determine the relative quality of the surface waters in the watershed area.

Geological watershed maps can be obtained from state geological surveys, the United States Geological Survey, or from local map dealers.

<u>Terms</u>

biological diversity: a wide variety of plant and animal life.

dissolved oxygen (DO): oxygen gas (O_2) dissolved in water.

drainage basin: an area drained by a main river and its tributaries.

monitoring: scrutinizing and checking systematically with a view to collecting data.

nonpoint source pollution (NPS): pollution that cannot be traced to a single point (Example: outlet or pipe) because it comes from many individual places or a widespread area (typically, urban, rural, and agricultural runoff).

pH: a measure of the concentration of hydrogen ions in a solution; the pH scale ranges from 0 to 14, where 7 is neutral and values less than 7 are progressively acidic, and values greater than 7 are progressively basic or alkaline; pH is an inverted logarithmic scale so that every unit decrease in pH means a 10-fold increase in hydrogen ion concentration. Thus, a pH of 3 is 10 times as acidic as a pH of 4 and 100 times as acidic as a pH of 5.

point source pollution: pollution that can be traced to a single point source, such as a pipe or culvert (Example:

industrial and wastewater treatment plants, and certain storm water discharges).

topographic map: a map showing the relief features or surface configuration of an area, usually by means of contour lines.

turbidity: the cloudy or muddy appearance of a naturally clear liquid caused by the suspension of particulate matter.

watershed: land area from which water drains to a particular water body.

ADVANCE PREPARATION

I. Setting the stage

A. Display a topographic map of the local area and define the watershed area.

B. Discuss the major streams, rivers, and sloping areas indicated on the map.

C. Hypothesize the factors that could cause pollution problems in the drainage area of the watershed.

D. Prepare copies of the student sheet for each student.

II. Activity

A. Have the students use the student sheet to answer the questions about the streams located in the watershed.

B. Have the students analyze the information, discuss possible contributing factors, and determine what other types of investigations will be necessary.

III. Follow-Up

A. Have the students make visual observations of local streams and creeks and locate these on the watershed map.

B. Display topographic maps of other watersheds in other areas. Ask the students to compare the size of the drainage areas.

IV. Extensions

A. Take a field trip to a local park located on the watershed.

B. Develop site monitoring groups for area streams and rivers.

C. Develop a resource file of organisms known to indicate biological diversity in local waters.

RESOURCES

United States Geological Survey (USGS) topographic map of local watershed.

Person, Jane L., Environmental Science: How the World Works and Your Place in It, Lebel Enterprises, Dallas, Texas, 1995.

SAMPLING INFORMATION OBTAINED FROM WATERSHED MONITORING SITES

SITE #	DO	pH	DIVERSITY	TURBIDITY (M)
1	.6	7.0	GOOD	.2
2	.8	7.5	POOR	.4
3	.7	7.0	GOOD	.1
4	.9	6.2	FAIR	.4
5	.4	5.0	POOR	0

QUESTIONS

1. At which site was the water most turbid?____
____

2. Does the topographic map indicate any reasons for the high turbidity at that site? ___________________
Explain.____
____

3. Which site illustrates the lowest dissolved (DO) oxygen content? ________________________________
What could have caused the low DO at this site?____
____

4. What could have caused the pH to be more acidic at site 5?
____
____

5. Does DO seem to cause poor biodiversity? _________________________________Explain. _________
____

6. What variables are present in monitoring of test sites?____
____

7. List the types of land use that might have an effect on each of the following:

dissolved oxygen____

pH____

turbidity____

other____

8. Based on the information given for each of the five sites, which site do you consider to be the healthiest?
Explain.____
____

WHIPPED TOP WATER

6-8

SUBJECTS:
Ecology

TIME:
50 minutes

MATERIALS:
6 large containers of cool whip
chart on water use (state/ national)
red, yellow, blue, and green food colors
plastic spoons and knives
six pieces of construction paper
paper plates for everyone
teacher sheet

OBJECTIVES

The student will do the following:

1. Read a graph.
2. Frost a pie using the information from the graph.

BACKGROUND INFORMATION

Water conservation does not mean doing without water. Rather, it means using water wisely and not wasting a drop. In certain areas of the country, the limited availability of drinking water has made water conservation mandatory. In other areas, reducing water use is necessary because supplies have been contaminated by landfills, toxic wastes, oil spills, or drought conditions.

On the average, each American uses about 150 gallons of water a day—most of it in the home. Nationwide, home use accounts for 57 percent of publicly supplied water. Public use for fire fighting, street cleaning, parks and recreation, and unaccounted for losses average 11 percent. The remaining 32 percent is used by businesses and industries.

Water conservation measures can stop the waste and help protect our water resources. Widespread reduction in water use can reduce the need for additional water projects that dam rivers, drain aquifers, and dry up wetlands and wells. It also can reduce the need for new or expanded sewage treatment facilities and reduce the amount of energy needed to clean pump, distribute, and heat water. By diverting less water, we leave more water to maintain stream flow, which improves water quality. Long-term conservation strategies can make our clean water supplies last longer.

ADVANCE PREPARATION

A. Divide students into teams of four or five.

B. Have each team make a no-bake cheesecake at home the night before the activity.

C. Prepare different colored frostings by using cool whip and food color. This will be done for each team, so make sure you have enough of each color. Each food color will represent a type of water use:
red = power generation
yellow = industrial
black (combine green and blue) = mining
blue = public water supply
green = agriculture
white = other

D. Have each color set up at different stations around the room. Also have on the table a piece of construction paper that has printed on it the amount of water used for that particular area. Arrange it so that the colors match the food color.

