FLOW
FISHERIES LEARNING ON THE WEB
UNIT 2: WATER | WWW.PROJECTFLOW.US

FLOW Unit 2: Water Overview

This series of five lessons from Fisheries Learning on the Web (FLOW) begins by introducing the concepts of watersheds and wetlands. The first two activities allow students to predict, observe and explain the movement of water. Lessons 3 and 4 discuss the relative availability of freshwater on earth and why water quality is so important. In the final lesson, students have an opportunity to make their own decisions concerning water quality, land use, and the environment.

Lesson 1: Exploring Watersheds

Simulates the movement and pooling of water representing rivers, lakes and ponds in a watershed.

Lesson 2: Wetland in a Pan

Demonstrates important wetland functions including filtering, flood buffering, and fish and wildlife habitat.

Lesson 3: Water Quantity

Reveals the relative amount of surface fresh water available for human use.

Lesson 4: What Makes Water Healthy

Helps students think about different ways to determine water quality.

Lesson 5: Hydropoly: A Decision-Making Game

Requires students to make land use decisions that affect the environment, especially wetlands.

Supplemental Materials

Note: Some lesson materials (cards, games, charts and other graphics) may be at the very end of this unit, rather than compiled with each lesson.

> See the lesson section ***materials and procedures*** and the ***Supplemental Materials*** section at the end of this document.

Lesson Assessment, State of Michigan Grade Level Content Expectations (GLCE) and National Benchmarks:

> See separate document: FLOW_Assessment_GLCE.pdf

Lesson 1: Exploring Watersheds

Activity: Students collaboratively build models of watersheds by placing a large piece of butcher paper over various sized objects in a large pan.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: Two 50-minute periods
Key terms: Elevation, Model, River system, Run-off, Slope, Watershed

Objectives

By creating a model of a watershed, students will be able to:

- Explain how water flows through a watershed
- Describe the characteristics of a watershed
- Demonstrate scientific concepts using a model
- Share ideas about science through purposeful conversation in collaborative groups
- Evaluate data, claims, personal knowledge through collaborative science discourse
- Communicate and defend findings of observations using evidence

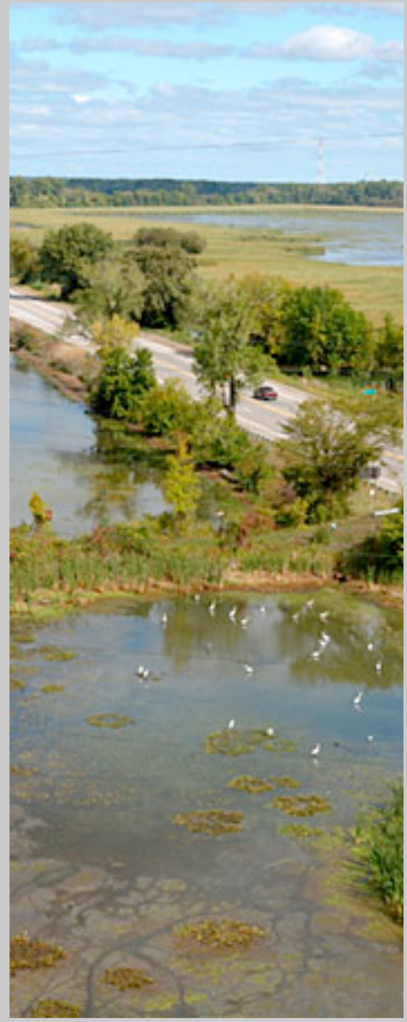

Photo: LaPorte

Summary

Students collaboratively build models of watersheds by placing a large piece of butcher paper over various sized objects in a large pan. As students spray their model watersheds with water, they observe and mark on their map the movement and pooling representing rivers, lakes and ponds.

Background

A **watershed** is an area of land that drains into a **river** system. Any water entering a watershed, usually as precipitation, travels from higher **elevations** to lower elevations. As the water moves downward, it forms streams and rivers. The channeling and pooling of water is determined by the shape or topography of the land. Water continues to move downward, and rivers may join with lakes or other rivers as they head toward the ocean.

Materials and Preparation

- Several tall objects and short objects (2 or 3 of each per model)
- White butcher paper (3’ x 4’ sheets)
- Large waterproof tin trays
- Transparency film
- Small spray bottles with water
- Newspaper

- Food coloring or tempra paint
- *Student worksheet. Part 1: What is a Watershed?*
- *Student worksheet. Part 2: Elevation and Observation Map*

Preparation: Educators should construct and test the watershed model prior to class to ensure that materials work appropriately.

Note:

- ***See Student worksheets, Parts 1 and 2,* at the end of this lesson (supplemental materials).**

Procedure

Preliminary Discussion

Ask students key questions:

- Does anyone know what causes a river to flow in a certain direction or how its shape may be altered?
- Do you think the land around our rivers affects the quality of the water?
- Introduce the term watershed. One way to introduce this term is to ask students to separate the word into "water" and "shed" (to pour or cause to pour off; to emit) and discuss what each word means. Ask students what "sheds" water? (The land around a river.)
- Inform the class that they will be learning about watersheds using a **model**, which is a simplified representation of a natural phenomenon. Models help scientists represent their current understanding of natural phenomena as well as construct new understanding.

Advance Preparation

1. Preview the materials and demonstrate how to build the watershed model. Connect the watershed model to the real world. Ask: What might be the purpose of this watershed model? Have students describe what the pieces of the model represent. (Paper = land. Spray bottle = precipitation.)
2. Have students form groups. Hand out Part 1 of the student worksheet: What is a Watershed?
3. Assign roles to group members: object placer, paper placer, taper, watershed transparency map creator, and/or sprayer. (Assigning roles is one strategy to facilitate small group interaction until students become adept at working together.)
4. Remind students that they are all responsible for creating individual watershed maps, filling out their predictions, observations, and explanations, and taking notes on the concepts they identify.
5. Distribute materials. Do not have the students get water bottles yet!

