PBIS

Living Together

AS A STUDENT SCIENTIST YOU WILL...

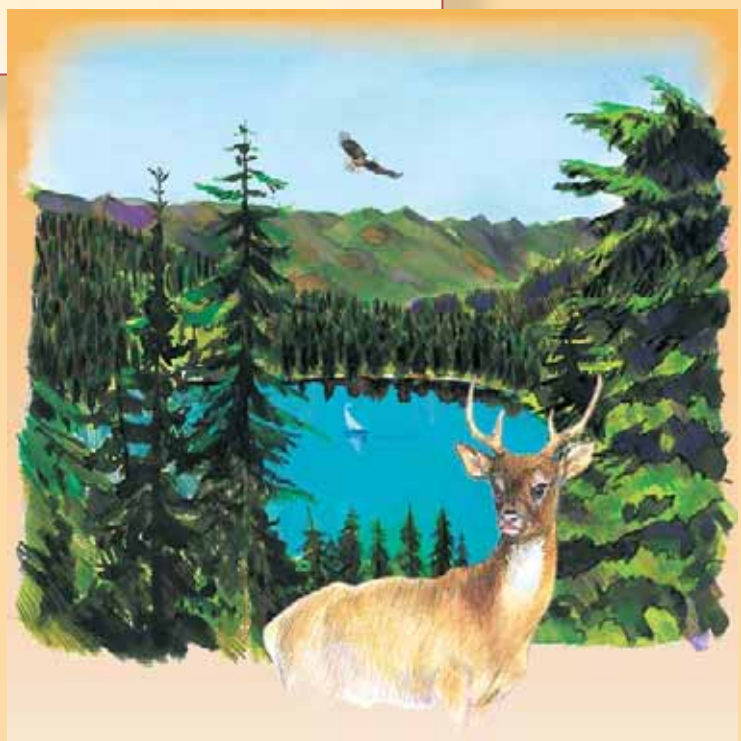
Ask QUESTIONS

Pursue ANSWERS

Share ANSWERS

Make MEANING

APPLY MEANING



Teacher's Planning Guide

Living Together

*28 class periods

UNIT OVERVIEW

In this Unit, Living Together*, students learn about the importance of water quality for all living things. Using a fictional community, students learn how everyday use of water in homes, local businesses, farming, industry, and recreation, affects the quality of water that living things depend upon. As a result, students conclude that the quality of water can change the land and affect organisms that depend on the water.*

Students engage in the practices of science and social practices of the classroom throughout the Unit. They work together as scientists, sharing their developing knowledge through presentations and Project Board *discussions.*

Content

The goal of this Unit is for students to learn about ecology and the relationships between the nonliving and living components in an ecosystem. To do this, they first focus on water, how water moves, and how different uses of water affect its quality and the quality of the lives of organisms in communities served by a river. The *Big Question* that students focus on in this Unit is, *How does water quality affect the ecology of a community?* To answer that question, students follow water through a watershed.

In *Learning Set 1* and *Learning Set 2*, students investigate the nonliving parts of an ecosystem. In *Learning Set 3*, they look more closely at living things in the ecosystem.

In *Learning Set 1*, students test how the shape of land affects the movement of water in a watershed. They learn, by investigation, that water flows predictably from higher to lower elevations in watersheds. Then they look at the variety of ways that land use affects water quality, including point and non-point sources that pollute water as they move through a community. Students build a watershed and consider what activities along the Rouge River in Michigan have affected the quality of the water in that watershed.

Looking Ahead

Save Jar 3 and Jar 4 for use in a demonstration in *Section 2.3.*

In *Learning Set 2*, students brainstorm and test indicators that scientists look at when determining water quality. Students learn how to test for pH, dissolved oxygen, temperature, turbidity, and fecal coliform bacteria in water. They learn that different organisms are sensitive to changes in pH.

In *Learning Set 3*, students study how changes in water quality affect living things by observing changes in actual organism populations. They practice classifying common aquatic macroinvertebrates. They use this knowledge to examine a case study that illustrates the effects of pollution on aquatic life. Students begin to look at food chains by analyzing a typical meal and tracing it back to its sources. Later, students predict how the presence or absence of

*A class period is considered to be one 40 to 50 minute class.

certain water quality indicators affects the numbers of members in a food chain. Students learn that stable ecosystems remain in balance but that this balance can change with a sudden explosion in the population of one member or the decrease of other members. These changes can occur due to changes in the non-living factors in the ecosystem.

To conclude the Unit, students use evidence they have collected to predict how water quality changes might affect a real-life situation involving the life and economic future of two communities along the Crystal River.

Investigations

In *Learning Set 1*, students work in groups to design and build a model watershed that provides them with clues as to how water flows through a watershed. Their understanding of watersheds is expanded when they use raised relief maps of the state of Michigan to track watersheds to the Great Lakes. Experimenting with stream tables, students model and predict how different kinds land use contribute to erosion and deposition in the land. Observing erosion and deposition of soil provides evidence that the way land is used can contribute to changes in water quality.

In *Learning Set 2*, students learn ways to test for a variety of water-quality indicators. Using duckweed, they begin by designing an investigation to test how various concentrations of common fertilizer components affect plant growth in water. This test is run over a period of five to ten days during which time, students track data each day. In a subsequent investigation, students test five different substances to learn about pH range. Students learn that many aquatic organisms are limited in where they can survive by the pH of the environment. A teacher-led demonstration using probe ware allows students to consider how high and low temperature of water in a stream and the speed of a stream affect the amount of dissolved oxygen the stream water can hold. This in term affects organisms that live there.

During *Learning Set 3*, students use a dichotomous key to classify aquatic macroinvertebrates. This provides a base for understanding that if populations in a community begin to change in some way, the ecology of the area also is changing. Students further investigate the effects turbidity on water quality. By studying the effects of light on photosynthesis in aquatic plants (Elodea) in an area, scientists determine whether enough oxygen and sugar is being produced to support animal life there. Students investigate how many individuals from different groups in a food chain interact with each other. Model populations are tracked with the use of a computer program, NetLogo® to determine how change in one group affect other populations. Students work in groups to find connections in feeding relationships that culminate in food webs.

Nature of Science

In this Unit, students are made aware that science has everyday importance. When the fictional town of Wamego on the Crystal River faces economic problems, students compile evidence on how the proposed solution might impact the town's land and water resources. Students engage in behaviors and habits of scientists by working in groups to design investigations to test a set of water quality indicators, both living and nonliving. Finally, they act as expert witnesses by presenting evidence based on experimentation to the town council. This process reflects science as a human endeavor and illustrates the role that scientific evidence can play in societal decisions.

Artifacts

Overall. the class uses a P*roject Board* to keep track of design plans, drawings of models, and accumulated evidence from investigations that supports how students should answer the *Big Question*. In *Learning Set 1*, students begin their *Project Board* after being introduced to the Unit challenge. They draw a design and model a watershed. They build a stream table incorporating a specific kind of land use (residential, commercial, industrial, or agricultural), keeping track of the effects of water flow that results from specific types of land use. They also create and present a poster of their land-use model indicating where erosion, deposition, and runoff occur. Students use a *Create Your Explanation* page to organize claims and evidence for their poster presentations.

In *Learning Set 2*, students update the *Project Board* with new thoughts about how to check water quality. In groups, students use a *Plant Growth Experiment Planning* Page to design an experiment to test the effect of various concentrations of fertilizers on growth of duckweed. This plan is then presented to the class. Data over 5 to 10 days are recorded on a *Plant-Growth Data and Observations* page. Students record results on a data chart while they test for pH as a water quality indicator.

In *Learning Set 3*, students update their *Project Board*. They classify aquatic organisms using a dichotomous key and record the names of the organisms as they are identified. An *Elodea Investigation* page is used to record data from an experiment in which students test the effect of turbidity on photosynthesis. Students prepare a poster in which they share the analysis of a meal to its sources. They draw a food chain and record factors that affect populations on a *Model Population Prediction and Observations* page. Students then use NetLogo® to simulate how populations of grass, mice, and coyotes change and how this affects an ecosystem.Teams utilize *Food-Chain Records* pages and posters to depict food webs.

Students use a *Create Your Explanation* page to think about and justify their recommendations for the town of Wamego. The Unit culminates with a presentation to the "town council." Final recommendations from each group are in the form of a poster, a PowerPoint® presentation, or a skit.