E. Bring at least one pie in case a group does not have a pie or does not make it to class with the pie they made.

PROCEDURE

I. Setting the stage

A. Explore the students' knowledge on the subject prior to the lesson by asking questions such as:

   1. How many of you use water?

   2. List some ways you use water.

   3. How is water used in our society and our environment?

B. Show the chart on water use. Discuss how the water is used. Stress the amount used in each area.

II. Activity

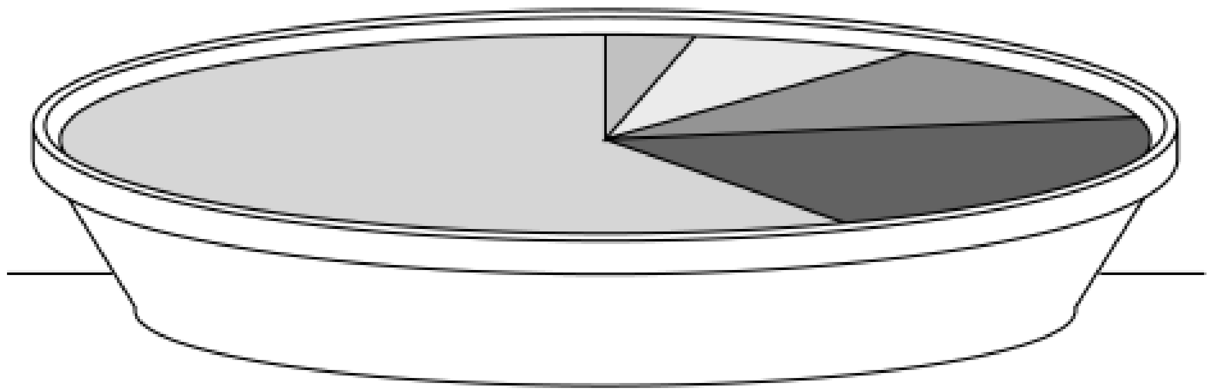
A. Show the students that different colored cool whip is located at different stations in the room. Each colored cool whip represents a water use. Example, agricultural uses are signified by the green cool whip.

B. When they arrive at that station, they will frost that percent of their pie used for agriculture with the green cool whip. This will give them an idea of how much water is used for agriculture.

C. Then the students are to rotate to another station and top their pie with the correct amount of colored cool whip represented on the chart.

III. Follow-Up

A. When finished, all pies should be decorated and the students may then reward themselves by eating a piece of their pie.



Amounts of each color will vary depending upon the water use in your particular area.

XERISCAPE - SEVEN STEPS TO WATER - WISE LANDSCAPING

SUBJECTS:
Botany, Ecology

TIME:
3 class periods
2 to 3 weeks for students to complete survey at home and design landscape

MATERIALS:
teacher sheets
student sheets

OBJECTIVES

The student will do the following:

1. Define xeriscape and identify specific landscaping methods that support xeriscape practices.

2. Differentiate between water conservation practices and standard landscaping practices.

3. Survey xeriscape practices currently in use at home and initiate new conservation practices indicated by the survey.

BACKGROUND INFORMATION

As increases in population and land development occur, the supply of usable water will continue to decrease and will lead to greater restrictions of water use. In recent years, droughts in many areas of the United States have forced residents to limit their use of water.

By using landscaping and horticultural techniques that reduce water use, many landowners can drastically reduce the overall need for water in landscaped areas. Xeriscape is the wise use of these strategies to minimize water use, reduce maintenance, and produce more drought-resistant gardens and landscaped areas.

A Xeriscape-type landscape can reduce outdoor water consumption by as much as 50% without sacrificing the quality and beauty of a home environment. It is also an environmentally-sound landscape, requiring less fertilizer and fewer chemicals. A Xeriscape-type landscape is low maintenance - saving time, effort, and money. Any landscape, whether newly-installed or well-established, can be made more water-efficient by implementing one or more of the seven steps. A landscape does not have to be totally redesigned to save water. Significant water savings can be realized simply by modifying the watering schedule, learning how and when to water, using the most efficient watering methods and learning about the different water needs of landscape plants.

There are several general principles that can be used in most home Xeriscape projects. These strategies include grouping plants with similar water uses, reducing the amount of irrigated turfgrass areas, using sufficient amounts of organic material, using an efficient watering system, and managing landscapes to reduce water demand.

Xeriscape can conserve water and also produce attractive, low-maintenance landscaped areas. Each person can make a difference in conserving water.

<u>Terms</u>

Xeriscape: the use of landscaping and horticultural strategies to minimize water use, reduce maintenance, and produce more drought-resistant gardens and landscaped areas.

mulch: a protective covering of various substances, especially organic; placed around plants to prevent evaporation of moisture and freezing of roots and to control weeds.

organic material: material derived from organic, or living, things; also, relating to or containing carbon compounds.

inorganic material: material derived from nonorganic, or nonliving, sources.

pruning: trimming or cutting off undesired or unnecessary twigs, branches, or roots from a tree, bush, or plant.

turfgrass: lawns

drought: a lack of rain or water; a long period of dry weather.

topography: the detailed mapping or description of the features of a relatively small area, district, or locality; the relief features or surface configuration of an area.

landscaping: improving the natural beauty of a piece of land by planting or altering the contours of the ground.

