Activity Guide

RiverWorks

TSONGAS INDUSTRIAL HISTORY CENTER

University of Massachusetts Lowell
Graduate School of Education

Lowell National Historical Park

Connections to National Standards and State Curriculum Frameworks

RiverWorks

Program Description

RiverWorks is a 90 minute workshop and 90 minute tour that explores the environmental history of the Merrimack River. The day will begin with arrival at Boardinghouse Park. School groups will be met by their museum teachers who will accompany the bus to the Bellegarde Boat House on the Merrimack River. The groups then will begin their day with either the bus tour or workshop segment of the program.

During the tour segment, students will visit the Francis Gatehouse by bus to learn about the dual use of the canals for power and transportation. They will hear the story of the "Great Gate" that saved Lowell from floods. The students will also visit the Pawtucket Gatehouse to view the Pawtucket Dam, the storage point for water that powered the mills and provides water for hydroelectric power today.

Lunch will be limited to a half hour between the river and boat house segments of the program. Groups will convene at the boathouse for a picnic style lunch on the boathouse deck. In the event of rain, shelter is available.

Please advise all participants to dress appropriately in all-weather shoes with good traction, outdoor clothing, and light jacket or covering. (The air is always cooler over the water.)

Theme

The Industrial Revolution was a defining era in American history. All that we consider "modern" in technology, politics, art, culture, the nature of work, and the environment was significantly shaped by this period.

During the nineteenth century, industrial centers began to spring up along waterways all over northeastern America. These waterways were used for powering machinery in the manufacturing process. This use had a profound effect on these waterways, and more often than not, the effect was a negative one.

RiverWorks will explore the story of one river, the Merrimack, from its origin as a pristine confluence of two New Hampshire streams to its heyday as a transportation/manufacturing resource, a period that had devastating effects on it, to the recent time when efforts are being made to restore the river to health and human use compatible with the river as an ecosystem.

Program Objectives

After visiting the Park and using activities in this guide, students will be able to:

- Explain the fragility of watersheds as fresh-water resources.
- Describe how the Merrimack River has been used historically
- Identify ways that the Industrial Revolution affected the ecosystem of the Merrimack River and how human uses continue to impact the river ecosystem.
- Explain ways the health and water quality of the river can be determined.
- Describe current methods of conservation and restoration of the river.

Introduction

The Industrial Revolution was not only a turning point in the economic development of the United States, it marked a changed relationship between the inhabitants of the country and their environment. With the development of technologies (water wheels, turbines) to harness water power and the evolution of textile machinery, previously labor-intensive activities such as cloth making happened under one roof. Cloth production left the farms and "cottage industry," and in what was known as the "integrated factory system," the bale of cotton was transformed to the finished bolt of cloth in one building, the textile mill.

Many of those familiar long, brick mill buildings are abandoned now, silent testaments to a period of productivity and economic expansion that began last century and continued into this one. Sadly, many remain as vacant monuments marking the demise of the river systems they relied on. The textile industry which occupied those mill buildings required the alteration of water courses with dams to collect large amounts of water to power the mills. In addition, miles of canals were constructed to divert water out of river systems into the wheelpits of the mills. Both of these modifications affected not only flora and fauna of the river environment but also had even more devastating impacts on the river--dyes, chemicals from the cloth making processes and even human wastes as a product of the thousands of workers required in the mills--were discharged into the river. Part of our history is just coming to light as we learn about the long-term effects of industrial development and its effect on our environment.

1. Do-It-Yourself-Watershed

Background

Water circulates in a hydrological cycle from the earth's atmosphere onto the land, out to the ocean and back up to the atmosphere. This continuous cycle is powered by the energy of the sun and by the force of gravity. When precipitation in the form of rain and snow falls upon the land, it has several paths that it can follow. It can be absorbed into the soil, evaporated from a puddle or pond, or it can flow off the land via a river system. The river systems funnel excess waters off the land and into the ocean basins. The oceans in turn give up huge amounts of water in evaporation, leading to the formation of clouds of water vapor which release water back onto the land as precipitation. Every living thing is part of the cycle, too. Plants, in a process called transpiration, give off moisture into the air. The breath of humans and animals return water to the atmosphere.