Build a Watershed Model

1. Review set-up procedure with students. (Steps 1-4 on the work sheet.)
2. Monitor students as they build their watershed models.

3. Create an elevation map. Describe the procedure for making an elevation map. (Steps 5-6 on the work sheet.) Students will mark high areas with "H" and low areas with "L" on both their model and on a separate transparency. Monitor students as they create maps.
4. Have groups raise their hands when maps are completed.
5. Predict water flow. Review steps for making predictions. (Step 7 on the work sheet.)
6. Monitor students as they make predictions and explanations on their worksheets or in journals, about how water will flow over their watershed model.
7. Have groups raise hands when predictions are completed.
8. Observe and test models. Inform the students that they are now ready to test their models and make observations. Remind them to keep detailed notes of their observations: they will use their observations to help explain their models.
9. Give each group a spray bottle. Students will use spray bottles to test their watershed model.
10. Monitor groups as students make observations. Return materials.

Source
Used with permission: Center for Highly Interactive Classrooms, Curricula and Computing in Education (Hi-ce), University of Michigan School of Education.

Discuss the Results

1. Have a few groups share their transparency elevation maps using an overhead projector. Ask:
    a. How did the water flow over the surface of the land? What patterns did you observe?
    b. How did the water accumulate? Where did the water accumulate?
    c. In what direction did the water flow? What caused the water to flow that way?
    d. The students have built a model (a representation) of a watershed. Review key concepts:
        - What is a model? What is the purpose of a model?
        - Have students describe what the pieces of the model represent.
2. Previously introduced watershed model parts:
3. Paper = land
4. Spray = precipitation
5. Newly introduced watershed model parts:
6. Branching pattern of the water flow (smaller rivers leading into larger rivers) = a river system
7. Wet portions of the paper = absorption of water by land
8. Flow of water over the paper = run-off
9. Change in elevations on land = slope
10. Entire model = watershed
11. Discuss how using the models can help them investigate their river.
12. Remind students that they observed the results from testing a model. To enhance understanding, students may wish to take notes, create a classroom chart, or make entries in a journal. The following key concepts should emerge:
    a. A watershed is an area of land that drains into a river system.
    b. Water moves from areas of high elevation to areas of lower elevation, following the slope in land.

   c. The flow of water occurs in a branching pattern in streams and rivers (i.e. stream system). Branches may combine to form lakes or larger rivers
   d. Effects of precipitation— i.e. rain and snow might be absorbed by the ground, or might form run-off that feeds into rivers.
13. Ask student to describe the direction of water flow within the watershed. Prompt students by asking them how elevation affects the flow of water. A common misconception is that all rivers flow south. Be sure to emphasize that rivers flow in all directions depending on the change in elevation in the watershed. (Use Michigan as an example.)
14. Ask students to draw the flow of water on their own maps.
15. Have students come to the front of the room and draw the flow of water for a specific part of the map. Students should explain why the water flows as they predict.
16. Repeat the above step until all map parts are explained.

Teaching Tips

Predict, Observe, Explain
The cycle of predicting, observing, and explaining is a strategy to support students in constructing understanding. Emphasize the reasons that predictions, observations, and explanations are made. Encourage students to question each other, elaborate on their ideas, and share their thinking with other groups.

Time Management
The purpose of sharing ideas is to determine that students understand main ideas. Often, however, there is not enough time for all groups to present their observations. Consider having a few groups present ideas, while others participate in the discussions by stating whether or not they observed the same patterns.

Assessment & Standards

See separate document: FLOW_Assessment_GLCE.pdf

FLOW Feedback

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Go to: http://www.miseagrant.umich.edu/flow/flow-feedback.html

Supplemental Materials, FLOW Unit 2

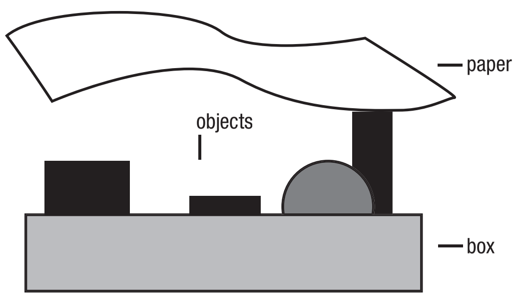
Lesson 1 - Exploring Watersheds - Documents:

- Student worksheet Part 1: What is a Watershed?
- Student worksheet Part 2: Elevation and Observation Map

Part 1

Build Your Watershed Model

1. Place newspaper under the tray.
2. Arrange a tall object near one edge of the tray and arrange the shorter objects toward the center of the tray.
3. Crumple up a piece of butcher paper. Be careful not to rip any holes in the paper.
4. Carefully cover the tall and short objects with the sheet of butcher paper, pressing the paper down so that it looks like tall and short hills. Use pieces of tape to keep the paper from lifting up from the tray.



side view of box w/ objects

Draw Your Elevation Map

5. On the model, mark high areas with an H and low areas with an L.
6. On the next page, draw an elevation map of your model. Sketch a bird's eye view of the high and low areas (as if you were looking down at your model). Mark the high areas with Hs and the low areas with Ls.

Note: Each member of your group should draw his or her own elevation map. Chose one member to draw the map on a piece of transparency film.

Make Your Prediction

7. On the next page, predict how the water will flow over the model if you spray water on it. Include where water will flow and accumulate. On your elevation map, draw arrows to show how the river will flow and draw circles to indicate where the water accumulates.

Observe Your Model

8. Hold the spray bottle about 5 inches from your model and spray for several minutes until you get a continual flow of water. Take turns spraying your model. Alternate where each person sprays.
9. Return spray bottles to the teacher.
10. Using a different color pen, draw on your map how the water flows over your model and where the water accumulates. Note the pattern of how the water flows over your model, how smaller rivers join to form larger rivers and how rivers flow into lakes.

Note: Each member of your group should draw his or her observations. One member should draw on the transparency film.