Targeted Concepts, Skills, and Nature of Science	Section
Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas. When another person's or group's idea is used, credit needs to be given.	All *Learning Sets*
Criteria and constraints are important in design.	*LS 1, LS 2*
Scientists must keep clear, accurate, and descriptive records of what they do so that they can share their work with others and consider what they did, why they did it, and what they want to do next.	All *Learning Sets*
In a fair test, only the manipulated (independent) variable, and the responding (dependent) variable change. All other variables are held constant.	*LS 2*
Scientists make claims (conclusions) based on evidence obtained (trends in data) from reliable investigations.	All *Learning Sets*
Explanations are claims supported by evidence, accepted ideas, and facts.	All *Learning Sets*
Scientists use models to simulate processes that happen too fast, too slow, on a scale that cannot be observed directly (either too small or too large), or that are too dangerous.	*LS 1,*
Scientists often break down big questions into smaller questions that they can investigate.	All *Learning Sets*
Predicting, observing, and explaining are important investigative skills.	*LS 1*
Students read raised relief maps and know the difference between three-dimensional and two-dimensional maps.	*LS 1*
An ecosystem is a complex community of interdependent organisms and the environment they share.	All *Big Question* sections related to the Unit challenge
Water is an essential substance in an ecosystem.	*LS 1*
Water and land interact with each other.	All *Learning Sets*
Water in a watershed travels predictably, from higher to lower elevations.	*LS 1*
Watersheds define the flow of water from an area of land into a river system and the flow of rivers systems into lakes and oceans. Watersheds are nested.	*LS 1, LS 2, LS 3*
Land structures and the materials that make up land, can change the quality of water moving in the ecosystem.	*LS 1*
Water flow transports and redistributes materials in a stream.	*LS 1, LS 2*
pH is a measure of how acidic or basic a substance is and is an indicator of water quality.	*LS 2*

Targeted Concepts, Skills, and Nature of Science	Section
Mixing less acidic (alkaline) solutions with acidic solutions changes the overall pH (acidity) of a solution.	*LS 2*
Some aquatic organisms are very sensitive to pH.	*LS 2*
Aquatic organisms use dissolved oxygen for respiration.	*LS 2, LS 3*
Dissolved oxygen is an indicator of water quality.	*LS 2*
The amount of dissolved oxygen in water increases as temperature decreases and as turbulence increases.	*LS 2, LS 3*
Scientists classify organisms based on criteria including physical appearance and feeding relationships and relationships to the environment.	*LS 2, LS 3*
All living things need energy to survive.	*LS 3*
Living things that produce their own food, such as plants, are producers.	*LS 3*
Living things that consume other organisms are consumers, which include herbivores, carnivores, and omnivores.	*LS 3*
Predators kill other organisms (prey) for food.	*LS 3*
Scientists use tools such as the dichotomous key to classify and identify different organisms.	*LS 3*
Food chains and webs help show who eats what in an ecosystem.	*LS 3*
Living organisms are made of cells, get energy from the environment, grow and develop; most reproduce and respond to changes in their environment.	*LS 3*
Plants absorb energy from sunlight using chlorophyll in their cells; they produce food by photosynthesis.	*LS 3*
Scientists can determine water quality using biotic indicators.	*LS 2, LS 3*
Plant growth can affect water quality.	All *Learning Sets*
Biotic and abiotic components interact in an ecosystem.	*LS 2, LS 3*
By following how water flows in and over land in an ecosystem, ecologists can learn how water is affected by organisms and by the land in the ecosystem.	*LS 1, LS 3*
Human activity can affect the ecology of a community. Humans use rivers for residential, commercial, industrial, and agricultural purposes. These activities affect water quality along a river.	All *Big Question* sections related to the Unit challenge

Materials Needed for Unit

Quantities based on 28-35 students in 7 groups		
Unit X- Durable Kit	Section	Quantity
jar, glass, 32 Oz.	ABQ, 2.3	5
building blocks, assorted dimensions, Pk of 7	1.2	8
spray bottle	1.2	8
stream table apparatus	1.2; 1.6	8
stream table, 27 Qt.	1.2; 1.6	8
Michigan, raised relief map	1.4; 1.5	2
transparency of 2 dimensional relief map of Michigan	1.4	1
laminated construction paper, black, 2" x 2"	1.6	40
laminated construction paper, black, 2" x 11"	1.6	40
box of Legos	1.6	1
wooden slats	1.6	9
bulb, Grow Lamp **	2.2, 3.4	2
light fixture with shield, 120 Volt **	2.2, 3.4	2
clamp, burette, coated jaw **	2.2, 3.4	8
beaker, 400 mL, plastic	2.2	16
hand lens	2.2	8
test tube rack	2.3	8
test tube, large	2.3	40
beaker, 150 mL	2.3	8
funnel	2.3	3
beaker, 600 mL	2.3; 2.4	8
sampling CD	3.2	1
bug pictures, Laminated	3.2, 3.7	8
plastic shoe box	3.4	16

**These items can be removed if you have access to sunlight

Quantities for 5 classes of 28-35 students		
Unit X- Consumable Kit	Section	Quantity
vinegar, 1.32 Gl	ABQ, 2.3	1
food coloring, red	ABQ, 2.3	1
food coloring, blue	ABQ, 2.3	1
baking soda	ABQ, 2.3, 3.4	2
marker, overhead, red	1.4	2
marker, overhead, green	1.4	2
marker, overhead, black	1.4	2
marker, overhead, blue	1.4	2
sand, coarse, lb	1.6	15
gravel, colored aquarium, lb	1.6	10
potting soil, lb	1.6	15
Spanish moss, 10" x 13" bag	1.6	1
duckweed plants, 2 oz.	2.2	1
liquid houseplant fertilizer (N:P:K =8:7:6), 8oz	2.2	1
rubbing alcohol	2.3	1
Elodea-10" sprig, Pk/10	3.4	4

Additional Items Needed Not Supplied	Section	Quantity
clay or short pieces of waterproof two-sided masking tape for each group simulation of river elevation setup	1.2	1 package or 1 roll per classroom
Projections of a local river or body of water	Unit Introduction Implementation	1 set per classroom

UNIT INTRODUCTION

What's the Big Question?

How does water quality affect the ecology of a community?

t *2 class periods**

Overview

The goal of this Unit is for students to learn about ecology and the relationships within an ecosystem. Students are introduced to the *Big Question* of *Living Together*, *How does water quality affect the ecology of a community?* They are also introduced to the challenge, which is to determine how the towns of Wamego and St. George, on the Crystal River, might survive ecologically, culturally, and economically if a new business were to move to Wamego. To begin to answer this challenge, the class considers five jars of different fluids. They think about the quality of each sample and discuss what it would be like to live in or drink the sample water. They work in groups and consider why it might be important to know the quality of water and think about factors in the environment that affect water quality. Students then think about what they might need to know to answer the *Big Question*. They create a *Project Board* for the Unit, which they will update as they gather evidence and information to answer the *Big Question*.

*A class period is considered to be one 40 to 50 minute class.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on other's ideas. When another person's or groups' idea is used, credit needs to be given.	Students should be able to cite instances during the learning set when they have behaved much as scientists would when sharing information with each other while discussing a problem.
Scientists often break down big questions into smaller questions that they can investigate.	Throughout the Unit, you should hear students discuss parts of *Big Question* in the context of the Unit challenge.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
Water is an essential substance in an ecosystem.	You should be able to hear students relate that water is essential to plant and animal life and that changes in water quality can affect plant and animal life.
Water and land interact with each other.	Students should begin to think about how water and land interact as they study the examples depicted in the photographs of the Rouge River.
An ecosystem is a complex community of interdependent organisms and the environment they share.	Students should be able to iterate that an ecosystem contains living organisms whose populations interact with each other and that when some nonliving factors change, these populations change in number and character.
Humans use rivers for residential, commercial, industrial, and agricultural purposes. These activities affect water quality along a river.	Students should be able to conclude from studying the photographs of areas along the Rouge River that human activity might be responsible for what is depicted and that water quality might be affected by these activities.

Materials

1 set per class	five jars labeled Jar 1, Jar 2, Jar 3, Jar 4, and Jar 5 with lids
per classroom	source of tap water
per classroom	coffee grounds
1 per classroom	container of cocoa powder
1 per classroom	red food coloring
1 per classroom	blue food coloring
1 per classroom	50 mL graduated cylinder
1 per classroom	vinegar
1 per classroom	box of baking soda
per classroom	200 mL pond or river water
1 pair per teacher	disposable gloves
per classroom	small amount of soil
1 per classroom	pH paper
1 per classroom	tablespoon measuring spoon

Activity Setup and Preparation

Select groups of three to four students to work together during this Unit.

What is Water Quality?

Set up a classroom demonstration consisting of five small jars, each with 200 mL of tap water, and each with a lid. Label each jar with a number and treat each as a different water sample by adding the following items. Allow time before the demonstration to set these up. You may have to experiment to get colors or pH readings exactly as they need to be.

- **Jar 1:** add coffee grounds and cocoa powder to 200 mL water until the water looks very dirty.
- **Jar 2:** Add a few drops of red and blue food coloring to 200 mL water. The water will turn purple but should be transparent.
- **Jar 3:** Add about 40 mL of vinegar to the water until it has a pH of approximately 5. Test the solution using pH paper while adjusting the pH.
- **Jar 4:** Add about ½ tablespoon of baking soda to the water so that the pH is about 8-9. Test the solution using pH paper while adjusting the pH. Jar 4 must test differently from Jar 3.
- **Jar 5:** Wearing disposable gloves, collect water from a local pond or river. It is all right to have a small amount of soil in the water. If you cannot get water from a local source, add a small amount of soil to tap water. Thoroughly wipe the outside of the jar and do not open it for students. When it is time to dispose of the water, dispose of it at its collection site if possible.

