Kentucky's Wonderful Commonwealth of Water

High School Unit
Be a Water Scientist

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High School

Unit Summary

This unit is research based and, though it touches on social studies and practical living, is more focused on science that previous units in this series. In this unit students learn the four different types of water pollution, where they originate and how they can be addressed. There is particular emphasis on water issues that affect Kentucky. In the culminating activity, students are given actual problems they must solve in order to protect valuable water supplies.

In this unit student will learn these things.

- What a watershed is and about watersheds in their own communities
- How people contribute to water pollution and how it can be prevented
- Where drinking water comes from and how it is (or is not) treated before reaching our homes.
- How to define overnutrification and how nutrients get into our water supply
- The standards for water pollution and how water pollution is measured
- How toxic chemicals get into our water and which chemicals are natural and which are manmade
- The role of water in transmitting disease
- The role of government and private citizens in protecting our water

Portfolio Suggestions: Using the research they do during the unit, have students write scientific papers describing their findings. Send these to local or state environmental officials.
Or
Write a persuasive paper describing why it is the responsibility of young people to convince their elders to protect water quality.

Suggested Open Response Question: You are a local fisherman. You have begun to notice large numbers of dead fish along the streams and rivers in your community. Describe two possible causes for these fish kills. Include both how the root causes might be addressed and who you would contact to get assistance to remediate the problems.

Technology Extensions

- Use GIS to study where streams and sewer lines exist in your community. Make maps of where you think water pollution problems may exist.
- Take samples of water and measure pH, water temperature, and dissolved oxygen in streams and creeks around your community. Use an excel spread sheet to create tables and graphs of your findings.
- Create a website and post your findings about water quality on the website. Use word-processing software to write a letter to the editor telling him or her about the website.
- Use desktop publishing to create a brochure that explains the different kinds of water pollution that exist in you community. Be sure and include names and phone numbers of places citizens can go for technical assistance to address these issues.

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Essential Question: How can I tell if my water is clean?

Standards

Science

SC-H-3.5.1, Students will understand that organisms both cooperate and compete in ecosystems. Often changes in one component of an ecosystem will have effects on the entire system that are difficult to predict. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years,

SC-H-2.2.1, Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different reservoirs. Each element on Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of geochemical cycles.

SC-H-3.5.5, Students will understand that human beings live within the world's ecosystems. Human activities can deliberately or inadvertently alter the dynamics in ecosystems. These activities can threaten current and future global stability and, if not addressed, ecosystems can be irreversibly affected.

S-H-Applications and connections, Students will investigate how science can be used to solve environmental quality problems and use science to investigate natural and human-induced hazards.

S-H-Applications and Connections, Students will use science to investigate natural hazards and human-induced hazards.

S-H– Scientific Inquiry, Students will use evidence, logic, and scientific knowledge to develop and revise scientific explanations and models.

Social Studies

SS-H-3.1.1, Scarcity of resources necessitates choices at both personal and societal levels.

SS-H-1.3.3, In order for the U.S. government to function as a democracy and preserve individual rights, citizens must assume responsibilities and duties for its functioning.

SS-H-4.4.4, Group and individual perspectives impact the use of natural resources (e.g., mineral extraction, land reclamation)

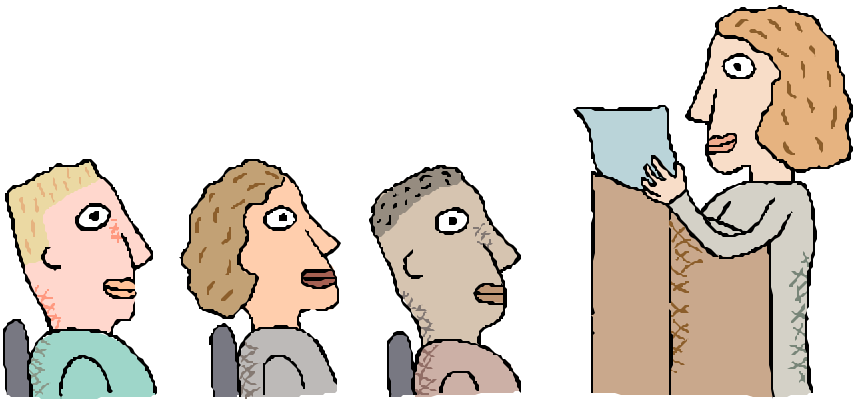
Practical Living

PL-H-3.3.2, Students will analyze community health standards and regulations

PL –H-3.3.3, Students will identify ways to protect the environment

Unit Overview	
Lesson	**Title and Description of Activities, Essential and Guiding Questions and Standards**
# 1	**" Let's Make a Watershed Model "-** Students will create watershed models that show examples of point and non-point water pollution sources and natural filters in a community. Students will also identify the interrelationships between a community and it's watershed. **Standards:** Science: SC-H-2.2.1 and Practical Living, PL-H-3.3.3 and Social Studies, SS-H-4.4.4 **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • What are some of the causes of water pollution? • What natural and manmade filters help clean water?
# 2	**"Who Dirties the Water? Not Me, Dude."-** Students will listen to, and interact with, a prepared script depicting the "history" of water pollution as they gain an understanding that pollution can occur as a result of many interacting factors. In Part 2, students will try to simulate nature's water filtration system by devising a system to filter out both visible and invisible pollutants from water. **Standards: Scientific Inquiry,** Students will use evidence, logic, and scientific knowledge to develop and revise scientific explanations and models and Science SC-H-3.5.5 and Practical Living, PL-H-3.3.3 **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • What is the most effective way to clean dirty water? • How do we know when it is clean? • Who is responsible for polluting the water and for preventing pollution?
# 3	**"Tapping Into Our Local Water Supply"—** Students will investigate where local water originates and what happens to it before it arrives at their homes. **Standards:** Science Applications and Connections**:** Students will investigate how science can be used to solve environmental quality problems and use science to investigate natural and human-induced hazards. Practical Living: PL-H-3.3.2**,** **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • Where do we get our drinking water? • What happens to it before it arrives in our homes? • What is a watershed?

Unit Overview	
Lesson	**Title and Description of Activities, Essential and Guiding Questions and Standards**
# **4**	**"Nitrates and Nutrients"—**students will collect water samples from different sites and test for nitrate levels. **Standards:** Science: SC-H-3.5.5 and Practical Living: PL-H-3.3.2 **Essential Question**: How can I tell if my water is clean? **Guiding Questions** : • Do the amounts of nitrate in natural bodies of water and drinking water vary? • What is "over nutrification?
#5	**"Searching for Nitrate Pollution Solutions"—**Students will collaborate in groups, without teacher direction, to carry out a complex project that examines a model of an environmental problem. **Standards:** SC-H-3.5.5 and Practical Living: PL-H-3.3.2 **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • What can affect nitrate levels in water? • What are the EPA and state standards for nitrate levels? • What can be done to keep nitrate concentration at safe levels in our drinking water?
#6	" **Can Being Clean Make You Sick?"—**Students will learn about toxins and how they enter the environment. They will also "survey" products used in their homes to see if they are potential pollutants. **Standards: Science, Applications and Connections:** Students will use science to investigate natural hazards and human-induced hazards. SC-H-3.5.1 and Social Studies: SS-H-4.4.4 and Practical Living, PL-H-3.3.3 **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • How do toxic substances get into the environment and into water sources? • Are there toxic substances in my home? • How can we prevent toxic substances from entering the environment?
# **7**	**"Scientific Sleuthing"—**In this activity, students will identify the role of water in transmitting diseases, compare symptoms of several waterborne diseases and analyze the characteristics of environments that promote transmission of these diseases around the world. **Standards:** SC-H-3.5.5 and Practical Living: PL-H-3.3.2 **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • What are the symptoms of different waterborne illnesses?

Unit Overview	
Lesson	**Title and Description of Activities, Essential and Guiding Questions and Standards**
# 8	**"Pollution Solution: A Culminating Activity"—**Students will work in groups and read scenarios that describe a variety of water pollution issues. They will then use knowledge gained in the unit, along with original research and problem solving, to come up with practical solutions and then present those to the class and defend their work. **Standards:** All standards from the unit plus Social Studies: SS-H-1.3.3 **Essential Question:** How can I tell if my water is clean? **Guiding Questions:** • All questions from the unit 

Kentucky's Commonwealth of Water – Be an Water Scientist
High School

Let's Make a Watershed Model

Adapted from "Making a Watershed Model", *Instructional Models For Use With Enviroscape*, Grades 6-8, pages 1-2

Standards

SC-H-2.2.1, Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different reservoirs. Each element on Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of geochemical cycles.
SS-H-4.4.4, Group and individual perspectives impact the use of natural resources (e.g., mineral extraction, land reclamation)
PL –H-3.3.3, Students will identify ways to protect the environment

Activity Description

Students will create watershed models that show examples of point and non-point water pollution sources and natural filters in a community. Students will also identify the interrelationships between a community and it's watershed. Or see teacher fact sheets for where to borrow an Enviroscape model. **Note: You may use an Enviroscape model in place of this activity. See the teacher fact sheets to borrow one near you.**

Materials

- An aluminum tray or cookie sheet
- Small plastic containers of various shapes and sizes.
- Modeling clay for creating contours on the model
- Materials to build and represent different natural and man-made areas in a community such as an industrial area, a residential area, a recreational area, agricultural areas, and a landfill. Materials could include: sponge bits, soil, pebbles, dried grasses, twigs, balloons (pond and landfill liners), toothpicks, plastic wrap, aluminum foil (pipes and drainage areas), household non-toxic materials such as powdered drink mixes, cocoa powder, pancake syrup, flour, sugar, etc.
- Water and spray bottle.

Length of Lesson

Allow two class periods to plan and build models and one period to demonstrate

Vocabulary

Nonpoint source pollution: pollution that cannot be traced to a single point (e.g. outlet or pipe) because it comes from many individual sources or a widespread area (typically urban, rural, and agricultural runoff).
Point source pollution: pollution that can be traced to a single point source such as a pipe or culvert (e.g., industrial, wastewater treatment plant, and certain storm water discharges).
Best Management Practice (BMP): effective ways to prevent or stop pollution.

Essential Question

How can I tell if my water is clean?

Guiding Questions

- What are some of the causes of water pollution?
- What natural and manmade filters help clean water?

Skills Used

Analyze	Hypothesize	Describe	Evaluate
Discuss	Identify	Observe	Design

Let's Make a Watershed Model, *continued*

Note: If you do not have time to build models, consider borrowing an Enviroscape (see teacher fact sheets) to teach students about nonpoint source pollution and watersheds . It is essential that students understand these concepts before proceeding with the unit.

Step 1: A few days before beginning this activity, explain to students that they are going to build models of their watershed. Let students know what types of materials are suggested for use when constructing the models. Ask students to look around at home for these materials, as well as other things they think might be useful when building the watershed models. (Check instruction sheet at the end of this activity for a detailed description of how to make and demonstrate a watershed. Share this with students.)

Step 2: Prior to beginning this activity, refer to **Teacher Fact Sheets** for detailed information on watersheds and a list of places that have Enviroscape models available to loan. If an Enviroscape model is available for class use, show students how the model looks, and demonstrate how it works. This should help students have a better understanding of what is expected of them as they build their watershed model. Gather materials needed to build the student watershed models.

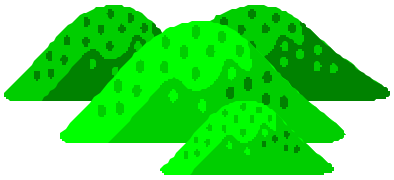
Step 2: Remind students of the importance of the hydrologic cycle to life on earth. Explain that as water precipitates back to the earth's surface, any materials spilled or placed on the ground's surface will eventually become part of the surface water system through runoff, or the ground water system, through infiltration. Explain that human activities such as landfill use, the use of chemicals in and around the home, improper industrial waste disposal, farming, etc. affect the quality of both the surface and ground water everywhere. Ask students if they can explain why this is so. (Remind students that water is known as the universal solvent, and mixes easily with other substances.)

Step 3: Explain to students that during this activity they will be working in small groups to build a model of their local watershed. Tell students that their community models will each need to include a water source (stream, pond, river, . . .) and at least 3 of the following areas: residential, industrial, recreational, agricultural, forests, transportation or landfills. **Also explain that each group of students should try to make the model as realistic as possible, since the models will be used to demonstrate point and nonpoint source pollution. (Explain these definitions, if the concepts have not yet been taught.)**

Step 4: Let students know what types of materials are available for them to use. Tell students that modeling clay needs to be used to build contours, terraces, rivers, or any downhill slope where water might be running on their models.

Step 5: Allow time in class for students to complete watershed models.

Step 6: Explain to students that part of the assessment on this activity will include a demonstration of each watershed model. During the demonstration, explain that each group must be prepared to identify possible types of pollutants produced in each area on their model. For example: septic tank leakage; fertilizers, herbicides and pesticides from lawns or golf courses, etc.; sediment from clear-cut areas and construction zones; oil and gas from parking areas or roadways. Ask students if they can explain what causes runoff water. What causes water to infiltrate, or soak into the ground? Show students different types of powders available for them to use on their models to show the pollutants.



Let's Make a Watershed Model, *contin-*

Day 2, Activity 1

Step 1: After the models have been completed, take 3 digital photos of each model; the first one before the demonstration begins, the second one after the pollutants have been sprinkled on the model, and the third one after the water has been sprayed on the model to simulate runoff. (This is optional, but it will be useful in Activity 2.)

Step 2: Gather students around one of the groups prepared to demonstrate how their model works. Encourage each group to be very dramatic and offer thorough explanations as to what is happening when they sprinkle the appropriate pollutants in each area of their watershed model (e.g., cocoa powder for sediment, pancake syrup for manure from farm animals, drink powder or tempura for pesticides, . . .).

Step 3: Once the pollutants have been sprinkled on the model, give the group a spray bottle filled with clean water to spray on the model until run-off occurs. Students in the group should identify the source of the pollution and explain whether it is point or nonpoint source pollution. Encourage students in each group to explain what is happening to the surrounding water sources as a result of the runoff water. Ask students if they think it would be cheaper and easier to clean up the water after it is dirty, or keep it from getting dirty in the first place.