Part 2

Elevation and Observation Map

Use space provided to make an elevation map and observation map of your watershed.

Elevation

Observation

1. Explain how the water flowed over your model (what patterns occurred)? What caused the water to flow the way it did?

2. Did your observations agree or disagree with your predictions? How were they similar or different?

Lesson 2: Wetland in a Pan

Activity: Students observe a simple wetland model that demonstrates wetland functions including filtering, flood buffering, and nursery for aquatic organisms.

Grade level: 4-8
Subjects: Science and social studies
Setting: Classroom and/or outside
Duration: 1.5 hours
Key terms: Nursery, Wetland

Photo: D. Brenner

Objectives

After participating in this activity, students will be able to:

- Observe building a model wetland
- Understand that wetlands are defined by plants, soil and water
- Identify some wetland types and their locations
- Relate importance of wetland function to people's needs and daily lives
- Draw conclusions from observations of multiple trials of the wetland model, including modifications to model
- Demonstrate wetland functions using the model

Summary

Wetlands provide some of the most important ecological functions of any habitat type. They provide **nursery** areas for fish, support an abundance of wildlife, help control flooding, filter nutrients and sediments and even some harmful pollutants. In the process, wetlands improve water quality and enhance our natural environment. By creating a wetland model, students observe these concepts in action and watch what can happen when a wetland disappears.

Background

Wetlands are an important feature of the Great Lake region. Marshes, a type of wetland, are found along the Great Lakes, but in some areas they've decreased by 90 percent. It is estimated that Michigan once had over 11 million acres of wetlands. Today, a little over 5.6 million acres remain.

A **wetland** is an area that periodically has waterlogged soils or is covered by shallow surface water. This surface water supports plants and animals that are adapted to living in a watery environment. Some major functions of a wetland are:

- Reduce flooding (flood buffering)
- Filter pollution
- Prevent soil erosion
- Provide habitat for aquatic and terrestrial animals and plants

- Serve as breeding, feeding, and nesting grounds

Wetlands are classified as marshes, bogs, swamps, vernal ponds, and wet meadows. These are the types found in Michigan. Some non-Michigan wetlands are salt marshes, mangrove swamps, and prairie potholes.

See: Great Lakes Coastal Wetlands, www.miseagrant.umich.edu/wetlands

Materials and Preparation

- Modeling clay
- Rolling paint pan (or small aluminum pan)
- Sponges
- Carpet or florist oasis foam
- Watering can or similar device
- Cup of soil
- Jar of muddy water

Procedure

Build a Model Wetland

The first part of the procedure demonstrates how wetlands prevent flooding and soil erosion.

1. Explain that wetlands, like all habitats, are very complicated natural systems. They perform some very important functions such as filtering pollutants, reducing flood damage, and preventing soil erosion. Some wetlands, at times, recharge groundwater supplies.
2. Explain that you will make a wetland model to demonstrate some of these functions in a very simplified way.
3. Put the clay along one side of the pan. Fit the piece of carpeting or sponge into the wetland area along the edge of the clay. Slowly sprinkle some rain on land (the clay) and let the students observe and describe what is happening. Ask: If I make it rain on the model, what do you think will happen to the rainwater? (Rain will flow downhill.) The wetland (carpeting) will slow the rate of flow, and the excess rain will slowly enter the body of water. Point out that the wetland absorbed some of the water—pick up the carpeting and squeeze some water out to prove it.
4. Ask: What do you think will happen if the wetland is removed? (The water will not be absorbed; it will flow more quickly into the body of water.) Remove the carpeting and water. Pour the same amount of water on the model at the same spot and rate as before. Have the students note any differences. The water should fill the body of water much more quickly and may eventually overflow and flood the land. That's because it is no longer retained by the wetland.

Discuss the Results

- Explain that most wetlands are shallow basins that collect water and slow its rate of flow and also retain water for a time. This slowing process helps reduce flooding and also helps prevent soil erosion. Ask: If a wetland is destroyed, and houses are built in its place, what might happen to the houses during a severe rainstorm?

Why? (They might be flooded because the wetland will not be there to absorb and slow the rush of water from higher ground.)

- In many areas, wetlands are drained and filled, and houses and marinas are built right along the water. Without a wetland buffer, these developed areas, particularly along the coast, are often subjected to severe flooding and erosion, especially during violent storms.

Modify the Wetland Model
The second part of the procedure demonstrates how wetlands improve water quality by filtering sediments and pollutants.

1. Pour the water from the last demonstration out of the model, squeeze out the "wetland" and replace the piece of carpeting. Spread a layer of soil over the clay. Explain that this demonstration will be just like the first, except that topsoil will cover the clay. Ask: What do you think will happen to the bare soil when it rains? (The rain should pick up and carry some sediment over the land and into the body of water. Explain that this water represents polluted runoff such as silt from farmlands and construction sites or salt from snow-covered streets.)
2. Ask the students to compare the water that ends up in the body of water with the muddy water in the jar. Explain that the carpeting trapped the soil particles, making the water in the body of water much clearer. The uphill side of the wetland should be coated with trapped sediment.
3. Remove the carpeting, pour out the water, and try the experiment again. What happens without the wetland in place? Ask the students why all the soil particles end up in the body of water this time. (The thick mat of plant roots in a wetland helps trap silt and some types of pollutants, much as the carpet or foam did in the model. Without a wetland, excessive amounts of silt and pollutants can end up in lakes, rivers, and other bodies of water.)

Discuss the Results

- How might muddy water affect fish? (Makes it harder for them to see and breathe with clogged gills, and could lead to their death.) How might the muddy water affect other animals and plants? (Settling sediment smothers clams, plants do not get sunlight needed for growth, birds and other animals that eat fish or plants have less to eat if food sources die or cannot be seen in muddy water, etc.)
- How might the muddy water affect boats and ships? (The mud settles out and eventually fills channels important for navigation.) How might all of this affect you? (Decrease in natural resources and food sources; decline in quality of drinking water; impacts on recreation such as swimming and fishing; change in aesthetics; change in community economy, such as shipping problems that affect jobs and industry, etc.) How can we prevent these undesirable effects? (By protecting wetlands and helping to make their benefits known!)
- Have students describe how wetlands function to reduce flooding and retain sediments.
- Have students analyze what would happen to water, sediments, homes and wildlife if wetlands were destroyed.