Homework Options

Reflection

- **Nature of Science:** Describe two ways that meeting in your group to solve the *Big Question* is similar to the way you think scientists solve problems. *(Students' answers might include that their group meeting was similar to scientists working together because they share ideas and may develop new ideas because of what is said by someone else in the group.)*
- **Science Process:** Summarize one idea about from the *Project Board* that interested you. *(Student choices will vary but should come from the information listed on the* Project Board.*)*

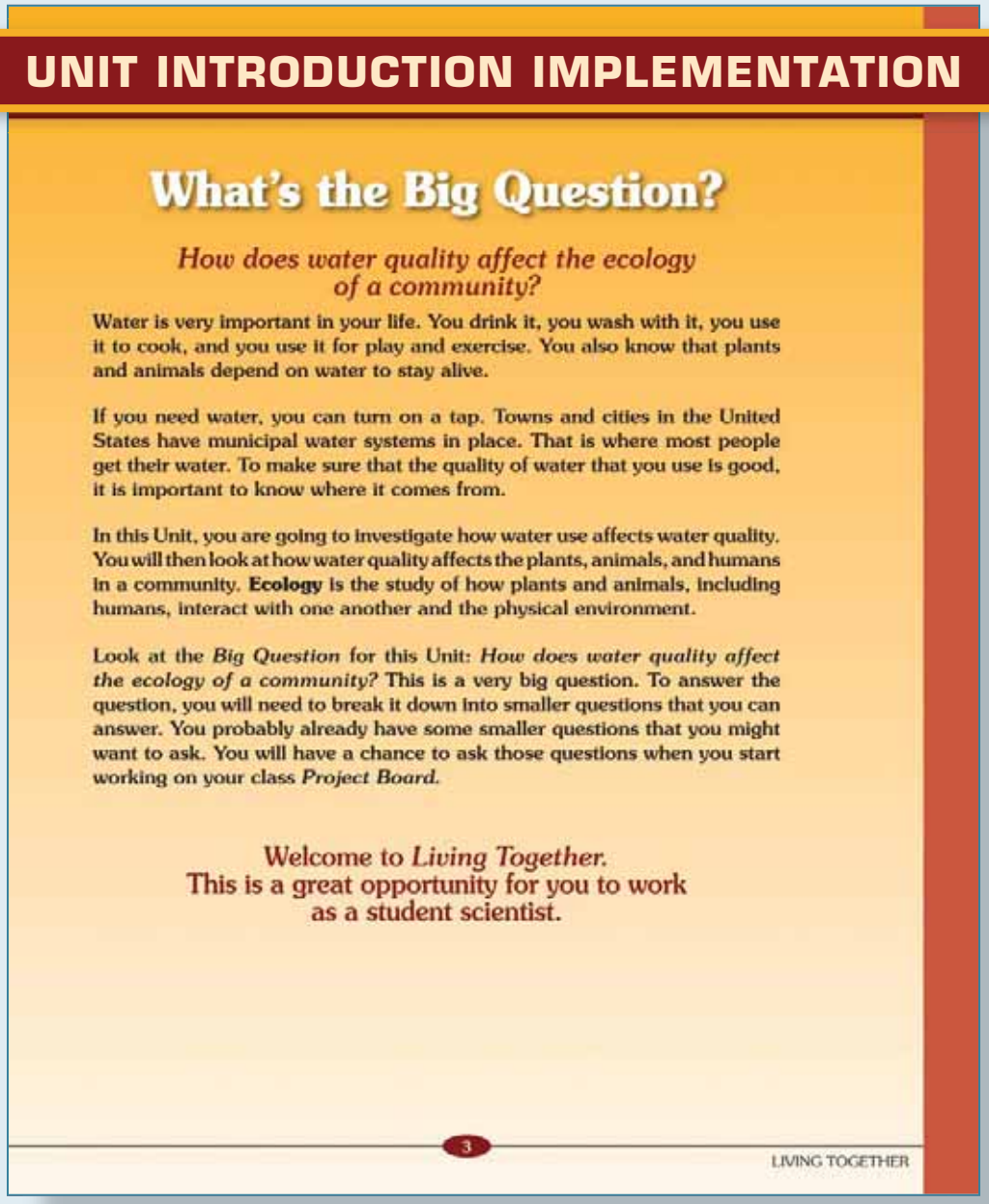
Preparation for 1.1

- **Science Content:** How do you think you would model what happens to rain after it hits the ground? *(Accept all reasonable responses. Students may suggest using colored water to tack the movement of rain.)*
- **Science Process:** What are two questions you might ask about how water and land interact with each other? *(Accept all reasonable responses. Students might ask, "How does water affect the land as rain falls?" and "Does rain change after it falls on the ground?")*

Check with your local environmental agency to make sure it is legal for you to collect water from local ponds.

NOTES

UNIT INTRODUCTION IMPLEMENTATION



What's the Big Question?

How does water quality affect the ecology of a community?

Water is very important in your life. You drink it, you wash with it, you use it to cook, and you use it for play and exercise. You also know that plants and animals depend on water to stay alive.

If you need water, you can turn on a tap. Towns and cities in the United States have municipal water systems in place. That is where most people get their water. To make sure that the quality of water that you use is good, it is important to know where it comes from.

In this Unit, you are going to investigate how water use affects water quality. You will then look at how water quality affects the plants, animals, and humans in a community. **Ecology** is the study of how plants and animals, including humans, interact with one another and the physical environment.

Look at the *Big Question* for this Unit: *How does water quality affect the ecology of a community?* This is a very big question. To answer the question, you will need to break it down into smaller questions that you can answer. You probably already have some smaller questions that you might want to ask. You will have a chance to ask those questions when you start working on your class *Project Board.*

Welcome to *Living Together.*
This is a great opportunity for you to work as a student scientist.

t *2 class periods**

What's the Big Question?

How does water quality affect the ecology of a community?

10 min.

Introduce students to the Big Question *to the class.*

META NOTES

Consider planning a field trip to a local river, pond, or lake for water to test in *Learning Set 2.*

Engage

During this introduction, you want to get students thinking about the importance of water. Begin by asking students to think about how they use water every day. (Possible responses include taking a shower, washing clothes, drinking, cooking, and washing hands). Create a class list of their responses.

*A class period is considered to be one 40 to 50 minute class.

TEACHER TALK

"Where do you think water for these activities comes from? Have you ever wondered about where water from the tap comes from? Let's make a list of places where you see water in the community. (*Probable responses are rain, snow, rivers, streams, lakes, ponds, water in the ground.*)

Now that you have thought about how you use water every day and listed some sources of water, think about this: Would you use water straight from the river to drink? Would you swim in water near the paint (or some other local example) factory down by the river? What are some reasons why you would or would not use this water? (*Students might say the water does not look clean or that it has an odor.*)"

☐ Assess

Turn students' attention to the *Big Question* of the Unit. Ask them to describe in their own words what they think the question means so that you can determine their understanding of the big picture. Listen to how they use some of the terms; in particular, water quality, ecology, and community.

TEACHER TALK

"Ecology is the study of plants and animals and how they interact with their physical environment or surroundings. What do you think makes up the physical environment? Think about what you interact with each day. (*Responses should include water, land, and air.*)"

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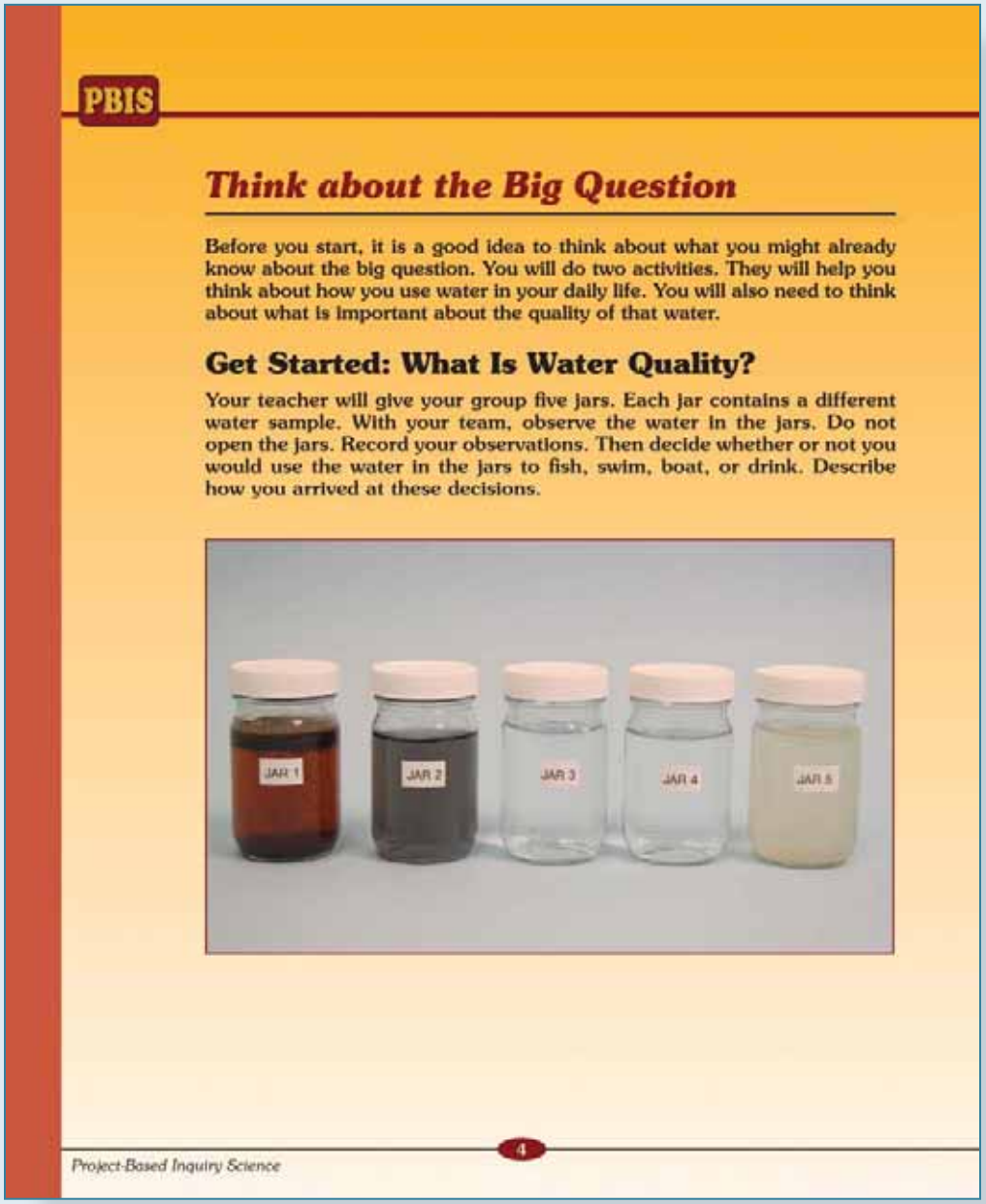

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Think about the Big Question

Before you start, it is a good idea to think about what you might already know about the big question. You will do two activities. They will help you think about how you use water in your daily life. You will also need to think about what is important about the quality of that water.