Step 4: As each group gets through demonstrating their watershed model, drain the dirty water off the model, squirt the model with clean water and dry it with paper towels. The models will be used in the following activity on pollution prevention. **(See Extension for ideas on what to do with dirty water.)**

Activity 2

Step 1: As a large group, brainstorm ways to prevent water pollution. As students come up with ideas, hand them something with which to build their **Best Management Practices** (BMPs or pollution control) such as a piece of clay, sponge, bean sprouts (for roots of trees and plants), etc. Allow time for students to build their BMPs onto the group model.

Step 2: If students have trouble coming up with suggestions for BMPs, offer some of the following ideas that might spur them to think in more divergent ways:

- Golf course – Use less fertilizer, plant a filter strip (sponge or porous shelf liner) at bottom of hill.
- Farm field – Build terraces of clay (parallel ridges) across the hill (not up and down).
- Cars and roads – Put sand or felt filter alogn highways to catch oil.
- Bare spots on landscape – Cover with grass or trees (felt or sponges).
- Factory – Build a little dam of clay to hold the effluent (waste disposal), pretend to treat it.
- Farm animals – Build a lagoon (pond or pit) to put manure in.
- Anywhere – Pick up trash.
- Use sanitary landfills, that are lined to prevent seepage, instead of sink holes or illegal dumpsites.

Let's Make a Watershed Model, *contin-*

NOTE: If time is a factor at this point, teacher may decide to do this step in small groups at the same time, instead of having a large group of students observe as the small groups take turns assessing the value of their BMPs.

Step 3: After BMP's have been added to the models, reapply the pollution to each spot. Try to make sure the pollution is inside or up-slope of the BMP. For example, if terraces are built on the farm field, try to sprinkle cocoa on the flatter spots between the terrace ridges, not on the terrace ridges themselves. If a lagoon is built for the animal waste, put the waste within the lagoon walls.

Step 4: Once again, have a group member squirt the model until the runoff reaches the body of water. Some pollutants will probably get into the lake; hopefully, it will be less than the first time when there were no BMP's in place. Discuss how BMP's do not stop pollution completely, but they do lessen the amount of pollution that reaches the water.

Step 5: Conclude this activity by having students analyze the ways they think pollution may be getting into the water in the school's watershed. Have them create a Best Management Practice Plan for helping to prevent the pollution. Students can then present the plan to the School Council as a Power Point presentation and/or by demonstrating one of

Assessment for these activities may take the form of group cooperation during the different activities, the finished product (the watershed model), the presentations, the Best Management Practices that were applied to help control pollution, and the final journal reflection. A rubric to assess oral presentations has been included to help with the scoring of the group presentations.

Extension

1. Assign groups of students to design brochures that highlight one area of watershed/ groundwater protection for their community (proper oil disposal; solid waste disposal; homeowners' use of chemicals, pesticides, or fertilizers on lawns). These brochures can be handed out to appropriate community leaders or community groups.

2. Collect the dirty water that was left over after each demonstration. Ask students for suggestions on what to do with the dirty water. (Refer to the activity in the primary water unit called "Filtering Away Pollutants" for a similar activity.)

Controlling & Preventing Pollution

There are 3 basic methods of pollution control or prevention.

1. Structural Controls – where you build something to prevent or treat pollution.

2. Vegetative Controls – where you plant something to treat pollution.

3. Management Controls – where you do something differently to prevent pollution.

When they are used to control nonpoint source pollution, these methods are called BEST MANAGEMENT PRACTICES OR BMPS.

How to Construct and Demonstrate a Watershed Model

Step One: Gather the materials you will be using to construct and demonstrate the model. These include the following.

An aluminum cookie sheet or other nonpermeable base for the watershed model.

Plastic, paper or styrofoam containers — used as "bases" to add height to various areas of the watershed. For example, a butter container might be the base of a large hill, while one section of an egg carton might be a small hill.

Balloons or other small pieces of flexible rubber or plastic: Used as the "bed" of streams or ponds. These materials should actually be able to hold and/or channel water.

Clay, or other moldable material for covering the "bases" so that the model both looks realistic and will actually allow water to flow across it. (Note: Paper mache and salt and flour clay may work on these models if they are only to be used for demonstration once or twice. However, since both are water soluble, they will disintegrate easily.)

Materials to make features on the clay base of the watershed. Materials could include: sponge bits, soil, pebbles, dried grasses, twigs, balloons (pond and landfill liners), toothpicks, plastic wrap, aluminum foil (pipes and drainage areas), model houses, tractors, farm animals, cars, etc.

Materials to simulate substances that get into the water from throughout the watershed. These can include the following (and what they represent): powdered tempera paint or powdered drink mixes in the following colors, green (to simulate fertilizer), red (to simulate pesticides and herbicides), brown (to simulate sediment and mud), pancake syrup (to simulate sewer and manure sludge), cooking oil to simulate oil on roads and parking lots.

Materials to simulate BMP's (Best Management Practices): These can include small pieces of green felt, sponges, absorbent shelf paper, or even alfalfa/bean sprouts (to simulate areas of plant cover), clay to construct barriers, levees or holding areas.

Step Two: Constructing the Watershed Model

Plan: Decide as a group how your watershed will look (e.g. high points, low points, number, type and size of water features, etc.). Decide what features your watershed will have and where they will be (e.g. housing development, construction sites, roads, farms, etc) List these features on paper and draw (or map) them as well.

Build: Construct your watershed to match your plan. Use the clay or other modeling material to cover the base of the watershed model and connect all the areas together. When the clay has been molded to the model, it should look like a watershed would look if there were no trees, grasses, building, etc. Don't forget that the lowest point in your watershed should be a river, stream or other body of water.

Step Three: Demonstrating Water Pollution on Your Model

Think: Decide as a group, what kinds of pollution might flow from the various features on your model (e.g. sediment from plowed fields and construction sites, fertilizers from lawns, oil from roads and parking lots) .

Pollute! Simulate pollution on your watershed model by putting the tempura paint, syrup, oil etc. on the appropriate features. Talk about the difference between point and nonpoint source pollution.

Precipitate: Using the water bottle, make it "rain" on your model. As the various kinds of pollution dissolve in water, watch where they go? What is happening to your watershed?!?

Remediate: Clean the model. Then using sponges, felt, clay, etc. create BMP's (Best Management Practices) to prevent the pollution from getting into your water. In the real world such features would include grassy areas, trees, wetlands, terraces, holding ponds etc.

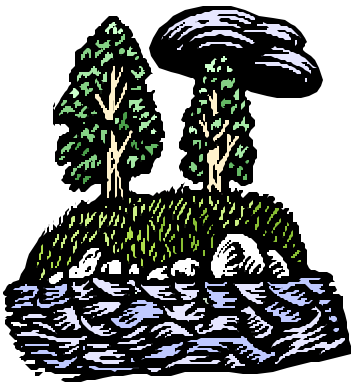
Pollute: Using the same amounts and patterns as before, place "pollutants" on your model again.

Precipitate: Using the water bottle, make it rain again in approximately the same places and amounts as before. Do your BMP's help prevent the pollution from getting into the water?

Discuss: Think about your school's watershed. Are there ways pollution might be getting into the water from your watershed?

Extension

1. Have the students go to other classes or even other schools to demonstrate their watershed models.
2. Have students create a video of what happens in the school watershed when it is raining. Show this to other classes.



Oral Presentation Rubric

Student Name_____ **Date**_____

Teacher Name_____ **Class**_____

CATEGORY AND SCORE	4	3	2	1
Preparedness	Student (group) is completely prepared and has obviously rehearsed.	Student (group) seems prepared, but might have needed a couple more rehearsals.	Student (group) is somewhat prepared, but it is clear that rehearsal was lacking.	Student (group) does not seem at all prepared to present.
Collaboration with Peers	Almost always listens to, shares with, and supports the efforts of others in the group. Tries to keep people working well together.	Usually listens to, shares with, and supports the efforts of others in the group. Does not cause "waves" in the group.	Often listens to, shares with, and supports the efforts of others in the group, but sometimes is not a good team member.	Rarely listens to, shares with, and supports the efforts of others in the group. Often is not a good team member.
Comprehension	Student (group) is able to accurately address almost all questions relating to the correlation between human activities and pollution of Kentucky's waterways, including how to prevent or reduce this pollution.	Student (group) is able to accurately address most questions relating to the correlation between human activities and pollution of Kentucky's waterways, including how to prevent or reduce this pollution.	Student (group) is able to accurately address a few questions relating to the correlation between human activities and pollution of Kentucky's waterways, including how to prevent or reduce this pollution.	Student (group) is unable to accurately address questions relating to the correlation between human activities and pollution of Kentucky's waterways, including how to prevent or reduce this pollution.
Content	Shows a full understanding of the topic.	Shows a good understanding of the topic.	Shows a good understanding of parts of the topic.	Does not seem to understand the topic very well.

_____**Total Score** **Comments:**

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High School

Who Dirties the Water? Not me, Dude.

Adapted from *Who Dirtied the Water?*, by Carmen Hood. Originally from the Science Education and Environmental Research (SEER) Water Project and Ginger Hawhee/Sandy McCreight (Omaha North High School, Omaha, Nebraska) whose original source was undocumented

Standards

Scientific Inquiry, Students will use evidence, logic, and scientific knowledge to develop and revise scientific explanations and models.
Science: SC-H-3.5.5, Students will understand that human beings live within the world's ecosystems. Human activities can deliberately or inadvertently alter the dynamics in ecosystems. These activities can threaten current and future global stability and, if not addressed, ecosystems can be irreversibly affected.
PL –H-3.3.3, Students will identify ways to protect the environment

Activity Description

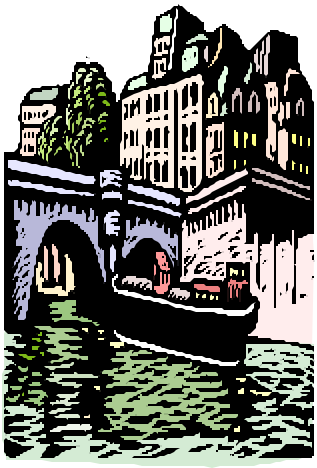
Students will listen to, and interact with, a prepared script depicting the "history" of water pollution as they gain an understanding that pollution can occur as a result of many interacting factors. In Part 2, students will try to simulate nature's water filtration system by devising a system to filter out both visible and invisible pollutants from water.

Materials

For Part 1

- Copy of script for teacher or assigned student to read
- Large jar or aquarium containing clean water
- Large spoon used to stir water
- Notebook and pencil for each student
- Film canisters labeled on the outside with the underlined word, and containing the substance listed on the right of the underlined word.

Beaver:	wood chips	**River:**	sand
Runoff:	charcoal	**Wetlands**:	dry grass
Shellfish:	crushed shell	**Aquarians:**	shells
Settlers:	organic garbage	**Carpenters:**	nails
Farmers:	potting soil	**Fisherman:**	nylon line
Straight Pipes:	toilet paper	**Boaters:**	Styrofoam
Sunbathers 1:	suntan lotion	**Homeowners:**	fertilizer
Sunbathers 2:	newspaper	**Factories:**	molasses
Sunbathers 3:	plastic pieces	**People:**	baking soda
Laundromats:	dish detergent		
Patients:	artificial sweetener tablets		



For Part 2

- Beakers — Rubber bands — Nylon mesh
- Sand — Charcoal — Cotton balls
- Water — Graduated cylinder — Test tubes
- Ring stand — Filter paper — Dirty water
- Class set of student task sheet found at the end of this activity

Who Dirties the Water?, *continued*

Length of Lesson

1 – 2 class periods

Vocabulary

Filtration—the process whereby a substance (e.g., water or air) is filtered, or cleaned.
Pollutant—a liquid, gas, dust, or solid material that causes contamination of air, water, earth and living organisms.

Essential Question

How can I tell if my water is clean?

Guiding Questions

- What is the most effective way to clean up dirty water?
- How do we know when it is clean?
- Who is responsible for polluting water and for preventing pollution?

Skills Used

Analyze	Write	Reflect	Experiment
Observe	Simulate	Organize	Compare
Investigate	Discuss	Hypothesize	Sketch

Class Preparation

Prior to class time, collect the materials needed to conduct these activities. Label the film canisters as indicated in the material list, and put listed materials inside canister. (Preparation time can be extensive, especially if setting up for more than one section of students, so seek help from student or parent volunteers.)

NOTE: A variation on the filtering segment of this activity may be done in order to set up a comparison study on the effectiveness of natural filters to man-made filters. If desired, have half the class use filtering materials that would be found in nature (pebbles, roots, grass clippings, sand) to try to filter pollutants from the water, while the other half of the class uses lab materials listed.

Who Dirties the Water?, *continued*

Part 1

Step 1: As students enter the room for class, hand them a film canister that contains materials that will be added to a clear container of water as the script is read.

Step 2: Once students are settled, explain that they will be listening to a story read by the teacher (or a designated student). Students with a canister will come forward as they hear the word on the outside of their canister read, tell the class who or what they represent, describe what they think is in the canister, and add it to the water. A group of three students reads the chorus in unison.

Step 3: On the board, write the following:

WHO DIRTIES THE WATER DATA TABLE

WHO IS ADDING	WHAT IS ADDED

Instruct students to copy this data table into their class notebooks and, as the script is read, record on their data table who or what is doing the adding and the actual substance that has been added to the container of water.

Step 4: Read the script. (Reader needs to use lots of expression and emphasize the capitalized words so students will be reminded to step forward with appropriate film canisters. Also, either the reader, or another designated student, should stir the murky substance and lift up the spoon from time to time so students can see how "gross" the water looks.)

Step 5: After the script has been completely read, give students an opportunity to reflect in their notebooks on the final two questions of the script:

1. Who dirtied the water?
2. Who is responsible for cleaning it?

Also, ask students to reflect on and discuss a third question:

3. Why do you think it is so important to keep our water supply free of pollutants?

It is important that students understand that, because of the small amount of usable water on Earth, clean water is not a limitless resource.

NOTE: Information about available water on Earth may be used at this time, if desired. See "What's all the Fuss About?" in the middle school unit.

Oceans	**97.2% of total water**
Ice caps/glaciers	**2.38%**
Ground water	**0.397%**
Surface water	**0.022%**
Atmosphere	**0.001%**

Add percentages to find available drinking water.