Adaptations

Students, individually or as small groups, can make their own detailed wetland models using small aluminum foil pans, clay, and florist's foam, carpet, or sponges. Provide reference books with pictures of different types of wetlands. Students can use an assortment of collected material to decorate their models. Have students present their models by explaining their particular characteristics.

Some ideas:

1. Use long pine needles for reeds and toothpicks to attach plants.
2. Shape wetland creatures from clay, or glue paper cutouts to toothpicks.
3. Dried flower heads make nice trees, and small pinecones painted green form evergreens.
4. For cattails, use cotton swabs. Paint sticks green and cotton parts brown, or paint toothpicks green, and attach bits of brown clay to the tops.

Source

Adapted with permission from "A Wetland in a Pan: from *WOW! The Wonder of Wetlands*, for the Great Lakes Education Program. Modified by Julie Champion, Metro Beach Nature Center, Michigan; Bette Nebel, Macomb Country Community College, Michigan; and Michael Schichtel, Mohawk Elementary School, Michigan.

Assessment & Standards

See separate document: FLOW_Assessment_GLCE.pdf

FLOW Feedback

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Supplemental Materials, FLOW Unit 2

Lesson 2 - Wetland in a Pan

- See Coastal Habitat: www.miseagrant.umich.edu/habitat

Lesson 3: Water Quantity

Photo: Dinny

Activity: Students remove measured amounts of water from a five-gallon bucket, simulating the amount of fresh water available on earth.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key terms: Freshwater, Groundwater, Salt water, Surface water

Objectives

After participating in this activity, students will:

- Experience the relative scarcity of freshwater on the planet
- Explain why some of the earth's water is not easily accessible
- Compare and contrast surface water systems and groundwater in regard to their relative sizes as Earth's freshwater reservoirs
- Manipulate simple tools that aid observation and data collection, make accurate measurements with appropriate units
- Use tools and equipment appropriate to scientific investigations
- Conduct scientific investigations using appropriate tools and techniques

Summary

Even though the earth contains an abundance of water, only a small percentage is fresh water. An even smaller amount of this freshwater is accessible and usable by the people and animals that need it. As the human population grows, the amount of freshwater available per person shrinks. The relatively small amount of available freshwater demonstrates how critical it is for everyone to help maintain clean, healthy lakes and streams.

Background

Oceans and seas contain more than 97 percent of the water on the planet. Because it is **salt water**, it is not healthy for humans and animals to drink. The remaining supply of water on Earth is fresh water.

The amount of freshwater available for use by living beings is very small (See chart below.) The Great Lakes contain 20 percent of the world's supply of surface freshwater.

Other reservoirs of freshwater are not available for use by humans. For instance, more than 2 percent of the Earth's freshwater is "locked" in ice caps and glaciers.

The Earth's supply of water remains the same: the planet has as much water as it will ever have. Yet world population continues to grow. The relatively small amount of available freshwater supports more than 6 billion people. As this number increases, the amount of fresh water available per person decreases. Thus maintaining the quality of the Earth's available fresh water is vitally important.

Amount of water in each major reservoir on earth:

Saltwater in oceans:	97.2%
Ice caps and glaciers:	2.14%
Groundwater:	0.61%
Surface water:	0.009%
Soil moisture:	0.005%
Total:	**100%**

Materials and Preparation

- 5-gallon bucket
- 2-cup transparent measuring cup
- 1-cup transparent measuring cup
- 1 eye-dropper
- *Water Body Worksheet*

Note: See *Water Body Worksheet* and other materials at the end of this lesson (supplemental materials).

Advance Preparation

Before class starts, fill the 5-gallon bucket with water. Have the other materials nearby in a place where the whole class can observe. **Note:** Be sure to wipe water off the floor if spills occur during this activity.

Procedure

1. Explain to students that the water in the 5-gallon bucket represents all the water on Earth. Ask them to name the kinds of water that exist in, on or around Earth. They should be able to name rivers, lakes, oceans, clouds or water vapor, ice caps, groundwater, water held in soil, and water held in plants and animals. Provide hints so that all types of water are mentioned.
2. Ask two students to come up and help with the demonstration. Ask one of them to remove two cups of water from the bucket, using a measuring cup. Have the student hold that amount so everyone in the class can see it. Ask: What does the water in the cup represent? (Freshwater.) Ask: What does the water remaining in the bucket represent? (Saltwater.) Explain that the saltwater is not usable by humans because drinking it would make us very sick.

3. Move the bucket aside. Ask the first student to pour 1/2 cup of water into the one-cup measurer held by the other student. Ask: What does the 1-1/2 cups still left in the two-cup measurer represent? (Polar ice caps.) Explain that this water is unavailable for our use because it is frozen. Set this cup aside. The first student can return to his or her seat.
4. Ask the class what the 1/2 cup of water represents. (Groundwater, surface water (e.g. lakes, rivers, wetlands), and water vapor in the atmosphere.) Have the class guess how much water should be removed from the cup to represent only the surface water on Earth. After a few guesses, pull out the eye-dropper from your pocket and draw some water into it. Place one drop of water into the hand of a few students. Explain that one drop of water out of a whole 5-gallon bucket represents the water that is available to us and other animals for drinking.
5. Allow the class to think about this for a minute. Then explain to them that the total amount of water on the planet is not going to change. Even though water moves around on the planet and changes from one kind to another, we will never have any more than we have right now.