Get Started: What Is Water Quality?

Your teacher will give your group five jars. Each jar contains a different water sample. With your team, observe the water in the jars. Do not open the jars. Record your observations. Then decide whether or not you would use the water in the jars to fish, swim, boat, or drink. Describe how you arrived at these decisions.

4

Project-Based Inquiry Science

Think about the *Big Question*

20 min.

Get Started: What is Water Quality?

Students work on their observational skills and begin to articulate their ideas of what they consider to be important factors in water quality

Engage

Ask the class what they think water quality means. Give students a few minutes to suggest ideas. If students have difficulty verbalizing a description, ask them to think about ads they might have seen or heard where the word "quality" was used.

META NOTES

As an alternate approach, set up the five jars as a demonstration to reduce the number of glass jars and the potential for glass breakage in the classroom.

TEACHER TALK

"If you hear about a product that has quality, does that make you want to have it or avoid it? What characteristics do you think a quality product has? *(List responses.)* Now if that is true for a breakfast cereal, or a car, or a piece of clothing, what characteristics do you want in the water that you drink or swim in?"

△ Guide

Tell students that you are going to provide samples of water for them to observe in their groups. Inform them that they should record what they observe about each sample.

META NOTES

Caution students not to open any of the jars. Ask them to observe and describe the water in each jar. For each jar, have students discuss what the water might be used for.

TEACHER TALK

"I'm going to put out five jars of water. Each has a number to make it easier to refer to when you write notes about it. I want you to look at each sample and think of how you might describe it. Make a guess as to where you think the sample came from? What is your reason? Describe how might you use each sample? Can you really decide on the quality just by looking at it? What else would you like to know about it?"

☐ Assess

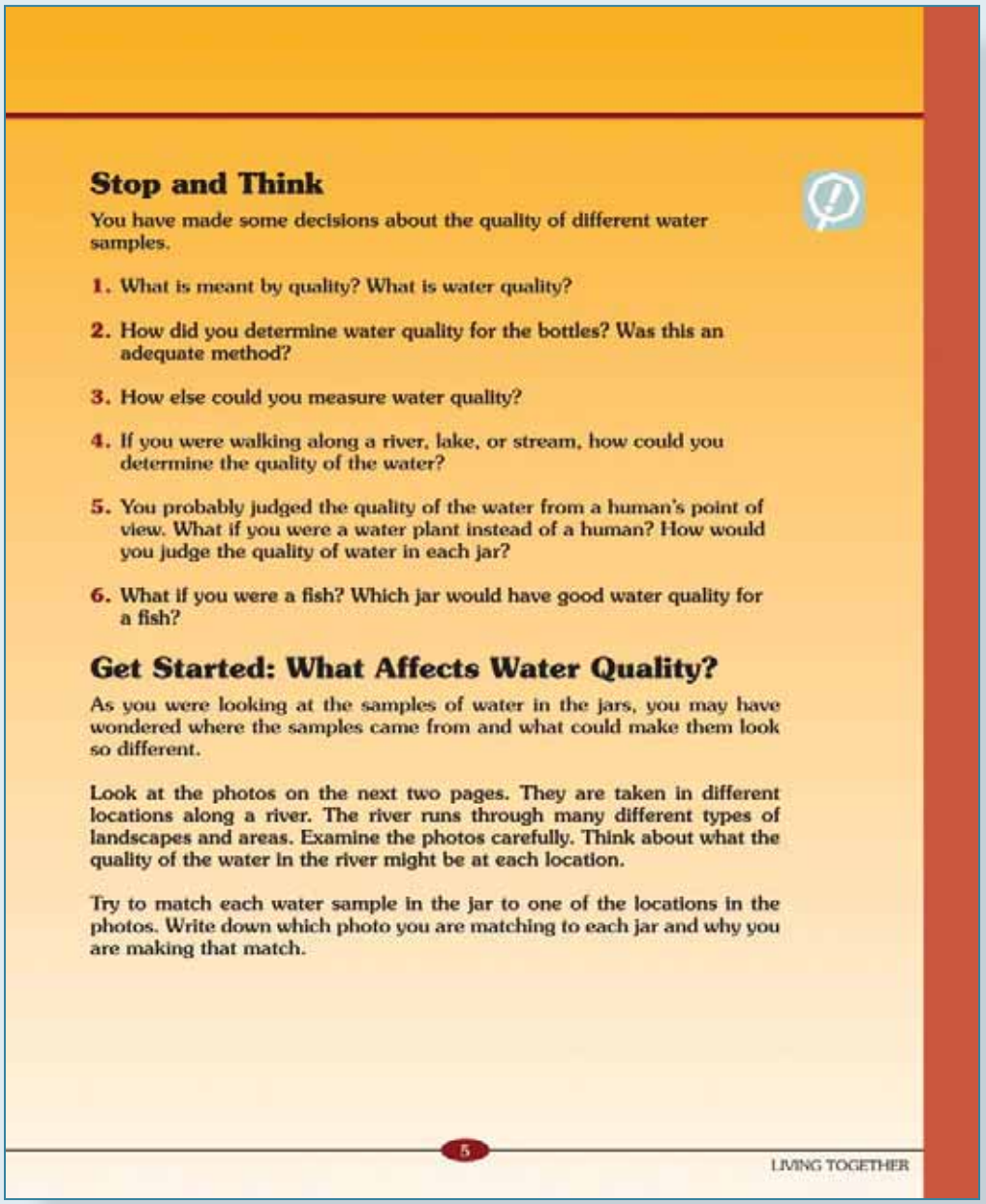
On a table, place five water samples marked Jar 1 through 5 respectively. Make sure that each group has time to look at the jars. Listen to the discussions in each group. Are students thinking aloud about where each sample might have come from? Listen to hear what students might say is different about each sample. If necessary, draw their attention to one particular sample.

△ Guide

Listen to find out if students are discussing reasons for using or not using each sample. If you do not hear that as you walk around the classroom, then ask a question of each group. Possible questions might be: "Which sample would you keep a goldfish in? Which sample would you swim in? Would you use the water in Jar 4 to cook in? Which sample would help if you needed a drink of water?" Remind them to come up with reasons for their responses.

TEACHER TALK

"What is there about Jar 3 that makes you think that a person might be able to drink the water? What is your reason? What do you see that makes it different from the water in the other jars?"



Stop and Think

You have made some decisions about the quality of different water samples.

1. What is meant by quality? What is water quality?
2. How did you determine water quality for the bottles? Was this an adequate method?
3. How else could you measure water quality?
4. If you were walking along a river, lake, or stream, how could you determine the quality of the water?
5. You probably judged the quality of the water from a human's point of view. What if you were a water plant instead of a human? How would you judge the quality of water in each jar?
6. What if you were a fish? Which jar would have good water quality for a fish?

Get Started: What Affects Water Quality?

As you were looking at the samples of water in the jars, you may have wondered where the samples came from and what could make them look so different.

Look at the photos on the next two pages. They are taken in different locations along a river. The river runs through many different types of landscapes and areas. Examine the photos carefully. Think about what the quality of the water in the river might be at each location.

Try to match each water sample in the jar to one of the locations in the photos. Write down which photo you are matching to each jar and why you are making that match.

5

LIVING TOGETHER

Stop and Think

15 min.

Discuss students' observations of the water samples using the Stop and Think *questions.*

Get Going

As groups complete their observations of the water samples, turn their attention to the *Stop and Think* questions. Tell them they have a few minutes to discuss possible responses within their groups and then they will discuss them as a whole.

Stimulate the discussion by focusing on questions 2 and 3. Students have just observed the jars with their eyes. Ask, "What else might you need to know or observe to detect if a fish or plant could live in the water or if you could drink the water?" Explain that later in the Unit, students will have the opportunity to test different characteristics of water to help them determine a more complete picture of the quality of these samples.

META NOTES

Determining the quality of the five samples by looking at them is a qualitative measure. In *Learning Set 2*, students will measure pH, temperature, dissolved oxygen, and turbidity—all quantitative tests of water quality.

META NOTES

It is all right, if at this point, students do not know what factors scientists use to determine water quality.