Ground water	_____
Surface water	_____
Total	_____

Step 6: If plans are to continue on into part 2 of this activity, pose the following question:

Now, how can we clean this dirty water?

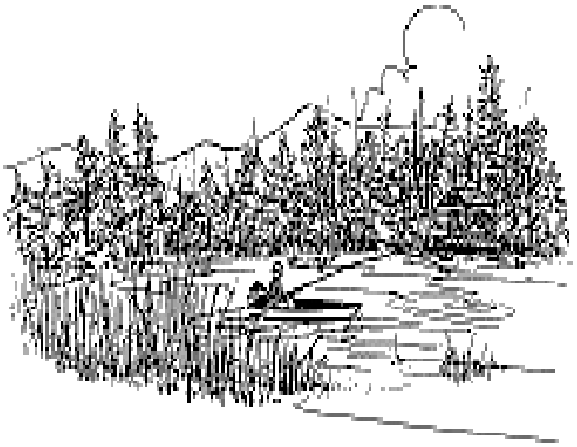
Who Dirties the Water?, *continued*

Part 2

Step 1: Collect the materials needed to conduct this lab (See Part 2 of Materials Section.) and copy the student task sheet, (included) or make a transparency to show on the overhead projector.

Step 2: Assign students to lab groups and instruct students to devise a filtration system that they will use to clean a dirty water sample. (If Part 1 of "Who Dirties the Water?" is acted out prior to beginning this activity, the water left at the end of that story can be used in this lesson. The molasses used in this activity can cause the water to have a yellowish look, even after it has been filtered.)

Step 3: Explain that, using the lab materials present in class, each group will need to write out, in detailed step-by-step instructions, how to filter the water sample. Each group will also need to sketch the filtration system set-up and label the parts. Tell students to also make a list of any questions they have about this activity.



Step 4: Give each lab group a sample of dirty water with instructions to make the water sample as clean as possible. Give students time to make any adjustments to their models that they feel are necessary in order to better cleanse the water sample.

Evaluation

Step 5: Assign the work found on the student task sheet (located at the end of this activity) to be completed by each student, and turned in, by a specified date. Encourage students to use the Internet to find answers to some of the research questions as well as questions of their own. Tell them that finding the answers to questions of their own will improve their grade!

Extensions

1. **Using classroom test kits, test for pollutant levels in unfiltered water samples, then redo the tests using the filtered water and compare the results.**
2. **Research the local watershed to learn more about the flow of pollutants into the surface and groundwater in your area.**
3. **Visit a local body of water (preferably a small creek) to observe, first-hand, how nature works to clean the impurities from water.**
4. **Challenge students to research different water filters available for consumer use, or the home filtration system currently being used, to determine their effectiveness at removing pollutants from drinking water. Report findings to the class.**

Who Dirties the Water Script

The Story:
Once upon a time there was a beautiful piece of land. It was almost an island, since it was onnected to the mainland by a narrow land bridge, and surrounded on three sides by a lake. The lake was filled with clear water and was dotted with a few small green islands. (Point to the jar.) Fish and other aquatic life thrived in the water. The land was covered with trees and the land and the lake teemed with wildlife.

Chorus:
Would you want to swim in this lake"
Would you eat fish caught in this water?
Would you like to go boating in this lake?

Animal life flourished along a nearby river and the **BEAVER** were plentiful. A **RIVER** ran along one side of the land, carrying sediment with it as it flowed into the lake.

WETLANDS bordered the edges of the lake. Grasses from the wetlands sometimes washed into the lake and became food for the fish.

In the shallow water, clams and other **SHELLFISH** thrived.

A small group of people lived on this land, which they called Aquarian. The people were called the **AQUARIANS**. The Aquarians fished for food and shellfish in the lake. They dumped some of their garbage near the lake. We still find the piles of the shells they left.

Chorus:
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

After many years **SETTLERS** from Europe came to live in the area. The settlers built a town much larger than the Aquarian villages. Some of the town's garbage was dumped into the lake. **CARPENTERS** built houses, farms, and stores that filled the Aquarian valley.

As the town grew, the settlers filled the wetlands to provide more land on which to build. **FARMERS** cut down trees to clear their fields. Without trees and wetlands to hold the soil, rain carried soil into the lake.

Chorus :
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

More and more houses and shops were built, and the town of Aquarian grew into a city. Sewer pipes were constructed to remove the waste from houses and bathrooms. Some houses sent their sewage into the rivers and lake without going into the sewage system. These were called **STRAIGHT PIPES**.

Since the wetlands had been filled in, **RUNOFF** water washed pollution from the streets directly into the lake.

Who Dirties the Water?
Script (cont.)

FISHERMAN found that nets made of plastic were stronger than those made of rope. Sometimes these nets got lost in the water.

Fisherman and **BOATERS** sometimes threw their rubbish overboard.

Chorus:
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

The city built **LAUNDROMATS** where people could wash their clothes. The detergents went down the pipes with the sewage into the lake.

People cleaned their houses. The **PEOPLE** used poisonous tile and drain cleaners, which flowed into the sewage system.

Even swimmers and **SUNBATHERS** going to enjoy the lake sometimes left garbage on its beaches.

As the city grew, **HOMEOWNERS** fertilized their lawns. The excess fertilizer poured into the lake.

Some of the **FACTORIES** built along the water's edge dumped their toxic wastes and chemicals into the water.

PATIENTS took medicines and tiny amounts of the medicines showed up in the water.

Chorus:
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

Who dirties the water? WE ALL DO.
Who is responsible for cleaning it up? WE ALL ARE.

Who Dirties the Water Filtration Design
Task Sheet

Name_____ Date_____ Class_____

Directions for first day:

A. Using the available equipment, devise a filtration system that you will use to clean your dirty water sample.

1. Write out, in detailed step-by-step instructions, how you will use the lab materials to filter the water sample. (Each group should have one set of instructions.)

2. Sketch your filtration system set-up and label the parts. (Each group should have one sketch.)

Directions for second day:

B. Using your proposed filtration system, work with your group to make your water sample as clean as you can.

C. As a group, make any adjustments to your model that are necessary in order to cleanse your water sample.

D. Individually, on another sheet of paper, thoroughly answer the following questions. Complete and return this assignment by _____.

3. Was your original filtration system successful?

4. Describe any adjustments you made to your original model.

5. Were you able to remove all impurities?

6. What were some of the limitations of your system?

7. How could you tell if your water was purified? (HINT: What physical and/or chemical changes took place that would indicate that you accomplished your goal?)

8. What kinds of tests could you perform on your filtered water to prove that it had been cleansed?

Research Extension: You may use library or community resources to find the following information or to find answers to your own questions.

9. Describe a water purification system that could be used in a municipal area.

10. What is our city's / town's / county's main source of drinking water?

11. What "natural filters" are present in our local water supply?

12. What kinds of tests are done on our water supply to meet health and safety standards?

13. What agency sets the criteria for water safety standards?

Protecting Kentucky's Water – Be a Water Scientist
High School

Tapping Into Our Local Water Supply

Adapted from "How Water Is Cleaned", ", found in ***Always a River***, EPA, 1992, pages 193-197.

Standards

Science Applications and Connections: Students will investigate how science can be used to solve environmental quality problems and use science to investigate natural and human-induced hazards.
Practical Living: PL-H-3.3.2, Students will analyze community health standards and regulations (e.g., air/water quality, immunization, health and safety protection of citizens).

Activity Description

Students will investigate where local water originates and what happens to it before it arrives at their homes.

Materials

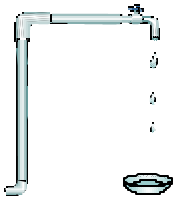
- Access to computers, telephone and library materials for research
- List of resource people to contact about local water
- Local watershed maps (at least 4 to be shared by groups of students)
- "How a Water Treatment System Works" handout, included
- Bucket containing 5 liters of "swamp water" (or add 2 1/2 cups of dirt or mud to 5 liters of water)
- One 2-liter plastic soda bottle with its cap
- Two 2-liter plastic soda bottles — one bottle with the top removed and one bottle with the bottom removed.
- One 1.5 liter (or larger) beaker or another soft drink bottle bottom
- 2 tablespoons alum (potassium aluminum sulfate), found at pharmacy
- Fine sand (about 800 milliliters in volume)
- Coarse sand (about 400 milliliters in volume)
- Small pebbles (about 400 milliliters in volume)
- Large beaker or jar (500 milliliters or larger)
- Small piece of flexible nylon screen (approximately 5 centimeters x 5 centimeters)
- A tablespoon, a rubber band and a stopwatch

Length of Lesson

1 class period

Vocabulary Words

Clean Water Act—the Federal Water Pollution Control Act of 1972, Public Law 92-500, is a law passed by the United States Congress, in 1972, that created guidelines for states to follow concerning water quality.
EPA standards—national standards for a variety of environmental programs that have been researched and set by the Environmental Protection Agency (EPA), which was established by the United States Congress in 1970, in an effort to control pollution of air, land and water.
Wastewater treatment plant—a large facility that treats wastewater from homes and industry to a point where it can be safely discharged into the environment.
Watershed—region draining into a river, river system, or body of water.
Water treatment plant—a facility that cleans and purifies water pumped from wells, rivers, and streams prior to distributing the water to customers.



Protecting Kentucky's Water – Be a Water Scientist
High School

Tapping Into Our Local Water Supply, *continued*

Essential Question	**How can I tell if my water is clean?**
Guiding Questions	• Where do we get our drinking water? • What happens to it before it arrives in our homes? • What is a watershed?
Skills Used	Observe, Research, Organize, Compare, Speculate, Investigate, Discuss, Communicate

****

Preparation

NOTE: Depending on the amount of time allotted to study this topic, this activity may be designed in different ways. The shortest way will be presented, but an extension is given that may be used to lengthen the activity and give students time to investigate their local watershed.

Step 1: Prior to beginning this activity, locate a Kentucky watershed map. A map may be obtained by contacting the local Conservation District or Soil Conservation Service office. A detailed watershed map may be obtained for about $6 from Kentucky Geological Survey, University of Kentucky, Lexington, 859-257-3896. Also, contact the local water company to find the names and numbers of people to contact in the community to learn more about local drinking water sources and quality.

Step 2: Refer to the materials section on the previous page for a list of supplies needed. Collect the equipment and materials before time for students to arrive. Copy the included handout: "How a Water Treatment System Works".

Activity

Step 1: Begin this activity by asking students where water originates. If, depending on student responses, you feel it is necessary, review the hydrologic cycle, and the amount of water found on Earth with students. Two activities from the middle school section of this publication address this topic thoroughly.

Step 2: Show students a Kentucky watershed map. Explain to students that watersheds are areas of land which drain into a stream, river, lake, or another body of water. Explain that within a single watershed, all of the precipitation drains to a given point in the same body of water, and that the elevation of the land determines the area of the watershed, with the highest ground forming the boundaries. Tell students that they are part of the largest watershed in the United States — the Mississippi River watershed — but that they are also located in much smaller watersheds that would include the closest ditch that water drains into after a large rain.

Tapping Into Our Local Water Supply, *continued*

Step 3: Pass out the watershed maps and have students move into smaller groups so they can locate their school on the map. Have students name the closest stream to their school. Next, ask students to follow the small stream to the next largest stream. Continue this until they arrive at a large lake, or the largest river on the watershed map.

Step 4: Explain to students that there are water quality guidelines that set the standards for local water companies to follow. Explain that these standards were developed by the Environmental Protection Agency and state agencies to keep our water safe for human consumption. (Refer to "Side Topics" for specific web sites that contain more information about water legislation.)

Step 5: Pour about 1.5 liters of "swamp water" into a 2-liter bottle. Have students describe the appearance and smell of the water. Tell students that, as a class, they will simulate what the local water companies must do to filter impurities out of the water and disinfect it so it is safe for us to drink when it reaches our homes.

Step 6: AERATION. Place the cap on the bottle of swamp water and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cutoff bottles, then pouring the water back and forth between the cutoff bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off. Explain that this process allows gases trapped in the water to escape and adds oxygen to the water.

Step 7: COAGULATION. Add approximately 2 tablespoons of alum crystals to the water. Slowly stir the mixture for 5 minutes. Explain that particles suspended in the water will clump together with the alum to produce floc.

Step 8: SEDIMENTATION. Allow the water to stand undisturbed in the bottle. Have students observe the water at 5-minute intervals for a total of 20 minutes and write their observation with respect to changes in the water's appearance. The floc should settle to the bottom.

NOTE: This would be a good time for students to begin locating information about the local drinking water supply. The local water company should have an Internet web site or a local telephone number so students might contact someone to find out where local water comes from, where it is stored, and where the local drinking water treatment and wastewater treatment plants can be found.

Side Topics for Student and Teacher Research

Visit the following web site to learn more about legislation that has affected Kentucky's drinking water quality by following links from the Environmental Timeline that was developed by the Kentucky Environmental Quality Commission: http://www.kyeqc.net/thirty/time/yeartime.html.

Also visit EPA's water web site (http://www.epa.gov/ebtpages/water.html) and follow links to research and learn more about drinking water standards, water pollutants, etc.

Visit the following web site for timely information about water quality issues in Kentucky: http://www.kyeqc.net/pubs/soke01/slide.html.

Tapping Into Our Local Water Supply, *continued*

Step 9: FILTRATION. While the floc is settling, construct a filter from the bottle with its bottom cut off:

- Attach the nylon screen to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle — the screen will prevent the pebbles from falling out of the neck of the bottle.
- Pour the course sand on top of the pebbles.
- Pour the fine sand on top of the course sand.
- Clean the filter by slowly and carefully pouring through 5 liters (or more) of the clean tap water. Try not to disturb the top layer of sand as you pour the water.

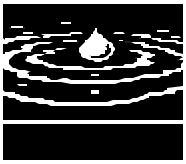
After a large amount of the floc has settled, carefully — and without disturbing the sediment — pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water into the collection bucket. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

Step 10: DISINFECTION. Inform students that a water treatment plant would, as a final step, disinfect the water (e.g., would add a disinfectant such as chlorine) to kill any remaining disease-causing organisms prior to distributing the water to homes. Therefore, the demonstration water is not safe to drink.

