Making a Splash: Water in the City

Terrace Town Workshop

Presented by:

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WISCONSIN DEPT. OF NATURAL RESOURCES

February 4, 2010
Monona Terrace

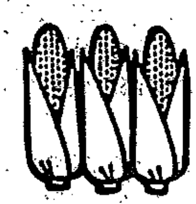
How You Use Water

Direct Personal Use - Eight percent of the nation's total, or 160 gallons per person, per day, is used for personal and home activities:

Average Amount of Water Required	Activity
3 to 5 gallons	Flushing a toilet
3 gallons	Shaving with a blade, leaving the water running
5 gallons per minute	Take a shower
8 gallons	Cooking (three meals)
8 gallons	Cleaning house
10 gallons	Washing the dishes (three meals)
20 to 30 gallons	Washing clothes
30 to 40 gallons	Taking a bath

Agricultural Use - About 33 percent of the nation's total, or 600 gallons per person, per day, is used in farm and ranch operations.

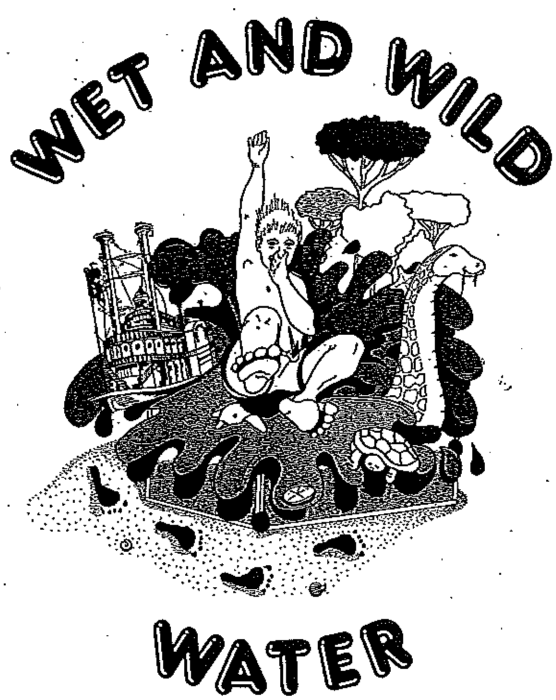
Average Amount of Water Required	Food Produced
40 gallons	One egg
80 gallons	One ear of corn
150 gallons	One loaf of bread
230 gallons	One gallon of whiskey
375 gallons	Five pounds of flour
2,500 gallons	One pound of beef



Industrial Use - About 59 percent of the nation's total, of 1,040 gallons per person, per day, is consumed in the production of material goods.

Average Amount of Water Required	Product
7 to 2 gallons	One gallon of gasoline
35 gallons	One pound of steel
280 gallons	One Sunday newspaper
300 gallons	One pound of synthetic rubber
1,000 gallons	One pound of aluminum
100,000 gallons	One new car

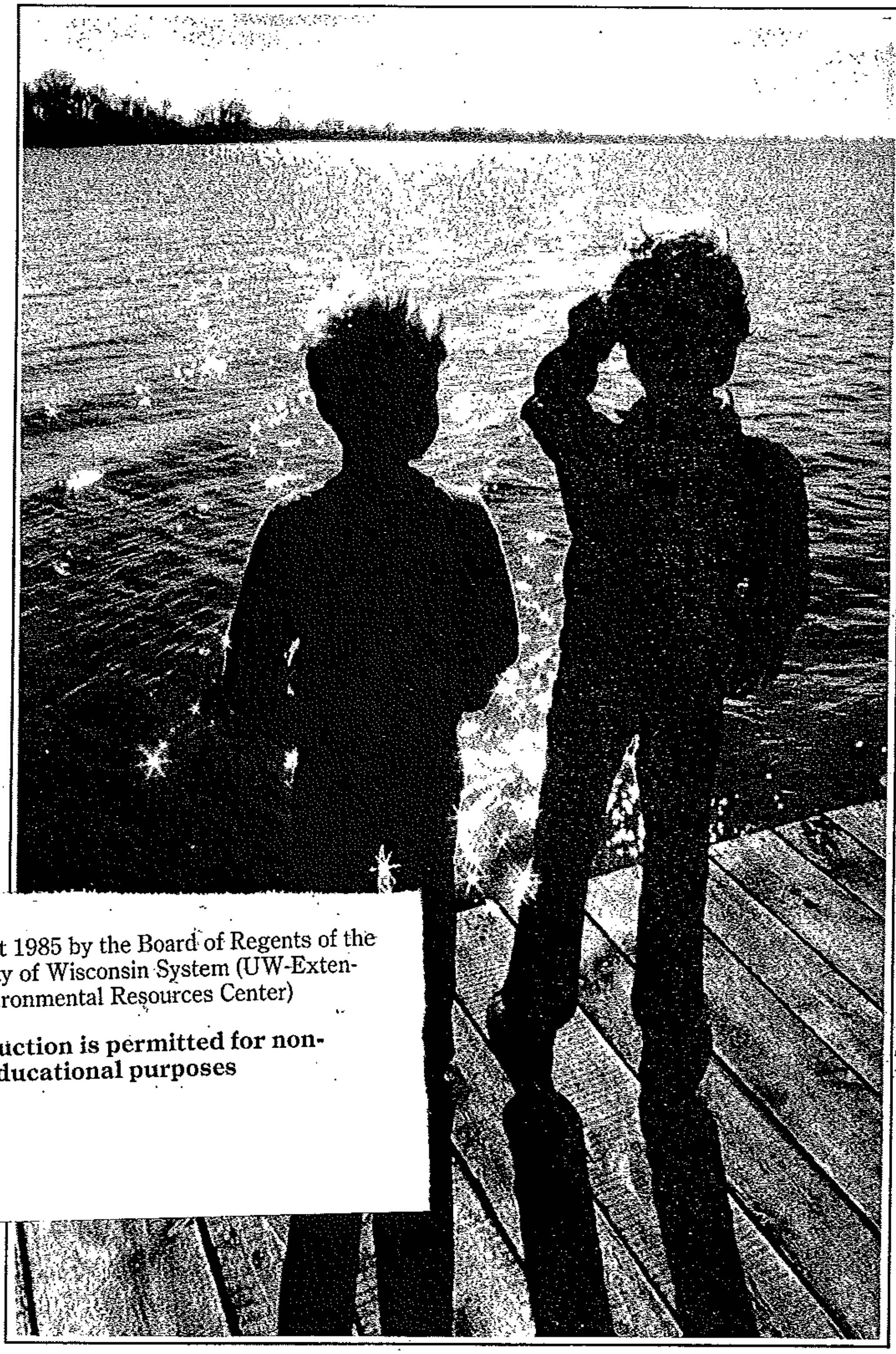
NOTE: About 720 gallons per person, per day is used as cooling water for electrical power plants.



Indiana Department of Education
Center for School Improvement and Performance
Office of School Assistance
Room 229 State House
Indianapolis, Indiana 46204-2798
(317) 232-9141

Our Great Lakes Connection

A Curriculum Guide For Grades Kindergarten Through Eight



By Lynn Entine • Project Director and Editor, Ellen Fisher

Activity 6: Here's Looking At Your Place: Community Profile Exchange

Students explore their own community and create a community profile that they exchange with students of Great Lakes communities.

Grades: 3-8
Subject Areas: Geography, Language Arts

Our home town geography is familiar to us. The geography of places we've never seen can seem sterile and boring. This activity will bring personality and life to a study of the Great Lakes coast. It will also help students appreciate their own environments as they develop a community profile.

Community profiles help governmental officials plan for economic development, municipal services (like sewer, water and roads), social services (like recreation facilities, clinics or hospitals, community centers, financial assistance budgets) and nearly every element of community supported programs. Businesses may review such profiles when considering whether to locate in a particular community.

Profiles usually include some or all of the following elements:

1. History
2. Physical geography and land uses
3. Environmental characteristics including climate and weather
4. Economics - sources of jobs and income
5. Demographics - the ages, incomes, ethnic backgrounds, training, etc. of the people who live there.
6. Sociological characteristics - the behaviors and values of the people who live in the community
7. Any major problems or issues facing the community (like school integration, pollution, entry or departure of a major employer, poverty, etc.)
8. Any special assets which enhance the community (highly educated population, attractive physical/environmental features, quality schools and government, major new developments like downtown revitalization, new harbor and boat docking facilities, ports, airports and rail depots.)

People don't always agree about elements included in profiles.

Procedure

1. Explain the idea of a community profile exchange to your students. Talk about how it will help them get to know their own community and compare it to one on the Great Lakes shore. Help your students choose and discuss locations on the lake shores they would like to learn about, then select a couple communities. You may want to exchange with more than one and you should have one in reserve in case you can't locate a cooperating teacher in your first choice community.

2. Contact a teacher who teaches a grade level close to yours in the chosen community(ies). You can do this by calling the public school office in that town. (Use long distance telephone information or check your library for telephone book from the community you're interested in.) The social studies, science or general curriculum coordinator for the school system may know an enthusiastic teacher who would enjoy the exchange opportunity. Get the name and address of the teacher and phone number if you want to call directly. Secure the teacher's agreement before continuing with the project. Discuss procedures such as: developing question lists independently then exchanging them for agreement on final list, general timetable, availability of special equipment like video cameras and playback equipment, plans for student letter exchange, etc.

3. Help your students develop questions for the exchange class. Your students will answer the same questions for the profile on their own community.

Make sure questions focus on how people use the lakes in the Great Lakes shore community. (If you are in an inland community you will want to identify a similarly important geographic feature near you, e.g. high quality farmland, forests, river, hill or mountain, etc. It may be more of a challenge for city schools to identify the important geographic feature(s) which attracted so many people to the area.) Some of the following might be included in your list:

How did the town get started?
What does it look like?
Who lives there?

Why do they live there?
How do they earn a living?
What do they do for recreation?
What is the weather and climate like?
What do the native trees, grasses, flowers and crops look like?
How big is the town?
How do people use the Great Lake where the town is located?
Do they have any environmental problems? What are they?
What's the biggest asset the town has?
What's its biggest problem?
What makes the community unique?

4. Include the questions in your letter to the exchange teacher. A sample letter is included here. Your students may want to help with the letter. Be sure to enclose a copy of this lesson plan for the teacher.

5. Have each student in the class write a letter to the exchange class describing a favorite outdoor place and why it is special, mother's and father's jobs, and one or two things about him/herself (favorite sport or activity, interesting experience, future plans, etc.) Enclose student letters with your letter to the teacher.

6. After the two classes have agreed on the questions to answer, develop a profile notebook about your community. Student volunteers can take photographs of the community and surrounding landscape. Make sure that each question you have developed is matched to at least one photo. You can collect the film and have it developed, then work with students to select the best photos for the notebook. (In a lower elementary class have your students plan a neighborhood or community journey. You might have to be the photographer.) Don't forget to include photos of the class, school and teacher. Students may also choose to bring copies of photos from home which show community scenes. Students not involved in the picture-taking can write captions describing each photo. Glue the photo to a sheet of paper and copy the description below it. Compile the photos in a binder.

Other materials that students have collected may also be included:

- A tourism brochure of community attractions (from Chamber of Commerce).
- A map. Mark locations of photos on it if appropriate.
- An article from the local paper describing a recent school or community event, especially if it relates to the natural environment.
- Rocks or leaves gathered from the local area and labeled. Look for things that are unique or characteristic: sandstone if that is the predominant kind of rock; a dried alfalfa plant or corn leaf if you are in a farming community.

You might want to keep a copy of your notebook for yourselves. Make a bulletin board display of your community profile, leaving it half empty to build up excitement and expectation for the materials coming from your exchange class. If you are exchanging with more than one Great Lakes community, describe your letter exchange with other coastal communities in your cover letter. Those Great Lakes communities may also want to contact each other.

7. When the exchange materials come, review them with the class and have your students arrange them on your bulletin board. Discuss the various parts of the community as the exchange class describes them. Check to see how each question was answered.

8. Discuss the activity with your students:

- What have you learned about the Great Lakes (or some other item) that you didn't know before?
- What questions do you have about the Great Lakes (exchange community or other topic) that are still unanswered?
- What have you learned about our community that you didn't know before?
- What questions do you still have about our community?
- How does our community affect our behavior and life-style?
- How is the exchange community similar to our community? Different?
- What evidence is there of the influence of the lake on the exchange community?
- What effects have physical features like hills, water, forests, etc. had on shaping the exchange community? Our community?
- What important economic activities go on in the exchange community? Our community?
- What forms of transportation do people use? What other places do transportation routes link the exchange community to?
- What do you like best about the exchange community? Our community?

9. Summarize your discussion and include it with thank you notes to the exchange class. (You may want to have students answer one of the questions in #8 on their own individual thank you notes.) Take a photograph of your bulletin board display to send along.

Taking It Further:

1. If your community or county has a planning department, invite a planner to come to your class and tell how she/he develops profiles. Display your own profile efforts. Ask how profiles have been used in your area.

Sample Letter To Exchange Class

Address
City, State (Province)
Postal Code
Area Code and Phone #
Date

Mr./Ms (*teacher's name*)
School's Name
Address
Community, State, (or Province, CANADA), zip (or postal code)

Dear Mr./Ms. ____________________ and Class:

We are studying the Great Lakes region and are eager to know about your community and the nearby shore. After talking to you on the phone, I know you would also enjoy knowing about our community. We will send you a notebook describing our community in exchange for similar information about yours. The enclosed activity sheet describes our procedure. We hope to have our community and natural environment profile ready to send you by (date).

To help us both in developing our community and natural environment profiles, here are some specific questions we would like you to answer:

1. ____
2. ____
3. ____

etc.

Our class developed these questions. We will answer the same ones and more to describe our community. Please include any others your students may want to add.

We look forward to hearing from you soon. To get us started we have each written a letter describing ourselves and something about our community. They are enclosed.

Sincerely,

Mr./Ms. ______________
xth Grade Class
City Elementary School

Enclosure:
Activity description and
Student Letters

Activity 10: Explorer's View Of The Great Lakes-Historical Perspective

Students appreciate the process of map-making by making their own maps, understanding the differing purposes of maps, and comparing Father Hennepin's 1687 map of the Great Lakes with a contemporary one.

Grades: 4-8
Subject Areas: Geography, History

We take our modern maps for granted. The technology of satellite and aerial mapping has taken some of the adventure out of going from here to there. In the days of the French explorers and fur traders, maps were carefully hand drawn. The explorers Marquette, Joliet and Champlain all were excellent geographers and map-makers. Since the major routes of exploration were by river and lake, maps made in the 17th and 18th centuries were quite accurate about the location of water routes but often distorted land shapes. The lower peninsula of Michigan was incorrectly depicted on maps until well into the 19th century.