△ Guide and Assess

Answers to *Stop and Think* questions will vary but during the discussion, listen to responses and guide the discussion as needed to bring out the responses listed below.

1. Students should be able to say that the term *quality* means the characteristics of something, generally the good or more positive characteristics of something. Water quality refers to how good or useful the water is, generally in terms of human health.
2. Most students will say that they determined the water quality in the five jars by sight. Students should be able to say that sight alone is inadequate for determining water quality.
3. Students' answers will vary because they probably have not experienced using quantitative methods but some may refer to some way to measure types and amounts of chemicals in the samples of water. Accept other reasonable responses.
4. Most students will respond that they would use their senses to determine the quality of the river water. Most will probably say sight and smell.
5. Even though plants cannot "judge" situations, they can respond positively or negatively. Water quality would be good if the plant received the nutrients it needed to stay alive. Water quality would be poor if the water does not supply the plant with what it needs and it dies.
6. Students may guess that the jars with the cleanest or clearest water would support a fish and keep it alive, but in fact, students cannot make this judgment at all because they do not know the composition of the water samples.

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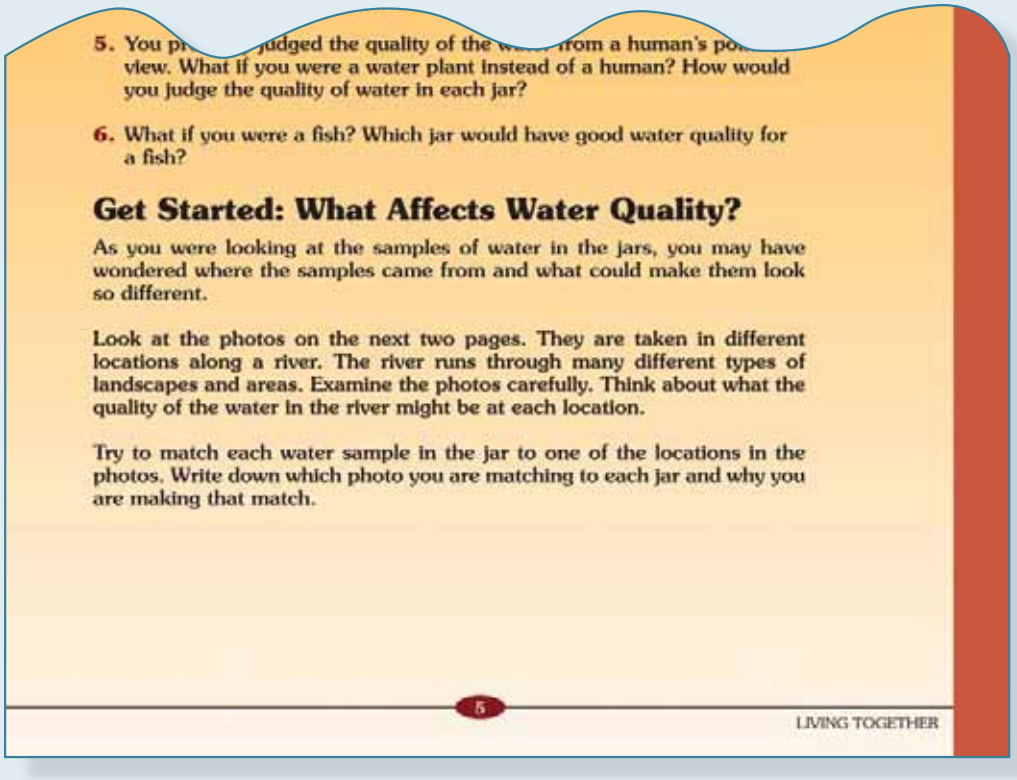

5. You pr[illegible] judged the quality of the w[illegible] from a human's po[illegible] view. What if you were a water plant instead of a human? How would you judge the quality of water in each jar?

6. What if you were a fish? Which jar would have good water quality for a fish?

Get Started: What Affects Water Quality?

As you were looking at the samples of water in the jars, you may have wondered where the samples came from and what could make them look so different.

Look at the photos on the next two pages. They are taken in different locations along a river. The river runs through many different types of landscapes and areas. Examine the photos carefully. Think about what the quality of the water in the river might be at each location.

Try to match each water sample in the jar to one of the locations in the photos. Write down which photo you are matching to each jar and why you are making that match.

5

LIVING TOGETHER

Get Started: What Affects Water Quality?

10 min.

Students are introduced to the idea that land use around a river can affect river water. Students begin to make this connection and articulate their ideas about how and why this happens.

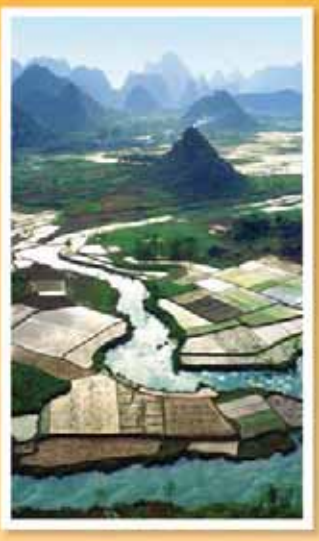
Engage

Divide the class into their groups or teams. Tell students that they are going to look at the water samples in the jars again and match them with the photographs on pages 6 and 7 in the student edition. Remind students to prepare for a class discussion by having reasons for matching a particular sample with the scene in the photograph.

TEACHER TALK

"Picture yourself in the setting shown in each photograph. Think of the kinds of things might you observe about the water. Remember to use your senses. How does the water look to you? Does it have a pleasant or unpleasant odor? What color is the water? Does the air smell fresh? Do you hear birds or see any fish swimming in the water? Which of the five jars looks like water from that setting? Make sure that you have a reason for the match to share with the class. Once you have made a decision, record your reason."

PBIS



Here the river runs through a farming community. The rows you see in the dirt were made by the large plows farmers use to plant seed.

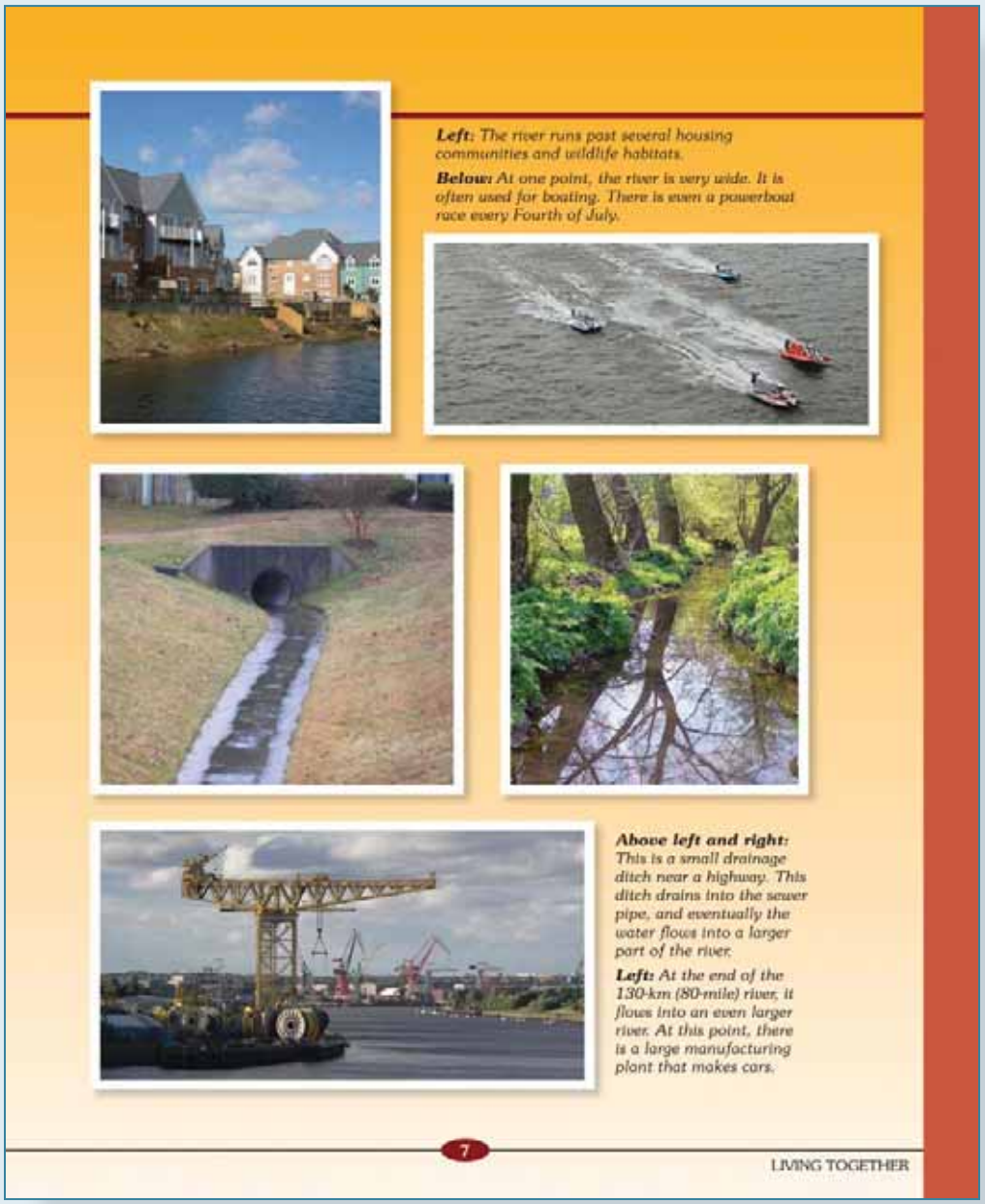
The river runs through a golf course. Notice the fairways and sand bunkers. In the distance there are several homes.