Discuss the Results

Spend some time discussing the activity with the class. The following questions are a good place to start:

- Were you surprised at how little water is available for human use?
- Would you call water a scarce or an abundant resource? Why?
- What do we need/use water for?
- Why can't we drink saltwater?
- The number of people who need to use Earth's freshwater keeps increasing. If the amount of freshwater cannot change, but there are more people who need it, what does that mean? What might happen?
- Can people and animals live without clean freshwater?
- What is the main cause of the increased demand for freshwater?

Ask students to think about the term "water quality." Find out from them what they think it means. If they get stuck, have them think about it in terms of low water quality or high water quality: would they want to drink, wash, swim, or cook with low quality water or high quality water? Have them come up with as many descriptions as they can for what might be "low quality" and "high quality" water. See: Lesson 2.4

Source

North Carolina Museum of Natural Sciences - Adapted with permission from the Girls in Science Program. Original source content: Hands On Save Our Streams - The Save Our Streams Teacher's Manual, Chapter One, Watersheds, Water Water Everywhere and Not A Drop to Spare, Water Supply Activity, The Izaak Walton League of America.

Assessment & Standards

See separate document: FLOW_Assessment_GLCE.pdf

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Supplemental Materials, FLOW Unit 2

Lesson 3 - Water Quantity, Documents:

- Water Body Worksheet

WATER BODY WORKSHEET

In class today, you have seen how much water is on the planet and how it is distributed. One thing people don't think a lot about is that we depend on water every day. If you don't get enough (clean) water, you can get very sick. In this exercise, you will calculate how much water is in your body right now, as well as how much water you are likely to utilize in your body over your whole lifetime.

1. Figure out how many pounds of water are in your body. Approximately five sixths of your body weight is water. Use this equation:

5/6 X __________________ lbs. = ___________________lbs.

2. Now use this answer to find out how many gallons of water are in your body. (Note: 1gallon of water weighs 8.1 lbs.)

/ 8.1 = __________________ gallons

(answer from part 1)

3. Now find out how much water your body needs during your life span. Each person's body needs to replace 1.5 million gallons of water throughout their life. To get a feel for this, a back-yard swimming pool holds about 20,000 gallons of water. How many swimming pools of water will you need in your life? Use this equation:

1,500,000 gallons / 20,000 gallons = ________________________

(swimming pools of water used in a lifetime)

Was there anything here that was surprising to you? Explain.

____

____

____

____

____

Lesson 4: What Makes Water Healthy?

Activity: Students make observations and measurements of several water samples. This activity helps students think about different ways to determine water quality.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 50 minutes or more
Key terms: Benthic, pH, Secchi disk, Sediment, Turbidity, Water clarity, Water quality

Photo: D. Brenner

Objectives

After participating in this activity, students will:

- Develop their own criteria for the quality of water
- Understand that there is more to water quality than "meets the eye"
- Engage in a few water quality tests used by scientists
- Explain how water quality in both groundwater and surface systems is impacted by land use decisions
- Classify solutions as acidic or basic, given their pH
- Classify substances by their chemical properties (flammability, pH, acid-base indicators)
- Use tools and equipment appropriate to scientific investigations
- Manipulate simple tools that aid observation and data collection
- Make accurate measurements with appropriate units
- Identify the need for evidence in making scientific decisions
- Use data/samples as evidence to separate fact from opinion

Summary

Water quality is one of the most important factors in a healthy ecosystem. Clean water supports a diversity of plants and wildlife. In turn, our actions on land affect the quality of our water. Pollutants, excessive nutrients from fertilizers, and **sediment** frequently get carried into local lakes and rivers via run-off from urban areas or agricultural fields. By observing and evaluating several water samples, students begin to consider the factors that influence water quality.

Background

Scientists measure a variety of properties to determine water quality. These include temperature, acidity (pH), dissolved solids (specific conductance), particulate matter (turbidity), dissolved oxygen, hardness and suspended sediment. Each reveals something different about the health of a water body.

The result of a single measurement, however, is actually less important than monitoring changes over time. For example, if you measure the pH of the creek behind your house and find that it is 5.5, you might think it is acidic. But a pH of 5.5 might be "normal" for that creek. If the pH or the turbidity of your creek begins to change, however, something may be happening (probably upstream) that is affecting water quality. Taking routine measurements at scheduled intervals allows you to monitor overall changes in water quality.

The following water properties are important in determining water quality:

- **Temperature:** Water temperature is important to fish and aquatic plants. Temperature can affect the level of oxygen, as well as the ability of organisms to resist certain pollutants.
- **Acidity — pH:** The measurement of pH is a measure of the amount of hydrogen ions ($H+$) present in a substance such as water. Knowing the amount of hydrogen in a substance allows us to judge whether it is acidic, neutral, or basic.
- **Dissolved Oxygen:** A small amount of oxygen, about ten molecules of oxygen per million molecules of water, is dissolved in water. Fish and microscopic organisms need dissolved oxygen to survive.
- **Turbidity:** Turbidity makes the water cloudy or opaque. Turbidity is the amount of particulate matter (such as clay, silt, plankton, or microscopic organisms) suspended in water.
- **Specific conductance:** Specific conductance measures the capacity of water to conduct an electrical current. It depends on the amount of dissolved solids, such as salt, in the water.
- **Hardness:** The amount of dissolved calcium and magnesium in water determines its "hardness." Water hardness varies throughout the United States.
- **Suspended sediment:** Suspended sediment is the amount of soil circulating in water. The amount depends in part on the speed of the water flow. Fast-flowing water can pick up and hold, or suspend, more soil than calm water.

Materials and Preparation

- 5 clear glass jars or clear soda bottles with lids
- Instant coffee and/or cocoa, salt, hydrochloric acid, isopropyl alcohol, and food coloring (to make a purple color)
- Local river or pond water
- *Water Quality Worksheet*
- Water quality testing kits that can be used to measure oxygen and pH

Note: See *Water Quality Worksheet* and other materials at the end of this lesson (supplemental materials).

Advance Preparation

Create water quality jars. Fill the 5 jars with water. (Jar 5 will be filled with the river water.)