Maps have many purposes. Contemporary maps may show roads, weather, political boundaries, natural resources, topography, agricultural products, vegetation, pollution and many other items (See Activities 17, 18, 19 and 20 for other types of maps of the Great Lakes region.) Historical maps of the 17th century were drawn by the Jesuit explorers for the use of later travelers. They showed locations of rivers, Indian tribes and forts in careful detail. (We now rely on road atlases for the same function.) Some maps were used for political purposes to show the territory claimed by a particular country. Some historians suspect that the Mississippi River was deliberately moved far to the west on many French maps because it was the boundary between the French and Spanish territories in America.

The historic map included in this activity was produced for Father Hennepin's books about his travels in the new world. It is not as detailed as the Jesuit maps and contains several elements designed to curry favor with the French king. Note that Lake Huron is named "Lac D'Orleans" honoring the royal family. In the upper left corner of the map, near the 260 degree line, the royal arms are shown fastened to a tree "at the place marked A." Whether such a landmark was ever really planted is questionable. Father Hennepin is notorious for stretching the truth in his writings. However his books helped to popularize the New World in Europe, gaining support for more exploration ventures financed by French entrepreneurs.

In this activity students make maps of familiar places, then compare the historical map to a contemporary one (included in the lesson). You will need to provide a road map of your state or province and the states of Wisconsin and Minnesota in order to complete the questions on the worksheet.

A wall-sized historic map of the trade routes to the New World is available for $4.00 (1983). It is a reproduction of a 1720 Dutch map and includes information on colonization and trade. To order your copy of "Colonization and Trade in the New World" write to the National Geographic Society, P.O. Box 1269, Washington, D.C. 20013.

Procedure

1. Briefly introduce the process of map-making by asking students why anyone would want to map an area. Discuss various uses of maps. Discuss how your students could make an accurate map of some familiar location (floor of the school building where your classroom is located or the classroom itself). Develop a purpose for such a map (such as showing new students how to reach the room, or showing cleaners exactly where to put everything back in your classroom after they've removed it to clean and paint).

2. Have each student sketch a map of the selected location in 10-15 minutes without talking to the other students. Put all the maps up on a bulletin board side by side. Talk about the differences in perspective as well as the various landmarks that each student put in. Ask: Which map has the greatest detail? The least? What do the maps include and exclude? What is absent from some maps that might make them difficult to use? Ask some of the map-makers: How did you begin? What problems did you have? How did you solve them? Who would you have liked to have asked for help?

3. Distribute copies of the Hennepin 1687 map and talk about what the map says. Ask: What do you see in the map? If you were traveling by river and lake, where would you stop to visit with other

European people? What does the map tell you about Indian people? What symbols does the map-maker use to provide you with information? What are the horizontal and vertical lines? What are they used for? ("Septemtrion" at the top of the map is French for "north" or "northerly.")

4. Distribute copies of the worksheet and contemporary map included in this lesson. You will also need a road map for your state or province and the states of Wisconsin and Minnesota. Students will need colored pencils or crayons.

5. After students have completed the worksheet and maps compare their answers to questions 6-9. Discuss the differences.

Taking It Further

1. Compare these historic and modern maps to other maps in these activities. Discuss the uses of various maps.

2. Divide students into teams. Have them hide "treasures" (candies, video game tokens or other inexpensive but desireable items) and draw maps showing their locations. Groups exchange maps and hunt for treasures. When all treasures have been found discuss strengths and weaknesses of the maps.

Resources:

Books

Holling, Holling Clancy, *Paddle-to-the-Sea*, Houghton Mifflin Co., Boston, 1941. Shows various maps and routes through the Great Lakes.

Syme, Ronald, *LaSalle of the Mississippi*, William Morrow and Co., Inc., New York, 1953. Story of the explorer LaSalle who traveled through Lakes Huron, Michigan and Erie and down the Mississippi River. An exciting story full of physical hardships and dreams of opening up an inland empire of fur trading.

Films

"Map Skills: Using Different Maps Together," 11 min., Color, Coronet, 1971. Shows how to read descriptive facts from different maps of the same geographic area to discover relationships among human use of physical and social features of the area. Includes animation to compare maps showing rainfall, industry, transportation and population. (Intermediate and junior high)

"Maps are Fun," 10 min., Color, Coronet, 1946. Uses a visit by two boys to a cartographer for a map covering their paper route to introduce fundamental concepts of map reading. Explains legend, scale and color references. Shows mapping a community on a sand table, transferring it to a large-scale map, then reducing it. (Intermediate, junior high, high school)

Worksheet — Explorer's View

Study the historic map of the Great Lakes region and the modern one, then make the following additions described in numbers 1-5 to the historic map included here. When you finish answer the questions given in numbers 6-9.

1. Add the following modern names to features on the historic map:

Mississippi River	Michigan
Lake Michigan	Ontario
Lake Ontario	Quebec
Wisconsin	

2. Locate the approximate site of the following by adding the names to the historic map:

The Soo Locks, Chicago, Detroit, Windsor, Ontario, Saginaw Bay (Lake Huron), Your Home Town

3. Use colored pencils to shade in the following areas on the historic map:

Great Lakes	Michigan
Ontario	Illinois
Minnesota	Ohio
Wisconsin	

Make a legend showing the colors you have used and any other symbols on the map (your own or those already there).

4. A. Trace a route on the historic map that French explorers might have used to travel mostly by canoe from Lake Michigan to the Mississippi River.

   B. Trace a water route from Lake Superior to the Mississippi River.

   C. Trace a water route from Quebec to Lake Huron that doesn't go through Lake Erie.

5. A. On the modern map. Show how you would travel today from Lake Michigan to the Mississippi River. (Use a road atlas to help.)

   B. Show a modern route from Lake Superior to the Mississippi River. (Use a road atlas to help.)

   C. Trace a route from your home town to the nearest big city on the Great Lakes.

6. Compare the historic and current maps. In what ways is the historic map different from the current one?

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7. What are some reasons for the differences?

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8. Imagine being an early explorer. What problems might you have because of the distortions of the 1720 map? What is the worst problem? The least problem?

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9. Which way would you prefer to travel from Lake Michigan to the Mississippi: the explorer route or the modern one? Why?

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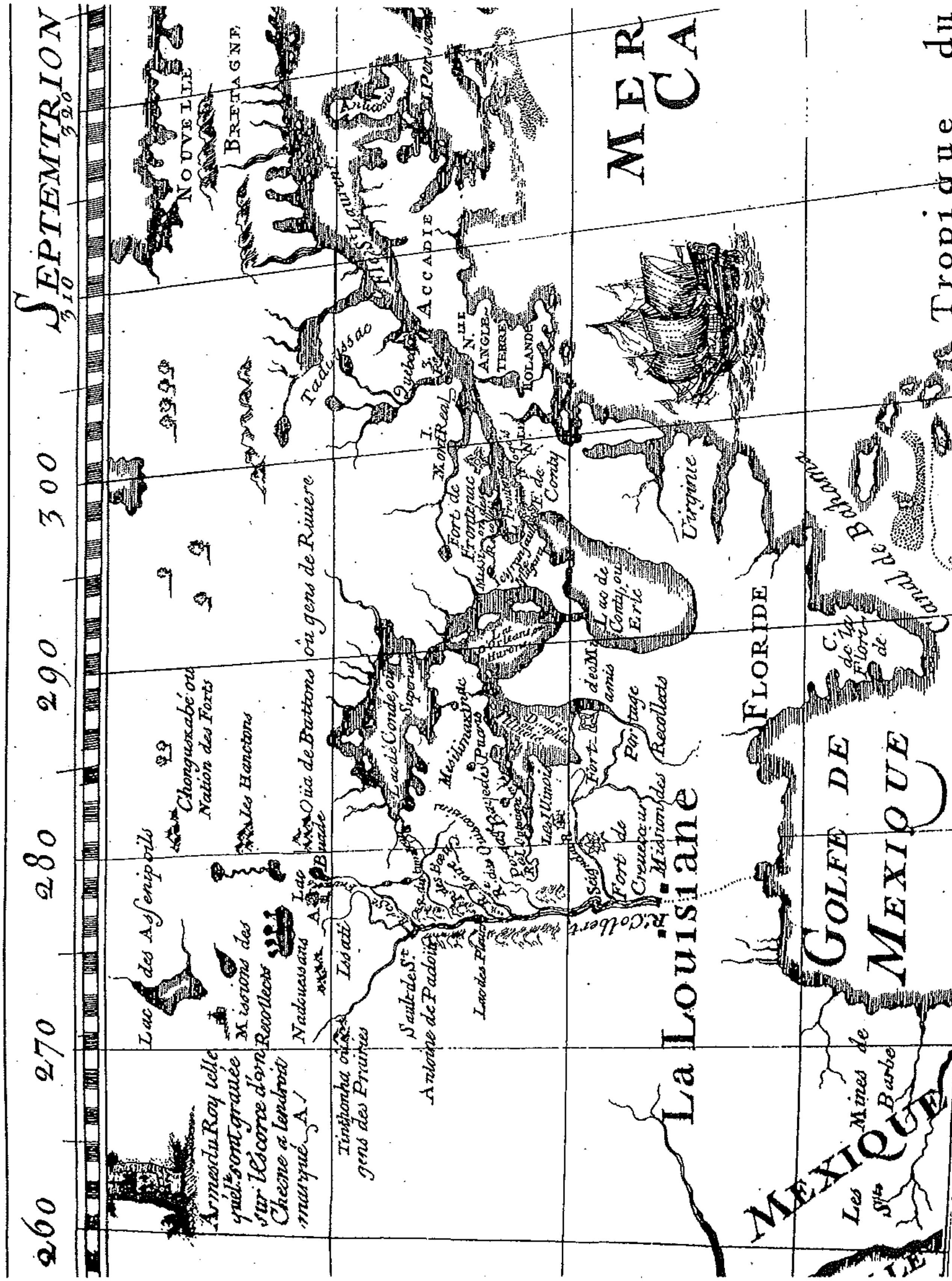
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Lac des Assenipoils
Missions des Recollects
Nadouessans
Les Hanctons
Nation des Forts
Les Ilinois
Fort de Creuecoeur
Sault de St Antoine de Padoue
R. Colbert
Fort de Frontenac
Tadoussac
Quebec
I. Mont Real
Armes du Roy telle quelles sont gravées sur l'escorce d'un Chesne a l'endroit marqué A
Tintonha ou gens des Prairies
Isati
Chonguaxabé ou Nation des Forts
Ouia de Battons ou gens de Riviere
Canal de Bahama
C. de la Floride
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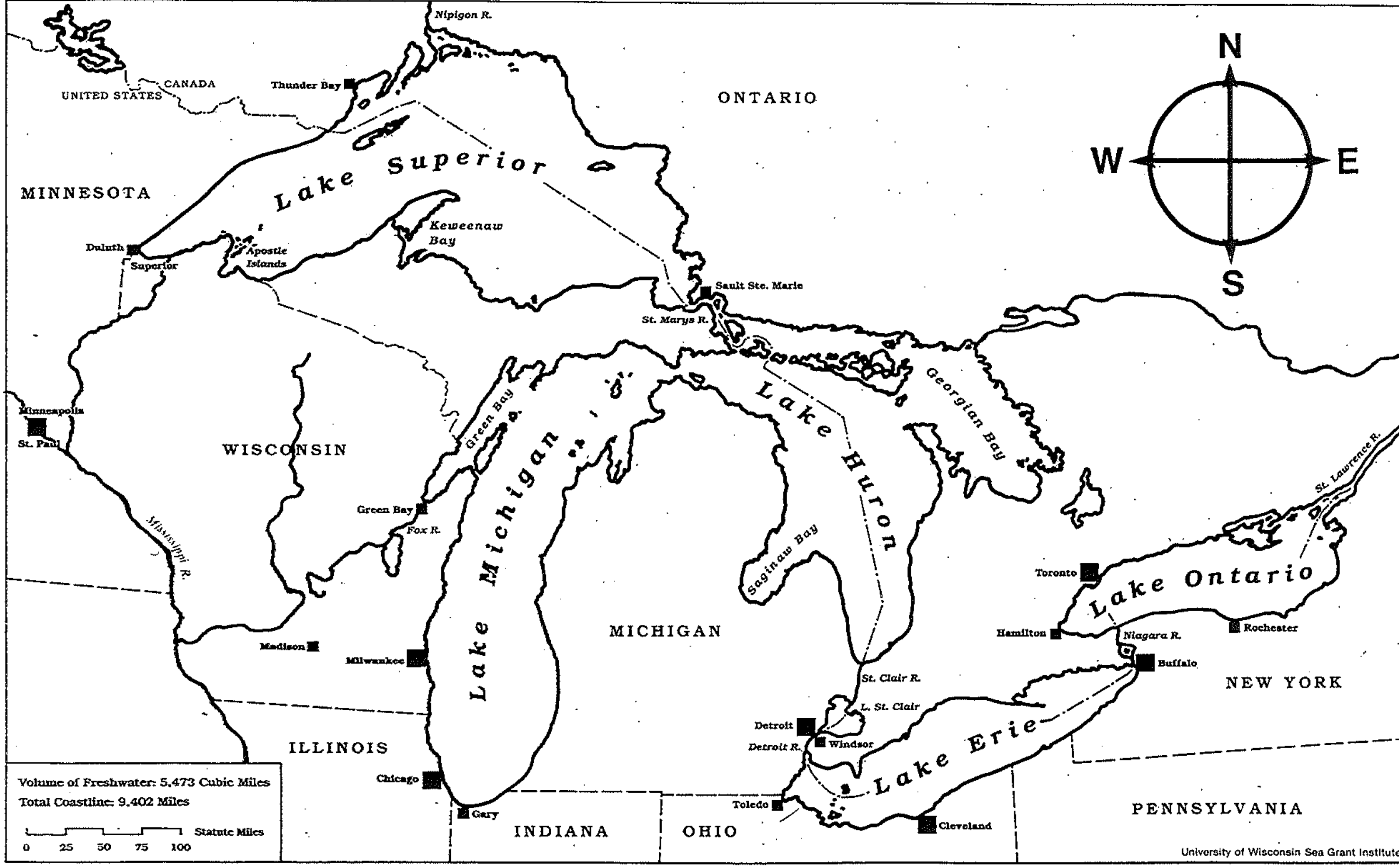
THE GREAT LAKES



Teaching Green

The Elementary Years

Hands-on Learning in Grades K-5

Edited by Tim Grant and Gail Littlejohn

New Society Publishers

Educating the Community: A Watershed Model Project

by C.S. Perryess

Grade levels: 3-5
Subject areas: science, social studies
Key concepts: watershed science, geology, geography
Skills: topography, framing, cement work, public speaking
Location: indoors and outdoors
Time: 3-4 weeks