Here the river winds through a shipping yard. Notice the docked barges. In the right front there is a plant that produces paint. The paint is then shipped by barge, train, and truck from the plant.

Here the river widens and moves very slowly. In fact, the river enters into a lake at one end, and then it exits the lake through a small stream at the other end. This picture was taken from the yard of a small cottage on the lake. The dock belongs to the cottage owner.

6

Project-Based Inquiry Science



Left: *The river runs past several housing communities and wildlife habitats.*

Below: *At one point, the river is very wide. It is often used for boating. There is even a powerboat race every Fourth of July.*

Above left and right: *This is a small drainage ditch near a highway. This ditch drains into the sewer pipe, and eventually the water flows into a larger part of the river.*

Left: *At the end of the 130-km (80-mile) river, it flows into an even larger river. At this point, there is a large manufacturing plant that makes cars.*

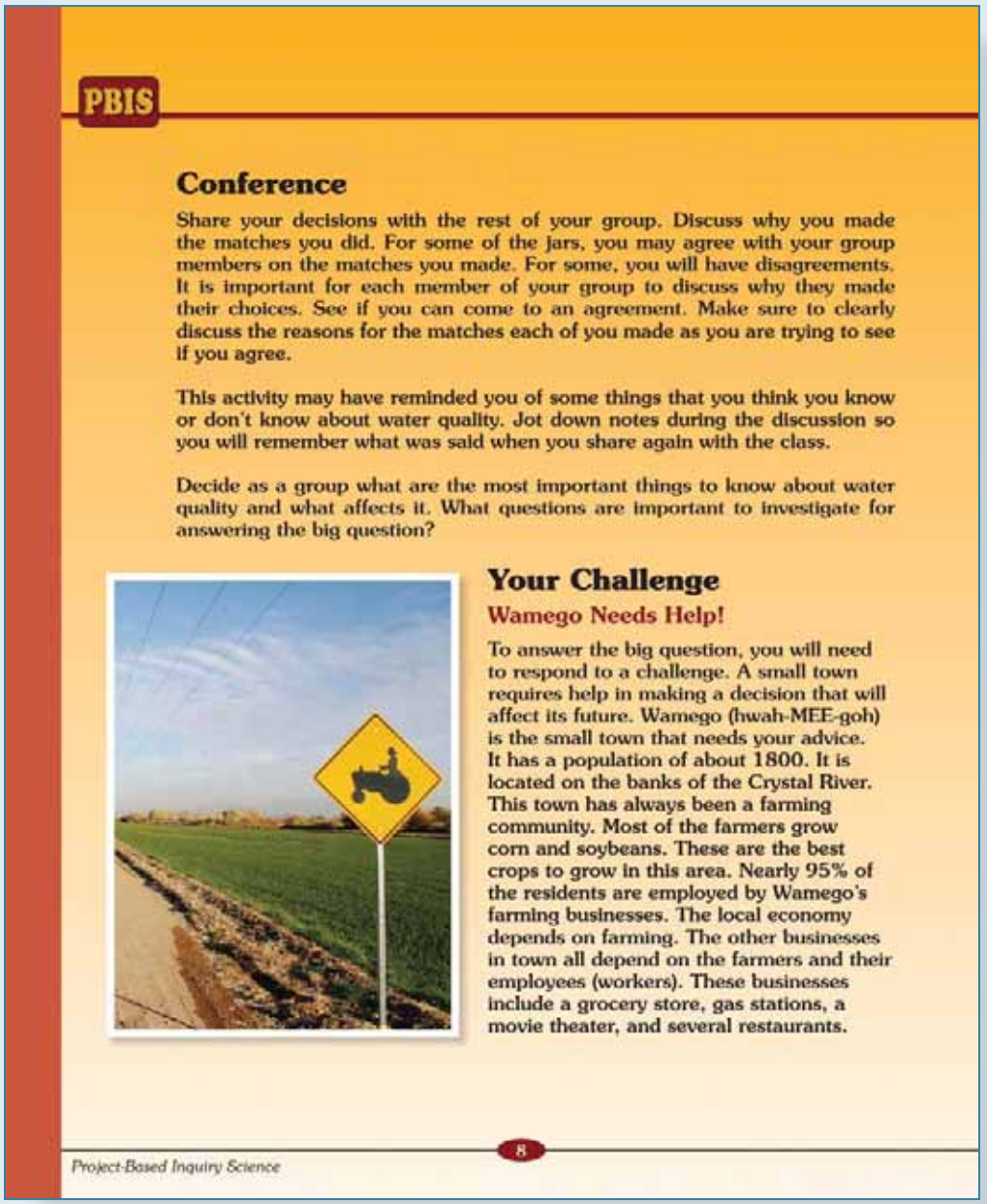
7

LIVING TOGETHER

Conference

15 min.

Working in groups, students may find that there is more than one way to look at evidence.



PBIS

Conference

Share your decisions with the rest of your group. Discuss why you made the matches you did. For some of the jars, you may agree with your group members on the matches you made. For some, you will have disagreements. It is important for each member of your group to discuss why they made their choices. See if you can come to an agreement. Make sure to clearly discuss the reasons for the matches each of you made as you are trying to see if you agree.

This activity may have reminded you of some things that you think you know or don't know about water quality. Jot down notes during the discussion so you will remember what was said when you share again with the class.

Decide as a group what are the most important things to know about water quality and what affects it. What questions are important to investigate for answering the big question?

Your Challenge

Wamego Needs Help!

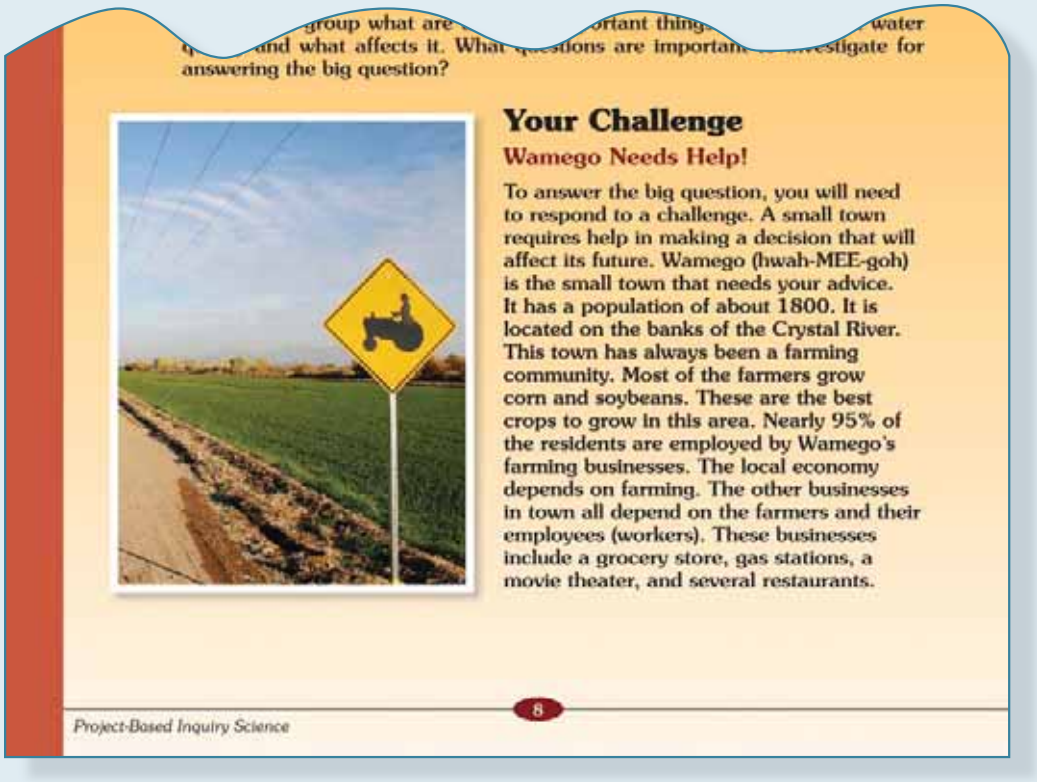
To answer the big question, you will need to respond to a challenge. A small town requires help in making a decision that will affect its future. Wamego (hwah-MEE-goh) is the small town that needs your advice. It has a population of about 1800. It is located on the banks of the Crystal River. This town has always been a farming community. Most of the farmers grow corn and soybeans. These are the best crops to grow in this area. Nearly 95% of the residents are employed by Wamego's farming businesses. The local economy depends on farming. The other businesses in town all depend on the farmers and their employees (workers). These businesses include a grocery store, gas stations, a movie theater, and several restaurants.

8

Project-Based Inquiry Science

△ Guide

After students have matched the jars and photographs, list the nine photographs and ask students to say which jar matches the first photograph for use during a class discussion. As students talk about each photograph, they may quickly realize that they do not all agree on each match. Let students know that it is all right to disagree. Explain that scientists often disagree when they begin to discuss a topic, but that each person presents a reason to support their viewpoint.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Your Challenge

10 min.

Telling the story of Wamego engages students in the challenge.