ADVANCE PREPARATION

A. Make overheads or handouts of Teacher Sheets.

B. Prepare copies of Student Sheets for each student. Run copies back and front to get on one sheet.

C. Read the Water Conservation Fact Sheets on pages F - 27 & 28 to become familiar with the seven steps used in Xeriscape-type landscaping.

PROCEDURE

I. Setting the stage

A. Discuss what happens to plants when there is insufficient rain or drought conditions. Ask students what restrictions are often placed on water use during these times.

B. Ask students if they have noticed that often plants in people's yards sometimes look wilted but plants in woods and fields do not. Discuss how native plants are adapted to a wider range of conditions than some plants used in yards.

C. Introduce the term Xeriscape. Explain that it was derived by combining the Greek word "Xeros," meaning dry, with the word "landscape." Give students the definition of Xeriscape.

D. Discuss each of the seven steps of Xeriscape landscaping given in the Water Conservation Fact Sheet. List steps on the board and tell students they will be using these steps later in the activity.

Step 1 - Planning and Design
Step 2 - Soil Analysis
Step 3 - Appropriate Plant Selection
Step 4 - Practical Turf Areas
Step 5 - Efficient Irrigation
Step 6 - Use of Mulches
Step 7 - Appropriate Maintenance

II. Activity

A. Pass out Student Sheet 1 - Landscape Symbols. Show Teacher Sheet 1 - Base Map and Site Analysis. Explain to students they are going to conduct a survey of their yards. If possible, pair students that live close together. If a student lives in an apartment, pair with a student who has a yard. The first step in Xeriscape landscaping is to begin with a Base Map of the existing area and conduct a Site Analysis. Point out the features in Teacher Sheet 1 and make sure students understand the extent of their assignment. You may want to call one student to the board to draw a base map of his or her yard. Explain that they will need to walk around the yard to get all the details. Use the landscape symbols to indicate the existing vegetation. Give students a couple days to complete this assignment.

B. Show Teacher Sheet 2 - Water Use Zones. Discuss why certain areas need more water than others and how shade affects water use. Using their Site Analysis, have students determine water use zones of their yards. There are plant exceptions to each of these use zones. It is best to find out from a local nursery person or Extension Agent which plants fit these zones for your particular area. Generally, these guidelines can be followed:

High - regular watering - some flower beds, turf grass in direct sun
Moderate - occasional watering - well established plants, plants in partial shade
Low - natural rainfall - do not need watering except in extremely dry conditions, full shade, woody ornamental trees, some turfgrasses.

C. Show Teacher Sheet 3 - Landscaped Water Use Zones. Ask students to describe the changes that have been made in the landscapes. Discuss the water use based on the "before" landscape as compared to the "after" landscape. Discuss what factors (shade-tolerant ground cover, mulch, native trees and shrubs, less turfgrass) changed the water use zones.

D. Pass out Student Sheet 2 - Survey of a Landscaped Area. Students should use the checklist to determine the ways that Xeriscape is or can be used in their home landscaped areas to reduce the amount of water used. Give students a couple days to complete this assignment.

E. Show Teacher Sheet 4 - Professional Landscaping. Discuss what was done to change the landscape. Also note the change in water use zones. You may need to review the landscape symbols so students are familiar with each one. Explain to students they are going to "landscape" their yards using Xeriscape practices and create a Master Plan for their yard. If students have yards that are already fully landscaped, pair with students whose yards are not landscaped. Remind students to include each Xeriscape Step including their plan for Appropriate Maintenance in the future. Soil analyses can be done by your local county Extension office. You may want to check with your local office before you have a large number of students sending in soil samples at the same time. Have students use their Base Map to create their Master Plan. Give students several days to complete this assignment.

F. Display completed plans in the room. You may want to have students "judge" the plans and award a Yard of the Month - type award for the plan that best adheres to Xeriscape principles and practices.

III. Follow-Up

A. Have the students take photographs of an area before it is xeriscaped and compare it to later photographs.

B. Have students keep a journal of differences in maintenance, weed control, pests, and diseases on plants, and the overall appearance of the site.