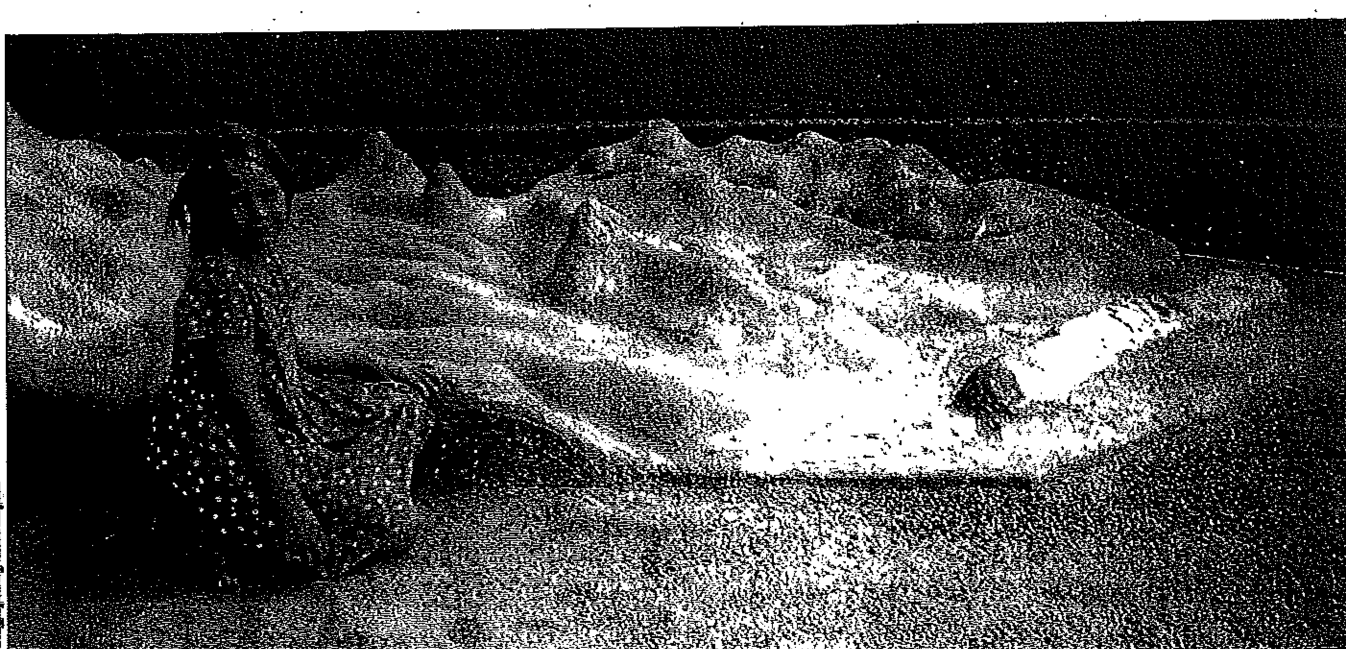
It's a Friday evening at Monarch Grove Elementary on California's central coast. A few dozen parents and community members mill around in the third grade courtyard. With a bit of bravado, a young man stands before the crowd. "Hi, I'm Shane. I'm in sixth grade here at Monarch, and I'd like to thank you all for coming out to see our watershed model." He is poised and comfortable in front of the crowd. "We made it out of cement, so I'll just stand here on it." He steps up onto two conical green mountains on the far end of the model and addresses the adults.

Shane explains that he is standing on a scale model of the 19,600-hectare (48,400-acre) Morro Bay watershed, built by local kids and their parents. The base of the cement structure is roughly 4 by 4 meters (12 by 12 feet). Its highest peaks rise nearly one meter (three feet).

"How many of you know what a watershed is?" Shane pauses. The adults look to one another. They raise eyebrows. A man in the back shrugs. A half dozen squirming kids raise their hands to answer. "That's right," he says to a second grader up front,

"a watershed sheds, just like a duck's feathers shed water. It also works like a shed in your backyard: it stores things. So, a watershed does two things. It stores water and it sheds it off. What you're looking at is a model of our watershed — all the land that drains through creeks to the Morro Bay estuary and out to the Pacific Ocean."

Shane then helps the crowd identify local landmarks. People point out Hollister Peak and Cuesta Ridge. They locate their favorite hiking spots: Bishop's Peak, the sand spit, and the Irish Hills. Shane points



Photography by C.S. Perryess

out the Morros, or Seven Sisters, ancient volcanic plugs that march between the two valleys of the watershed. He names each of them, ending with the area's most photographed landmark, Morro Rock. Next, he steps off the model. "Let's say I spray some rain right here." A few people back up as he unrolls a garden hose and carefully sprays onto the green, cement hillside. "Notice. The rain goes down the hills into San Bernardo Creek, then flows into Chorro Creek, and out into...." Shane looks up hopefully. A few kids up front join him, saying, "the estuary."

He turns off the hose and moves near the highest mountains. "Now, if I spray some rain here at the very top of Cuesta Ridge some of the water flows into the headwaters of Chorro Creek, past the prison and the college, then out to the estuary. But what happens to the rain that falls on the other side of the ridge?"

He points to the water flowing over a painted blue stream, and then off the backside, onto the gravel path that surrounds the model. "See, that's the edge of our watershed, because right at the top of Cuesta Ridge, one raindrop can flow into the Morro Bay watershed, while one that falls right next to it could go down the other side and into Atascadero. From there it joins the Salinas River, and guess where that flows into the ocean?"

Top: Fertilizing the fields with bright red drink crystals. Bottom: Rainfall on Los Osos Valley.

"Monterey?" somebody asks.

"Yes, over a hundred miles away!" Shane lugs the hose around the model, identifying all the streams by "raining" on them. He points out sub-watersheds and the southern and eastern boundaries of the watershed. He then introduces Maura, a third grader who also helped build the model.

Maura explains how important topsoil is to the local farmers and then sifts dirt onto their fields. She asks how many people in the crowd wash their cars. Hands go up.

"Great," she says. "Here's your car, and here's yours." She points out two adults and skips across the model to place two toy cars in the most populated areas. "You use soap on your cars, don't you?" She looks out at the group. "On your dishes you use soap to get rid of germs, 'cause you eat off 'em, right? So, do you eat off your cars?" Maura pauses and smiles. "Well, we'll put some soap on anyway." She squirts some soap on top of each car.

"Do you all like nice green lawns?" she asks. "We'll need some fertilizer." She shakes some powdered drink mix through the suburbs. "Oh, and let's not forget the golf courses — they need lots of fertilizer." She hops across the model. "And the farmers need fertilizer to grow the food we eat." She shakes a bit more on the farmlands. "And," she continues, "do any of you have dogs? Do you walk your dogs? And what do your dogs do on their walks?" There are a few throat-clearings, but no real response. Maura holds up a plastic bottle of cake sprinkles. "When dogs take walks, they poop!" She unscrews the lid of the bottle. "They poop over here, and they poop over there." She shakes sprinkles through the suburbs. "I bet you walk your dogs on the beach! I bet you walk them out on the sandspit, too, and out by Morro Rock." She bounds over the model, generously sprinkling as she goes.

She uses an eyedropper to squirt a little motor oil on the roads, and in an imagined empty lot where somebody pours his used oil instead of using the county's curbside oil recycling program. Next, she grabs the garden hose. "So," Maura asks, "where will that topsoil and the fertilizer go? Where will the motor oil and dog poop go when it rains?"

"The estuary," a few members of the audience say.

"The estuary!" she repeats. She smiles and showers her garden-hose rainstorm onto the hills. The creeks run red from the fertilizer, transporting suds, soil, and cake-sprinkle dog poops. Maura stops the storm and an ugly swirl of oil rises to the bay's surface. Topsoil settles, filling in the estuary, and a dirty stream of sudsy water flows out past Morro Rock to the sea.

"So," she says, putting down the hose. "Isn't that the bay where you like to kayak? Isn't that beach by the rock where you like to surf?" Heads nod. A little girl in the front row kneels to point out the dog poop lining the edges of the bay.

Maura looks very serious now. "What can we do to keep that from happening?" She leads the group in a discussion that starts with leaving the detergent in the kitchen and keeping our cars in good mechanical shape. She explains how washing our cars on the lawn will allow the runoff to percolate into the soil instead of draining down the driveway, out to the street, and downhill to the estuary. The discussion moves to the possibility of driving our cars less, to fertilizing sparingly, and taking plastic bags along while walking the family dog. She even demonstrates the use of the plastic bags. Maura bows, accepts her applause, and yields the lumpy cement floor to a thin, intense boy.

Wire mesh holds the cement on the vertical edges of the model.

"I'm Will. I'm in fourth grade, and I bet you think those farmers will be out of business soon if they keep losing their topsoil." Will launches into a lively discussion of riparian buffer zones, illustrated with soil-catching strips of fleece laid along the creek banks.

"See how the farmers keep their soil, now that I planted that buffer zone?" he asks, "And notice how only a little of the dirt gets into the stream. If I hadn't planted that buffer zone, where would all that soil end up?"

"The estuary!" the audience says.

He then walks over the Morros to point to a low-lying piece of land near the bay. "Anyone know what's here?" Will is pointing to Chorro Flats, farmland rife with flooding problems for years. Recently, local agencies have worked together to restore a portion of the farmland to flood plain. "When they broke the levee and let Chorro Creek meander through this field," he explains, "the water slowed down and all these willows grew in." He slaps the soggy fleece down. "Now," he says, sprinkling soil upriver, "the topsoil has time to stop and settle in Chorro Flats." He digs through his pocket to find a crumpled piece of paper. "Over 160,000 cubic yards in the last five years."

The crowd watches as Will sprays a light rain on the hills and the model works its magic. "And," Will says, "just like the soap and the oil and the dog poop, where would all that topsoil end up if the river didn't slow down on Chorro Flats?"

The crowd chants out, "The estuary!" Will takes a bow.

Last, a woman who has watched from the sidelines steps out front. "Hi," she says, "I'm Judy Neuhauser, 4H Watershed Project Coordinator. How about a round of applause for our presenters, Shane, Maura, and Will?" The crowd applauds. Judy breaks in, "Now don't think you've seen it all tonight. The model will help the kindergartners study the water cycle. Third graders will get a more complex look at the water cycle and will study where the Chumash villages were. They may even build some temporary villages right here where the Chumash lived, comparing lifestyle, resource use, and population density now and then. Fourth graders will bring their geology study out here, mapping soil types and taking a look at substrates; and fifth graders will demonstrate the model, as you've seen tonight, during their landforms and watershed unit.

"It took about thirty volunteers just over three weeks to build it." She lists all the volunteers and asks for another round of applause. As the audience leaves for home and the sun sets, Judy is wresting the hose from Will and Maura, who are performing a second show for no audience at all.

C.S. Perryess, formerly at Monarch Grove Elementary School, teaches English, dramatic arts, and home economics at Los Osos Middle School in Los Osos, California.

The Morro Bay watershed model at Monarch Grove Elementary School was coordinated by Judy Neuhauser of the 4H Watershed Project in San Luis Obispo, California. Judy worked with at-risk high school students to construct a similar model of the Arroyo Grande watershed south of Morro Bay. An eight-minute video of their experience, *The Watershed Project*, is available from Davidson Films, 735 Tank Farm Road, Suite 210, San Luis Obispo, CA 93401, <www.davidsonfilms.com>. *The Watershed Model Construction Manual*, which includes detailed building plans and curriculum notes, is available at the San Luis Obispo County 4-H Office website at <http://clubs.ca4h.org/sanluisobispo/r2rwe/conman.html>.

Building a Watershed Model

by C.S. Perryess

A project such as the Morro Bay watershed model requires administrative approval and sufficient open space on the school grounds. If your school ground space is limited, consider building the model in partnership with a local park. Alternatively, a smaller model can be constructed using architectural foam board covered in papier mâché and finished with a few coats of polyurethane. The prototype for the Morro Bay model was a nearly-portable model built on a 4-by-4-foot piece of ¾-inch plywood. Such a model can provide a similar educational function. We found, however, that finding storage space for our smaller model was actually more challenging than adding the larger model as a permanent feature on the school grounds.

The cost of materials for a large model can mount up, but we found local contractors and hardware stores who were excited to support the project — including a contractor who loaned us his cement mixer. The cost of the Morro Bay model was just under $1,500. Such an expense would have been out of the question for an isolated one-time project for one class; but because the model is permanent and available for various curricular ties, we considered it money well spent. As time passes, we imagine the model will inspire previously unthought-of applications. Might it help in the study of slope, gravity, physics, local vegetation patterns, measurement? Time — and engaged students and teachers — will tell.

The following outlines the basic materials and procedure used in constructing the 4-by-4-meter (12-by-12-foot) Morro Bay watershed model.

Materials: 20 rigid 2-inch foam boards with plastic or foil backing, 2-by-6-inch framing boards for the perimeter; sand and gravel or decomposed granite; rebar; chicken wire; 1 cubic meter (30 cubic feet) of cement; 7.5 liters (2 gallons) concrete glue; cement dye

Procedure:

1. Identify the boundaries of your watershed and mark them on a topographical map.

2. Determine a scale that will work for the topography and area of your watershed and the size of the site you have available for the model (the 48,400-acre/19,600-hectare Morro Bay watershed translated well into a 12-by-12-foot/4-by-4-meter model). It is wise to accentuate hills and mountains to ensure that landmarks are recognizable and that water will run off. Do this

continued next page

The 12-by-12-foot schoolyard model of the Morro Bay watershed in California was constructed from layers of Styrofoam insulation assembled on a foundation of crushed granite and covered in cement and stucco. The vertical scale was exaggerated by a factor of three to ensure functional runoff and make landmarks easier to identify. Volunteers as young as three donned rubber gloves to smooth and color the mountains and valleys with dyed stucco.

continued from previous page

by working on a larger scale vertically than horizontally. For example, the Morro Bay model represents landforms ranging from an elevation of 730 meters (2,400 feet) down to sea level. Its vertical scale is three times its horizontal scale. Landmarks are easy to identify and it functions better as a runoff model than it would without the vertical exaggeration. We used one 2-inch layer to represent every 60 meters (200 feet) of elevation, but this ratio should be adjusted to the topography of your watershed. For example, in a fairly flat watershed the features will be more recognizable and the drainage improved by using one layer of foam for every 30 meters (100 feet) of elevation.

3. Stake your site and lay 2-by-6-inch boards as cement forms along its perimeter. Inside the perimeter, dig an area for a footing approximately 30 centimeters (1 foot) wide and 10-13 centimeters (4-5 inches) deep, reinforce with rebar, and pour cement. Check for level, and scree (scratch) the surface of the cement before it dries (if your watershed is relatively flat, consider "level" to be a slope that is 10-15 centimeters/4-6 inches higher at the top of the watershed than at the outflow). Inside the footing, lay down crushed granite or construction-grade sand as a base for the model, again grading from the top of the watershed to the outflow to accentuate the vertical dimension.