Step 11: Ask students the following questions to trigger discussion of what they observed:

- What was the appearance of the original swamp water?
- Did the aeration process change the appearance or smell of the water? (If the original sample was smelly, the water should have less odor. Pouring the water back and forth allowed some of the foul-smelling gases to escape to the air of the room.)
- How did sedimentation change the water's appearance? Did the appearance of the water vary at each 5-minute interval? (The rate of sedimentation depends on the water being used and the size of alum crystals added. Large particles will settle almost as soon as stirring stops. Even if the water contains very fine clay particles, visible clumps of floc should form and begin to settle out by the end of the 20-minute observation period.)
- How does the treated water (following filtration) differ from the untreated swamp water? (The treated water should look much clearer and have very little odor.)

Step 12: After the experiment has been concluded, distribute copies of the "How a Water Treatment System Works" handout. Compare the steps you have just performed with those in a water treatment plant.



Extensions/Variations

A more complete study of the local watershed may be conducted, and a model of the local watershed built so on-site study can take place to determine how the water flows and possible causes of point and nonpoint source pollution in the area. Contact the local 4-H Agent to obtain a copy of the "Watershed Construction Manual", or visit the following web site: http://www.slo4h.org/!conman.html. For a general study of watersheds and point and nonpoint sources of pollution, an Enviroscape model may be borrowed from several locations listed in the Teacher Fact Sheets.

Kentucky's Commonwealth of Water – Be a Water Scientist
High School

Nitrates and Nutrients

Adapted from *Living in Water*, "What's in our water", Activity 18, National Aquarium in Baltimore, 1997

Standards

Science: SC-H-3.5.5, Students will understand that human activities can deliberately or inadvertently alter the dynamics in ecosystems. These activities can threaten current and future global stability and, if not addressed, ecosystems can be irreversibly affected.

Practical Living: PL-H-3.3.2, Students will analyze community health standards and regulations (e.g., air/water quality, immunization, health and safety protection of citizens).

Activity Description

Students will collect water samples from different sites and test for nitrate levels.

Materials

For each group:
- One or more water samples
- Nitrate test vials
- Tablets #1 and #2 from nitrate test kit

For class:
- 1-2 nitrate test kits
- Map of geographic area sampled
- Three colors of paper, cut into 1/2 inch by 2 inch strips, to be used to identify the level of nitrate concentration. (For example, green can represent 0-3 ppm nitrate, yellow for 4-7 ppm, and red for 10 ppm or more.)

For each student:
- Goggles
- Lab sheet (found at end of this activity) and pen or pencil

Length of Lesson

One class period

Vocabulary Words

Nitrate (NO_3)—an important plant nutrient and type of inorganic fertilizer (most highly oxidized phase in the nitrogen cycle). In water, the major sources of nitrates are septic tanks, straight pipes, feed lots and fertilizers, although some level of nitrates is normal due to decomposition of plants and animals, etc.

Water Pollution—the contamination of water by the discharge of harmful substances.

EPA standards—regulations set by the Environmental Protection Agency (EPA) limiting the nitrate levels in public drinking water supplies to 10 ppm (parts per million)

Nitrates and Nutrients, *continued*

Essential Question — **How can I tell if my water is clean?**

Guiding Question — Do the amounts of nitrate in natural bodies of water and drinking water vary?
What is "over nutrification?

Skills Used — Observe, Speculate, Measure, Investigate, Organize, Discuss, Compare, Write

Activity

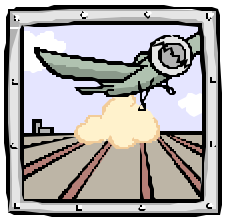
Step 1. (Preparation) Have students collect water samples from local sources (including drinking water). Make sure everyone uses the same collection techniques and, on a local map, locate where samples were gathered. Display map in the classroom.

Nitrate is stable in water samples stored out of the light where algae cannot grow. Collect water samples from streams, lakes and drinking water supplies. Colleagues or students can bring samples from home. (Just caution about storing the samples away from light sources.) It is especially interesting to compare rural well water from an agricultural area with city tap water.

If all the water you have access to comes from the same water source, you can buy bottled water samples from different geographic regions and compare them with your tap water. Many bottled waters are carbonated. If you cannot avoid them, open the bottles or cans several days ahead of time and let the gas out. Shaking helps. The water must be "flat".

Step 2: Assign students to lab groups. If students have not participated in a nitrate lab previously, take the time to explain how to conduct the test, and why testing for nitrate levels is important. Remind students to follow the instructions closely on the lab sheet.

Step 3: As the water samples are tested, instruct students to write the results on the lab paper and the board with the sample name and location, as well as whether it is drinking water or water from a natural habitat. At this time, students should also write the results on the colored paper, following the code explained in the materials section, and post it on the map in the classroom



Nitrates and Nutrients, *continued*

Activity

Step 4: Study the class results and look for any problems or patterns of pollution on the charts and on the map. Ask some of the following questions: Where might nitrate pollution come from? Is it point source or nonpoint source pollution? (Use Enviroscape models to show the difference. See the **Teacher Facts Sheets** for a place near you where you can borrow a model.) If any of the drinking water samples exceeded 10 ppm nitrate, why might this have happened? (EPA does not regulate private wells or bottled water.)

Step 5: If there appear to be no problems, then students may conclude that the area studied has good water quality with regard to nitrate levels. If there are problems, consider doing one of the extended lessons.

Evaluation

Step 6: At the completion of this lab, remind students that a written lab report will be due on a specified date.

NOTE: Extension activities may be assigned for extra credit.

Extensions

1. **Do research to learn more about drinking water quality standards, both state and federal. Discover why high nitrate levels in drinking water and in natural bodies of water are reasons for concern?**
2. **Did any of your samples test above 10 ppm nitrogen as nitrate? If so, have students make sure the proper authorities know. Look in your phone book under county or city government for the agency responsible for water quality, or try the Internet. Have students write letters reporting their findings and asking if there are programs in place to improve water quality.**
3. **Have students research the sources of nitrate in drinking water in your area by contacting local water suppliers, agricultural agents, environmental organizations, etc. Collect information and share with class. Have student groups write informational material specific to your area and distribute it to parents and others who can help reduce nitrate use.**
4. **Have students research to find out if there is a watershed protection program for your drinking water supply if it comes from surface water? Is there a groundwater protection program if it comes from wells? (Check on service learning hours for students who become involved in these projects.)**
5. **Correspond by email, letters or KTLN (The Kentucky TeleLinking Network) with other groups of students and compare test measurements.**
6. **Go to the Kentucky Geologic Survey Website to see results of well water testing across the state.**

Nitrates and Nutrients
Lab Sheet

Name_____ **Date**_____ **Class**_____

Do the amounts of nitrate in natural bodies of water and drinking water vary?

1. Working together, your group should test the water samples you have for nitrogen as nitrate. Follow the instructions carefully. Be sure you keep the samples straight if you have more than one to test.
2. Describe how your group made sure the samples were not switched or confused with each other.
3. Write your results on the board to share with others in your class. Make a table of the class's results showing location, date of sample (if available), nitrate level and whether it was from drinking water or a natural body of water.
4. If 10 ppm is the most allowed in drinking water, did you identify any problems with water for humans? If so, where?
5. If anything over a trace (up to 1 ppm) may be a problem in natural bodies of water, have you identified any problems in natural habitats? If so, where?

Source and location	**Date**	**Nitrate (ppm N as NO_3)**	**Drinking water or natural habitat**

Note: 0-3 ppm nitrate indicates no human health concern
4-9 ppm nitrate indicates a reason to think about nitrate
10 ppm nitrate or more is over the drinking water standards set by the Environmental Protection Agency

Nitrates and Nutrients
Lab Sheet
(Sample Answers)

Name_____ **Date**_____ **Class**_____

Do the amounts of nitrate in natural bodies of water and drinking water vary?

1. Working together, your group should test the water samples you have for nitrogen as nitrate. Follow the instructions carefully. Be sure you keep the samples straight if you have more than one to test.
2. Describe how your group made sure the samples were not switched or confused with each other.
   We each labeled our jars and then we only worked with our own sample. We could not label the test tubes because you have to see through them.
3. Write your results on the board to share with others in your class. Make a table of the class's results showing location, date of sample (if available), nitrate level and whether it was from drinking water or a natural body of water.

Source and location	Date sample collected	Nitrate (ppm N as NO_3)	Drinking water or natural habitat
Tap Leitchfield	4/5/02	3 ppm	Drinking
Bear Creek	4/9/02	5 ppm	natural
Well Grayson Co.	4-6-02	15 ppm	drinking
Well Grayson Co.	4/3/02	4 ppm	Drinking
Rough River	4.9/02	trace	natural

4. If 10 ppm is the most allowed in drinking water, did you identify any problems with water for humans? If so, where?
   Yes, one person had a well that was over EPA limits. She thought since she lived in a nice area in the country she had good water. She was shocked.

5. If anything over a trace (up to 1 ppm) may be a problem in natural bodies of water, have you identified any problems in natural habitats? If so, where?
   Bear Creek had algae growing on the bottom, and it was too high.

Protecting Kentucky's Water – Be a Water Scientist
High School

Searching for Nitrate Pollution Solutions

Adapted from *Living in Water*, "Water pollution detectives", Activity 19, National Aquarium in Baltimore, 1997

Standard

Science-H-2.2-2.6, Students will investigate how science can be used to solve environmental quality problems (e.g., over consumption, food distribution).
PL-H-3.3.3, Students will identify ways to protect the environment.

Activity Description

Students will collaborate in groups, without teacher direction, to carry out a complex project that examines a model of an environmental problem.

Materials

For each large group:
- Monroe River watershed map (found at end of activity description)
- 2-4 nitrate test kit vials
- 8 each of tablets #1 and #2 from nitrate test kit
- 4 labeled water samples (about 50 ml of each) in clean cups
- 4 clean plastic spoons
- 4 stick-on labels

For class:
- 2 nitrate test kits
- 4 Nutritabs
- 4 clean sample bottles: plastic milk jugs or soda bottles
- 4 stick-on labels
- 1 gallon distilled water from grocery store or tap water lower than 1 ppm nitrate

For each student:
- Goggles
- Nitrate pollution information sheet (found at end of this activity) and pen or pencil
- Worksheet (found at end of this activity)

Length of Lesson

2-3 class periods and homework

Essential Question

How can I tell if my water is clean?

Guiding Questions

- What can affect nitrate levels in water?
- What are the EPA and state standards for nitrate levels?
- What can be done to keep nitrate concentration at safe levels in our drinking water?

Skills Used

Observe	Measure	Organize	Graph
Infer	Communicate	Average	Investigate

Protecting Kentucky's Water – Be a Water Scientist
High School

Searching for Nitrate Pollution Solutions, *continued*

Preparation

Step 1: Prepare samples for class use in the following manner (1 quart should do 20 samples or more):

Clean and label bottles according to this recipe:

sample 1 – 1 liter or quart tap water (below 1 ppm) or distilled water

sample 2 – 1 liter or quart tap or distilled water with 1/2 Nutritab

sample 3 – 1 liter or quart tap or distilled water with 1 Nutritab

sample 4 – 1 liter or quart tap or distilled water with 2 Nutritabs

Prepare student samples by labeling four cups for each group with F, J or L and then one of the seasons. For example, one group gets F spring, F summer, F fall and F winter. Line the cups up to match the table below and put about 50 ml of the sample as indicated in this chart in each cup.

Group	**season written on sample cup**			
Letter on	spring	summer	fall	winter
F-Farmtown	Sample 4	Sample 3	Sample 2	Sample 2
J-Jacksonburg	Sample 2	Sample 2	Sample 1	Sample 1
L-Lincoln City	Sample 3	Sample 3	Sample 2	Sample 2

Step 2: Copy worksheets, maps, and reading sheets for each student. **Assign reading as homework prior to beginning this lab.**

Activity

Step 1: Challenge students to work as real environmental scientists do on a large scale problem. Assign a location to each group:

* Farmtown—the watershed is heavily fertilized corn fields; the corn is fed to cows, chickens and hogs which produce manure
* Jacksonburg—where the Jackson River enters the Monroe River; its watershed is heavily forested wilderness areas and a national park.
* Lincoln City—where millions of people use the Monroe River for drinking water from an upriver intake and do sewage disposal downriver.

Step 2: Explain to students that each group is located in a different county along a large river and works for its county government. All the cities are located on the Monroe River because they were founded before trains and roads when almost everything traveled by water, up and down the river. Each group is responsible for testing the river at their location (marked with an X on the map) for nitrate throughout the year. The samples have been stored, and each group will test a full year's samples at one time. In order to understand the river as a whole, the groups must work together even though they work for different county agencies. They should plan their work before beginning. The Monroe River map gives them details about their watershed and sampling location. Pass out the maps and data sheets, and let the learning begin!

Fast Facts

- **There are 89,431 miles of rivers and streams in Kentucky.**
- **In 1999, out of approximately 7,000 miles of monitored waterways, 34% were impaired by pollution.**
- **Groundwater pollution incidents have been reported in almost every county of the Commonwealth.**
- **61 species of freshwater fish are considered at risk due to pollution and ecosystem alterations.**
- **State, local and private sector efforts to restore water quality have been ongoing since the passage of the federal Clean Water Act in 1972.**

Background Information on Nitrate Pollution

Nitrate produced by humans

Humans have increased the amount of nitrogen in natural systems. Nitrogen enters in the form of ammonium, nitrate, or nitrogen oxide gas which forms acid rain as nitric acid. Naturally occurring bacteria convert all of these to nitrate. There are also bacteria that fix atmospheric nitrogen in a form available for plant use. These bacteria live in association with the roots of legume crops (alfalfa, beans, clover). They also add to the world's nitrate supply. Our current production of nitrate far exceeds the ability of the natural world to use it. Each year we add more.

Some nitrate sources are at specific sites which can be measured and regulated by laws. They come from a point source. Examples include nitrate in city sewage discharge, nitrous oxide gases from an electrical power station which burns fossil fuels, nitrous oxide from a large trash incinerator, nitrate in manure runoff from a major stockyard, or nitrate or ammonium leakage from a fertilizer plant. Nitrous oxide from cars can be regarded as point source, too.