IV. Extensions

A. Invite speakers from landscaping associations or master gardners to speak to the class about xeriscape.

B. Have students develop a miniature Xeriscape terrarium that models the landscaped area at home.

C. Have students create a Xeriscape landscape plan for the school campus.

D. Have students observe other yard and business landscapes and determine if Xeriscape practices were followed.

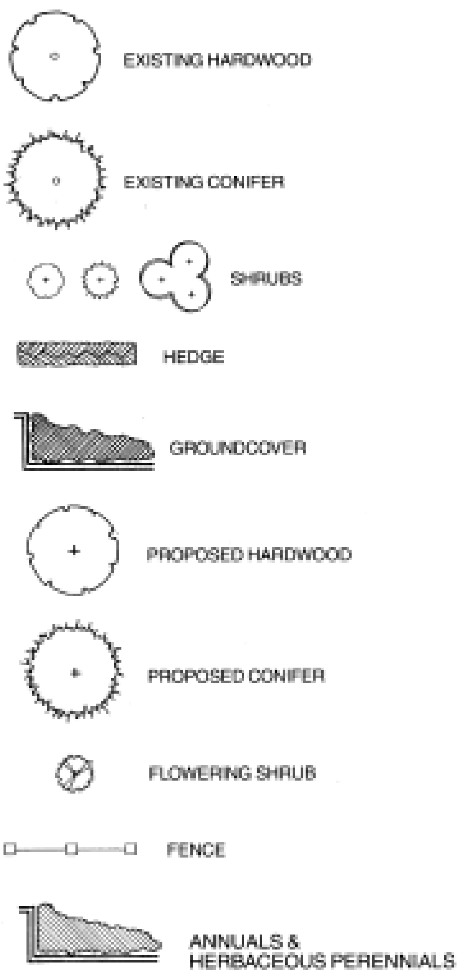
RESOURCES

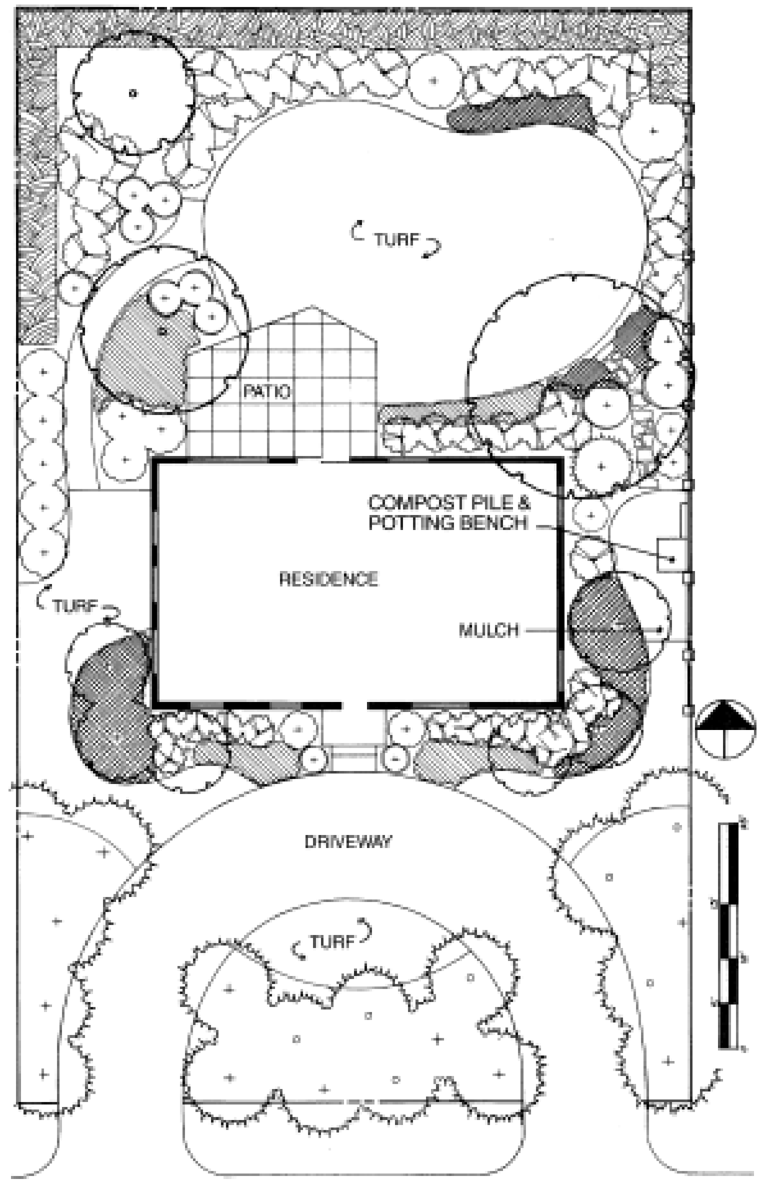
National Xeriscape Council, Inc., POB 767836, Roswell, GA 30076.

Water Ways: A Water Resource Curriculum. St. John's Water Management District, Jacksonville, FL, 1991.

Xeriscape: A Guide to Developing a Water-wise Landscape, Cooperative Extension Service, University of Georgia, 1992.

Symbols


EXISTING HARDWOOD
EXISTING CONIFER
SHRUBS
HEDGE
GROUNDCOVER
PROPOSED HARDWOOD
PROPOSED CONIFER
FLOWERING SHRUB
FENCE
ANNUALS &
HERBACEOUS PERENNIALS