Topographical lines traced onto transparencies are then projected onto foam boards.

4. Transfer a topographical map of your watershed to a transparency. Project the transparency onto 2-inch foam insulation boards and use a marker to trace each contour line onto the foam, beginning with the lowest elevation. Cut along the lines with a jigsaw. It will be easier to position the layers after they have been cut if you trace the next-highest elevation line on each piece of foam. For example, when tracing and cutting out the 60-meter layer of a 240-meter hill, trace the next highest contour (90-meter or 120-meter, depending on your interval) on the same piece of foam as a guideline for placing the next layer. Pin the insulation pieces to one another by pushing nails from one level into the next.

5. Place the assembled foam pieces on the site, pinning the bottom piece into the sand with nails. If your watershed has landforms so flat that they do not appear on your lowest contour lines, use thinner foam or shape the sand itself to represent these finer points.

6. Cover the model with cement, filling in the stair steps of the foam layers to create smooth hills. To ensure that water will flow where it is supposed to, make sure that exuberant volunteers do not fill in gullies, near-flat valleys, and any other subtle water flow areas. These areas must be shaped carefully to create slightly accentuated divets where the streams will flow. Run chicken wire around the vertical edges of the model, pinning it to the foam with nails. Spread cement onto the mesh.

7. When the first coat of cement is dry, check the model for runoff and identify areas that need special care. Then add a thin second coat of cement, being certain to cover any still-exposed foam and taking special care with the problems, if any, identified during the runoff test. Cement any landmark rocks into the appropriate landforms. Conduct another runoff test after the second coat of cement has dried, again identifying areas for special care.

8. Add a stucco coat (no gravel in the mix). Again, smooth it on by hand, being sure not to cover landmark rocks. Check runoff once the stucco has dried.

9. Finish with a thin coat of stucco that is mixed with cement dye to approximate local colors. We used an orangey tan for grasslands and a green for scrub areas and riparian corridors. Apply the color just as you did the first coat of stucco. To obtain a mottled, more natural effect, mix a wet slurry of slightly darker and/or lighter color to sponge randomly over the original color coat. Finally, paint in the riverways, streams, bays and such with blue-dyed stucco.

WHERE DOES WATER RUN OFF AFTER SCHOOL?

OBJECTIVE

Students will be able to describe relationships between precipitation, runoff and aquatic habitats.

METHOD

Students measure and calculate the area of the schoolground; calculate the volume and weight of water falling on the schoolground; determine specific and annual rainfall and runoff; and trace the course of that water to aquatic habitats.

BACKGROUND

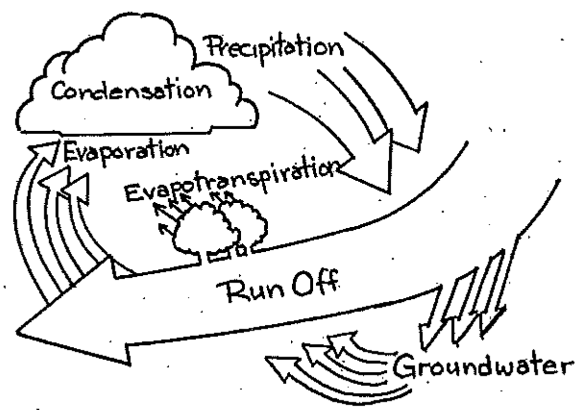
Rainfall is obvious—but runoff from rainfall is a relatively abstract concept. Although we may notice and in fact get drenched in a rainstorm, we don't typically stop to wonder how much rain is falling. The volume and mass of the water in a rainstorm is astounding to those who calculate the values. NOTE: See "Puddle Wonders" for an interesting related activity.

Developing an understanding of precipitation and runoff is an important part of understanding the water cycle. Rainfall is one form of precipitation. Rainfall is one way water re-enters aquatic habitats. Once rain falls upon a surface, water begins to move both laterally outward and vertically downward. Lateral movement is runoff and finds its way into streams, rivers and lakes. Vertical movement seeps into the soil and porous rock and re-charges groundwater supplies.

Paving and soil compaction can reduce an area's water absorbing ability and therefore increase runoff. Reduced absorption rates can negatively impact vegetation and groundwater recharge.

Runoff is the dominant way that water flows from one location to another. It is in runoff that many pollutants find their way into moving waters. These are kinds of pollutants called "nonpoint source." What this means is that widespread sources of pollution such as garden insecticides, automobile emissions caked on parking lots, lead from paints and exhaust, etc., are washed by runoff into streams, rivers, lakes and oceans. Eventually the water becomes part of an aquatic habitat and the toxins begin their damage.

Runoff is also responsible for erosion, transportation and deposition of sediments scoured from the land's surface. Substandard agricultural and other land practices often prepare fields and their topsoil to be washed away.



On the positive side, the contamination levels in much of runoff are negligible. Runoff waters are necessary to renew many aquatic habitats that are dependent upon inflow for continuity. The inflow prevents lakes from shrinking due to evaporation and it prevents streams from going below minimum flow levels. Inflow thus helps support aquatic life. Without some runoff, aquatic habitats would suffer. In this activity, the students calculate both the volume and the weight of rainfall. They consider relationships between rainfall and runoff, including effects on wildlife and the environment.

The major purpose of this activity is for students to increase their awareness and appreciation of some things they may take for granted—rainfall, runoff and the connections between surface waters and aquatic habitat.

MATERIALS

writing materials; meter or yardsticks; long piece of twine with marks every yard or meter; rain gauge; local rainfall data

OPTIONAL: calculator; trundle wheel.

PROCEDURE

1. In this activity, students will find out how much rain falls on their schoolground—and how much it weighs! First, the students must determine the total area of the schoolground. For the purposes of this activity, the outer dimensions of the property will satisfy. There is no need to subtract the area of the buildings since it is assumed that rain falls upon them as well.

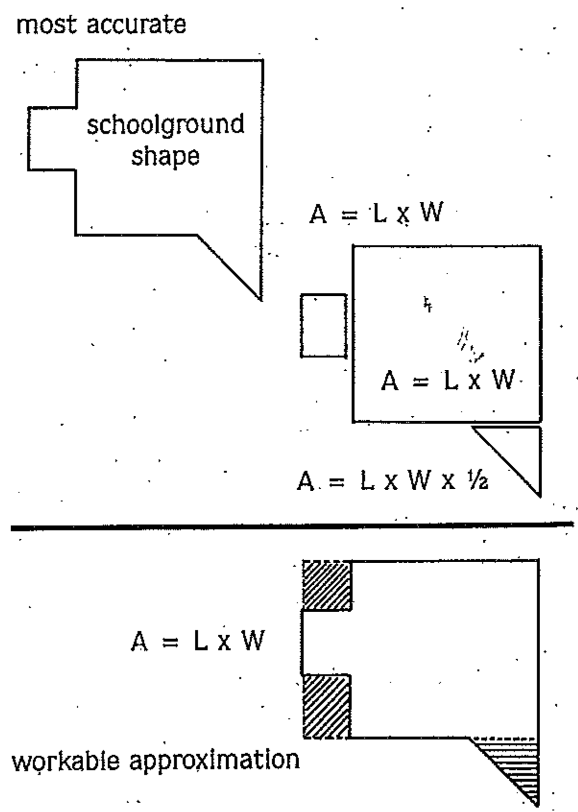
The formula for calculating area is:
Area = Length x Width (or A = LW)

NOTE: See the extensions to this activity for metric approximations.

The length and width of the schoolground must be measured. The students can use a length of twine (approximately 100 feet in length). Mark the twine every three feet. The marking can be done with an ink marker, short pieces of string tied every yard, or a knot each three feet. If a trundle wheel is available, it is convenient to use for measuring.

NOTE: A trundle wheel is a device that makes the measurement of linear distance simple. It is a wheel that operates a counter or clicks as it is rolled over the surface attached to a handle. Each revolution of the wheel represents one yard or meter. Check to see if the school has one. City road crews often have them and may loan one to you for a few days.

The main difficulty with calculating the area in this activity comes from irregularly-shaped schoolgrounds. Try not to get bogged down in detailed exactness. A healthy approximation will do. Here are a few examples:



2. Once the area of the schoolgrounds has been established, the next step is to determine the amount of rain that falls in the area. Three options are possible:

- Calculate the annual rainfall on the schoolgrounds using information from resource agencies, e.g., weather bureau, soil conservation service, local TV weatherpersons, local newspapers.
- Using a rain gauge, measure the amount of rain over a period of time.
- Calculate the amount of rain that falls in a given storm.

When the students have decided on a way to measure the amount of rain that falls on their schoolground during a specified period of time, ask them to calculate the amount. This provides the students with a value for the depth of rainfall on the surface of the land.

3. With the depth of rainfall determined, and the area of the schoolground measured, the next step is to calculate the volume of rainfall. For example, suppose the area of the schoolground is 50,000 square feet and the annual rainfall is six inches or .5 feet. Then the volume of rain would be:

50,000 square feet x .5 ft of rain =
25,000 cubic feet of rain

The volume of rain is 25,000 cubic feet of rain.

4. Knowing the volume, the students can now calculate the weight of the rain. Water weighs 62.5 pounds per cubic foot, thus the weight of six inches of rain (25,000 cubic feet) is:

25,000 x 62.5 = 1,562,500 pounds or 781.25 tons of rain.

5. All of the measurements and calculations done in this activity are intended to impress upon students that there are remarkable volumes and weights of water moving through the water cycle. Even short periods of rainfall produce amazing amounts of water. All the water that the students measure eventually finds its way to a wildlife habitat. A major issue of concern is how humans affect the quality and quantity of water that eventually reaches aquatic habitats. Consider and discuss the following questions:

- Where does the water from rainfall go when it leaves the school site?
- How much water is absorbed by the different surfaces on the school site?
- With what kinds of potential pollutants does the water come in contact?
- Where is the location of the nearest wildlife habitat that receives the school's runoff?
- How do people use the water between the time it leaves the school and arrives in the wildlife habitat?
- What are some of the positive and negative effects that the water may have on the environment at various points on its journey?

EXTENSIONS

1. Obtain a map of the school and check it against the accuracy of the one you made. Make a copy of the school district map, or use your own map, and plot runoff routes on it. Check periodically during rainstorms to identify the drainage patterns. Try to find a way to estimate how much water is draining in specific places.

NOTE: Most school districts have maps in the administrative department concerned with buildings and grounds.

2. If you did not already, place a rain gauge on the schoolground and measure actual amounts of rain. Repeat your calculations.

3. Do this activity in metric:
   - 100 feet = 30.48 meters
   - 3 feet = 1 yard = .9114 meter
   - Square feet x .0929 = square meters
   - Inches x 2.54 = centimeters
   - Feet x .3048 = meters
   - Pounds x .4536 = kilograms

4. A serious modern concern is the contamination of groundwater. How might water in the groundwater table or aquifer become contaminated with chemicals potentially harmful to human health? To the health of other animals, including wildlife? Identify as many sources of contamination to groundwater and runoff in your area s possible. What can, or is, being done to reduce or eliminate these sources and their effects?

EVALUATION

1. Describe at least two relationships between aquatic habitats, precipitation, runoff and surface water.
2. Name two human activities that have affected the quality of runoff.
3. Name two human activities that have affected the quantity of runoff.
4. Name two ways that runoff can affect humans.
5. Name and describe two ways that runoff can affect aquatic wildlife.
6. Write an advertising campaign slogan to convey the importance of runoff to wildlife. Include the need for clean water without toxins.
7. Write a short list of steps to take for wildlife to protect the quality of runoff water.

Age: Grades 6-12
Subjects: Math, Science
Skills: analysis, computation, description, discussion, estimating, inference, measuring
Duration: two 45 to 60-minute class periods; one period, if dimensions of the school grounds are provided
Group Size: any
Setting: outdoors and indoors
Conceptual Framework Reference: III.A.1., III.B., III.B.1., III.B.3., III.C., III.C.1., I.A.1., I.A.2., I.A.3., I.B., I.C., I.C.2., I.C.3., I.C.4., I.D.
Key Vocabulary: runoff, precipitation, volume, area, weight
Appendices: Outdoors, Metric Charts

Pollutant Information Sheet

Sediments

Particles of soils, sand, silt, clay, and minerals wash from land and paved areas into creeks and tributaries. In large unnatural quantities, these natural materials can be considered pollutants. Construction projects often contribute large amounts of sediment. Certain lumbering practices affect sediments in runoff. Sediments may fill stream channels and harbors that later require dredging. Sediments suffocate fish and shellfish populations by covering fish nests and clogging the gills of bottom fish and shellfish.

Petroleum Products

Oil and other petroleum products like gasoline and kerosene can find their way into water from ships, oil drilling rigs, oil refineries, automobile service stations, and streets. Oil spills kill aquatic life (fish, birds, shellfish, and vegetation). Birds are unable to fly when oil loads the feathers. Shellfish and small fish are poisoned. If it is washed on the beach, the oil requires much labor to clean up. Fuel oil, gasoline, and kerosene may leak into ground water through damaged underground storage tanks.

Animal Waste

Human wastes that are not properly treated at a waste treatment plant and then released to water may contain harmful bacteria and viruses. Typhoid fever, polio, cholera, dysentery (diarrhea), hepatitis, flu, and common cold germs are examples of diseases caused by bacteria and viruses in contaminated water. The main source of this problem is sewage getting into the water. People can come in contact with these microorganisms by drinking polluted water; also by eating fish or shellfish from, or swimming in, this water. Often unexpected flooding of barnyards or stock pens can suddenly increase the toxic effects of animal waste in water. Animal waste can also act as a fertilizer and create damage by increasing nutrients. (see Fertilizers)

Organic Wastes

Domestic sewage treatment plants, food processing plants, paper mill plants, and leather tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Fish die if too much oxygen is consumed by decomposing organic matter.

Inorganic Compounds

Detergents, pesticides, and many synthetic industrial chemicals are released to waterways. Many of these substances are toxic to fish and harmful to humans. They cause taste and odor problems and often cannot be treated effectively. Some are very poisonous at low concentrations.

Inorganic Chemicals

Inorganic chemicals and mineral substances, solid matter, and metal salts commonly dissolve into water. They often come from mining and manufacturing industries, oil field operations, agriculture, and natural sources. These chemicals interfere with natural stream purification; they destroy fish and other aquatic life. They also corrode expensive water treatment equipment; and increase the cost of boat maintenance.