Other nitrate sources are widespread over entire watersheds (nonpoint source) and are very hard to regulate by laws. These include nitrate and ammonium from inorganic fertilizer or animal manure spread over fields, lawns, gardens, golf courses and parks, from manure of domestic animals, including both farm animals and pets, and from human waste in septic systems or from sewer pipes that go straight into the streams. All these add nitrate to ground and surface water. In these instances, education, tax incentives and other programs may be the only solution.

Nitrate in natural ecosystems

Plants and algae need nitrate, but too much nitrate in aquatic habitats causes the too much algae growth. These algae cannot be eaten fast enough by grazers. The algae sink and die. Bacteria which breakdown the dead algae use oxygen. The bacteria use so much oxygen that the bottom water cannot support animals which need oxygen to live.

High nitrate also changes which kinds of algae grow in an aquatic environment. It may favor less nutritious or even toxic species. Places like farm ponds, animal watering troughs, and swimming pools can all produce these 'bad" kinds of algae if nitrate levels in them are too high.

Sometimes the algae is so dense that it blocks light from reaching plants rooted on the bottom, killing them by shading. Coral reefs become overgrown with algae in nutrient rich water. Corals have single-celled algae living inside the coral animal that need light. Corals die when their tiny helpers are shaded by seaweed growth.

Nitrate in drinking water

Drinking water with nitrate above certain levels is dangerous for both humans and animals. It causes a condition in which red blood cells of babies and baby animals are unable to carry oxygen. Nitrate is relatively non-toxic. However, it is changed by stomach bacteria to nitrite. In normal adults less than 5% of nitrate taken in becomes nitrite. Adults with low stomach acid and bacterial infections can change as much as 50% of nitrate to nitrite. Babies make more nitrite because their stomachs are low acid. Babies have special oxygen-carrying chemicals in their blood which combine permanently with nitrite, making them unable to carry oxygen. Babies drinking nitrate-contaminated milk (from their mother or formula) may die or suffer brain damage from low oxygen. No babies have died yet in the United States, but they have in Europe. Baby cows and sheep are even more likely to be hurt. They have died in some places in the United States due to nitrate water pollution.

Because of human risk, the U.S. Environmental Protection Agency (EPA) limits nitrate in public drinking water supplies in less than 10 milligrams per liter nitrogen as nitrate (10 ppm). No one regulates private wells even though they are at risk for this kind of pollution.

Nitrate itself does not cause cancer, but nitrite can combine with other chemicals to form probable human carcinogens. Farmers exposed to high nitrate in their well water are being studied to see if high drinking water levels of nitrate are linked to cancer.

No easy solutions

What can be done? The EPA regulates point sources, but education and individual action are necessary to reduce many of the nonpoint sources. Here are some problems and approaches.

Farm nutrient management programs

Some farmers may spread commercial fertilizer, manure or both without measuring soil nitrate or timing the fertilizer application to coincide with maximum crop growth. This leads to groundwater contamination and surface runoff. Nutrient management programs help farmers plan their fertilizer and manure use. These also save farmers money. Some areas have so much livestock, they lack enough land to dispose of the manure. Composting manure for home or garden use may help.

Urban sewage systems

These systems discharge large amounts of dilute nitrate into surface waters. They are regulated and have to meet standards. New treatment methods reduce nitrate discharge. Some small communities use wetlands they have created for sewage treatment. Bacteria in wetlands are capable of returning nitrogen to the atmosphere as a gas.

Land application of sewage sludge

Sewage treatment removes some nitrate in the solids collected as sludge. This creates a sludge disposal problem. It may be used as fertilizer on farms in place of chemical fertilizer. If it is spread too thickly, sludge nitrate may enter surface waters or contaminate ground water.

Homeowners, parks, sod farms and golf courses

Lawn fertilizer is very high in nitrate. Home owners often use too much. This problem is greatest in the northeastern U.S. where 34% of the total fertilizer use is non-farm use. Lawn products also mix pesticides, herbicides and fungicides with fertilizer, resulting in a chemical cocktail. Soil testing and restriction of use to periods of active plant growth help. The best solution is to change the way we manage our yards, school grounds and parks, reducing grass in favor of trees and shrubs. What grass we have should be cut taller to reduce runoff.

Septic systems

Building houses on rural land around cities causes the construction of many septic systems. These leach nitrate to groundwater, often the same water that the new homes use for drinking water. Nitrate is not filtered out by the soil. A family of four contributes about 73 pounds of nitrate per year to the groundwater. Septic system owners need education about their use and problems. Where septic systems are crowded along shorelines, the water itself becomes overloaded with nutrients leaching directly into it. Changing land use practices and constructing sewage treatment systems are two potential solutions to this problem. The first is very difficult due to opposition from developers, and the second is very expensive.

Searching for Nitrate Pollution Solutions

Name_____ **Date**_____ **Class**_____

A. Working in your group

1. Circle the location of your group: Farmtown Jacksonburg Lincoln City

2. What is the major river or stream in your watershed called?

3. Review the nitrate pollution information sheet as a group.

4. Using the Monroe River map of your area, the description of your watershed, and the nitrate pollution sheet, along with your knowledge of watersheds and water pollution, list the sources of nitrate water pollution you predict your watershed contributes to your sampling location.

   a. Point source

   b. nonpoint source

5. Test each seasonal water sample twice for nitrate. Design and make a table showing all of your data. Also, show the averages for each season.

6. Explain why each test was done twice.

7. Can you account for the nitrate levels you measured by looking only at your own small watershed? Explain your answer.

B. Working with all three groups together

1. Each environmental group sends one person with its data to an annual meeting. Elect your representative and send her/him to the front of the room. The representatives must decide on a table to display all the group information for the whole year in a logical fashion. While they are meeting, your group can clean up. The representatives must present their table to the class. It must be explained and may be modified, based on comments from the class.

2. Draw the final data chart here:

3. Can you now explain the nitrate levels measured in your part of the river better, including why there was seasonal variation? What have you learned by sharing data?

4. Applying information from the nitrate pollution information sheet, predict two problems that might occur along the Monroe River below Lincoln City that could be caused by nitrate pollution in the river. They may be problems for things living in the river or for humans.

5. If your group was in charge of the entire Monroe River watershed, list three things that you would do to reduce the level of nitrate in the river below Lincoln City. Explain how each would help improve the water quality of the river.

6. Explain why the rainfall graph was important for understanding the nitrate measurements you got.

Searching for Nitrate Pollution Solutions

(sample answers)

Name_____ **Date**_____ **Class**_____

A. Working in your group

1. Circle the location of your group: Farmtown Jacksonburg Lincoln City

2. What is the major river or stream in your watershed called?

   Jackson River

3. Review the Nitrate Pollution information sheet as a group.

4. Using the Monroe River map of your area, the description of your watershed, and the Nitrate Pollution sheet, along with your knowledge of watersheds and water pollution, list the sources of nitrate water pollution you predict your watershed contributes to your sampling location.

   a. Point source

   There might be a sewage treatment plant for Jacksonburg.

   b. nonpoint source

   There is almost none except for things like fertilizer in town or nitrogen from air pollution.

5. Test each seasonal water sample twice for nitrate. Design and make a table showing all of your data. Also, show the averages for each season.

season	Test 1	Test 2
spring	4 ppm	3 ppm
summer	3 ppm	3 ppm
fall	1 ppm	0.5 ppm
winter	1 ppm	1 ppm

6. Explain why each test was done twice.

   We did two tests to check our work and make sure we didn't make an error.

7. Can you account for the nitrate levels you measured by looking only at your own small watershed? Explain your answer.

   No, since it does not make any sense that we have so much since we really don't have that many sources of pollution.

B. Working with all three groups together

1. Each environmental group sends one person with its data to an annual meeting. Elect your representative and send her/him to the front of the room. The representatives must decide on a table to display all the group information for the whole year in a logical fashion. While they are meeting, your group can clean up. The representatives must present their table to the class. It must be explained and may be modified, based on comments from the class.

2. Draw the final data chart here:

	spring	summer	fall	winter
Farmtown	18 ppm	9 ppm	4 ppm	4 ppm
Jacksonburg	4 ppm	4 ppm	1 ppm	1 ppm
Lincoln City	8 ppm	9 ppm	5 ppm	5 ppm

3 .

Can you now explain the nitrate levels measured in your part of the river better, including why there was seasonal variation? What have you learned by sharing data that helped?

Our watershed added clean water to a polluted river and diluted the pollution. Then the city down river added more nitrate. The big spring rain and fertilizing the fields made a big difference in our results. By putting data together we were able to account for high and low levels and for seasonal changes.

4. By using information from the Nitrate Pollution Information Sheet, predict two problems that might occur along the Monroe River below Lincoln City that could be caused by nitrate pollution in the river. They may be problems for things living in the river or for humans.

1. If we don't reduce the levels, the water might one day exceed EPA regulation levels.

2. We could have very large algae blooms and fish could die.

5. If your group was in charge of the entire Monroe River watershed, list three things that you would do to reduce the level of nitrate in the river below Lincoln City. Explain how each would help improve the water quality of the river.

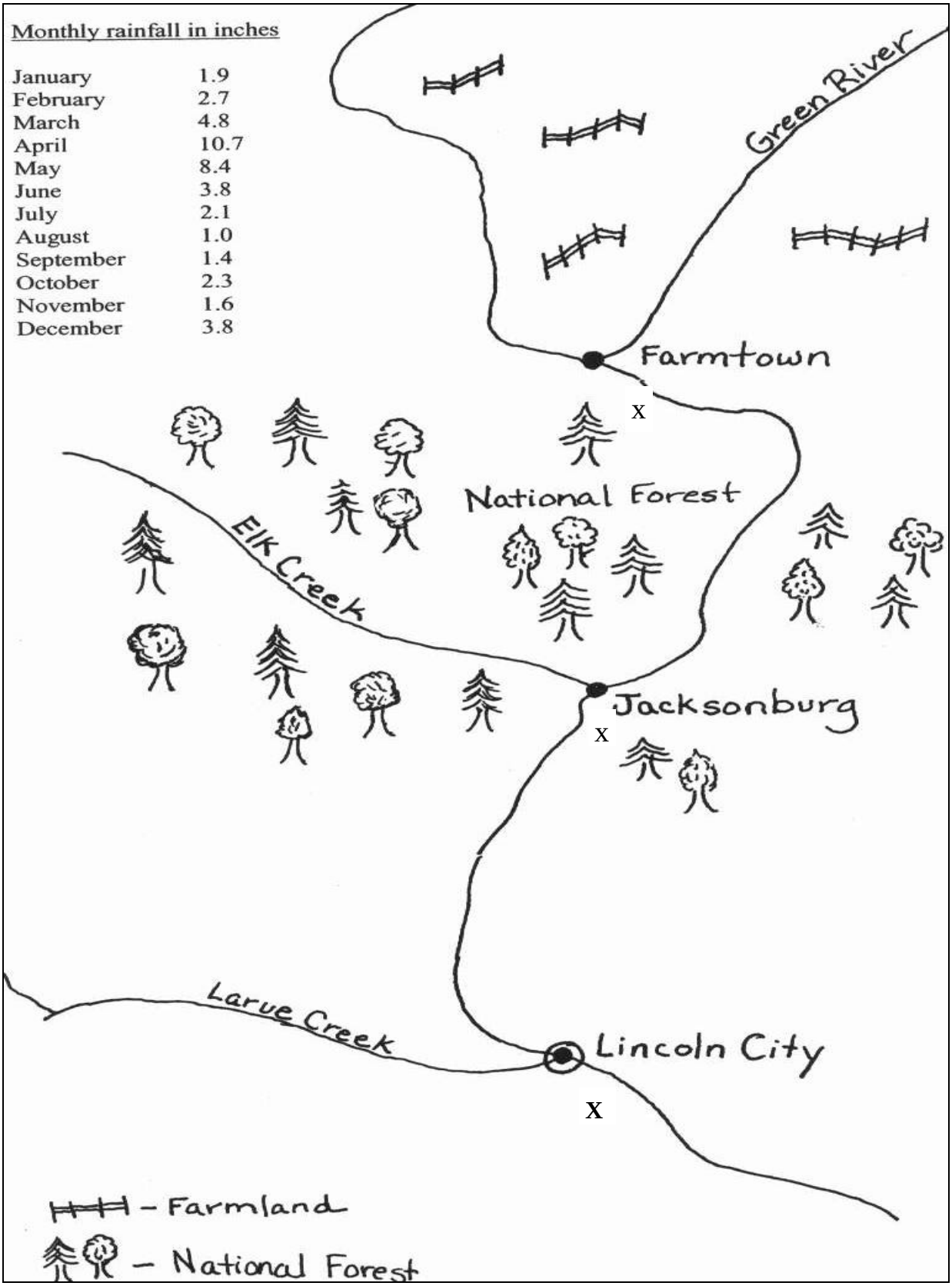
1. I would help the farmers reduce the loss of manure and fertilizer so they could keep it where they need it — on the fields.

2. I would make the Lincoln City sewage treatment plant work really well.

3. I would have programs to teach people how to reduce nitrate pollution in their yards.

6. Explain why the rainfall graph was important for understanding the nitrate measurements you got.

The big spring rain carried soil, manure and fertilizer into the river.


Monthly rainfall in inches
January 1.9
February 2.7
March 4.8
April 10.7
May 8.4
June 3.8
July 2.1
August 1.0
September 1.4
October 2.3
November 1.6
December 3.8
Green River
Farmtown
x
National Forest
Elk Creek
Jacksonburg
x
Larue Creek
Lincoln City
x
- Farmland
- National Forest

Kentucky's Commonwealth of Water – Be a Water Scientist
High School

Can Being Clean Make You Sick?

Adapted from EPA Water Sourcebook activity "Contaminant Scavenger Hunt"

Standards

Science, Applications and Connections: Students will use science to investigate natural hazards and human-induced hazards.
SC-H-3.5.1, Students will understand that organisms both cooperate and compete in ecosystems. Often changes in one component of an ecosystem will have effects on the entire system that are difficult to predict. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years,
Social Studies: SS-H-4.4.4: Group and individual perspectives impact the use of natural resources

Activity Description

Students will learn about toxins and how they enter the environment. They will also "survey" products used in their homes to see if they are potential pollutants.