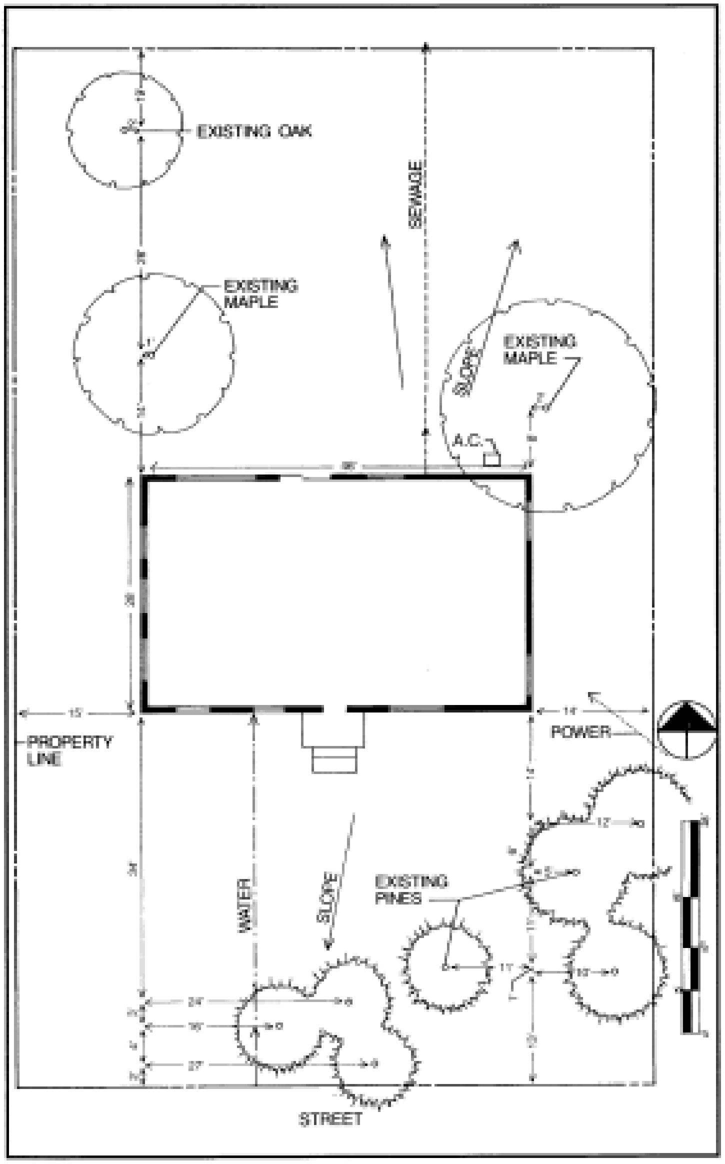

TURF
PATIO
COMPOST PILE &
POTTING BENCH
RESIDENCE
MULCH
TURF
DRIVEWAY
TURF

Survey of a Landscaped Area

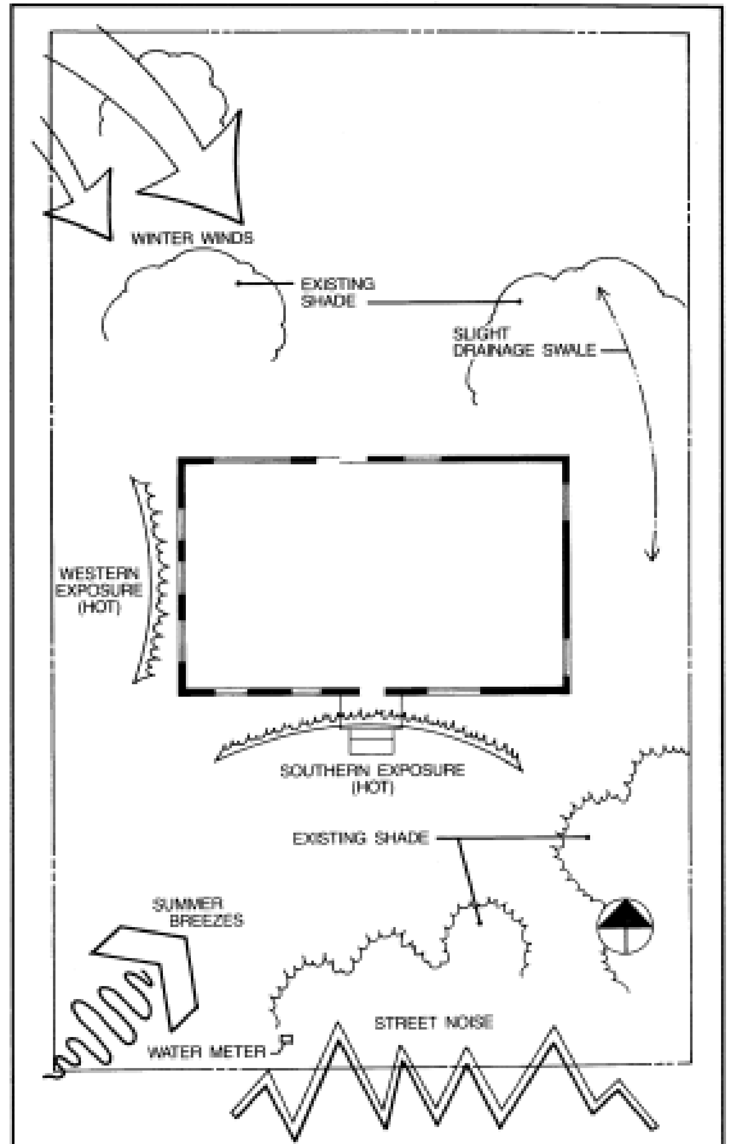
Directions: For each practice, indicate which of the seven xeriscape steps it illustrates. Refer to Fact Sheet on Water Conservation, pages 27 and 28. Also determine what landscaping practices are currently being used in a landscaped area and if there are xeriscape practices that can be implemented to conserve water.

Step Number	In Use	Can Implement	
______	______	______	Plant varieties that are well adapted to this locality and soil conditions.
______	______	______	Group plants with similar water needs together.
______	______	______	Use moisture-loving plants for wet, poorly drained areas.
______	______	______	Use drought-tolerant plants for drier, sunnier areas.
______	______	______	Use turfgrass to cover excessively large areas.
______	______	______	Grow grass under a densely shaded area of shallow-rooted trees
______	______	______	Grow grass around shrubs.
______	______	______	Grow grass on steep slopes, in rock outcroppings, or in very narrow spaces.
______	______	______	Grow grass in areas where play tramples all vegetation.
______	______	______	Check pH regularly to maintain pH of 6.0 to 7.0.
______	______	______	Fertilize three times per year.
______	______	______	Add lime to create a higher soil pH and to make lawn more drought-resistant.
______	______	______	Control weeds.
______	______	______	Maintain a cut-lawn height of 2–1/2 to 3 inches during the summer for cool season grasses or between 1 to 1–1/2 inches for warm season grasses.
______	______	______	Water the lawn only as needed.
______	______	______	Check for stress areas and water them first.
______	______	______	Water only in the cool of the morning or when the area is shaded.
______	______	______	Check sprinklers for accurate spraying. Avoid watering pavement, sidewalks, and driveways.
______	______	______	Mulch is used around trees, shrubs, and perennials rather than turfgrass.
______	______	______	Transplant smaller trees into areas rather than large trees that experience greater transfer shock.
______	______	______	Transplant trees in the fall when feeder-root systems can be established.