Fertilizers

The major source of pollution from agriculture comes from surplus fertilizers in the runoff. Fertilizers contain nitrogen and phosphorous that can cause large amounts of algae to grow. The large algae blooms cover the water's surface. The algae die after they have used all of the nutrients. Once dead, they sink to the bottom where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water. Once the free oxygen is gone, many aquatic animals die. This process is called eutrophication.

Heated or Cooled Water

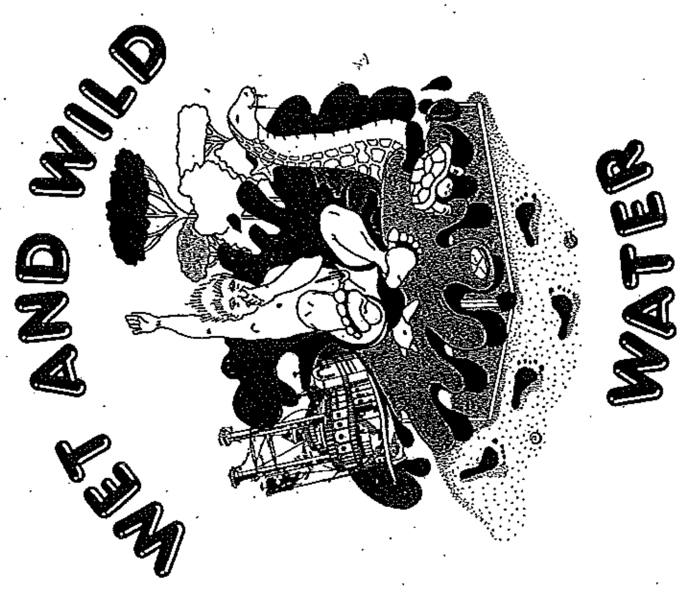
Heat reduces the ability of water to dissolve oxygen. Electric power plants use large quantities of water in their steam turbines. The heated water is often returned to streams, lagoons, or reservoirs. With less oxygen in the water, fish and other aquatic life can be harmed. Water temperatures that are much lower than normal can also cause habitat damage. Deep dams often let extra water flow downstream. When the water comes from the bottom of the dam, it is much colder than normal.

Acid Precipitation

Aquatic animals and plants are adjusted to a rather narrow range of pH levels. The pH value is a measure of the acidity of a solution. When water becomes too acidic, due to inorganic chemical pollution or from acid rain, fish and other organisms die.

Pesticides, Herbicides, Fungicides

Agricultural chemicals designed to kill or limit the growth of life forms are a common form of pollution. This pollution results from attempts to limit the negative effects of undesirable species on agricultural crop production. Irrigation, groundwater flow, and natural runoff bring these toxic substances to rivers, streams, lakes, and oceans.



Indiana Department of Education
Center for School Improvement and Performance
Office of School Assistance
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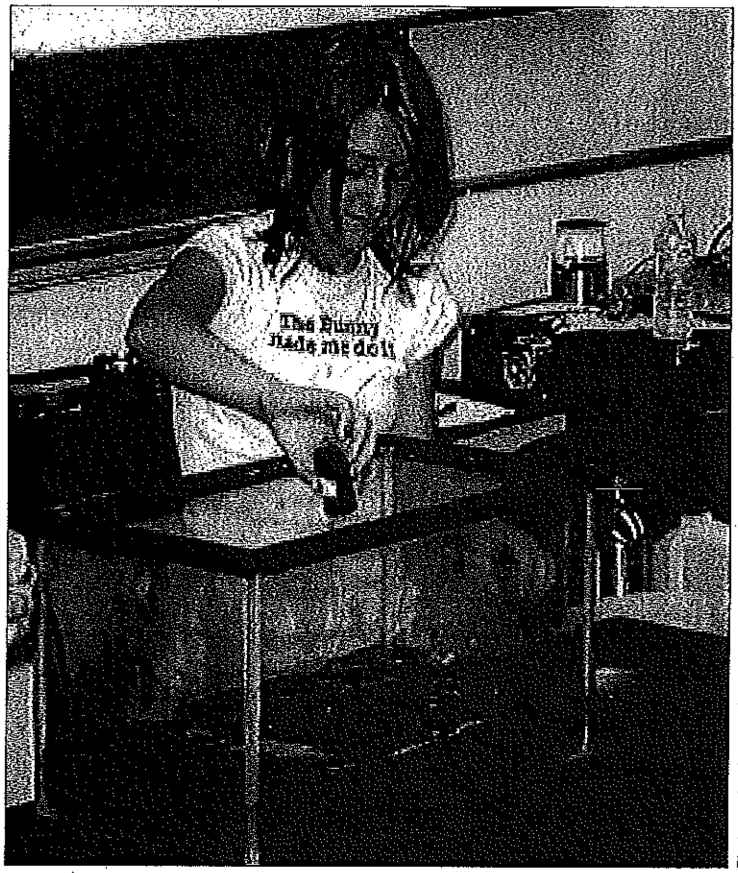
Water:
Local Pollution, Global Confusion!

Activities for raising awareness of water-quality problems and solutions



Photographs: Amanda Tetrault

by **Amanda Freedman Tetrault**

WATER, WATER, EVERY WHERE, / *Nor any drop to drink.* The ancient mariner's lament is a frightening reality of everyday life for more and more people on our planet. Access to clean water is an enormously important issue, both locally and globally, and one of the best ways to teach students about it is through experiential activities. The two activities presented here help students understand the causes of water pollution in their own communities and raise awareness of the global disparity in technology and resources needed for dealing with water-quality problems. The activities have been used predominantly with middle years students.

Who polluted the Red River?

This activity, based on the Population Connection activity "Who Polluted the Potomac?," provides a graphic demonstration of what causes pollution in local waterways and challenges students to think about our collective responsibility to protect the quality of water sources.

Materials: Large aquarium tank, one film canister or other small container for each student, a variety of substances and items to represent water contaminants (see opposite).

Preparation: Fill the aquarium halfway with clean water. Prepare the film canisters or other small containers by placing one water "pollutant" in each canister and labelling it as indicated. There should be one canister per student, so you may need to prepare more than one canister of some of the pollutants. The listed sources of water pollution are the ones mentioned in the accompanying "Who Polluted the Red River?" story (see page 30). Feel free to adapt the story and substitute materials, but keep in mind the nature of middle years students: it is important that all of the "pollutants" are safe, and even edible!

Yuck! We did this to our river?

Label on canister	Pollutant in canister
Trees	dry leaves (organic material)
Building construction	dry soil (eroded soil)
Farmers	baking soda (fertilizer)
Barnyards	water and instant coffee (leachate)
Septic tanks	water, yellow food colouring, toilet paper (human waste)
Coal mine	vinegar (acid)
Electric power plant	vinegar (acid)
Hydroelectric dam	silver cake sprinkles (mercury)
Commuters	vegetable oil and vinegar (motor oil and particulates)
Gardeners	baking soda (fertilizer)
Antifreeze	water and blue food colouring
Washing the car	water and dish soap
Expired medication	jellybeans (pills)
Mystery liquid	water and red food colouring (poison)
Motorboats	vegetable oil (motor oil)
Picnicking	candy wrappers, pop cans (litter)
Fisherman	dental floss (fishing line)
Wastewater	raisins (human waste)

Procedure:

1. Place the aquarium, half full of clear water, at the front of the classroom. Provide each student with a labelled canister containing one of the substances representing water contaminants. Instruct the students not to open their canisters yet, but to read and remember the word(s) on the label.

2. Begin telling the story of your local water source, briefly recounting human activities and development on or near the water and linking those activities to various pollutants. Ask students to listen for the word(s) printed on their canister as you tell the story. When they hear it, they are to come up to the tank, open the canister and pour its contents into the "river" (the aquarium).

   For example, in my class in Winnipeg, Manitoba, we recount the history of the Red River, which flows through the city (see "Who Polluted the Red River?"). I ask students how the first humans to live in the area might have used the river, and we talk about how clean the water likely was at that time. We then continue our story: As settlers arrive, building construction causes soil to erode into the river. At this point, the student who has the film canister labelled "Building construction" comes to the front, opens the canister and pours clay soil into the aquarium. As the story progresses and the aquarium water becomes more and more polluted, the students are horrified!

3. When all of the canisters have been emptied into the aquarium, invite the students to look at the "river" up close. At this point, I ask students, "Who did pollute the Red River?" Of course, they realize that we have all played a part in its contamination.

4. Follow the demonstration with a discussion of sustainability. Explain that there are three main impacts to be considered when we talk about the sustainability of an activity: its impact on the environment, on the economy, and on human health and well being. Guide students to think about the impacts of some of the activities and practices that pollute water sources. For the environmental impact, the answer is easy: contamination of the water source. Students will also readily grasp how human health and well-being are affected: that we need clean drinking water to survive, and we want our rivers and lakes to be clean for swimming, fishing and other purposes. It may be more difficult for students to make the link to economics. A discussion that leads to the cost of water treatment facilities in the local community will demonstrate that there is an economic cost to cleaning the water after we have polluted it.

5. Finally, challenge students to think about what can be done differently in their own lives at home and at school. Students may come up with many ideas, such as not flushing objects down the toilet, returning expired medications to the pharmacy for safe disposal, picking up pet wastes, and using compost rather than chemical fertilizers on gardens. Following this discussion, point out that while the class has come up with many good suggestions for preventing water pollution, there still remains a question: What do we do with the polluted water in our "river" (the aquarium)? This is where the second activity comes in.

Who Polluted the Red River?

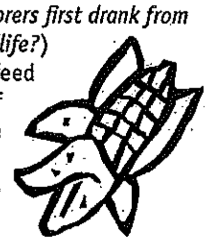
Instructions: Sources of water pollution are highlighted in bold type. As each is read aloud, the student with that canister comes forwards and empties its contents into the "river."

For thousands of years, people have lived on the banks of the Red River. Aboriginal people hunted in the forests, harvested food from wetlands and caught fish in the river. One of the first European explorers to visit the river wrote in his journal about the tributaries of "sweet water" and seeing so many fish that his crew tried to scoop them out of the river with a frying pan. (Ask the students: *Imagine that the water in the tank was taken from the river about 500 years ago. Would you drink this water? Eat fish that came from it? Swim in it?*)

Colonists began to arrive from Europe. They found fertile land, forests teeming with wildlife, and a river that provided ample food and water. It was an outstanding environment for settlement, and the colonists prospered. (Ask the students: *How do you think the colonists used the river? Do we use our rivers in the same ways today?*)

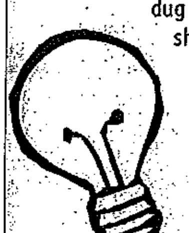
The river has changed since it was first explored. This is a story of those changes. *Listen for the word printed on your canister. When you hear it, come up to the tank, open the canister and pour its contents into the river.*

Years go by, and occasional storms drench the area. High winds whip through the **trees** and blow leaves into the river. Gradually the city of Winnipeg grows on the banks of the Red River. Developers clear wetlands and forests to build houses and businesses. Rain washes loose soil from **construction sites** into the river. (Ask the students: *Is this water safe to drink? Did the river have leaves or soil in it when explorers first drank from it? Would you swim in it? Is it safe for wildlife?*)



Upstream, **farmers** plant crops to feed the city's growing population. Some of the fields extend right to the banks of the river, and fertilizer washes into the water. Other farmers keep livestock in their **barnyards.** As rainwater drains from barnyards, it carried manure into a little creek that flows into the river. (Ask the students: *Would you drink this water now? Would you swim in it? Go boating in it? Is it safe for wildlife?*)

Since the city is so close to Manitoba's beautiful lakes, many people build cottages nearby. These cottages are not connected to the city sewer system. Instead, wastewater flows into septic tanks underground. Some homeowners do not maintain their **septic tanks,** and poorly treated sewage seeps into the nearby lake.



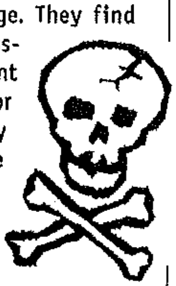
To meet the energy needs of the city, a **coal mine** is dug far upstream. Rainwater drains into the mineshaft, and as it soaks through mining wastes it becomes very acidic. It then trickles on to the river. The coal is burned to power the turbines of an **electric power plant** that is built along the river. Gasses from the smokestacks combine with moisture in the air to form acids. These pollutants return to the ground as acid rain or smog. To make more electricity, **hydroelectric dams** are built. When the river is dammed, land is flooded. Mercury contained in submerged soil and rocks is converted by bacteria into a form that is toxic to living organisms. (Ask the students: *Would you drink this water now? Would you swim in it? Go boating? Could fish or water wildlife live in water that is acidic or poisoned with mercury?*)

Winnipeg is now the largest metropolitan area in Manitoba.

Traffic congestion is starting to become a problem for **commuters** who drive their cars to and from work every day. Car exhaust causes acid rain, and cars that are not kept in good repair often leak oil and other fluids. These contaminants are washed off the pavement and into the river with the next rain.

And how do the residents of the city and suburbs spend their time? In one neighbourhood, **gardeners** are out working in their yards. Many are using weed killers and insect sprays to keep the lawns beautiful. The next rain will wash these poisons into a little creek nearby, which then flows into the river. A father is teaching his daughter how to change the **antifreeze** in their truck. They pour out the used antifreeze onto the driveway. Antifreeze tastes sweet and can poison any animal that licks it. It can also get into the nearby creek and poison fish.

Nearby a boy is **washing the family car.** The soapy water rushes down the driveway into the storm drain, which empties into the river. The grime on the car contains asphalt from roads, asbestos from brakes, rubber particles from tires, toxic metals and rust. If the boy had gone to a local car wash, the water would have been treated before it entered the river. While the boy washes the car, his mother is cleaning out her medicine cabinet and discovers some **expired medication.** Instead of throwing it into the garbage where children or animals might get to it, she decides to flush it down the toilet. Most of these contaminants will be cleaned from the water by the water treatment system, but 2 to 3 percent will still be in the water when it released back into the river.



Next door, a family is cleaning out their garage. They find an old rusty can with a tattered "skull and crossbones" label. It looks dangerous and they want to get rid of it before someone gets hurt. Junior gets an idea: "Let's pour it down the drain by the curb!" So the **mystery liquid** goes down the storm drain. The poison is out of sight — but is on its way to the river.

It's a nice day and many people head down the river. Some zoom up and down in **motorboats** and don't notice that a little engine oil leaks into the water. On the shore, a **fisherman** snags a hook on a log and breaks off the fishing line. Many people are **picnicking** in the parks along the river. But a wind is coming up and some of their trash will blow into the river. At the water treatment facility in the north end of the city, a malfunction occurs and untreated **wastewater** flows directly into the river....