A watershed is all the land area that contributes runoff to a body of water. Every part of the earth is in a watershed. Watersheds begin at high elevations in mountain ranges or high plateaus. The water flows downhill, joining tiny rivulets together into streams and eventually joining the streams into rivers.

Activity

The purpose of this activity is to let students study how a watershed works by constructing one and watching it operate. Students can work in groups of three to four.

Activity: For each group, you will need the following materials:

- 1 large plastic stoage bin (a 22" x 16" x 9" tote size works well)
- crumpled newspaper
- Masking tape
- A supply of water tinted with blue food coloring (provided in a watering can or somethiing that the students can pour from)
- A sheet of heavy-duty aluminum foil long enough to fit over the bin with some extra left over (to wrap over the edges of the bin)

Time: 45 minutes

Each group will follow the same procedure:

Crumple some of the newspaper and use it to line the bottom of the bin. Explain that the height of the newspaper needs to decrease from one end of the bin to the other. This creates a slope down which water can flow. Take the sheet of

aluminum foil and carefully lay it over the bin. (Warn students that the foil is easily punctured; they should be careful handling it.) Gently mold the foil over the lumps of newspaper to simulate the contours of the land. Students will be forming high areas for mountains, depressions for lakes, narrow trenches for streams and rivers. The foil should follow the slope down to one corner of the bin. When students have formed the contour, they can loosely tape the sides of the foil down to the sides of the bin. (Use only one piece of tape per side, since they will need to lift the foil to change the shape of the land.)
When the students have their landscape formed, they are ready for rainfall. Have them take turns pouring the blue water gently onto the landscape, principally in the high-elevation areas. They should observe how the water flows, seeking the lowest pathways, pooling in the depressions to make lakes, flowing through the crevices to make rivers, and finally arriving at the bottom of the bin, the ocean. Continued rainfall causes lakes and ponds to overflow into the river system.

Have students empty the water out of the bin back into their water supply. Then, let them carefully lift the tape holding the foil down so that they can manipulate the foil. Have them remold the foil to cause changes in their "landscape". When they have a new contour ready, they can again let it rain on their landscape. What changes do they observe in the flow of the water? What happens when they withhold water from the system (drought)? What happens if they pour too much water too quickly (flooding)? What would happen if they dammed up one of their rivers?

While all of the water in this watershed will eventually reach the ocean, explain that in the real world, not all of the rain that falls on the land actually reaches the ocean. Why not? Where else can water in the real world go? It can soak into the ground, be evaporated directly back to the air, end up in a reservoir and enter the water supply system of a city, be taken up into a plant, etc. This activity can be used to stimulate discussion about how water interacts with, and links together, the earth's lithosphere, biosphere and atmosphere.

2. What's My Eco-Address?

Background
Just as each of us has a street address that connects us to the rest of the world via the postal service, we each, also, have an "eco-address," a place in the watershed where our town or city belongs and by which we are connected to the rest of the watershed. Every part of every land mass is in a watershed. If we know our eco-address, we can locate ourselves in our watershed and see how our location connects with other addresses both upstream and downstream.

Activity
Maps of your watershed are available at your town or city hall or from your local watershed council or agency. Post watershed map in an area where students can gather around it. Have students locate your town on the map. What streams and rivers run through or near your town? Are there any marshes or other wetlands nearby that may connect with or seep into the river?

Have students record the name of the stream closest to their house. They should then trace that stream until it joins a larger stream and record the name of that stream. Have them continue to record the paths of connecting waters until they reach the ocean, the ultimate destination for each river. An example of an eco-address might be:

Town of Waterville Valley, NH
Mad River Sub-Basin
Pemigewasset River Basin
Merrimack River Watershed
Atlantic Ocean

Where does our flush go?
Once students know their eco-addresses, discuss how your local water supply and waste disposal (sewer system) affects not only their own section of the river, but the entire watershed system downstream from them. Emphasize the interconnectedness of the watershed area, that it functions as a complete system. What happens in the tiny rural stream ultimately affects life in and along the mighty rivers. We are all "downstream" from someplace.