Engage

Introduce the challenge by first describing the story of Wamego and its concerns about its economic and ecological future.

TEACHER TALK

"Wamego is a small community on the Crystal River. The cold and clean river water supports an abundance of trout. In fact, each year Wamego has a Trout Festival. Most of Wamego's business is farming, but the festival supplies a lot of income for the town.

In the past five years, farming hasn't been so profitable. People have moved away. FabCo, a company that manufactures cloth is interested in building a new factory in Wamego. FabCo will benefit because it needs the river water and the cost of living in the town is low. The town will benefit because FabCo will provide new jobs, new homes, and increased taxes. Some members of the community however, are concerned that the new factory would change the land and the water quality of the river."

META NOTES

The story provides the motivation for students to begin to think about how they will solve the challenge.

The Crystal River is also important to Wamego. The river is a source of water for the crops. The river is also known as a good trout-fishing river. Trout need very clean, cold water to thrive. Crystal River suits their needs. Every summer Wamego has a Trout Festival. Many people who enjoy fishing travel to the area. The festival celebrates trout fishing and preservation.

The festival also educates people about what trout need to thrive. The goal of the education effort is to keep the number of trout at a healthy level. In that way, people can enjoy fishing there for many years to come. This festival is fun for many residents and tourists. It is also another income source for the residents of Wamego.

Lately, the farming business has not been good. Crop prices have dropped. The farmers are not making very much money. There is not enough to pay their workers or to support themselves. Some of the farmers have gone bankrupt. As a result, Wamego has lost 15% of its population during the last five years.

9

LIVING TOGETHER

Present the challenge to students. Inform them that first they will design and build a model that shows how water flows through land before it gets to a river. Then they will investigate a variety of ways that land can affect water and water can affect land. Finally they will learn about the organisms that live in the river water and how changes to the water can affect these organisms. Tell them that the evidence that they collect will enable them to answer the *Big Question* and advise the town on what might happen ecologically if FabCo develops a new factory.

PBIS

The town council is very concerned. They know farming will always be a part of life in Wamego. They do, however, worry about the town losing too many people. They do not want to get so small that there will be very few businesses and residents in Wamego.

FabCo Wants to Move In

A mid-sized manufacturing company called FabCo has contacted the town council. FabCo manufactures cloth. The cloth is sold to companies that make clothes. FabCo is looking for a new location to build its company headquarters and manufacturing plant. FabCo is very interested in relocating to Wamego for several reasons.

- Wamego has a fairly large river and a train line running through the town. This, along with roads, would provide transportation routes for their products.
- The cost of living in the town is low. Their employees would like that.
- The river provides a natural resource (water). Water is important to the production of their cloth.

If FabCo is allowed to move to Wamego, the town could benefit as well. It would mean the following benefits.

- About 15,000 new residents would relocate to Wamego. This would require the building of many new homes, roads, and parks. A new school would need to be built. New businesses offering services to the company and the new residents would be needed. This means more buildings, parking lots, and roads would appear in Wamego.
- FabCo would offer many new jobs to Wamego's residents.
- The town would have money from taxes collected from FabCo and the new residents. This extra money could be used to improve life in Wamego in many ways, including a new hospital.
- The town would not have to depend on farming alone.

10

Project-Based Inquiry Science

TEACHER TALK

"Your challenge is to investigate to find out what changes might occur to the land and the water around Wamego if FabCo moves in. You will use the evidence you collect from, models, investigations, and the science knowledge you read throughout the Unit to advise the town council about how to save their town, especially how to maintain the river's water quality. As you prepare to talk with the town council, you will answer the *Big Question* and learn how important a healthy environment can be."

Sounds Great! So, What's the Problem?

Many of the residents, including some town council members, are concerned. They worry that FabCo could mean problems for their community. Currently, the land is used for agriculture. If FabCo comes to town, the use of the land will change. The land will be needed for residential, commercial, and industrial purposes. Some people, including the organizers of the Trout Festival, wonder if this will change the river and the wildlife of Wamego.

Wamego residents are not the only ones concerned. Ten miles downstream is the town of St. George. It is also located along the Crystal River.

St. George is an even smaller town than Wamego. It is a resort town. People travel from all over to vacation in St. George. They use the river for recreation. There is fishing, swimming, boating, hiking, and camping in the area. There are several hotels and bed & breakfasts that provide accommodations for tourists. The Crystal River's water quality is very important to St. George's economy and residents. The residents of St. George are worried that the changes in Wamego might affect their lives.

△ Guide

At this point you may want to allow class groups to read the more detailed description of the Wamego story in their textbook and then conference for about five minutes so that they can begin to sort through the parts of the story on their own. Listen for whether students grasp the scope of the town's problem. What kinds of questions do you hear them asking other students within their own group? Watch faces to see if anyone displays confusion over what is going on. At the end of that time, let the class discuss or almost retell the story to insure that you know they understand the various parts. If necessary, list events as they recount the story. You may want to post a map of Wamego and the river.

Setting up a *Project Board* might point out where and how a very large problem might need to be broken down into more manageable parts. If students have trouble getting the big picture, ask them to verbalize what they do understand. Treat each student's version as a piece in a puzzle. Then ask students how to draw the pieces together. If necessary, write each part on a separate piece of poster paper, then let students put them in order. Transition the whole class into focusing on the use of a *Project Board* as a place to brainstorm ideas and use as an organizational tool.

TEACHER TALK

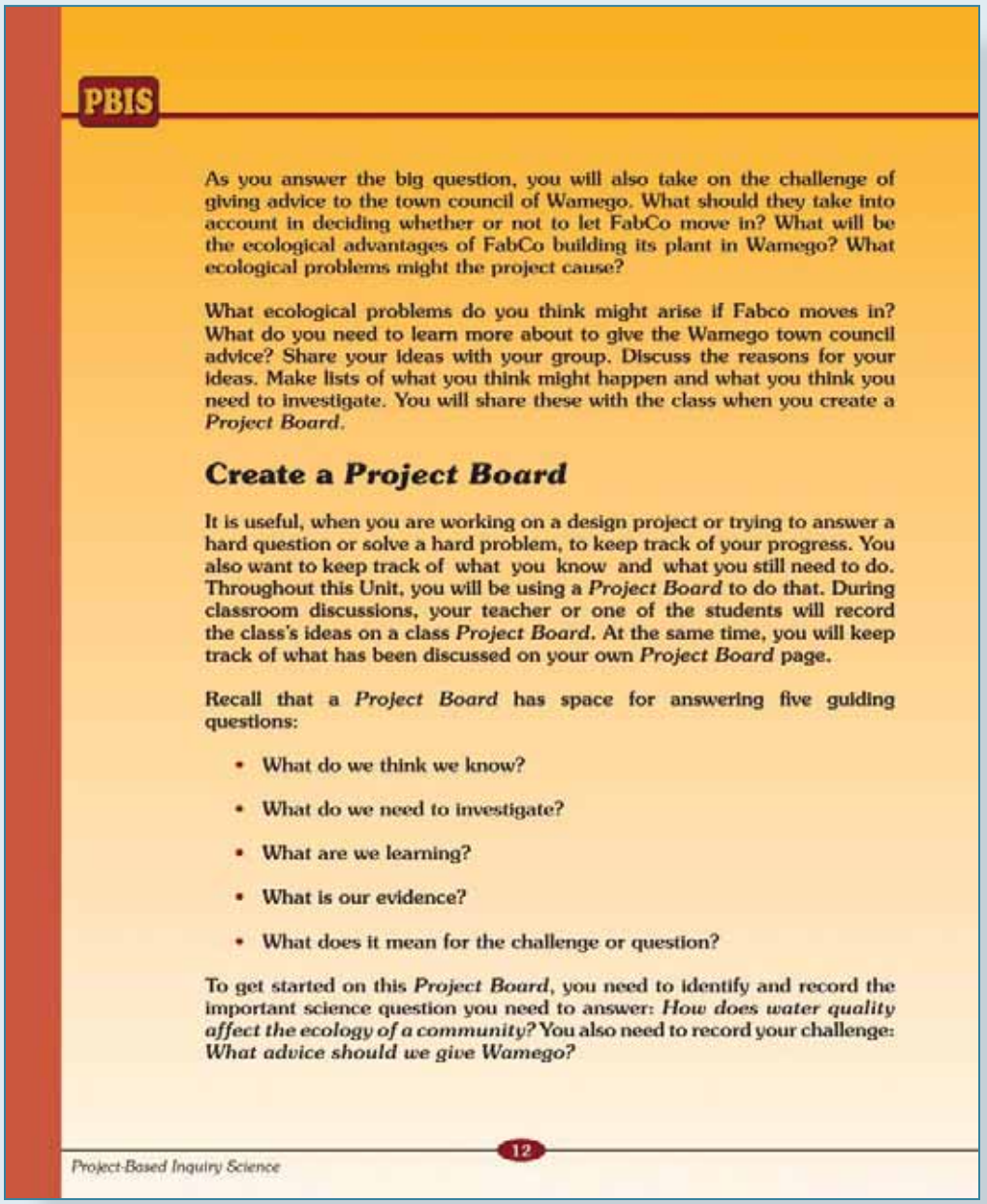
"As we begin to think about the challenge that the town faces, we need to think about ways to organize our thoughts so that we can investigate their problem logically. A *Project Board* is a way to keep track of ideas and progress. Let's begin by recording what we think we already know about water quality and ecology."