—adapted with permission from "Who Polluted the Potomac?" by Population Connection

Clean Water for the World

This activity broadens the lens for a more global view. The class is divided into groups representing different countries, both rich and poor. Each group must construct a water filter to clean the water that was polluted during the previous activity. However, their ability to do so will depend on which country they are in — that is, on how much money they have to purchase the materials for their filter and how easily they can read the instructions.

Time: 1-3 classes, depending on whether students do additional research on their countries.

Materials: World map, play money, country profiles and water filter instruction sheets (see "Preparation" below), clean water, dirty water from the preceding activity. In addition, you will need the following materials for each group.

Materials provided "free":

- 2-litre pop bottle with the bottom cut off (used for filter)
- the bottom of a 1-litre pop bottle, or a transparent cup (used to catch filtered water)
- 500-ml measuring cup or the bottom of a plastic bottle (used to hold water for cleaning filters and to scoop dirty water from the tank for filtering)

Items to have available for "purchase":

- 1 cup fine sand
- 1 cup coarse sand
- 1 cup fine gravel
- 1 cup coarse gravel
- ½ cup of activated charcoal, available from aquarium stores (or crush charcoal briquettes)
- 1 cotton ball
- 1 small piece (about 10 cm x 10 cm) of cheesecloth
- 1 rubber band

Preparation:

1. For each "country package" (one package per group of four students), create a country profile (see Country Profile template, page 32) using the data provided on the Country Data chart (see page 32). Countries may be substituted, but ensure that a wide range of affluence and literacy is represented. Data for all countries can be obtained from *The World Factbook* by the U.S. Central Intelligence Agency at <www.cia.gov/library/publications/the-world-factbook/index.html>. Additional water usage information can be found at the EarthTrends site of the World Resources Institute <www.earthtrends.org/>.
2. For each country, prepare instructions for making the water filter. As shown in the two examples (see page 33), countries with high literacy rates, such and Canada and the United States, should receive instructions that are completely readable. For countries with lower rates of literacy, replace some of the words with gibberish according to the literacy rate. For example, the instructions for Ghana would be approximately 58 percent gibberish to reflect that country's literacy rate of 57.9 percent.

   The diagram of the completed filter (see page 33) may be included in all country packages. Alternatively, it may be provided only to the wealthier countries and omitted from packages for poorer countries, such as Afghanistan, Ghana and the Sudan. In that case, the diagram represents advantages, such as technology, education and health care, which make life easier in wealthier countries but are lacking in many developing nations.
3. Place play money into each country package as follows:

Sweden — $1,100	Brazil — $200
United States — $1,000	Ghana — $60
Canada — $825	Sudan — $50
Afghanistan — $18	

4. Prepare a price menu showing the cost of each of the materials for making the filters:

Activated charcoal	$50/half cup	Rubber band	$5 each
Cheesecloth	$5/square	Sand, coarse	$20/cup
Cotton	$5/ball	Sand, fine	$20/cup
Gravel, coarse	$10/cup	Water, clean	$10/litre
Gravel, fine	$10/cup		

Procedure:

1. Begin with an overview of the quality-of-life indicators that students will encounter in this activity, such as life expectancy, literacy and population growth rate.
2. Appoint two students to play the role of the World Bank. Select students who are not likely to be intimidated by their classmates, as one of the bankers' tasks will be to make life difficult for everyone! Divide the rest of the class into groups of four students.
3. Distribute the country packages to the groups and direct students to read their country's statistics and locate their country on a world map. Allow about 10 minutes for this and then open a discussion of any surprising things they have learned about their county. For example, the literacy rate in Sweden is 99 percent, while in Afghanistan it is only 36 percent. Students may also wish to speculate about reasons for more subtle differences, such as the differences in infant mortality per 1,000 births among Sweden (2.8), Canada (4.6) and the United States (6.4).

   Depending on the time available, you may wish to extend this part of the activity by inviting the students to conduct additional research on their country. Knowing more about the country they represent will help them to understand the reasons behind the statistics, such as historical events (e.g., has the country been at war?), natural events (e.g., has the country experienced prolonged drought?) or the style of politics, which may account for certain aspects of the country's situation.
4. Explain to the groups that their task will be to construct a water filter using the instructions in their package. Then give students a chance to view the materials price list and count their money. Sweden will discover that it has $1,100 — no supply out of their reach! — whereas Afghanistan

Country Data

	Afghanistan	Brazil	Canada	Ghana	Sudan	Sweden	United States
Area (km²)	647,500	8,511,965	9,984,670	239,460	2,505,810	449,964	9,826,630
Official languages	Afghan Persian, Pashto	Portuguese	English, French	English	Arabic	Swedish	English
Population	31,889,923	190,010,647	33,390,141	22,931,299	39,379,358	9,031,088	301,139,947
Population growth rate (%)	2.63	1.01	.087	1.97	2.08	0.16	0.89
Freshwater withdrawals (m³/year per person)	779	318	1,386	44	1,030	296	1,600
Domestic use (%)	2	20	20	24	3	37	13
Industrial use (%)	0	18	68	10	1	54	46
Agricultural use (%)	98	62	12	66	96	9	41
Life expectancy (years)	43.8	72.2	80.3	59.1	49.1	80.6	78
Infant mortality (per 1,000 births)	157	27.6	4.6	53.6	91.8	2.8	6.4
Adult literacy (%)	28.1	88.6	99	57.9	61.1	99	99
GDP (US$/person)	$880	$8,600	$35,200	$2,600	$2,300	$31,600	$43,500
Overseas aid (US$)	N/A	N/A	$2.6 billion	N/A	N/A	$1.7 billion	$6.9 billion

Source: U.S. Central Intelligence Agency, The World Factbook, <www.cia.gov/library/publications/the-world-factbook/index.html>.

Country Profile Template

Country Name

Area:
Main language(s):

Population:
Growth rate:

Water resources
Total water withdrawals: ____________ cubic metres per person
Domestic: ____________ %
Industrial: ____________ %
Agricultural: ____________ %

Health
Life expectancy (years):
Infant mortality rate: ____________ deaths/1,000 live births

Literacy
Age 15+ literacy: ____________ %

Economy
GDP per capita (US$/person):

Overseas aid
US$/person:

receives only $18 and will discover there is almost nothing they can afford to purchase. Students will need to prioritize the materials they will purchase once they read the instructions.

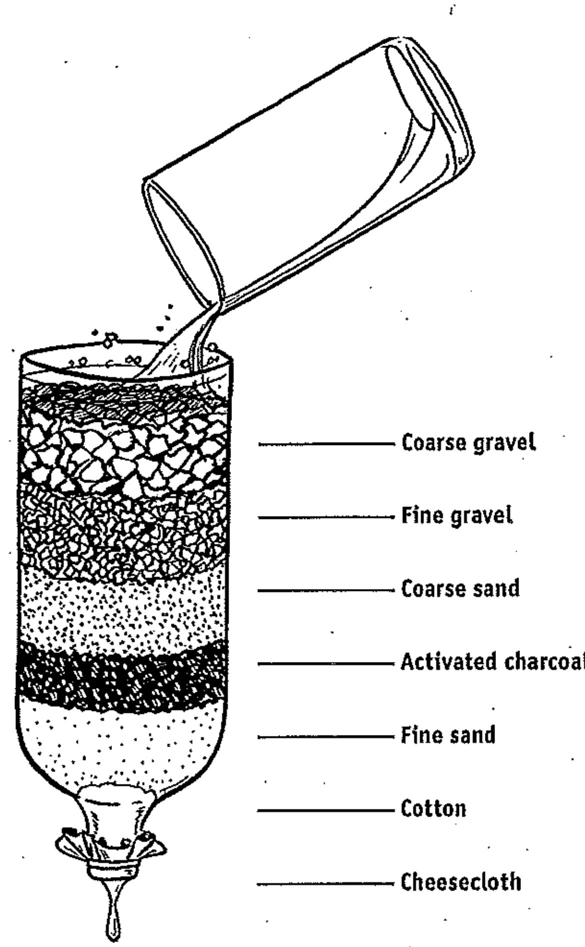
5. Have the students look at the water filter instructions in their package. The countries with a high adult literacy rate will not notice anything special about their instructions, but the countries that have a low literacy rate are met with a surprise — their instructions are seemingly gibberish. Ask the students: *Without a high adult literacy rate how can people understand written instructions?*

   If the packages have been prepared so that some countries have diagrams showing the filter construction and some do not, ask the students why this might be. (The diagrams can represent a variety of advantages, such as technological know-how, higher education and better health care.)

6. Provide each group with a two-litre plastic bottle with the bottom cut off, to be used as the container for their filter. Set a time limit, allowing them about 20 minutes to purchase the rest of their supplies from the World Bank and to make the filters. As they approach the World Bank for their supplies, they are met with road blocks. Sometimes the bank is closed, sometimes the staff takes "breaks" when the countries are lined up waiting, and all the while the groups are being reminded of their time limit. This creates a sense of urgency to complete the filter for the final test.

7. When the time has expired, ask each group to appoint a representative to bring their filter to the front of the classroom for the filter test. At this point, the differences between the "have" and "have not" countries become very obvious. The developing nations with few financial resources and low literacy rates will likely have very basic filters, as they could not purchase very many supplies or easily read the instructions. On the other hand, the developed nations may have constructed superfilters, using more supplies than required, and may still have a great deal of money left over.

   Have students first pour one litre of clean water through their filters to flush out any dust on the sand or gravel.



Then have them test the filters by pouring approximately 250 millilitres of the polluted "river water" through them. Just as the materials used to construct the filters make it obvious who are the "have" and "have not" countries, so does the visual inspection of the filtered water.

Reflection and discussion

Ask the students:

- Did you feel that you began to take on the role of your country?
- Did any country do anything out of desperation, or did any country take a position of power over another country?

Water Filter Instructions (examples)

Canada

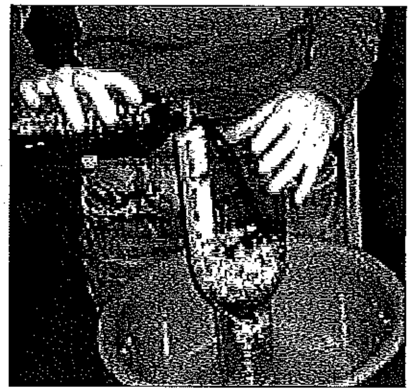
1. Place a cotton plug loosely in the neck of the cut bottle. Then cover the neck of the bottle with a piece of cheesecloth secured with a rubber band.
2. Pour a 1-cm layer of fine sand over the cotton plug, followed by activated charcoal, 1 cm each of coarse sand, fine gravel and coarse gravel.
3. Clean the filter by slowly and carefully pouring one litre of clean water through it (over a container).
4. Place the filter over a plastic cup. Test your water filter by pouring the dirty water through the filter.

Afghanistan

1. Æ±¤- a µ¾¿ðð Ìð-Ω µ¶{{¶§ in the ¾¿ of the ðµÆ½ ©©-¶. Then °»µ{ the of the bottle with a ½ ± of ¥«¬ cloth ¥ÐµÐð § with a ©ððµ ¶µ´.
2. Pour a 1-cm #-¬ of fine ¤Ð¥ over the µ ðð@¥Ð Ω, followed by µ*½Æ¤µÐð {{¶§µ¥ l, 1 cm of{ {¶§ ´ ¤Ð¥, fine ³#¾¿ # and ¥§´ ³#¾¿¥#.
3. Æµ½© the £Ð¥Ì by #@¥Ð£¿ and -ΩÌð-- pouring ¥Ð©£¿-- ¶-Æ(ð of clean *½Æ¤µ (over a Ð¶).
4. Æ±¤- the £Ð¥ Ì over a Æµ©¤ cup. £©-¶ your ½Æ¤µ £Ð¥Ì by ðÌΩ the Æ^(@½Æ¤µ µ©£ð¿*- the £Ð¥*Ì.

- Was there any collaboration between countries?
- How did this activity make you feel?
- How does this activity simulate real life? How is it different?

As in the first activity, ask students how this activity is linked to the three aspects of sustainability: economics, human health and the environment. A variety of answers and opportunities for discussion may come up in this final discussion, and students often have thoughtful responses to the experience, especially if they have been on either end of the scale of affluence and literacy. It is important that they see that economics plays a large role in determining water quality in various parts of the world. In addition, share statistics that help students understand the links between water quality, health and economics. For example, 443 million school days are lost each year due to water-related illness. When children are too ill to go to school, it is difficult for them to obtain an education that could enable them to improve the economic well-being of their family.



Student testing a water filter.

Taking action: Challenge your students to take action to protect water sources, whether by helping clean up a local water source or by decreasing their own personal water consumption. Students may also wish to plan a fundraising campaign or event to help support an international development organization working to provide communities with access to clean water, such as Ryan's Well Foundation <www.ryanswell.ca> and PlayPumps International <www.playpumps.org>.

Amanda Freedman Tetrault teaches Grade 7 science at École River Heights Middle School in Winnipeg, Manitoba, and is a graduate student at the University of Manitoba.

"Who Polluted the Red River?" is based on the activity "Who Polluted the Potomac?" in *People and the Planet: Lessons for a Sustainable Future* by Population Connection <www.populationeducation.org>; it was adapted from an activity originally developed by the Hard Bargain Farm Environmental Center in Accokeek, Maryland.

"Clean Water for the World" was adapted with permission from an activity in the Water for the World workshop developed by Engineers Without Borders/Ingénieurs Sans Frontières Canada, a nonprofit organization that works in partnership with people in developing communities to implement technologies that will improve their lives. EWB volunteers visit high schools across Canada to present interactive, in-class workshops on water, food security and energy resources. For information about school workshops, visit <www.ewb.ca> or contact Sarah Takaki at sarahtakaki@ewb.ca.

Stormwater Runoff:
Understanding the Ecological Impacts of Changing Land Uses

Joan Chadde

by **Joan Chadde**

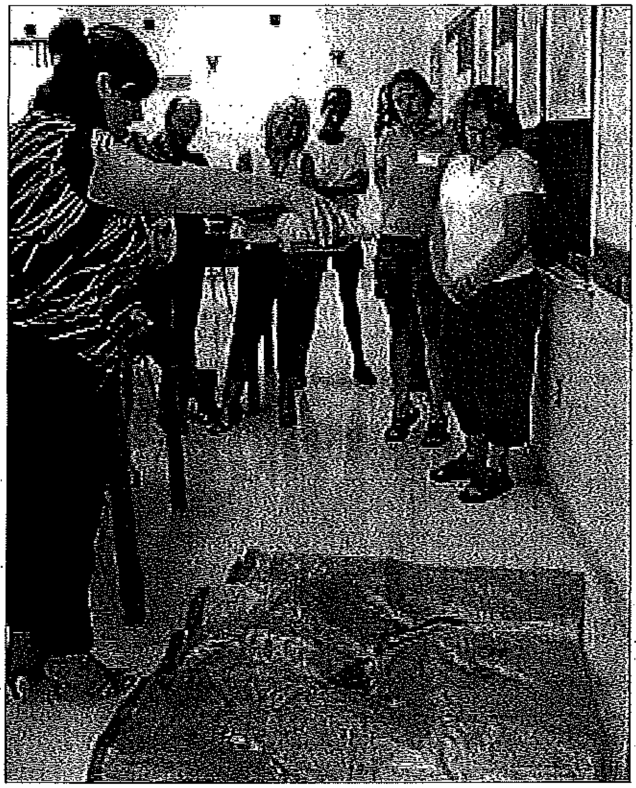
AS COMMUNITIES SPRAWL, new shopping malls spring up on their edges, big parking lots creep across the landscape and signage grows like weeds. Cookie-cutter architecture and big-box stores replace historic downtowns. As the built environment takes on a new look and feel, the natural environment changes too — but how?