Materials

Two copies of the "Contaminant Survey" and one copy of the "Alternative Cleaning Products" Sheet for each student. An overhead of the "House Cutaway Sheet. Household products (or labels) brought from home.

Length of Lesson

2 class periods

Vocabulary

Toxic Substance: A chemical or chemical mixture that may present an unreasonable risk of injury to health or the environment

Pollution: Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems..

Essential Ques-

How can I tell if my water is clean?

Guiding Ques-

How do toxic substances get into the environment and into water sources?
Are there toxic substances in my home?
How can we prevent toxic substances from entering the environment?

Can Being Clean Make You Sick? *continued*

Step 1: Read the following excerpt from Silent Spring, by Rachel Carson.

"The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials...The poisons circulate mysteriously by underground streams until they emerge and, through the alchemy of air and sunlight, combine into new forms that kill vegetation, sicken cattle, and work unknown harm on those who drink from once pure wells...They travel from link to link of the food chain."

Step 2: Assign students to read and research Silent Spring, including reading about those who opposed its findings. Hold a debate, with one group of students taking Ms. Carson's side and another the side of the chemical industry officials who opposed her findings.

Note: As a shorter alternative, you may wish to do your own research on the topic and merely present it to students. Here is a brief overview.

Rachel Carson was a biologist who worked for the National Fish and Wildlife Agency in the 1960's. She wrote several books about the environment but her last book, Silent Spring, was a best seller that caused a revolution in the way people thought about science and the environment.

Silent Spring outlined, with scientific precision and in very readable prose, how chemicals of various kinds and amounts from numerous industrial, agricultural and household sources were getting into our ecosystems and often into our bodies. It has been cited as one of the most influential books of the 20th century and is credited by many as being the catalyst that created the environmental movement and made Americans begin to see science in a different light.

The book was very controversial and it had many opponents, especially in the chemical industry, who believed Ms. Carson's findings were biased and incorrect.

Step 2: Tell students that many of the substances we use to make our lives easier and more comfortable are made of chemicals that, in certain circumstances, can be potentially harmful. Some examples include pesticides, herbicides, carbon monoxide from cars, drain cleaners, oven cleaners, laundry detergents, floor or furniture polish, paints, and chemicals used in manufacturing processes.

Step 3: Tell students that, while there are many kinds of chemicals in the environment, they will be studying those found in our homes and looking at less toxic alternatives.

Step 4: Assign students to study the website http://www.epa.gov/kidshometour/ then discuss the site as a class. (The site examines toxic substances, answers students questions, and looks at potentially dangerous chemicals in household products.)

Can Being Clean Make You Sick? *Continued.*

Step 5: Tell students that, in this activity, they will be examining possible toxic substances in household products (For a list of possibly harmful substances go to the EPA's http://www.epa.gov/reg5rcra/wptdiv/p2pages/hhw.pdf to see potentially harmful chemicals and how they can be avoided.)

Step 6: Put the overhead of the house drawing (found at the end of this activity) up so all students can see it. Have students name various products that might be used in each room. Don't forget products in the garage; lawn and garden products; and medications. Discuss whether each product might end up as a water pollutant.

Step 7: Once you have a class list, divide the class into small groups and give each group a portion of the list. Have them either bring the actual products, or the information listed on the labels of the products, to class. (Note: for very toxic substances such as rat poison or pesticides, have students get help from adults to identify and get information from the product label.)

Step 8: Once students have assembled information about their products, have each group fill out the contaminant survey sheets for their products. This will require some research on their part. They can do this research on the Internet, contact the Kentucky Natural Resources Environmental Protection Cabinet or their local cooperative extension office for assistance.

Step 9: Once students have completed their contaminant survey forms, have them begin looking for less toxic alternatives to these products. (A sample list is at the end of this activity.)

Step 10: (Assessment) Have each group do a PowerPoint report on the products they researched and on some of the less toxic alternatives they discovered as well.

Extensions

1. As a culminating activity, have students compile their research on alternative products and create a brochure that can be given to parents and other interested citizens.
2. Have students go to the website <http://kyeqc.net > This is the website for Kentucky's Environmental Quality Commission. The EQC monitors the state of Kentucky's environment and publishes its findings in an online report. Have students review the section on toxics.
3. As a portfolio piece, have students write a review of Silent Spring, by Rachel Carson.

Student Sheet **Alternative Cleaning Products**

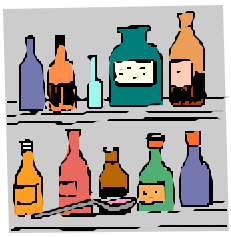
Product	Safe Alternative Ingredients

Student Sheet

Contaminant Survey

Product Name	Four Main Ingredients	Container (plastic, glass, metal)	Caution Statement	First Aid	Disposal Procedure

List products in each room (or area) that might contain toxic substances .



A Few Alternatives to Common Household Products

ammonia-based cleaners	baking soda & water
abrasive cleaners	half a lemon in borax
floor/furniture polish	1 part lemon to 2 parts olive oil
silver cleaner	boiling water, baking soda, salt, and a piece of aluminum
toilet cleaner	baking soda and a toilet brush
disinfectants	1/2 cup borax in 1 gallon of water
drain cleaners	1/2 c. baking soda and 1/4 cup of vinegar in boiling water
rug/upholstery cleaner	dry cornstarch
mothballs	cedar chips, lavender flowers
oil-based paints	latex or water-based paints
furniture stripper	sandpaper
house plant insecticide	dishwater or bar soap & water
garden insecticide	cooking oil mixed with garlic and hot pepper
ant and roach killer	borax or boric acid

Kentucky's Commonwealth of Water – Be a Water Scientist
High School

Scientific Sleuthing

Adapted from *Project WET Curriculum and Activity Guide*, "Super Sleuths", Pages 107 – 115.

Standards

Science: SC-H-3.5.5, Students will understand that human activities can deliberately or inadvertently alter the dynamics in ecosystems. These activities can threaten current and future global stability and, if not addressed, ecosystems can be irreversibly affected.

Practical Living: PL-H-3.3.2, Students will analyze community health standards and regulations (e.g., air/water quality, immunization, health and safety protection of citizens).

Activity Description

In this activity, students will identify the role of water in transmitting diseases, compare symptoms of several waterborne diseases and analyze the characteristics of environments that promote the transmission of these diseases around the world.

Materials

For class:

- Symptom Card, included (3 copies, cut apart), numbered envelopes
- Class set of "Clue Sheet", included
- Copies of Scenarios, included, one Scenario per group of 6-7 students
- World map, newspapers and magazines (optional)

Length of Lesson

1 to 2 class periods

Vocabulary

Waterborne disease—disease acquired by ingesting contaminated water.
Epidemiologist—a scientist who studies the incidence, transmission, distribution and control of disease.
Pathogen—any disease-producing bacterium or microorganism.
Bacterium—any widely distributed unicellular microorganisms exhibiting both plant and animal characteristics and ranging from the harmless and beneficial to those that cause disease.
Protozoan—microscopic, single-celled organisms, largely aquatic and including many parasites.
Virus—any of a class of filterable submicroscopic pathogenic agents, chiefly protein in composition, and typically inert except when in contact with certain living cells.

Essential Question

How can I tell if my water is clean?

Guiding Questions

- What are the symptoms of different waterborne illnesses?
- How are pathogens introduced into my local aquatic systems?

Skills Used

Analyze Interpret Communicate Research

Scientific Sleuthing, *continued*

Preparation

Step 1: For the first activity in this lesson, copy a class set of the "Clue Sheet" found at the end of this activity. Make 3 copies of the Symptom Cards (depending on number of students in class, since each student needs a symptom envelope, and at least one other student needs to have the same disease) and cut the symptoms apart. Put them into separate, numbered envelopes, one disease per envelope. DO NOT put the identity of the disease in the envelope. Mix up the order of the envelopes containing the symptoms by randomly numbering them. REMEMBER to make yourself a "cheat sheet" so that you can easily determine which "disease" a pair of students have. To do this, label the envelopes with a unique number (1 — # of students in class). On a separate sheet of paper, list each disease and the corresponding numbers of the envelopes which contain the symptoms for that disease. For instance, if the envelopes numbered 4 and 17 contain symptoms of Giardiasis, write down Giardiasis — #4 and #17 on your sheet. Then when students ask questions about whether they have identified the correct disease, you will know at a glance.

Step 2: Have computers and other research tools available for student use, if plans are to extend this activity to include the Scenarios found at the end of the first activity. If Scenarios are going to be used, copy and cut apart the four scenarios found on the next two pages.

Visit the following web sites and decide how much help you want to give to your students during the research phase of this activity. If computers or other sources for research are not available, information may be printed from the following web sites so students have access to research materials that will help them find the answers to the questions following each Scenario.

Information on waterborne illnesses:

- **http://www.cdc.gov/ncidod/dpd/parasites/waterborne/default.htm**
- **http:www.pasteur-lille.fr/english/health/vaccine/gpwat.htm**

Information on emergency disinfection of drinking water

- **http://www.epa.gov/safewater/faq.emerg.html**
- **http://www.epa.gov/safewater/faq/faq.html**

Information on recreational water quality:

- **http://www.cdc.gov/healthyswimming/**
- **http://water.nr.state.ky.us/dow/dwswim.htm**

Information on fish consumption advisories:

- **http://www.scdhec.net/eqc/admin/html/fishadv.html**

Activity

Step 1: Ask students if they can identify the world's number one killer. Explain that thousands of children die each year from diarrhea, and that diarrhea is caused by microorganisms such as bacteria, viruses and protozoa. Define these terms, if needed. Ask students if they can identify the source of these organisms.

Step 2: Show students two glasses of water — one murky due to sediment, the other clear. Pretend to sneeze on the clear glass. Ask students which glass of water they would prefer to drink. Make the point that disease-causing organisms can be found in clear, clean-looking water.

Step 3: Tell students that like epidemiologists, they are going to compare symptoms and mode of transmission of diseases that they and others in the class have "acquired".

Scientific Sleuthing, *continued*

Step 4: Hand out the symptom envelopes and "Clue Sheets", one to each student. Instruct students to pull out only one symptom card at a time from their envelope. **(**Many students in class will have similar symptoms, but only a few will have the same disease.)

Step 5: Direct students to circulate around the classroom, asking other students about their symptoms. The goal of each student is to locate other students who have symptoms similar to their own. (Give students a choice as to whether they want to take notes, or just try to remember who has which symptom.)

Step 6: After one or two minutes of "sleuthing", instruct students to remove a second symptom card from their envelopes. They should continue to search for other students in the room with the same illness. Continue removing a new clue every one to two minutes until all clues have been removed from the envelopes and everyone has found at least one other person sharing the same waterborne disease.

Wrap Up

Step 1: Call on students to read their list of symptoms to the class, review the disease descriptions from the Clue Sheet, and identify their disease. Ask students to infer how they contracted the disease, how the disease was transmitted, and how it can be prevented.

Step 2: Discuss the control cards. Explain to students that these cards describe conditions that are not related to waterborne diseases. (For example, the person was tired in the late afternoon because he or she worked long days, and the pain and rattling in the chest were likely caused by smoking.)

Step 3: Direct students toward available research tools so they may conduct research to confirm their answers and to investigate where these diseases occur throughout the United States and the rest of the world. Have a world map available so students can plot their diseases and discuss conditions that might allow for the spread of these diseases (e.g., inadequate water treatment systems, concentrated population, political upheaval that forces large migrations of people suffering from lack of food and water, the presence of disease spreading organisms such as beavers or snails).

Step 4: Discuss the role of water in the transmission of disease. Emphasize that most waterborne diseases result from inadequate water treatment and poor sanitation practices. However, contamination occasionally occurs despite sound water treatment practices.

Step 5: Discuss how the cause and transmission of disease are studied by epidemiologists. The website http://www.ph.ucla.edu/epi/snow/uabsnow.htm tells the story of John Snow, a pioneering epidemiologist who stopped an 1854 cholera epidemic in London by locating cholera cases on the map of a London neighborhood and then deducing that the source of the disease was a water pump used by many residents. When the handle of the pump was removed, the epidemic stopped.

Activity 2

Step 1: Explain to students that people are faced with water issues every day, and that they are going to be given the opportunity to work through some common problems with a small group of classmates. Assign students to small groups, and pass out the Scenarios found at the end of this activity, one Scenario to each group of students.

Step 2: Give students time to read their group scenario, then discuss different ways students may go about trying to find the answers to the questions.

Scientific Sleuthing, *continued*

Step 3: Allow time for research, then, as a group, take turns reading the Scenarios and discuss the answers to the questions. Conclude this activity with the following assessment suggestions.

Resources

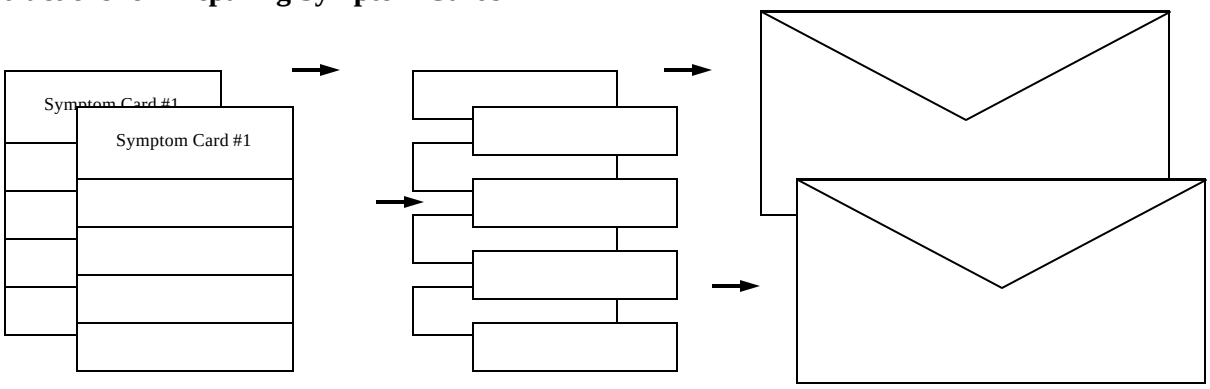
- **For information about occurrences of specific diseases within the United States and around the world, as well as information about specific diseases, students can contact the Center for Disease Control, 1600 Clifton Road NE, Atlanta, GA 30333. (404) 639-3311, www.cdc.gov/ . Follow the link "Health Topics A-Z".**
- **Contact a local health department official to talk to students about local water related illnesses and/or health careers.**

Assessment

Have students:

- **Describe the symptoms of several waterborne diseases.**
- **Relate how some waterborne diseases are transmitted.**
- **Analyze conditions that promote the spread of waterborne diseases.**
- **Research and identify career opportunities available in the health industry that deal specifically with waterborne illnesses and prevention.**

Instructions for Preparing Symptom Cards



Make 3 copies of each symptom card. This will be enough for 24 students.