What we live on is a watershed. The depth of our ignorance of our relationship to place is always measured by our lack of understanding of our watershed. What it is, where and how it is.

…..I've learned that when I'm in a new place and I want to figure out its morphology, its geography, the first thing to determine is what watershed it's in. If you want to determine how appropriate a lifestyle is for the land you're living on, find out where the water comes from. In many ways, the watershed seemed like a core concept for basic nature literacy.

Robert Hass – Nature Poet
America's Poet Laureate 1995

3. Impact of Urban Development on Watershed Area

Early Agricultural Environment of East Chelmsford

The environmental impact of the early farm settlement may not be obvious to students. However, poor agricultural practices can be very harmful to water quality. Although the use of fertilizers would not have been an issue as it is today, allowing animal wastes to run off into the river, clear cutting of trees and brush whose roots stabilized soils and prevented erosion, overgrazing of pasture land that would also lead to increased sediments washing off—all would have had detrimental impact on the water resources of the area.

Activity

Included with this packet are three views of Lowell:

- a map showing the undeveloped farmland of East Chelmsford that became the city of Lowell
- the city of Lowell thirty years later
- a birds-eye view of the city as it appeared in 1876.

[NOTE: To receive copies of these graphics please call 978-970-5080 or email: Beverly_Perna@uml.edu. Thank you]

Make transparencies of each of the three views and ask the class to hypothesize how industrialization affected the environment. Then ask the students to identify the effects of urbanization on the environment.

Questions to ask when looking at each of the three maps:

1. How did the people who lived in this area get their drinking water?
2. How were the organic wastes of people and animals disposed of?
3. How much vegetation is shown on this map and how would it impact run-off?
4. What would happen to precipitation in this area?
5. Where are there areas of increased run-off?
6. Where would the run-off go?

How does the development of a city alter the watershed? Urbanization not only produces profound economic and social changes, it has a substantial impact on the environment. Here are just the major effects:

- Precipitation that formerly seeped into the ground then collected in ground water systems now runs off as a result of hitting vast amounts of impermeable surfaces, such as buildings, city streets and parking lots.

- Infiltration into the soil is diminished. More run-off means flood conditions in some areas

- Vegetation that once absorbed large quantities of moisture is removed when a city is developed, thus excess water once absorbed by plants contributes to flooding.

- Population density leads to increased pollutants leaching into the ground water systems or into local streams.

4. Early Human Use of the Merrimack River

The first humans to use the Merrimack River were Paleo-Indians, nomadic people who followed the herds of caribou, mastodon and mammoth that roamed what was then a bare tundra. Since that time ten thousand years ago, the river has sustained human activity, providing food and a means of transportation. As these Native Americans learned agriculture, they stayed in places longer periods of time. Archeologists have dated camps that were active 3,500 years ago. The evidence shows they grew a variety of crops including corn, beans, cucumbers, pumpkin, and squash--and they made and decorated pottery.
During the spring when the fish "ran," tribes would gather at the Pawtucket falls along the river. The scene is described in *Colby's Indian History*:

. . .the Indian could stand through day and night if he chose and throw spear and dip-net without missing a fish. . .At Pawtucket Falls, the fish arrived usually about the first of May and continued throughout the busiest time of corn planting, but at Amoskeag Falls they did not arrive until about June when the planting season was over, thus affording the Indians plenty of time to take and cure them without interruption from their agricultural pursuits."