I wanted to engage my middle school students in learning about these changes in their community so that they would better understand the consequences of wishing for another fast food restaurant or mini-mall. As a science teacher, I needed to find a way to connect learning about land use and community character with my middle school science curriculum. I decided to build a unit around stormwater, since a leading cause of water pollution is contaminants carried into lakes and rivers by stormwater runoff. Stormwater is also something that students can easily see and do something about.

Objectives

The stormwater unit brings up problems and solutions that students encounter every day, but rarely think about. Many students are not aware that land use changes in their communities are planned, or intentionally unplanned. By the end of our study, students are able to:

- describe ways in which humans change the environment and describe some of the possible consequences of those changes.
- explain the effects of agriculture and urban development on ecosystems.
- describe how changes in land use and land cover change community character and appearance and affect the environment.
- explain how pavement increases runoff into streams, lakes and coastal areas.
- describe how stormwater runoff can lower the water quality in streams, lakes and coastal areas, affecting sports and commercial fishing, altering picturesque waterfronts and causing beach closures.
- explain how increased stormwater runoff reduces groundwater recharge, potentially lowering the water table and impacting private drinking water wells.
- use measurement to describe the real world and to solve problems.


Joan Chadde

Simple watershed demonstration model using a plastic tarp laid over crumpled newspapers

I begin the unit by asking students these questions:

- How does community growth change the land cover?
- How do these changes in land cover affect the quantity, quality and timing of stormwater runoff?
- How will creating more pavement affect the groundwater table and drinking water wells?
- How does the loss of natural vegetation along riverbanks and shorelines change the water quality of streams and lakes and alter the aquatic ecosystem?
- How do all of these changes affect a community's appearance and natural character?

Investigating runoff

Stormwater runoff occurs when water from rainfall or snowmelt flows over the surface of the ground instead of percolating down into soil. As water flows over roads, lawns, parking lots and construction sites, it picks up fertilizers, pesticides, dirt, road salt, motor oil and animal wastes. Often these contaminants are then carried into nearby lakes, streams, rivers, wetlands or coastal waters. In some cities, any rainwater that enters a storm drain is discharged untreated into local water bodies — the same ones that people use for swimming, fishing and possibly even drinking water. In cities that have a combined sewer and storm drain system, millions of gallons of untreated or partially treated sewage can be released into lakes and rivers during large rainstorms when wastewater treatment plants become overloaded.

I demonstrate the movement of runoff with a simple watershed model that I create using a plastic sheet (a picnic tablecloth or shower curtain also works) laid over balled newspapers (one can also use a ready-made EnviroScape® watershed model). I invite the class to gather around as I make it "rain" onto the model using water from spray bottles or cups, illustrating how runoff moves downhill into rivers and lakes.

Next, I use a "stormwater metaphor" game to get students thinking about the potential contaminants in stormwater. Each group of three to four students receives one of the following items and must tell the class how the item is related to stormwater:

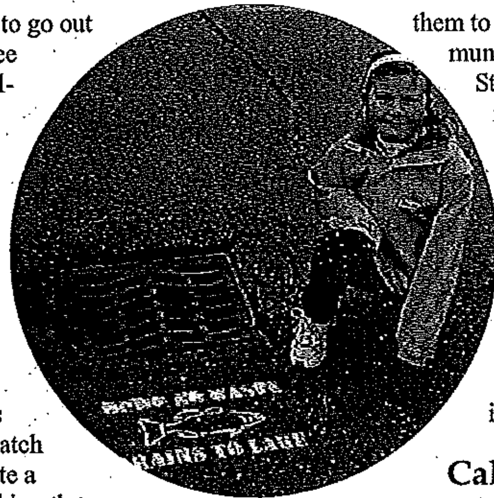
- toy car (motor oil, gasoline, antifreeze)
- pet leash (pet wastes)
- snow shovel (road salt)
- toy house (fertilizers and pesticides on lawns)
- fast food bag (litter/garbage)
- plastic turf or golf ball (fertilizers and pesticides from lawns, gardens, farms)
- paintbrush (paints and paint thinner poured down the storm drain)
- packet of seeds (exposed soil contributes sediments such as sand and silt)
- toy bulldozer (sediment from new construction)
- toilet paper (human wastes from wastewater treatment plant overflow)

After discussing stormwater — where it comes from and where it goes — I take my class on a short walk outside to identify areas that might contribute to runoff and to discuss the types of contaminants that could be carried from those areas to the nearest body of water. When possible, we take this walk during or right after a rainfall. I liken it to being environmental detectives and looking for clues or evidence. One day, as we walked to the river near our school, the maintenance department was painting the soccer field and a worker rinsed the paint sprayer in the parking lot. As they watched a plume of white paint come down the river, the kids quickly recognized the source of the pollution. It was a non-toxic, water-based paint, but we stenciled the storm drain and alerted the maintenance supervisor to the potential problem. If you can locate the pipes in your community that discharge storm water, you may have similar opportunities to see a plume of contaminated water outflow into the river or lake.

Using best management practices

Students investigate the potential impact of land use changes on the quality and quantity of surface water. As a class, we brainstorm different land uses and list potential contaminants associated with each. I remind students that land use changes aren't inherently bad, that it depends on how they are implemented. Best management practices (BMPs) are structural or nonstructural methods of preventing or reducing the movement of runoff carrying sediment, nutrients, pesticides and other pollutants from land to surface water. We identify several BMPs for each land use (see table "Runoff Control: Best Management Practices").

Students are given an assignment to go out into the community to photograph three BMPs being used to protect water quality, and three examples of sites where BMPs should have been put in place but are missing. Students learn to read the landscape as they identify sedimentation basins for catching runoff from large parking lots, vegetated or rock-lined drainage channels, and silt-control fences that keep soil from construction-related disturbances out of waterways. Some note the presence of vegetation buffers along shorelines, and rain gardens to catch runoff from parking lots. Students write a short description of each photo, describing the BMP or recommending a particular BMP if it is missing.



I review with students some of the planning and design decisions that have been made in our community, discussing local growth trends and how they directly affect our watershed. Using the guidebook *Design Guidelines to Enhance Community Appearance and Protect Natural Resources*, we look at examples of, and alternatives to, urban sprawl. (Other books or websites on community design or community character could be used, or students could be asked to do web research on urban sprawl and collect photos of it to share with the class.) It is important for students to understand sprawl visually, rather than only verbally. Therefore, I ask them to identify new development in our community and document it with digital photos. Students then select one photo and make recommendations for minimizing the visual and environmental impacts of the new development. They print the photo, lay tracing paper over it, draw in the parts of the scene they want to keep as is, and then add "best management" recommendations to show how the new development could be enhanced to better blend into the community and minimize water-quality and other environmental impacts.

Calculating runoff

If there is time, I have students calculate the amount of stormwater runoff from the school building. First, they measure the school building and transfer the dimensions to grid paper. Students then estimate the area of the building by counting the number of squares it occupies on the grid. To obtain the volume of water that falls on this area during a rain event, they multiply the area by the depth of the rainfall as follows:

U.S. measures (per inch of rainfall):

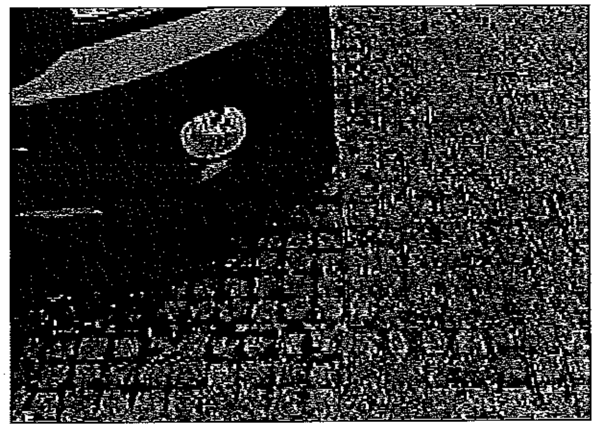
1. Rooftop area in square feet x 0.0833 feet (1 inch) = cubic feet
2. Cubic feet x 7.48 = volume in U.S. gallons

Runoff Control: Best Management Practices

Land Use	Possible Pollutants	Best Management Practices (BMPs)
Urban/commercial (parking lots, city streets)	Road salt Sediment Automotive fluids Motor oil Thermal warming of runoff water	• Use porous asphalt or pervious concrete • Create vegetated islands in parking lots • Construct runoff retention ponds to collect runoff and allow time for infiltration • Leave parking lots unpaved • Create vegetated or rock-lined drainage channels so that runoff can slowly seep into ground
Managed forest (logging roads)	Sediment	• Maintain vegetation buffer along stream to filter out sediment • Do not locate roads immediately adjacent to streams
Residential (lawns, driveways)	Pesticides Fertilizers (nutrients) Pet wastes (bacteria) Road salt Detergents	• Use minimal amounts of pesticides and fertilizers on lawns • Pick up and dispose of pet wastes • Maintain areas of native vegetation to promote infiltration • Irrigate lawns sparingly • Wash car where soapy water will infiltrate into lawn, not run off
Agriculture (livestock grazing)	Animal wastes (bacteria, nutrients)	• Maintain vegetation buffer along streams to slow and filter runoff • Fence along streams to limit or prevent access • Provide off-stream water tank for livestock
Agriculture (cropland)	Sediment Fertilizer Pesticides	• Maintain vegetation buffer along streams to slow and filter runoff
New construction	Sediment	• Use erosion-control fabric to prevent soil from moving off site

Metric measures (per centimeter of rainfall):

1. Rooftop area in square meters x 0.01 meter (1 cm) = cubic meters
2. Cubic meters x 1,000 = volume in liters



thingemeijg, UK

Permeable paving made of recycled plastic enables rain water to soak into the ground naturally, rather than into the municipal drain system.

I ask students, "Will all of the rain that falls on the school grounds reach the river or lake?" I display the table "Percent Runoff for Different Land Use Cover Types" to show that the type of ground cover determines how much precipitation infiltrates the ground and how much runs off. Other factors affecting runoff include the soil type and its infiltration rate; the intensity and amount of rainfall; whether the ground is frozen or saturated; whether the forest is a young, fast-growing forest that uses a lot of water or a slower-growing mature forest; the slope of the terrain; and the amount of soil compaction (high density residential lawns are quite compacted, greatly limiting infiltration). I show students aerial photos of our community taken in 1975 and in 2002, which clearly illustrate changes in land cover due to changes in land use (aerial photos may be obtained from local land management agencies or city planning offices and, in the U.S., from county offices of the USDA Natural Resources Conservation Service).

Lastly, the students tackle calculating the total volume of runoff from the school grounds in one year. We first look at an aerial photo or engineering sketch of the entire school grounds and note the different land covers: pavement/impervious parking lots, sidewalks and rooftops; football field/lawn; small wooded area. I let students loose with measuring tapes and calculators to measure the area of each cover type (measurements could be done from aerial photos if a distance legend is available). After obtaining these measurements, students calculate the total area of each cover type, which they multiply by the average annual rainfall and by the appropriate runoff factor (the percent of precipitation that runs off, as shown on the table "Percent Runoff for Different Land Use Cover Types"). Finally, students convert these volumes to liters or gallons of runoff. (See chart "Calculating Runoff from School Buildings and Grounds.")

We wrap up this unit by brainstorming ways to reduce runoff from our school grounds, such as by planting a rain garden, installing a green roof, using impervious asphalt in the parking lot, and planting shrubs and trees. We also do storm drain stenciling on the storm drains around the school. Many students are not aware that land use changes in their communities can affect the water quality of nearby streams, rivers and lakes. After this unit, they are better able to connect changes in community appearance to ecological changes resulting from changes in land cover.

More land-use investigations

The following are other science-based ideas for measuring the ecological impacts of changing land uses:

- Measure the difference in water quality at river sites upstream and downstream of a town, shopping mall, or other land use, using benthic macroinvertebrates as bio-indicators. The EPA website is a good place to start to learn about sampling methods, identification, state monitoring programs and more: <http://www.epa.gov/wbioindicators/html/invertebrate.html>.

Percent Runoff for Different Land Use Cover Types

Land Use	Description of Ground Cover	Percent Runoff
1. Agricultural	Row crops and crop residue cover	30%
2. Commercial	Buildings, sidewalks, paved parking areas	95-100%
3. Forest	Trees and shrubs	20-30%
4. Pasture/fields for livestock or wildlife	Grasses, legumes	10-30%
5. High density residential	Lot size smaller than 0.2 hectare (0.5 acre)	80%
6. Low density residential	Lot size equal to or larger than 0.2 hectare (0.5 acre)	50%
7. Industrial	Buildings and paved parking areas	70-90%
8. Open space/non-forested	Lawns, parks, golf courses	20-40%
9. Wetland	Standing water, vegetated	5%

Source: Urban Hydrology for Small Watersheds, USDA Natural Resources Conservation Service, 1986

Calculating Runoff from School Buildings and Grounds

Building or Other Location	Column A Area (square meters or square feet)	Column B Annual rainfall (meters or feet)	Column C Volume of annual rainfall Col. A × Col. B (cubic meters or cubic feet)	Runoff factor (%)	Volume of annual runoff Col. C × Runoff factor (cubic meters or cubic feet)
				Total school runoff	
				Convert cubic meters to liters: multiply total by 1,000 **Convert cubic feet to U.S. gallons:** multiply total by 7.48	

- Identify changing land uses in your community and discuss the potential visual and environmental consequences. See the "Changing the Land" activity in the *Looks Count!* curriculum unit at <http://wupcenter.mtu.edu/education/land_use/index_looks_count.htm>.
- Compare plant biodiversity in urban areas to plant biodiversity in undisturbed natural areas. See "Biodiversity Study: Disturbed vs. Undisturbed" from the *Looks Count!* curriculum unit at <http://wupcenter.mtu.edu/education/land_use/index_looks_count.htm>.
- Use artificial bird eggs (made of modeling clay and laid out in groups of three eggs in a series of parallel transects) to measure variation in predation on eggs laid by ground-nesting birds as the distance from human development is reduced. See "Artificial Nest Predation Investigation" from the *Looks Count!* curriculum unit at <http://wupcenter.mtu.edu/education/land_use/index_looks_count.htm>.