Cut along dotted line to cut each card apart, then cut into strips along the thin solid lines.

Put each set of symptoms in separate numbered envelopes. **Do not include illness identity.**

Background Information for "Scientific Sleuthing"

Waterborne diseases are those acquired through the ingestion of contaminated water. About 80 percent of all diseases are water-related. In many of these illnesses, water infiltrated with sewage spreads the disease. An infected person or animal may pass pathogenic bacteria, viruses, or protozoa through waste into the water supply.

The microorganisms that cause illness cannot be seen, smelled, or tasted; contaminated water often appears fresh and clear. This causes particular concern with municipal water supplies. Contamination may not be detected until a noticeable number of people have become ill.

Most ailments caused by ingestion of water infiltrated with sewage are intestinal, causing gas, cramping, and diarrhea. Some pathogens (harmful microorganisms) attach to intestinal linings and produce toxic materials which the body then tries to purge. Others invade intestinal epithelial cells and cause inflammation but do not produce toxins. Fluids containing disease-fighting white blood cells are secreted into the intestine to aid in attacking or flushing the harmful organisms from the body. Unfortunately, this loss of fluids also causes dehydration, the major concern in patients with these types of diseases.

If the patient is very young, elderly, or malnourished, dehydration can be life-threatening. Children with diarrhea must be closely monitored. They have not developed the immunities of adults, and their systems can be quickly overwhelmed by the sheer number of pathogens. As many as one-third of pediatric deaths in developing countries are attributed to diarrhea and the resulting dehydration. Africa, Asia, and Latin America experience an estimated 3-5 billion cases of diarrhea, with 5-10 million deaths, each year. *Vibria cholerae, Salmonella sp., and Shigella* species of bacteria are among the leading causes of bacterial diarrhea.

Bacteria are everywhere, including in our water. However, municipal water supplies are monitored to prevent contamination by fecal pathogens in concentrations that will produce infections in humans. Water treatment facilities routinely test for these pathogens by checking levels of indicator bacteria, such as *Escherichia coli* (a common organism in our intestines). If these organisms rise above a set level, fecal contamination has occurred and more intensive water testing should begin. This does not mean other pathogens are present, but serves as an "indicator" that they may be. It may be necessary to accelerate water treatment procedures. Also, the source of contamination must be located and protective measures taken to avoid further contamination.

Until recently, Americans have regularly suffered through epidemics of waterborne illness such as cholera and typhoid fever. Improvements in wastewater disposal practices and the development, protection, and treatment of water supplies have significantly reduced the incidence of these diseases. The treatment and chlorinating of municipal water have made infection by microorganisms rare in developed countries; however, in many developing countries treatment of wastewater is minimal or nonexistent. In some cases, sewage and other wastes are dumped directly into rivers that are used by people downstream for drinking and washing.

Epidemiologists study the incidence, transmission, distribution, and control of disease. When outbreaks of a particular disease occur, epidemiologists research symptoms, incidence and distribution of the cases; they try to determine the cause of the disease, its means of spreading, and possible methods for controlling or preventing the illness. With waterborne diseases, determining how the water supply was contaminated is critical to solving the problem. The case histories of affected patients and any associations among patients help epidemiologists solve the mysteries of disease. (Reprinted from with permission, from "Super Sleuths", Project WET Curriculum and Activity Guide, The Watercourse and Council for Environmental Education, pages 107 – 108.)

Note: More than 36,000 "straight pipes" have been found in Eastern Kentucky alone. Approximately 25% of all Kentuckians get their water from wells. (Source, Ky Division of Water)

Clue Cards for Scientific Sleuthing Activity

Cholera, caused by *Vibrio cholerae* bacteria

This disease is extremely contagious; if untreated, dehydration can lead to death. Cholera originated in Europe and was spread to the United States by transatlantic liners through New Orleans. Outbreaks have been linked to eating food that has contacted contaminated water.

Giardiasis, caused by the *Giardia lamblia* protozoan

Sickness results with only a low dose of the protozoan; it is the most commonly reported causative pathogen of waterborne outbreaks. The giardia protozoan is killed by boiling water for at least five minutes or is removed by passing water through a filter whose pore size is at least 0.2 microns. Found in fresh water.

Arsenic

Arsenic can enter water from natural sources, such as bedrock or from arsenics in pesticide runoff. Can cause anemia with paleness, weakness, and breathlessness. Affects the skin, causing thick patches on hands and feet.

Lead

Lead can get into water from pipes or solder in the home plumbing system. Homes built up to the early 1900's often used lead for interior plumbing. Can cause serious nerve, brain, and kidney damage, especially in young children.

Cryptosporidiosis, caused by *Cryptosporidium*

This was first identified as a cause of diarrhea in people in 1976. It can be transmitted through contact with animals, particularly cattle and sheep, other humans (especially daycare centers) and contaminated water supplies.

Hepatitis A., caused by *Hepatitis A* virus

This is the third most common cause of waterborne disease in the United States. The term hepatitis relates to inflammation of the liver. Symptoms include jaundice.

Control Card

You probably don't have a waterborne disease. Many of the symptoms are confusing and must be diagnosed by a competent health care professional. Many things in our environment and our lifestyles affect our health.

Legionnaire's disease, caused by *Legionella pneumophilia* bacteria

Found naturally in water environments; bacteria often colonize artificial water systems such as air conditioners and hot water heaters, and can be inhaled with aerosols produced by such systems. Smoking and lung disease increase susceptibility to disease.

Salmonellosis, caused by species of *Salmonella* bacteria

This is carried by humans and many animals; wastes from both can transmit the organism to water or food. The largest waterborne salmonella outbreak reported in the United States was in Riverside, California, in 1965 and affected over 16,000 people.

Shigella, caused by species of *Shigella* bacteria

Most infection is seen in children 1 – 10 years old; a very low dose can cause illness. Waterborne transmission is responsible for a majority of the outbreaks.

Symptom Cards for Scientific Sleuthing Activity

Cut symptoms apart and place in envelope, without identity.

Symptoms #1 — Cryptosporidiosis	**Symptoms #2 — Hepatitis A.**
Four years old	Visited favorite beach and swam with friends
Attends a daycare center five days a week	Malaise – general weakness and discomfort
Diarrhea	Anorexia – loss of appetite
Nausea and vomiting	Fever
Fever	Nausea, mild diarrhea
Sucks thumb	Jaundice – yellowing of skin and whites of eyes
Recently swam in a local pond	Sick for a week

Symptoms #3 — Control Card	**Symptoms #4 — Giardiasis**
Lives on a ranch that raises cattle and chickens	Symptoms occurred two weeks after backpacking trip
Just returned from visiting friends in Mexico	Filled water bottle with clear, fresh-tasting water from a stream below a beaver dam
Lives in a home that is constantly air conditioned during the summer months	Abdominal cramps
Is tired in the late afternoon	Intermittent dysentery (which is greasy and odorous)
Often conducts pack trips in the mountains	Excessive intestinal gas
Works 14 hours a day, usually seven days a week	Malaise – general weakness and discomfort
Drinks eight glasses of water per day	Weight loss

Cut symptoms apart and place in envelope, without identity.

Symptoms #5 — Legionaire's disease

Chain smoker living in warm climate

Lives in a home that is constantly air conditioned during summer months

Sudden onset of fever that progressed to a high fever with shaking chills

Developed a cough and excessively rapid breathing

Pain in chest; lungs have rattling sound when breathing

General, diffuse muscular pain and tenderness

Intense headache and mental confusion

Symptoms #6 — Lead Poisoning

Attends a daycare center five days a week

Sucks thumb

Recently swam in a local pond

You are two years old

You live in a home built in 1889 in a big city

The doctor has found you have some damage to your nervous system

Symptoms #7 — Cholera

Recently returned from Bangladesh

Symptoms occurred two days after eating fruit thoroughly washed at outdoor pump

Family members have begun coming down with the same symptoms

Severe dehydration

Painless diarrhea, vomiting

Severe muscular cramps in arms, legs, hands and feet

Eyes and cheeks appear sunken; hands have dishwashing appearance

Symptoms #8 — Arsenic poisoning

About four months ago, had fever, cough, diarrhea, and muscular pain

Numbness and tingling in toes and fingertips

Weakness in hands and thickened patches of skin on hands and feet

Does not smoke

Has lived on his farm for 10 years and drinks well water

Other family members are not ill

Scientific Sleuthing
Student Scenario Extension Sheet #1

Directions: Read the following scenario then, in your group, research and answer the accompanying questions .

SCENARIO ONE:
Nicole is 16 today and a pool party is planned. It has been raining for two days straight after a long dry spell, but today the sun is shining. She has prepared everything needed including making ice, pitchers of lemonade, filling the pool and preparing the balloons for the water balloon toss game. Her mother phoned and said that she was late for work due to a water main break and will be home late. All seems fine and then Nicole hears on the radio that there has been a "boil water advisory" for her county. Does Nicole have to cancel the birthday party?

- **Describe boil water advisories?**
- **Who is responsible for issuing boil water advisories?**
- **List two reasons in this scenario that could have caused the advisory?**
- **Determine possible pathogens for the illness in this advisory?**
- **What professionals would you call for complete information on the advisory?**
- **Compile a list of boil water advisories for your area of Kentucky with causes.**

Directions: Read the following scenario then, in your group, research and answer the accompanying questions .

SCENARIO TWO:
You and some friends have just returned from an afternoon of fishing at a local river. The fish were biting, and you have a small cooler full of fish that are going to make a delectable feast for dinner. You have already invited your friends to stay for dinner.

Upon arriving back at the house, you prepare to clean the fish as your dad walks out and asks where the mess of fine looking fish were caught. Everybody talks at once, relating the great story of the exciting fish catch over on the banks of the local river.

As he listens to the story, you notice your dad is not as excited as you and your friends are about the big catch. When asked what is wrong, your dad announces that a "fish consumption alert" for the river where these fish have been caught has been announced on the television and radio for the past two days. What are the implications for the planned fish fry?

- **Why are fish consumption advisories issued?**
- **Who is responsible for issuing fish consumption advisories?**
- **What possible contaminants may be present in the fish?**
- **What is currently known about the dangers to humans of contaminants found in some fish?**
- **Are some members of the general population at a greater risk than others? Explain.**
- **What can be done to reduce the health risks from eating fish?**

Scientific Sleuthing
Student Scenario Extension Sheet #2

Directions: Read the following scenario then, in your group, research and answer the accompanying questions .

SCENARIO THREE:

Trish is an experienced hiker and has traveled to Red River Gorge for the week before school. Trish is an instructor at the high school and is enjoying her last week of summer vacation. On her 12 mile hike, she comes across inexperienced campers who have run out of drinking water. She gladly shares hers knowing that her campsite has a nice spring from which she can get water. A week after school starts, she begins to feel ill. What could be wrong?

- **Why did Trish get sick?**
- **Compile a list of possible pathogens that could have caused this sickness?**
- **What are the exact symptoms for the infection of the pathogens you described above?**
- **What could have prevented the illness for Trish?**
- **What could have prevented the illness for the environment?**

Directions: Read the following scenario then, in your group, research and answer the accompanying questions .

SCENARIO FOUR:

Greg and several of his friends are on a three day canoe trip on the Licking River. Spotting a sandy beach and a rope swing, they feel the perfect place for camp has been found. As they approach the shore, they observe a pipe coming straight out of the hillside and detect a yucky odor. When Greg beaches his canoe, he cuts his foot on a broken bottle. The camp sight has lost its intrigue.

- **List five questions you think Greg and his friends are forming and debating.**
- **Describe the pathway of infection from the possible pathogens for Greg and his friends.**
- **Compile a list of professionals and their organizations that should be alerted to the straight pipe and odor.**
- **What are the legal regulations that have been violated?**
- **Determine what Greg and his friends should do so this area of the river can be safe for others.**

Kentucky's Commonwealth of Water – Be a Water Scientist
High School

Pollution Solution: A Culminating Activity

Standards

All standards from the unit plus

SS-H-G0-GC-3: students will analyze the importance of rights and responsibilities of citizens in a democratic society.

Activity Descrip-

Students will work in groups and read scenarios that describe a variety of water pollution issues. They will then use knowledge gained in the unit, along with original research and problem solving, to come up with practical solutions and then present those to the class and defend their work.

Materials

Scenarios (on page three of this activity); research sources such as the library, the Internet and local and state experts who can provide information; power point or other software and/or materials that can be used to make a class presentation.

Length of Lesson

One half hour to explain the project, form groups and hand out scenarios. One hour for groups to take inventory of what they know and hand out assignments for gathering more data and information. Several hours for groups to analyze the information, come up with a solution and put together a presentation (or this can be done as a homework assignment), at least one hour for groups to present and answer questions.

Essential Question

How can I tell if my water is clean?

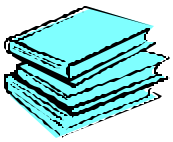
Guiding Questions

All questions from the unit

Skills Used

Research Communicate Present Defend
Speculate Organize Discuss

Pollution Solutions, *continued*



Activity

Step 1: Read the pollution solution scenarios on the next pages to make sure you understand them thoroughly. You will need to serve as a facilitator for students as they go through the process of coming up with solutions to the problems.

Step 2: Tell the librarian that your students will be doing independent research on water issues over the next few weeks. Ask if she can be ready to assist them.

Step 3: Tell students you are going to put them into groups to solve four water pollution problems. You may form four or eight groups depending on the size of the class. If you form eight groups, two groups will come up with solutions to one problem. In that case, they should do so independently to see if they create the same or different solutions.