My Gift to the Earth
The Native Americans who lived in this area were part of the Algonquin nation, one of

the eight great groups of Native Americans who occupied what is now known as the United States. They settled in areas of major river drainage basins, such as the Merrimack and spoke a single language with regional dialects. The tribal confederations that occupied the Merrimack River Valley were the Abenakis in the northern portion and the Penacooks in the southern portion. Combined, their territory stretched from the Penobscot River to the Connecticut River and included all of New Hampshire, part of Massachusetts and a part of Maine. The Penacooks were under the leadership of Passaconaway and, later, led by his son Wannalancet and then grandson Kancamankus. These are names still seen in this area of New England.

It is said that the Pennacook called the river "Merroh Awke" which meant "strong place." One tribal seat was located nears the falls in Lowell which they called Pawtucket meaning"place of loud noise or falling water." The river and the Pawtucket Falls were central to the Pennacook way of life.
The local tribal units were the Pawtuckets, who lived in the general vicinity of Pawtucket Falls and the Wamesets, who lived near the confluence of the Concord and Merrimac Rivers. For the Eastern Native American, the salmon, shad, and other fish were as important as buffaloes were to the Western Native American. Although the groups became scattered throughout New England and Canada after the Industrial Revolution, they continued to meet at the falls until the last 1930's. The local tribes still maintain their traditions and culture with 134 families registered as members of the Greater Lowell Indian Cultural Association who regularly meet for POW wows, ceremonies and rituals.

Special empathy for all parts of the earth is the foundation of Native American culture. Native Americans believe that even inanimate objects such as rocks, water, wind have spirits with which humans share a kinship. Human control of the environment is contrary to Native American beliefs. This connection to every other living and non-living part of nature creates a special sense of stewardship for the earth, a "connectedness" among all facets of environment. The Native Americans did not feel an "ownership" of the earth but rather a "stewardship." By contrast, by the middle of the 19th century, Americans of Euro-origin professed their "manifest destiny," the notion that the Untied States had divine sanction "to overspread the continent allotted by Providence for the free development of our multiplying millions." As we know, these two perspectives became a source of great conflict.

Activity

These are words used by Native Americans in Massachusetts. Unless otherwise indicated, vowels are pronounced as follows: "a" as in father, "e" as is they, "i" as in marine, "o" as in note, and "u" as in flute. "Ai" is pronounced as the "i" in fire and "au" as the "ow" in now.

Black Bird	Cho' gan	Rain	so kan' on
Rabbit	tup'saas	Sky	ke' suk
Weasel	am'ucksh	Sun	ne' pauz
Cedar tree	chik' kup	Waterfall	paw' tuck
Pine tree	co'waw	Crow	kon' kon tu
Ice	kup'padt	Deer	ah' tuk
Thunder	pad toh' quoh han	Eagle	Womp sik' kuck
Lightning	uk ku tshau'mun	Fox	wonk' sis
Morning Star	Mish an' nock	Moose	moos
Moon	mun nan' nock	Muskrat	musquash
Rock	qus' suk	Night	nu' kon
Star	an' ogas	Owl	oh o' mons
Water	nip' pe	Partridge	poh poh' kussu
Bear	mosq	Squirrel	ane' qus
Beaver	tum' munk	Wolf	muk' quo shim
Skunk	au' sonnch	Oak tree	noo ti' mis
Wildcat	pus' sough	Day	ke' suk
Ash tree	mo' nunks	Forest	tou' oh ko muk
Cloud	ma' toqs	Lake	nip' pis se
Fire	noo' tau	Mountain	wad' chu
River	we' pu ash	Snow	ko' on
Wind	wa' ban	Earth	oh'ke

Have each student draw a name from the following Native American vocabulary list. Give each an index card and have them write their name on it. Have them think about what their role is on earth--where do they live, where are they in the web of life, the food chain, what happerns to them when they die or are killed; if they are inanimate, of what use could they be?

Form a circle. Whoever chooses the name for the sun should go to the middle of circle, say his/her Native American name and explain his/her gift to Ohke (the earth)--"I am Nepauz, the sun, the source of all life, warmth and growth."

The sun should then pick someone else to come to the center of the circle and explain his/her gift to Ohke.