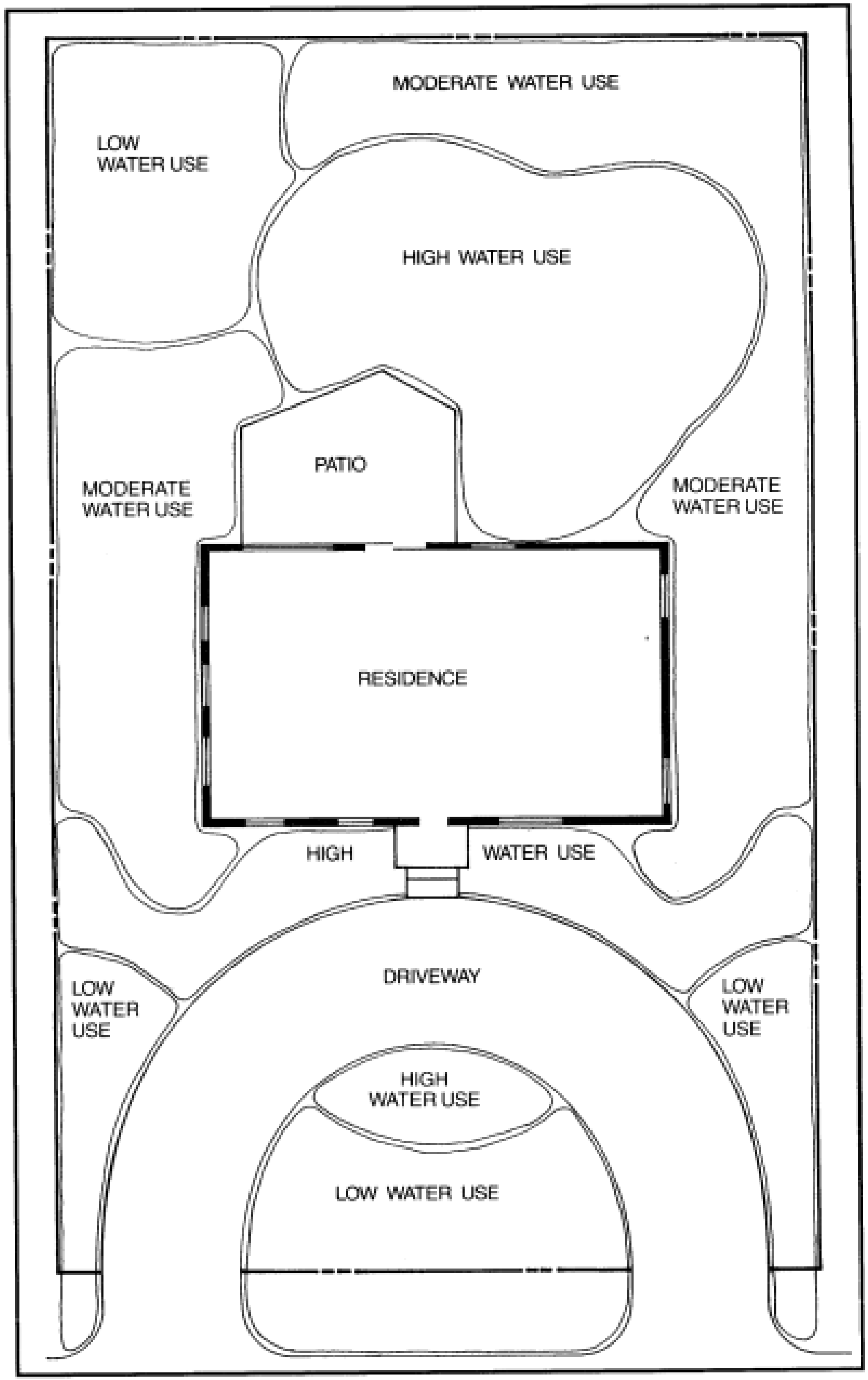
Step Number	In Use	Can Implement	
______	______	______	Avoid planting during drought periods. Use natural periods of rainfall in the fall or spring.
______	______	______	Prepare planting holes that are broad, saucer-shaped and two to three times the size of the root ball.
______	______	______	Incorporate compost into the soil to improve the water-holding capacity rather than adding organic matter as fill in the planting hole.
______	______	______	Use a trickle of water in newly planted trees and shrubs to settle the soil and prevent dry pockets of air.
______	______	______	Create a saucer around newly placed plants to create a water basin.
______	______	______	Use two to three inches of mulch around newly planted trees and shrubs.
______	______	______	Control weeds around newly planted shrubs and trees by mulching, pulling, mechanical cultivation, or herbicides.
______	______	______	Use organic mulch that includes straw, leaves, manure, pine needles, leaf clippings, shredded bark, sawdust, compost, etc.
______	______	______	Use inorganic mulch that includes gravel, pebbles, cobblestones, or weed control mats.
______	______	______	Use white marble chips that raise soil pH and cause iron deficiency, leaf scorch, and glare.
______	______	______	Use natural stones to break the force of splashing water and provide area for planting of annuals and perennials.
______	______	______	Use a recommended watering schedule for the area when there is insufficient rainfall.
______	______	______	Water newly planted sod and freshly planted grass seeds daily for the first week and every other day until the lawn is green.
______	______	______	Use a water gauge to measure water applied to lawns when there is not 1 to 1/2 inches of rain per week.
______	______	______	Water lawns when there are visible signs of wilting.
______	______	______	Avoid watering dormant lawns.
______	______	______	Use a deep soaking method (about one inch of water) to encourage deep root development.
______	______	______	Avoid overhead sprinklers that are 75% efficient as compared to drip or subsurface sprinklers that are 90% efficient.
______	______	______	Use an alarm on sprinkler systems to remind you to turn them off.