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Resources

Chadde, Joan, Rulison, Linda, Smith, Ruth Ann, and Dunstan, Jean. *Design Guidelines to Enhance Community Appearance and Protect Natural Resources*, 2nd edition. Houghton, MI: Western Upper Peninsula Center for Science, Mathematics and Environmental Education, Michigan Technological University, 2004. Features line drawings and color photos that visually address 20 of the most common development issues. Contact jchadde@mtu.edu to order a copy (US$5 each).

Chadde, Joan, and Linda Rulison, Ruth Ann Smith, Jean Dunstan. *Looks Count! Community Planning, Natural Resource Protection and the Visual Landscape*, 2nd edition. Houghton, MI: Western Upper Peninsula Center for Science, Mathematics and Environmental Education, Michigan Technological University, 2002. An interdisciplinary middle school unit containing 15 science and social studies lessons that guide students in assessing their community's character, measuring changes and proposing community enhancements.

Michigan Department of Environmental Quality. *Water Quality — Pollutant Sources and Impacts*. Michigan Environmental Education Curriculum Support (MEECS). A Michigan Tech Alive interactive web module describing types of water pollutants, their sources, pathways, impacts, and strategies to control their impact, available on-line at <http://techalive.mtu.edu/meec_index.htm>.

West Michigan Environmental Action Council. *Rain Gardens of West Michigan: Beautiful Solutions for Water Pollution* <www.raingardens.org>. Information on planning and planting rain gardens as catch basins for runoff.

USDA Natural Resources Conservation Service <www.nrcs.usda.gov/>. Provides excellent resources on soils; regional offices can provide aerial photos (click on "service centers" and follow the links to obtain the phone and address for the nearest office).

U.S. Geological Survey. "Effects of Urbanization on Water Quality: Urban Runoff." On-line September 28, 2007, <http://ga.water.usgs.gov/edu/urbanrun.html>.

WETLAND UNDERSTANDING LEADING TO PROTECTION

A Comprehensive, Multidisciplinary Wetlands Unit for Middle Schools

OUTDOOR SKILLS CENTER

Financial Assistance Provided By:
WI Coastal Management Program, State of Wisconsin, Department of Administration, Division of Energy & Intergovernmental Relations, and Coastal Zone Mgt. Act of 1972, as Amended. Administered by Office of Ocean and Coastal Resources Mgt., National Oceanic & Atmospheric Administration.

WETLANDS ARE DIFFERENT--LIKE YOU AND ME

PURPOSE
The purpose of this activity is to compare 3 common wetland types found in Wisconsin.

METHOD
Using information sheets provided, students will conduct research on common wetland types and develop a mural depicting each.

CONCEPTS
*Wetlands are not all the same.
*Wisconsin has three main types.

OBJECTIVES
The student will be able to: 1) identify 3 common wetland types and 2) compare similarities and differences of these types.

SUBJECTS
Science, Art.

SKILLS
Analysis, Classification, Comparison, Description, Research.

MATERIALS
*Student copies of Wetland Types Information Sheets.
*Butcher paper, or wide roll paper.
*Materials for making a mural (colored paper, scissors, glue or tape, markers or crayons, etc.).

GLOSSARY WORDS
Prairie Potholes, Fens.

TIME CONSIDERATIONS
Two 50 Minute Periods.

BACKGROUND
Wetlands come in all shapes and sizes. No two are exactly alike, but they can be put into major categories. For our purposes, the discussion will center around three main types: marshes, wooded swamps, and bogs. These are the most common wetland types found in Wisconsin. Many other wetland types are found throughout the world--vernal (summer) ponds, **prairie potholes**, **fens**, and wet meadows. The differences between these types are great, but all of the wetland types have particular vegetation, soils, and hydrology (water). The differences in form are reflections of the local water movement, availability, composition, and structure of the area on which they are found.

Marshes are characterized by relatively shallow water and a large surface area. Marshes are commonly found in association with lakes, rivers, or streams in areas of low topography. Their position in relation to a river or stream may either be alongside the main channel, or in the middle, with the channel entering and exiting them. Their location affects the shape and make-up of the marsh. Marshes commonly support a wealth of life including: Cattails, bulrushes, sandhill cranes, a variety of waterfowl, red-winged blackbirds, dragonflies, crayfish, painted turtles, and northern pike.

Wooded swamps may be located on the edges of marshes or off by themselves. They are characterized by the presence of woody vegetation in the form of shrubs such as red-osier dogwood, willow or alder, or trees like tamarack and ash. They provide necessary habitat requirements for organisms such as wood ducks, whitetail deer, skunk cabbage, and mosquitos.

Bogs are usually formed in glacial areas and represent the latter stages of old kettle lakes. Kettles are deep cone-shaped depressions in the ground formed by large pieces of ice deposited by glaciers. This depression fills with glacial meltwater and, in time plant communities establish themselves around it. One of the plants that is found in abundance in these areas is sphagnum moss, which moves in as soon a thin soil layer is formed. Sphagnum moss and sedges form a mat and slowly grow over the open water, closing in toward the middle. The water is very cold due to the depth and sunlight-blocking sphagnum mat. The sphagnum moss prefers water with a low ph, so it secretes acidic chemicals. Decomposition of dead plant and animal materials is low due to low temperature and pH. Plants and animals found in bogs need to be very specialized and well-adapted to the unique demands of bog life. Carnivorous plants such as the pitcher plant and the sundew have found a way to get nutrients and water, in these areas where they are hard to get. Other plants such as leather leaf and heath have developed waxy leaves or the ability to turn their leaves vertically to avoid water loss during the day. The stickle-back minnow is the only fish that can take the low pH. All forms of life must have big tricks up their sleeves to live in bogs.

PROCEDURE

1. Tell your students, "Now that we know what makes a wet-land a wetland, it is important to realize that there are different kinds." Discuss the fact that these differences are related to the wetlands' location and the physical make-up of the surrounding land. A wetland found isolated in the middle of a forest is going to be different than a wetland found in the middle of a river channel.

2. Divide your class into three groups. Tell them that each group will be learning about different wetland types. After researching different wetland types, they will be asked to create a mural or diorama which shows the wetland in cross section. Murals should depict the organisms found there.

3. Assign one group the marsh wetland type, one wooded swamps, and one bogs. Hand out copies of the Wetland Types Information Sheets to the proper groups. Ask the students to read over the information, then go to your school or public library and have the students search for related information.

4. After collecting further information, have each group plan their mural. Suggest that they draw a sketch of their mural on a small piece of paper before starting the mural.

5. Have the groups complete their murals, referring to the information sheets and research collected as needed. When they are complete, have the group hold their mural up for the whole class to see. A spokesperson for the group should discuss the mural and the wetland type they drew.

6. Discuss the variation and similarity between the wetland forms. Review the necessary components of wetlands: plants, soils, and water. Discuss how each of the three wetland types viewed in this activity possess these three characteristics.

WETLAND TYPES INFORMATION SHEET

MARSHES

Marshes are wetlands with shallow water. They can spread over large areas of land. Some marshes are found in low areas on the edges of lakes, rivers, or streams. Other marshes are found by themselves as a shallow pond or depression. Marshes commonly support a wealth of life including a variety of plants, fish, mammals, reptiles, waterfowl, and other birds. Below are lists of some of the most common marsh organisms.

PLANTS

cattail
bulrush
duckweed
arrowhead
pond lily
water milfoil
wild rice
red-osier dogwood

ANIMALS

mallard duck
great blue heron
sandhill crane
red-winged blackbird
yellow-headed blackbird
marsh hawk
Canada goose
mink
muskrat
beaver
northern pike
yellow perch
painted turtle
bullfrog
dragon fly
giant water bug
crayfish

WETLAND TYPES INFORMATION SHEET
WOODED SWAMPS

Wooded swamps may be located on the edges of marshes or off by themselves. They usually have soggy ground with little surface water. They can be recognized by the presence of shrubs like red-osier dogwood, willow and alder, or trees like tamarack, cedar, and ash. Unlike other wetland types, these shrubs and trees grow throughout the wetland. They provide necessary habitat requirements for a variety of organisms.

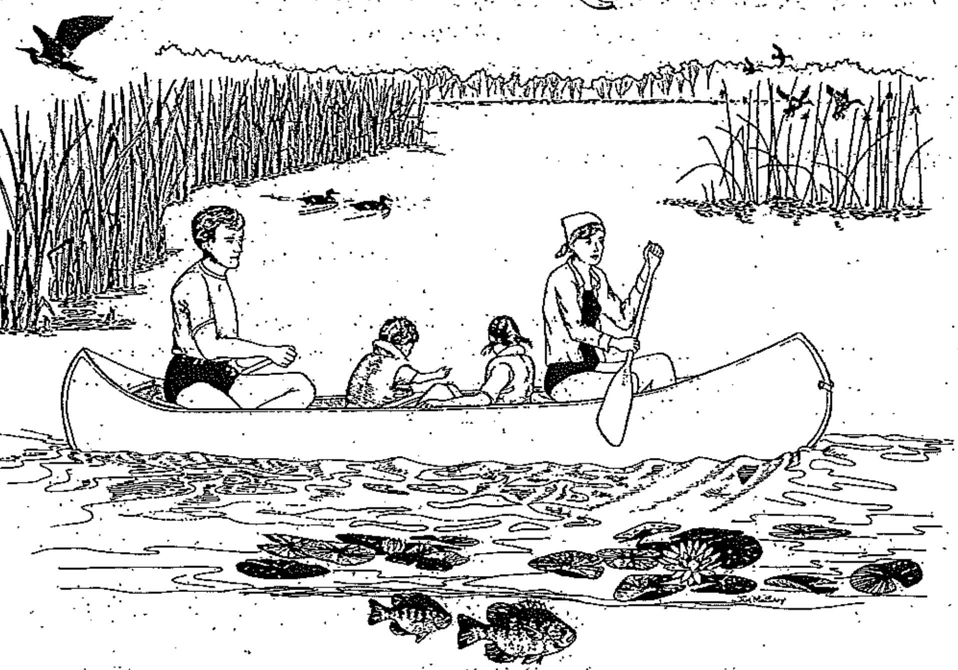
PLANTS	**ANIMALS**
red-osier dogwood	whitetail deer
poison sumac	raccoon
alder	barred owl
tamarack	snowshoe hare
cedar	ruffed grouse
ash	mosquito
skunk cabbage	wood duck
marsh marigold	common water snake
sphagnum moss	green tree frog
	tiger salamander
	grey fox

WETLAND TYPES INFORMATION SHEET
BOGS

Bogs are usually found in areas where glaciers once moved across the land. They are later stages of old kettle lakes. Kettles are deep cone-shaped depressions in the ground formed by large pieces of ice deposited by glaciers. These depressions fill with glacial meltwater. In time sphagnum moss and sedges form a mat and slowly grow over the open water. Eventually this mat may form across the lake. The water in a bog is very cold due to the depth and sunlight-blocking sphagnum/sedge mat. Carnivorous plants such as the pitcher plant and sundew are found here. Bogs are acidic, sort of like Coca Cola. The stickle-back minnow is the only fish able to withstand the low pH. All forms of life must have big tricks up their sleeves to live in bogs.

PLANTS	ANIMALS
pitcher plant	stickle-back minnow
sundew	ruffed grouse
sphagnum moss	great grey owl
sedge	bog lemming
tamarack	snowshoe hare
cranberry	mink
blueberry	American woodcock
	black bear

IT'S A QUESTION OF VALUES



PURPOSE
The purpose of this activity is to examine values associated with wetlands.

METHOD
After a discussion on environmental values students will evaluate and differentiate examples into appropriate value categories.

CONCEPT
Wetlands are important to different people for different reasons.

OBJECTIVES
The student will be able to: 1) describe six value categories, and 2) recognize examples of each.

SUBJECTS
Language Arts, Social Studies

SKILLS
Analysis, Classification, Comparison, Identifying, Matching, Recognizing

MATERIALS
*Values category worksheet
*Value Cards

GLOSSARY WORDS
None

TIME CONSIDERATIONS
One to Two 50 Minute Periods

BACKGROUND
What is a wetland worth? Each of us value an environmental area for different reasons. It's a matter of perspective. Some recognize the money to be made, while others enjoy it's beauty. Individuals may value an area from a recreation, education, egocentric, ecologic, economic, and/or aesthetic point of view. While many of these are linked, others are diametrically opposed and are therefore the source of conflict.

Value Categories

Economic- Worth in terms of dollars and cents. Example: This wetland is valued at one-million dollars for development purposes or tourism potential.

Aesthetic- Worth in terms of appreciation of the beauty of the natural surroundings. Example: This wetland is a sea of color and sound.

Recreation- Worth in terms of leisure time uses. Example: This wetland is the best place to hunt ducks in the county.

Education- Worth in terms of learning/instructional benefit. Example: This wetland is a place where my fourth grade class goes to learn about adaptations.

Egocentric- Worth in terms of what it offers an individual. Example: This wetland is my favorite place to sit and read.

Ecologic- Worth in terms of maintaining the integrity of natural systems. Example: This wetland is a place where 300 Canada geese nest every spring, and 20,000 stop at on their migration South for winter.

PROCEDURE
1. Introduce the definition of values. A value is the relative worth placed on an object or area. Discuss with the students, the six different value categories, giving the students an example of each.

2. Hand out the one Values Category Worksheet to each student and one sheet of value cards.

3. Have students cut out each value card (cut along lines). Each student should have 18 value cards.

4. Students should begin by placing the value cards on the chart without gluing This will allow them to move the cards if necessary. Each value category will have three values. It is important for students to understand that some belong under more than one value category. Once the cards are in place, have them glue them down.

5. After students have completed glueingluingards, discuss where they placed each value, and why. Discuss that some of these values could be in more than one category.

WETLAND VALUE CARDS

this marsh is my secret hunting spot	fishing	duck hunting	spawning grounds for northern	bird watching	millions of dollars saved in flood control
draining and filling wetlands for farmlands and/or development	cleanses water	classroom visit to a wetland	I own this wetland I can do what I want	trapping and selling furs	listening to frogs
smell of the cool damp air on a hot summers evening	discovering microscopic plants and animals	this is my favorite place, I grew up playing here	canoeing	collecting insects	nursery for migratory birds

WETLAND CATEGORY WORKSHEET

ECONOMIC	AESTHETIC	RECREATION	EDUCATION	EGOCENTRIC	ECOLOGIC