- Jar 1 -Add enough coffee grounds and cocoa powder until the water has a good "dirty" look. Label the jar 1.
- Jar 2- Add food coloring so that the water appears clear purple. Label the jar 2.

- Jar 3- Add a trace of hydrochloric acid. The HCl solution should be clear and colorless. Label the jar 3.
- Jar 4- Add a few tablespoons of kosher table salt. The salt will dissolve in the water, resulting in a clear colorless solution. Label the jar 4.
- Jar 5- Fill a jar or bottle with water from your local river. Label the jar 5.

Procedure

1. In small groups, have students examine the water sample jars. You may choose to have students record their observations on the Water Quality Worksheet or in their notebooks.
2. Ask groups of students to work together to determine which of the water samples they would be willing to use for such things as fishing, swimming, boating or drinking.
3. After students have observed all the jars, have them share their consensus and rationale for their decisions regarding water use. Prompt students to provide evidence for their decisions. (You may also choose to record the class data in a chart.)
4. Using this shared experience, facilitate a discussion that leads to an agreed upon definition of "water quality."
5. Have students brainstorm answers to the following questions: What is meant by quality? What is water quality? How can we determine water quality? Why is water quality important to us and to other animals? How did we determine water quality for the bottles? Are these methods trustworthy? How else could we measure water quality? How might scientists measure water quality?
6. Introduce the concepts of dissolved oxygen and pH. Explain what numerical values for each are necessary for life. Explain that scientists use these numerical values to measure water quality.
7. Use one of the water samples from before to demonstrate how each test is conducted.
8. Allow groups of students to measure oxygen and pH for the other water samples. Summarize the results on the board. Discuss the results from a scientist's perspective. Which sample has the highest quality based on this data?
9. Discuss whether these results are consistent with the determinations made just by looking at the water.
10. Explain that water quality is a complex concept and there are many other variables that scientists use to measure it. Explain that you can't tell true water quality just by looking at it.

Adaptations

Provide students with articles from newspapers that refer to the water quality of local rivers. Choose articles that address living organisms in the water or human uses of the water. Describe how members of the community talk about their river or what actions they're taking to prevent or reduce water quality problems.

Source

Used with permission: Center for Highly Interactive Classrooms, Curricula and Computing in Education (Hi-ce), University of Michigan School of Education.

Assessment & Standards

See separate document: FLOW_Assessment_GLCE.pdf

FLOW Feedback

Please take 10 minutes to provide us with your feedback.
Go to: http://www.miseagrant.umich.edu/flow/flow-feedback.html

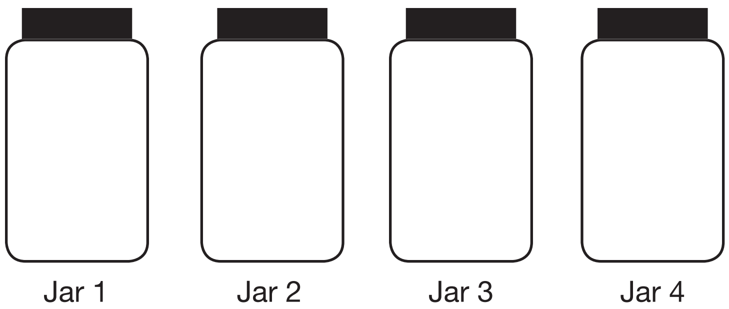
Supplemental Materials, FLOW Unit 2

Lesson 4 - What Makes Water Healthy, Documents:

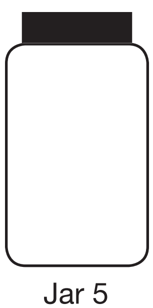
- Water Quality Worksheet

DIRECTIONS:

Look at jars 1-4 that your teacher has provided. Would you use the water in each of those jars to fish? Swim? Boat? Drink? Record your answers on the back of this sheet. Provide reasons for your answers.



Look at jar 5. Would you use the water in that jar to fish? Swim? Boat? Drink?



1. How did we determine water quality for the bottles? Was it an adequate method?

2. How else could we measure water quality?

3. If we were walking along a river, lake or stream, how could we determine its quality?

Lesson 5: Hydropoly: A Decision-Making Game

Activity: Students play a board game to hone their decision-making skills. Through the various choices posed in the game, they are asked to consider both economic and environmental well being in making decisions.

Grade level: 4-8
Subjects: Science, social studies
Setting: Classroom
Duration: 1 hour
Key terms: Land use, Wetlands

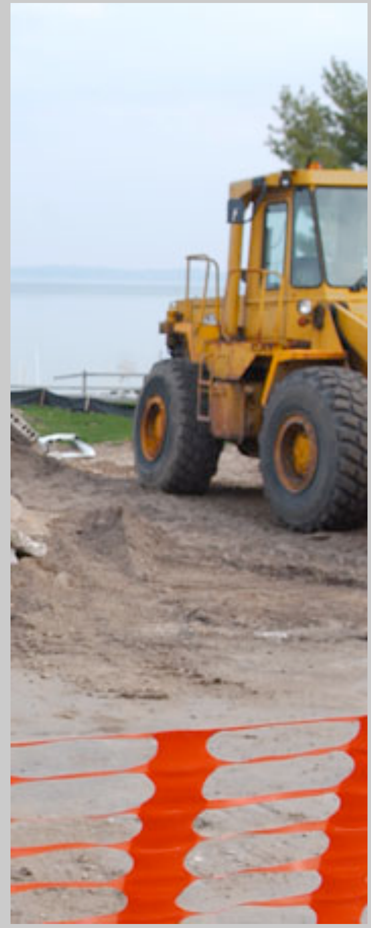


Photo: Marsee

Objectives

After participating in this activity, students will be able to:

- Discuss land-use practices that affect Great Lakes wetlands
- Make decisions and recognize personal priorities with regard to wetlands
- Describe some of the economic factors that often drive **land use**

Summary

Every day we make choices. We decide simple things like what to wear, what to eat, or how much time to allow for homework. Some decisions, however, require us to think critically and consider the potential consequences of our actions. Through the various land-use choices posed in the board game Hydropoly, students must consider both the economic and environmental consequences of their decisions. This type of decision-making helps prepare young people for situations they'll encounter throughout their lives.