NOTES

Create a *Project Board*

15 min.

A Project Board *can reflect progress in what students learn about a challenge.*



PBIS

As you answer the big question, you will also take on the challenge of giving advice to the town council of Wamego. What should they take into account in deciding whether or not to let FabCo move in? What will be the ecological advantages of FabCo building its plant in Wamego? What ecological problems might the project cause?

What ecological problems do you think might arise if Fabco moves in? What do you need to learn more about to give the Wamego town council advice? Share your ideas with your group. Discuss the reasons for your ideas. Make lists of what you think might happen and what you think you need to investigate. You will share these with the class when you create a *Project Board*.

Create a *Project Board*

It is useful, when you are working on a design project or trying to answer a hard question or solve a hard problem, to keep track of your progress. You also want to keep track of what you know and what you still need to do. Throughout this Unit, you will be using a *Project Board* to do that. During classroom discussions, your teacher or one of the students will record the class's ideas on a class *Project Board*. At the same time, you will keep track of what has been discussed on your own *Project Board* page.

Recall that a *Project Board* has space for answering five guiding questions:

- What do we think we know?
- What do we need to investigate?
- What are we learning?
- What is our evidence?
- What does it mean for the challenge or question?

To get started on this *Project Board*, you need to identify and record the important science question you need to answer: *How does water quality affect the ecology of a community?* You also need to record your challenge: *What advice should we give Wamego?*

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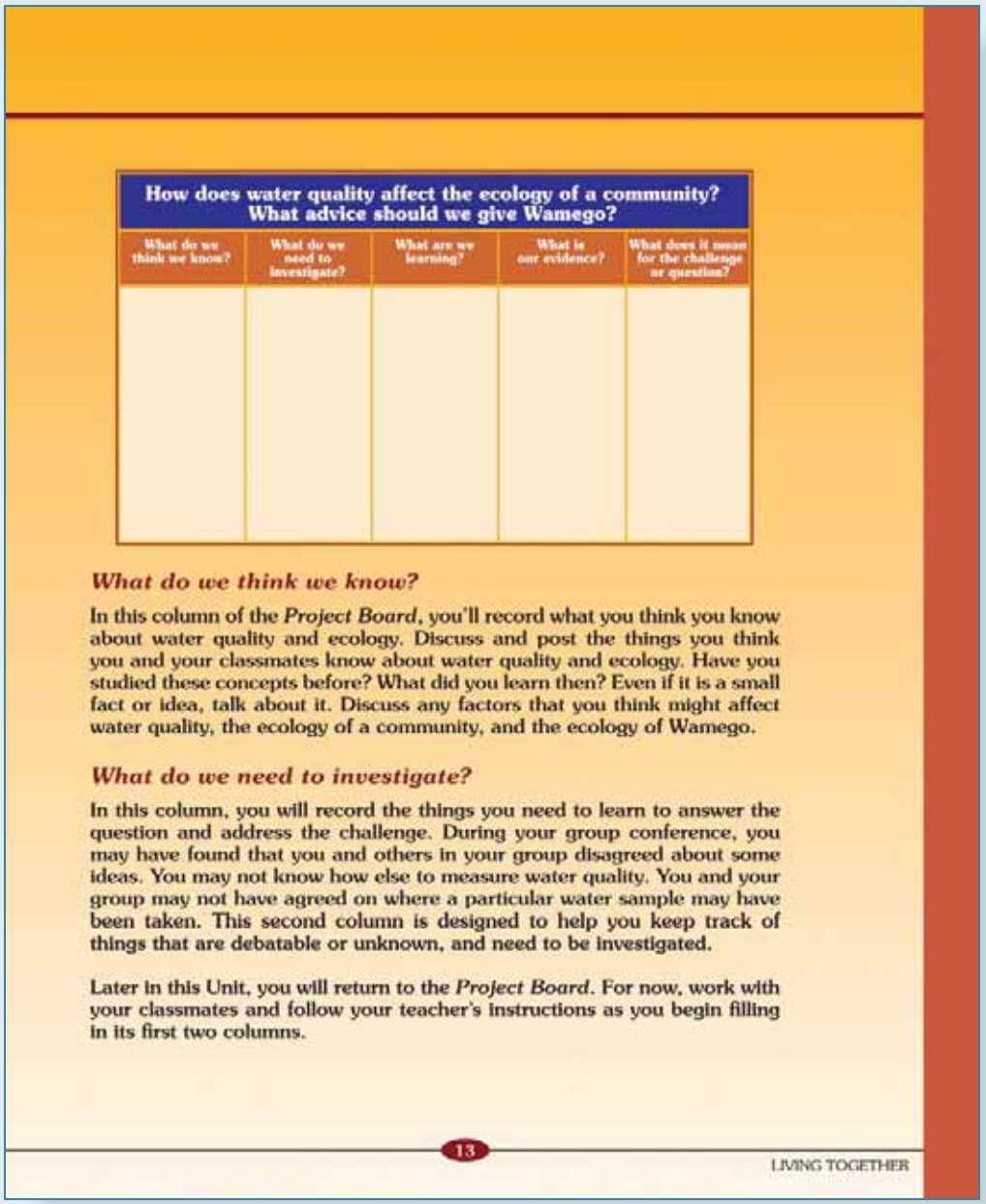
Project-Based Inquiry Science

△ Guide

At this point, the class will be supplying start-up information for the first two columns of the *Project Board (What do we think we know?* and, *What do we need to investigate?)*. Emphasize that more can be added to these two columns throughout the Unit.



How does water quality affect the ecology of a community? What advice should we give Wamego?

What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

What do we think we know?

In this column of the *Project Board*, you'll record what you think you know about water quality and ecology. Discuss and post the things you think you and your classmates know about water quality and ecology. Have you studied these concepts before? What did you learn then? Even if it is a small fact or idea, talk about it. Discuss any factors that you think might affect water quality, the ecology of a community, and the ecology of Wamego.

What do we need to investigate?

In this column, you will record the things you need to learn to answer the question and address the challenge. During your group conference, you may have found that you and others in your group disagreed about some ideas. You may not know how else to measure water quality. You and your group may not have agreed on where a particular water sample may have been taken. This second column is designed to help you keep track of things that are debatable or unknown, and need to be investigated.

Later in this Unit, you will return to the *Project Board*. For now, work with your classmates and follow your teacher's instructions as you begin filling in its first two columns.

13

LIVING TOGETHER

Distribute the student *Project Board* pages at this time. Remind students to keep a personal copy of the class *Project Board* to refer to as needed. Draw students' attention to the first column of the class *Project Board* to have students volunteer information to be recorded.

How does water quality affect the ecology of a community? What advice can you give Wamego?				
What do you think you know?	**What do you need to investigate?**	**What are you learning?**	**What is your evidence?**	**What does it mean for the challenge or question?**
1. We know that water quality needs to be such that it can support life. 2. We know the layout of Wamego and the river.	1. How water quality might change if the land use is different from what it is now. 2. How is water quality measured?			

Assessment Options

Targeted Concepts, Skills, and Nature of Science	How do I know if students got it?
Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas. When another person's or group's idea is used, credit needs to be given.	**ASK:** In what way do you play the role of scientists during conferencing or when you work in small groups? **LISTEN:** You should hear students relate that during conferencing or when working in small groups, they act like scientists because they share ideas, even if the ideas are different from one another.

Targeted Concepts, Skills, and Nature of Science	How do I know if students got it?
Scientists often break down big questions into smaller questions that they can investigate.	**ASK:** When did you begin to think about the many facets that make up water quality? **LISTEN:** Answers will vary. Some students may verbalize the necessity of thinking about needing a variety of ways to study water quality when they look at the five different water samples or when they look at the nine different settings pictured along the Rouge River.
Water is an essential substance in an ecosystem.	**ASK:** In what ways is water important to you and everything around you? **LISTEN:** You should be able to hear students say that plant and animal life are dependent on water to stay alive; that changes in water can affect all living things.
Water and land interact with each other.	**ASK:** How do you know that water and land interact with each other? **LISTEN:** Students should be able to say that water and land interact as they study the examples depicted in the photographs of the Rouge River. Some students may know from personal experience something about erosion or changes in the quality of the water that they drink.
An ecosystem is a complex community of interdependent organisms and the environment they share.	**ASK:** How is an ecosystem a complex community of interdependent organisms? **LISTEN:** By the end of the Unit, students should be able to iterate that an ecosystem contains living organisms whose populations interact with each other and that when some nonliving factors change, these populations can change in number and character.

Targeted Concepts, Skills, and Nature of Science	How do I know if students got it?
Humans use rivers for residential, commercial, industrial, and agricultural purposes. These activities affect water quality along a river.	**ASK:** How does the use of rivers by humans for residential, commercial, industrial, and agricultural purposes affect the quality of a river. **LISTEN:** By the end of the Unit, students should be able to conclude from their investigations throughout the Unit and through studying information about areas along the Rouge River watershed that water quality is affected by human activities.

Teacher Reflection Questions

- The Unit challenge was introduced. It is designed to motivate students to learn the concepts presented throughout this Unit. Could you tell if students were motivated by the challenge story? What can you do to maintain their motivation throughout the Unit?
- Were students able to successfully match the various jars with photographs?
- Were most students able to follow the story of Wamego and its problems? Are there too many factors for most students to follow and account for? Should the story be modified to reduce the amount of detail?

NOTES