Base Map of Property

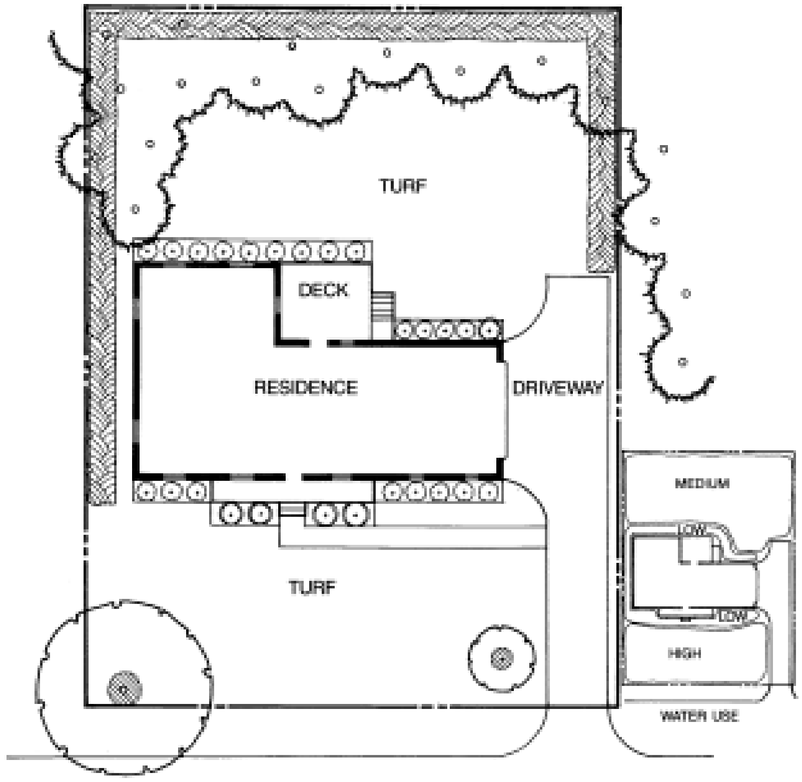


Site Analysis of Property


MODERATE WATER USE
LOW
WATER USE
HIGH WATER USE
PATIO
MODERATE
WATER USE
MODERATE
WATER USE
RESIDENCE
HIGH
WATER USE
DRIVEWAY
LOW
WATER
USE
LOW
WATER
USE
HIGH
WATER USE
LOW WATER USE

TEACHER SHEET 3 LANDSCAPED WATER USE ZONES

6-8



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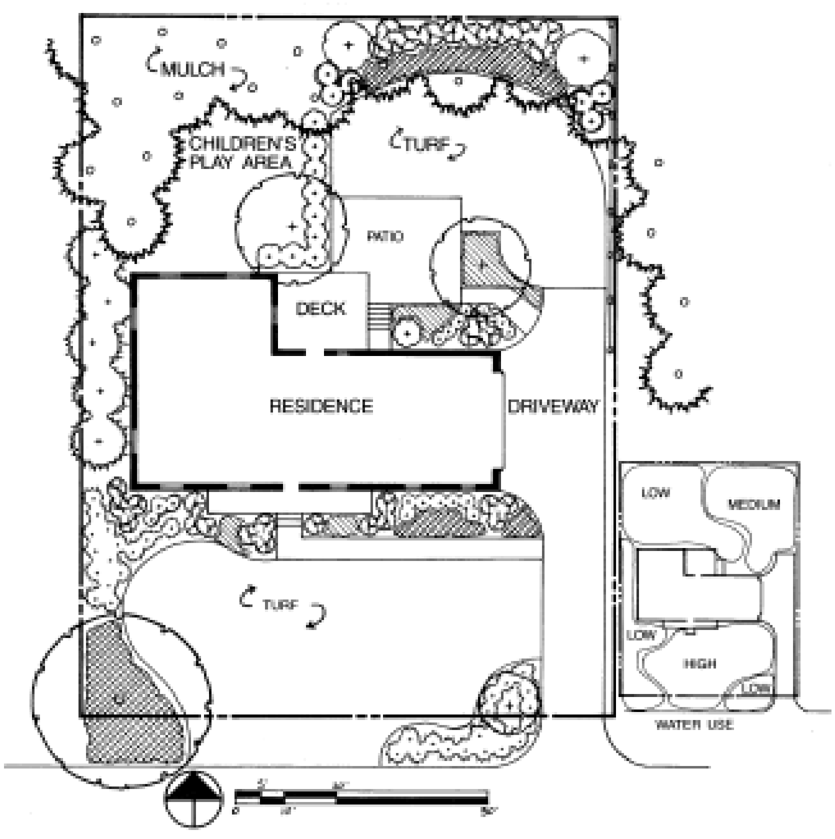