Background

Coastal and inland communities in the Great Lakes region face difficult land use decisions every day. Land use refers to how land within a community is used—whether for houses, businesses, agriculture or natural areas. Local leaders must decide where to build houses and what type of industry to support. Communities must also consider another important factor—the health of the environment. A healthy environment that allows for natural areas, open green space, and clean water attracts residents and enhances quality of life.

Protecting wetlands is another way to enhance our natural environment. Wetlands provide important ecological benefits—such as water filtration, habitat and flood control—that need to be considered in land use decisions. Yet wetland benefits are frequently overlooked. Financial gain and economic concerns often override environmental issues. Despite this historic trend, some communities are recognizing that a healthy environment is closely tied to a healthy economy. We could call this principle "eco-nomics"—the healthy marriage of ecological protection and economic growth.

In essence, all land use decisions have short- and long-term consequences that affect the environment. It's important to weigh the pros and cons of every decision and make the best choices possible.

Materials and Preparation

- Hydropoly game boards (one for each small group of students)
- One set of *Hydropoly Decision Cards* per game board
- One die (not pair) per game board
- Tape
- Scissors
- Six different-colored playing pieces per game board (construction paper squares or pieces from another game)

Note: See *Hydropoly Decision Cards* and other materials at the end of this unit (Supplemental Materials).

Advance Preparation

1. Read the game instructions below.
2. Copy Decision Cards (2-3 sets). Cut apart individual cards.
3. Design a game board for use in your classroom. The game board should have the following types of labeled spaces: Start, Roll Again, Lose a Turn, Decision Card, many blank spaces, The Winner.

Procedure

1. Ask students to describe decisions that they have made recently. What do they like and dislike about making decisions? What helps them make a wise choice? Have them list important considerations. Have any of them made a wrong decision recently (or ever)? How can wrong decisions be a good experience? (We can learn from our mistakes.)
2. Divide the class into small groups. Hydropoly may be played by 2-6 players, or 2-6 teams of players. Discuss "eco-nomics" before beginning to play.

Review the Rules

1. Each player (or team) selects a game piece and places it on the space marked "Start." Each player rolls the die. The player who rolls the highest number goes first. Play proceeds in a clockwise direction.
2. The first player rolls the die and moves his or her playing piece the number of spaces indicated on the die. Move in the direction indicated by the arrows on the board. When a player lands on a blank space, his or her turn is over, and play advances to the next player. When a player lands on a space marked "Roll Again," s/he may do so and move along the board as before. If a player lands on "Lose A Turn," the turn is over, and s/he must skip the next turn.
3. Decision Cards: when a player lands on a "Decision Card" space, s/he must randomly select one of the cards (cards should be face-down). An opponent reads the top

portion of the card aloud. (Do not read the "Consequences" out loud.) The player has a maximum of two minutes to make a decision. If playing in teams, team members may discuss the decision quietly. When a player announces his or her decision, the person holding the card reads the "Consequences," which tell how many spaces the player has earned or lost for the decision. The player must follow the instructions given on the card and return the card to the pile. The player's turn continues until landing on a blank space or "Lose A Turn." Play then moves to the next player or team.

4. Players may only reach "The Winner" space by an exact roll of the die. (If a player is 4 spaces away, for example, and rolls a 5, s/he may not move and must forfeit the turn. If a player rolls a 3, s/he moves 3 spaces but must then roll a 1 to win.)

Note: The consequences specified on each *Hydropoly Decision Card* rewards learners for choosing certain actions in relation to their environments. If you wish other values to be considered, have the class or team of students determine a new set of consequences and substitute them on the "Decision Cards" before the game begins.

- When students understand the rules, play the game! You may choose to have learners play "blind" first, and then discuss eco-nomics after the game. Play several games.
- After the games have ended, discuss the results—who won, and why the winner reached the end more quickly than others. What did players think about while making decisions? Students can revise or confirm the considerations they made in the opening discussion.

Discuss the Results

Discuss why it is important to consider wetlands, coastal resources, and other environmental matters in scenarios like those presented in the game. Have students research community actions regarding aquatic resource management. Do they think wise decisions were made?

Source

Adapted for the Great Lakes Education Program "Hydropoly" with permission. Original source: WOW! The Wonders of Wetlands, pp. 260-265.

Adaptations

Have students write a series of Decision Cards that apply to the management of a wetland or other aquatic resources (such as lakes, rivers and coastlines) in their community. Include current political debates if possible.

Assessment & Standards

See separate document: FLOW_Assessment_GLCE.pdf

FLOW Feedback

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Supplemental Materials, FLOW Unit 2

Lesson 5 - Hydropoly: A Decision-Making Game, Documents:

- Hydropoly Decision Cards

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You have inherited $500,000! Now you can buy land and build your dream home. You narrow your choices down to two properties. One (A) lies right along the shores of beautiful Crystal Lake; the other (B) is nestled in a quiet upland forest. Both properties cost the same. Which will you choose?

CONSEQUENCES

(A) Building that close to the water will surely harm or destroy wetlands! Move back three spaces. (B) If you cut down only enough trees to make room for the house, you will harm less natural habitat than you would in (A). Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You live in a bustling city that lies near the Clinton River. It is election day for a new state governor. Candidate A promises increased economic growth and more jobs. He supports the construction of a huge new shopping mall near the river. Candidate B proposes to increase economic growth by promoting travel and recreation. He also wants to build a mall in an abandoned building near a major highway. Will you vote for A or B?