Step 4: Tell students that each group will be responsible for doing research on their problem and using that research and their own knowledge to create a possible solution to the problem. Tell them solutions must be practical. Also tell them they will responsible for making a presentation to the entire class on how they would solve the problem and why they chose that solution. The class can then question them about their solution and even challenge them on it. Therefore they need to be ready to defend their idea and back it up with solid information.

Step 5: Give each group the first part of a scenario. Save the second part (the solution, which is in italics) until after the presentations are complete. Also give each student the "Pollution Solution Process" sheet to help them think through how to create a solution. **Have students create their own assessment rubric using the Pollution Solution Process as a guide.**

Extension

1. **Have students write their own scenarios of water pollution problems as portfolios pieces.**
2. **Have students use the information they have gathered and learned on the different kinds of water pollution to write an educational article for the local paper.**
3. **If they have not already done so in their unit, have students test local streams for different kinds of pollution identified in this unit.**
4. **Have students make a presentation to the local city council or fiscal court about what they have learned, especially as it relates to their community.**
5. **Have students research different careers in which people help monitor and protect water.**

Scenario One—Siltation

A large new shopping mall is being built in Mountainville, Kentucky. The builders say it will bring business to the community and make it easier for local residents to buy goods and services at competitive prices. The mall will include a new movie theater. Local teenagers look forward to this. However, there is a problem. There has been a great deal of rain this year and dirt from the building site has been running off into the Boone River, which runs through Mountainville. Dead fish have been found along the river banks and a bad odor is pervading the town.

Find out why the fish are dying and what is causing the odor. Find a solution to the problem that includes both the completion of the new mall and the restoration of the river.

Possible Solution

A large amount of dirt has been washed into the river filling it up with silt and mud. This means that the river is so shallow in some places that very little water is flowing at all. When a river or stream becomes much more shallow than before, several changes occur. First, the water becomes warmer because sunlight reaches to the bottom. Also because sunlight reaches the bottom, many more plants grow in the river, thus using up much of the oxygen. These changes will cause some fish to go elsewhere where the ecosystem is more to their liking. The fact that the plants are using up the oxygen is killing some fish.

The smell may have several sources. The dead fish smell bad of course, and other organisms are dying as well because of the changes in their ecosystem. In addition, since a more shallow stream flows more slowly, pollutants such as fecal matter from straight pipes, that are usually washed away by the stream, now pile up and begin to smell. These pollutants can even cause health problems.

A number of things can be done to prevent the siltation of the river. The first is for the builders of the mall to have the dirt carried off to a more suitable site. The second is to plant filters such as trees and shrubs along the river near the building site to "capture" some of the silt that is now being washed into the river. Finally, straight pipes can be eliminated along the stream.

Scenario Two—Nutrients

Due to a fire, a large whiskey distillery has accidentally spilled thousands of gallons of whiskey into the Kentucky River. Fish in the area of the spill are beginning to die in large numbers. Find out why the fish are dying and what can be done to help save the rest of the fish.

Possible Solution

Whiskey contains alcohol which is a type of sugar. The sugar that is released into the stream in the form of alcohol causes an algae "bloom". This simply means that millions of new algae grow in a very short time. As the large number of new algae die, the decaying process uses up large amounts of oxygen. This means there is little left in the river for fish and the fish literally suffocate. It is this "imbalance" in the ecosystem that causes the many problems that result from having too many nutrients in the water.

The solution to the whiskey spill and to other "overnutrification" problems such as manure from feedlots and fertilizers from lawn runoff, is two-fold. First, efforts should be made to reduce the amount of nutrients being put into the ecosystem. The second is to build buffer areas and vegetation between the source of the nutrients and bodies of water.

Scenario Three - Pathogens : In August, the Smalltown Baptist Church held a Saturday morning revival. The young preacher gave several very moving sermons, the choir sang rousing versions of old hymns and the congregation turned out a wonderful picnic dinner. By the afternoon, many new folks had come forward to be baptized and over twenty people were baptized in the pool at the mouth of Coldwater Creek, which runs by the church.

However, the next morning only a few of these new converts appeared at church. When the young preacher began to investigate why, he found that nearly all had succumbed to stomach ailments, including, nausea, diarrhea and stomach cramps. He is puzzled because a similar event, including a baptism, was held in early May with no problems.

Come up with at least two scenarios for what might have happened to the folks of Smalltown Baptist Church and how it could have been avoided.

Possible Solution

There are two possible explanations for the parishioners' distress. The first it food poisoning. Since there was a picnic and the day was warm, (it was August) the food that was brought, even if it was prepared with the greatest care to cleanliness, might have set out too long, allowing bacteria to grow. Bacteria that often grow when such foods as potato salad and fried chicken are allowed to set at warm temperatures can easily cause the distress experienced by these folks. However, in this case, only those who were baptized became ill. Therefore, there is another and more likely explanation.

Coldwater Creek is at the mouth of Coldwater Hollow. About twenty families live in the hollow and nearly all of them have straight pipe sewer systems. In other words, human waste goes directly from the toilet to the creek without being treated in any way. Many such systems exist across the state. On a hot August day when there has been little rain for the past few weeks, bacteria from these straight pipe sewer systems are at very high levels in the water of the creek. People who were baptized in the Creek were immersed in the water and came up with water—and bacteria— in their noses and mouths. The bacteria quickly made its way from their mouths to their guts . In contrast, though the same bacteria exist in the stream in May, the spring rains insure that they are much more dilute since water levels are higher and the stream is moving at a much faster rate.

There are two possible solutions to this problem. The first is simply to stay completely out of the streams. That means no swimming , no boating, no fishing and no baptisms. It also means no tourism dollars that might result from using Kentucky's beautiful streams for recreation.

A second solution is to eliminate straight pipe sewer systems. If you did not do so in your presentation, explore the extent of this problem in your community (if it exists) and possible solutions. Present these findings to your local fiscal court or city council. Remember, bacteria can also get into streams when wastewater treatment facilities become overloaded. This is a more and more common occurrence in the Commonwealth.

Scenario Four: Toxins

Bill has been fishing with his grandfather in the Boone River since he was four. About twice a month (in good weather) they catch crappie and small mouth bass and bring them home for Bill's grandmother to cook. Bill is now in high school and his chemistry class is studying chemicals that exist naturally in some streams and about those that are introduced by human activity. Bill has learned that some chemicals that get into the water make their way up the food chain and get into fish. These fish can be unhealthy to eat. The Kentucky Division of Water even issues "Fish Consumption Advisories" to warn people of the dangers of eating fish from certain streams.

Bill becomes concerned about eating fish from the river, especially since his grandmother has recently been treated for cancer. However, when he tells his grandparents of his concerns, they are upset. They say they have been eating fish from the river for 60 years and fresh fish, fried in Grandma's special batter, is one of their favorites.

Scenario Four—Toxins (cont.)

Your task is to find a way that Bill can help himself and his grandparents understand and deal with this problem?

Possible Solution

Fish consumptions advisories have been issued across the United States for more that thirty years. Numerous human activities—and some natural ones - can cause toxic build ups in fish that humans consume. Some come from particular sources such as runoff from pesticides and factories, others come from the deposition of chemicals that have been released into the atmosphere. Bill can do several things.

- *First he can determine whether there is a Kentucky Division of Water fish consumption advisory for the river where he and his grandfather fish. If there is not, he can be extra cautious by asking the local county health department to test the water and fish where he and his grandfather like to fish.*
- *If there is a fish consumption advisory for the river, or if health department testing finds problems, Bill and his grandfather have two choices. They can begin searching for the source of the chemicals that are getting into the fish and, if they can find the source, try and have it removed.*
- *If they are unable to find or remove the source, they can follow the guidelines that the Kentucky Division of Water issues for how often fish from the river can be eaten and the best way to prepare the fish to minimize the danger. Since many fish consumption advisories are for pregnant and nursing women and small children, Bill and his grandparents may be at less risk than others.*

If you have not done so already, search the Division of Water Website for fish consumptions advisories. Do any occur near your community? If so, do you know the cause?

The Following websites may be especially helpful. Student should search for other websites as well. Www.state http://water.nr.state.ky.us/dow/regs.htm and http://www.epa.gov/ebtpages/water.html

The Pollution Solution Process

1. **Summarize what you know: Have your group read and summarize what you know about the scenario. It may be helpful to write down all the important pieces of information you already have. It is just as important to write down the information that you don't have but think you will need in order to come up with a realistic solution.**

2. **Brainstorm: As a group, brainstorm possible causes of the problem and possible solutions. It is important at this stage not to get into long discussions but rather to just think of as many ideas as possible, as quickly as possible. Respect all ideas - no matter how improbable they may seem at the time— and write them all down. Once again list information you may need.**

3. **Research: Look at the information you have and the information you think you will need. Assign group members to do research and gather information that the entire group thinks is needed to solve the problem. Do this in a least two stages. After initial information is gathered, reconvene the group to share that information and to see what other facts and concepts are needed and if any new information suggests the need for other areas of research. Repeat this until the group feels comfortable that it has enough information to create a solution.**

4. **Summarize the Research. Make a list of facts and ideas you have discovered. Discuss how each affects the problem.**

5. **List solutions: Based on your own ideas and the information you have gathered, create a solution to the problem. Remember, the solution should be one that you think could be accomplished in your own community.**

6. **Prepare to defend: Once you have come up with a solution, think how others may view it. Is it practical? Is it a solution with which most people would agree. Make a list of possible criticisms of your solutions and how you would counter those criticisms.**

7. **Create your presentation: Using the talents and skills of your group members to organize, draw, compute, speak, etc., create an presentation that will both explain your solution to the problem given in the scenario and share with your classmates the knowledge you gained while researching possible solutions.**

High School Reading List*

Cadillac Desert: The American West and Its Disappearing Water. By Marc Reisner. This is a history of the American West's water and its great water projects that transplanted water to allow the phenomenal growth of California and the Southwest. The book's perspective of water rights, and ecologic and economic consequences of such actions focuses on government and business tactics.

Food and Water: Threats, Shortages and Solutions. By Bernard S. Cayne (Editor), Jenny E. Tesar. Discusses the vital importance of having an adequate supply of food and water and the effects of pursuing this need though various forms of storage and farming methods.

From Reclamation to Sustainability: Water, Agriculture and the Environment in the American West. By Lawrence J. MacDonnell. Tells the stories of four places in the West where development and use of water, primarily for irrigated agriculture, have been central to economic and social development.

Gila: The Life and Death of an American River. By Gregory McNamee. Follows the ecologic history of the Gila River from its source in New Mexico, through its confluence with the Colorado River and into Arizona. Today, half of the Gila is dead, due to overgrazing, damming, and other practices.

Ground Water and Surface Water: A Single Resource. U.S. Geological Survey Circular 1139. Presents an overview of the interaction of ground water and surface water, in terms of both quantity and quality, as applied to a variety of terrains across the country. Discusses the firm scientific foundation for policies governing the management and protection of aquifers and watersheds.

Last Oasis: Facing Water Scarcity. By Sandra Postel, Linda Starke (Editor). The worldwide water crisis, according to this book, is due to its ready availability, low cost, people's overuse, and lack of respect for this life-sustaining resource. Solutions are giving for restoring and sustaining this essential lifeline.

A River No More. By Philip L. Fradkin. This is a definitive history of the development of the Colorado River and the claims made upon it from its source in the Wyoming Rockies to the Gulf of California, where it evaporation in the sand.

* Please note that not all books on this list are included in the PRIDE list approved for purchase. See http://www.kypride.org/ for that list.

The High School Reading List about Water, cont.

Silent Spring. *By Rachel Carson. Considered a classic, this book describes the dangers of manmade chemicals to the environment and to human health. Often credited with being one of the books that led to the environmental movement of the 1970's.*

A Story That Stands Like a Dam: Glen Canyon and the Struggle for the Soul of the West. By Russell Martin. A narrative history of hydroelectric dams and their impact on ecological processes downstream and its drownings of natural landscapes behind their headwalls.

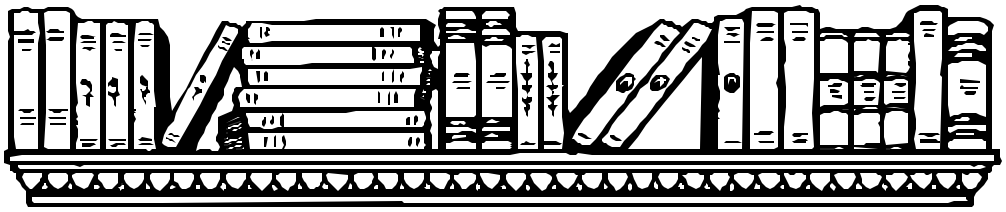
Tapped Out: The Coming World Crisis in Water and What We Can Do About It. By Paul Simon. Discusses increasing global population and a water supply that cannot increase; faced with this crisis, what can the average citizen do?

Vision in the Desert: Carl Hayden and Hydropolitics in the American Southwest. By Jack L. August. Focuses on longtime Arizona senator, Carl Hayden, whose career was centered on water and its distribution, inseparable from the history of the West and development of arid lands.

Water: A Natural History. By Alice Outwater. Takes us on a journey 500 years past to present to recover a lost knowledge - how the land cleans its own water, how natural ecologically interacting systems can create healthy waterways.

Water : A Resource in Crisis. By Eileen Lucas. Discusses the quality and quantity of water on a global scale and includes discussions of resources, the ways we use water, pollution, making water safe, taking care of our water, and taking action.

Water: Almost Enough for Everyone. By Stephanie Ocko. Through case studies, anecdotes, facts, and theoretical explanations, this book provides a look at the social and environmental implications of severe droughts, their causes, and some possible solutions.

Water Conservation: Student Edition. By Leslie Crawford, Jeri Hayes (Editor), Cathy Anderson (Editor). Shows students different ways to analyze, consider options, and take action on issues such as sources of water pollution, community water supply, the school water system, reading a water bill, conservation technologies and practices, and assessing costs and benefits.

Water Wars: The Fight to Control and Conserve Nature's Most Precious Resource. By Olga Cossi. Discusses how we have to change our habits and our ways of thinking in order to preserve the earth's water resources - the crucial role water plays in nature and how dwindling supplies are affecting the various ecosystems of the world.