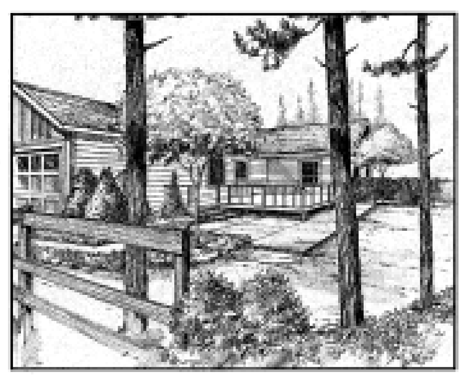

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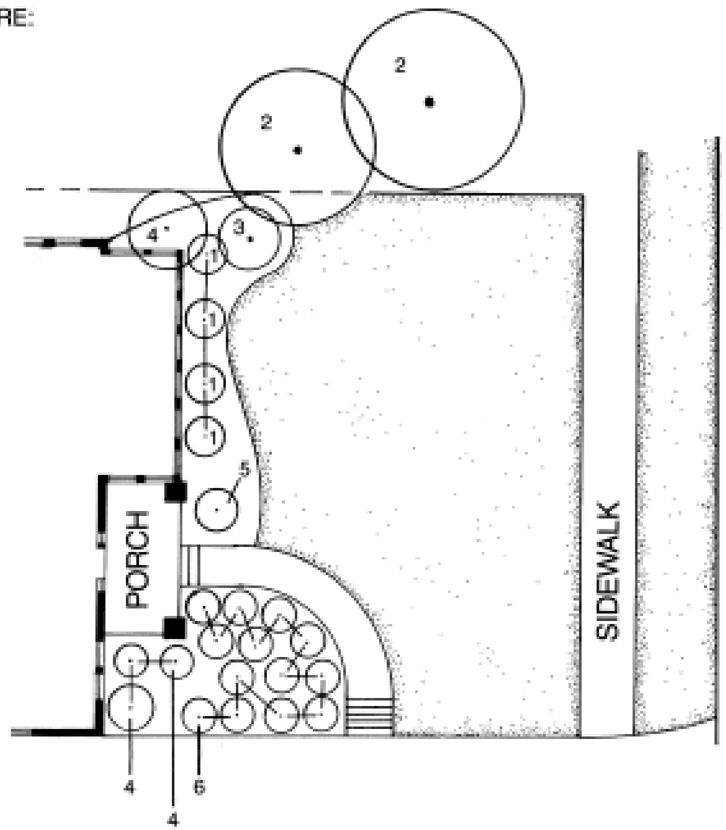
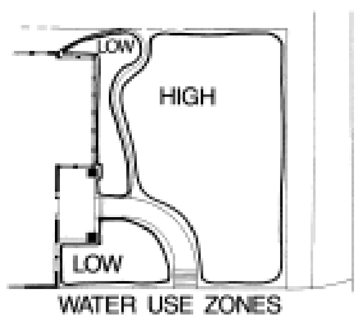


PLANT LIST

1. Boxwood
2. Dogwood
3. Eleagnus
4. Holly
5. Nandina
6. Pfitzer Juniper



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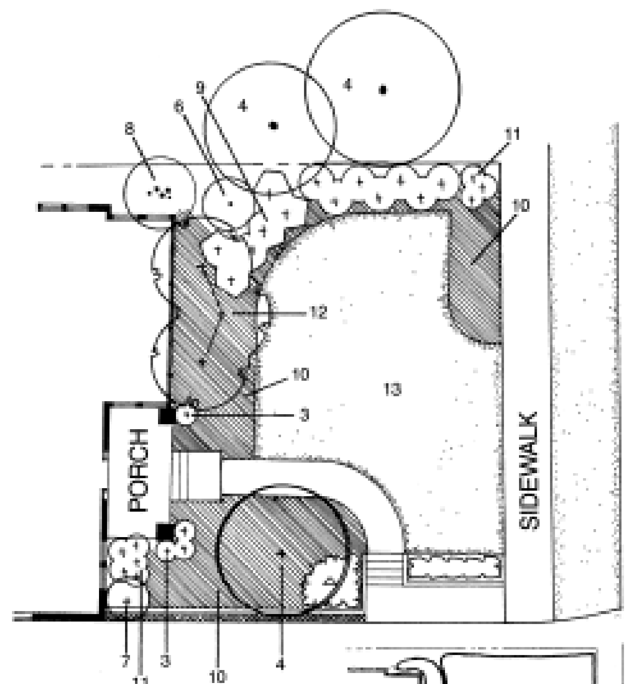

PLANT LIST

1. Azalea, George Tabor
2. Azaleas, Gumpo
3. Boxwood, American
4. Dogwood
5. Dogwood, Existing
6. Eleagnus, Existing
7. Foster Holly
8. Holly, Existing
9. Hydrangea, Bigleaf
10. Mondo Grass
11. Otto Luyken Laurel
12. Yaupon Holly (Tree Form)
13. Zoysia Turf

Credit: Design Courtesy of William T. Smith & Associates Atlanta, Georgia Redd-Chezmar Residence Designer: William T. Smith