CONSEQUENCES

(A) Building close to the Clinton River will surely harm or destroy wetlands. The city and state do not seem to be badly in need or growth and can make money in other ways. Move back three spaces. (B) It makes sense to build in an area that is already developed, keeping wetlands intact so they can add to the economy in other ways. Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a kindhearted person who donates $200 each year to a charity or good cause. You have been asked to give money to either (A) a conservation organization that helps protect wetlands worldwide, or (B) a local Boy Scout troop. If you choose A, you will be helping to preserve wetlands and protect wildlife all over the world. If you choose B, you can ask the Scouts to use the money to clean up and restore a small wetland in your community. Which will you choose?

CONSEQUENCES

Both choices have their merits and positive results. Move ahead one space.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a farmer who is getting older and thinking about retiring. Your land was once a Great Lakes wetland (a shallow area that stayed very wet throughout the spring). If you stop plowing the land, it will turn into a wetland again. You need to sell your land to earn retirement money. You are offered money from (A) someone who will develop the land for housing or business, and (B) a conservation organization that will keep the land as a wetland preserve, providing you with a tax break. The developer offers you twice as much money. Which will you choose?

CONSEQUENCES

(A) Move back two spaces. (B) Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a town zoning officer. You decide the number and type of places that can be built in your Great Lakes area. One of only a few wetlands in the town is due for rezoning. The townspeople are encouraging you to vote in one of two ways on the zoning: (A) zone the area for preservation. Which will you choose?; (B) allow housing for the poor to be built there (this housing is badly needed)

CONSEQUENCES

(A) With so few wetlands in town, too many benefits would be lost by destroying the site in question. Move ahead two spaces. (B) The housing is needed, but it can be built in another location. The wetland is needed for good water quality. Move back two spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a very wealthy landowner who is about to build a housing development that will make you even richer! The land contains some Lake. St. Clair and Clinton River wetlands that would be destroyed by the project. You can (A) cancel the project, or (B) go to great expense to build new wetlands nearby to replace the one that will be destroyed. Which will you choose?

CONSEQUENCES

(A) Move ahead three spaces. (B) Move ahead one space. The plan to replace the wetland is a decent choice, but the costs (money and habitat) may outweigh the benefits. Natural wetlands are likely to be healthier.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You are a farmer. You own 100 acres near the Kalamazoo River, which you plant in corn. Times are tough and you and your spouse are expecting a child. In the past, you have always left a strip of land along the waterway unplowed. The natural growth of the aquatic plants helps keep the water clean and provides habitat for many animals. But if you planted corn there instead, you would have about 15 extra acres of crops. Will you plow it this year (A) or not (B)?

CONSEQUENCES

(A) Move back three spaces.
(B) Move ahead 4 spaces. That is a tough decision!

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

Today is Saturday, and you have tickets to a very cool outdoor concert that you have been looking forward to for months. The tickets cost you a month's allowance, but it is worth it. Your little brother just came in and told you about the Lake Gogebic wetland clean-up day near his school. They plan to pick up trash and plant new plants all around the area. He is very excited and wants you to come and help, since they need lots of people to get the work done. If you go, you will miss the concert. Where will you go? (A) With your little brother; (B) to the concert.

CONSEQUENCES

(A) What a sacrifice! Move ahead three spaces. (B) Move back one space.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You work for the state's highway department. A new road being built will destroy six acres of Great Lakes coasts and wetlands. To get the permit to build the road, the department had to promise to replace the wetlands. You are in charge of hiring a company to do the work, and you must choose between two companies. The expensive one guarantees that the new wetlands will survive; the cheaper one does not, but thinks their wetland will be good. Will you (A) save state money and take a chance on the wetlands' survival or (B) spend more and get the guarantee?

CONSEQUENCES

(A) Move back four spaces. (B) Move ahead three spaces.

HYDROPOLY DECISION CARDS

DECISIONS! DECISIONS!

You have designed your dream house, and you are very proud of it. The plans show a beautiful front that faces a quiet street and a garage in the back with a long driveway around to it. There are Au Sable River wetlands in your back-yard that will have to be filled in for the driveway and garage. Will you (A) put the garage and a shorter driveway in front of the house? (This will be cheaper, but will wreck your design and obstruct the view of the front of your house.) or (B) build the house as planned.

CONSEQUENCES

(A) Move ahead two spaces. (B) Move back two spaces.

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Water Glossary / Key Terms

Benthic: Refers to animals that live in or on the bottom of a lake, sea, or river.

Elevation: Height above sea level.

Freshwater: Not salt or ocean water.

Groundwater: Water held below the surface of the land, underground.

Land use: Refers to how land within a community is utilized. Some examples of land uses include urban, suburban, commercial (businesses/shopping districts), agricultural (farming), or natural areas.

Model: Simplified representation of natural phenomena. Models can be manipulated and used as tools to make predictions or test hypotheses.

Nursery: Breeding or nesting grounds for plants or animals.

pH: Measurement of the amount of hydrogen ions present in a substance such as water. Knowing the amount of hydrogen in a substance allows us to judge whether it is acidic, neutral, or basic.

River system: A network of small rivers leading into larger rivers.

Runoff: Excess rainfall or snowmelt that flows over land into lakes and rivers because it was not absorbed by soil or plants.

Saltwater: Ocean or sea water.

Secchi disk: Instrument used by scientists to measure water clarity. The depth at which the disk's black and white marks cannot be seen is called the "secchi depth."

Sediment: Soil and other particles carried by water or settled on the bottom of a water body.

Slope: Change in elevation, such as downhill or uphill.

Surface water: Water that is above ground (e.g., in lakes and rivers).

Turbidity: Measurement of sediment and/or other particles stirred up or suspended in water.

Water clarity: Measurement of the clearness of water (e.g., low turbidity).

Water quality: Measurement of many factors that contribute to the overall health of water in an ecosystem.

Watershed: The area of land that drains into a river system.

Wetland: An area, such as a bog, swamp, or marsh that has seasonally wet soils and a distinct plant community. Wetlands provide valuable nursery areas and habitat for many plants and animals.