The second person remains in the center and chooses someone with whom it has a "connection, " for instance, if sun chooses Mosq (bear), Mosq might choose Qussuk (rock). Mosq (bear) tells why it feels it has a connection to Qussuk (rock) , for instance,"Qussuk warms me when I lie on it."

Mosq leaves the circle and Qussuk stays to explain how it is a gift to Ohke. Then Qussuk picks something with which it has a connection, "I pick Kuppadt (ice). Kuppadt is a gift to me because it erodes me and returns me to the soil."

After everyone has explained their gift to each other and to the earth, gather all the cards and bury them. Discuss how this is also a "gift to the earth."

5. FALLING WATER EQUALS POWER

In our Power to Production program, we emphasize how the early mill owners used the waterpower of the Merrimack River to run their machinery. But what must the water actually *do* in order to create this power? Water must fall vertically from a high to a low elevation, expending energy during its fall. The force of the water travelling downward through a distance creates power. This activity demonstrates that falling water can deliver power, and students can actually feel this power.

Getting Started

You will need the following items for this activity: six to eight clear plastic two-liter bottles; wide, clear packing tape; two plastic gallon jugs filled with water; a large dishpan (16-quart or larger); and a funnel.

Cut off the ends of the two-liter bottles and assemble them into a continuous tube. Secure each joint with tape. This is your waterfall tube. The entire tube should measure three feet. (If students bring in bottles, you can use the extras to build several tubes of varying lengths).

Feeling the Power!

To demonstrate that falling water has power, have two students support the waterfall tube vertically over the dishpan. Then:

- Carefully pour the gallon of water down the center of the tube, keeping the flow from the jug slow and uniform.
- Have students take turns feeling the pressure of the water at the top of the fall by placing two fingers one inch below the mouth of the jug.
- Have them compare that with the pressure of water hitting their hand directly beneath the tube.

• Ask students to predict what change they would feel in pressure if the pouring rate were increased. Run the gallon of water through the tube again, increasing the pouring rate. Were their predictions correct?
• Ask students to predict what change they would feel if you did not alter the pouring rate but doubled the height of the fall. To test their prediction, try using waterfall tubes of varying lengths.
• Students can use the funnel to refill the jugs as needed.

Conclusion

Students should understand that the power in a waterfall depends upon two factors: the height of the fall (the higher the fall, the greater the power), and the rate of the flow (the higher the rate, the greater the power). Ask students what other characteristics they think a waterfall might need in order to be a good power source for industry (for example, an available work force, nearness to port cities or railroads, enough land to support the building of a city, etc.).

1. CALCULATING THE POWER OF FALLING WATER

(recommended for students with some knowledge of pre-algebra)

During the previous activity, students learned that the power in a waterfall depends upon the height it drops (the *head*) and the rate at which it is pouring (the *flow*). The head is measured in feet and the flow is measured in cubic feet per second, or cfs. The power of the fall is the product of these two quantities times the conversion factor 0.113, which renders the product into the familiar units of horsepower:

power of the fall (hp) = head (in feet) x flow (in cfs) x 0.113

Your will need the materials from the previous activity, plus a stopwatch and calculator, to find the power of your classroom waterfall. Set the waterfall tube into position. Then:

- Have students use the stopwatch to time how many seconds it takes (run time) for you to pour the entire gallon through the tube.
- Calculate flow by dividing 1 gallon by the run time; this yields flow in gallons per second. Convert this to cubic feet per second by multiplying by the conversion factor 0.125 (cubic feet/gallon).
- Use the flow in cfs and the 3-foot head in the above equation to find the power in the classroom waterfall.

For Example . . .

Suppose it takes 30 seconds to pour 1 gallon of water through 3 feet. The flow in gallons per second is:

1 gallon / 30 seconds = 0.033 gallons per second

Convert this to cfs by multiplying by 0.125:

0.033 gallons per second x 0.125 cubic feet/gallon = 0.0042 cfs

Calculate the power using the equation:

3 ft x 0.0042 cfs x 0.113 = 0.0014 hp

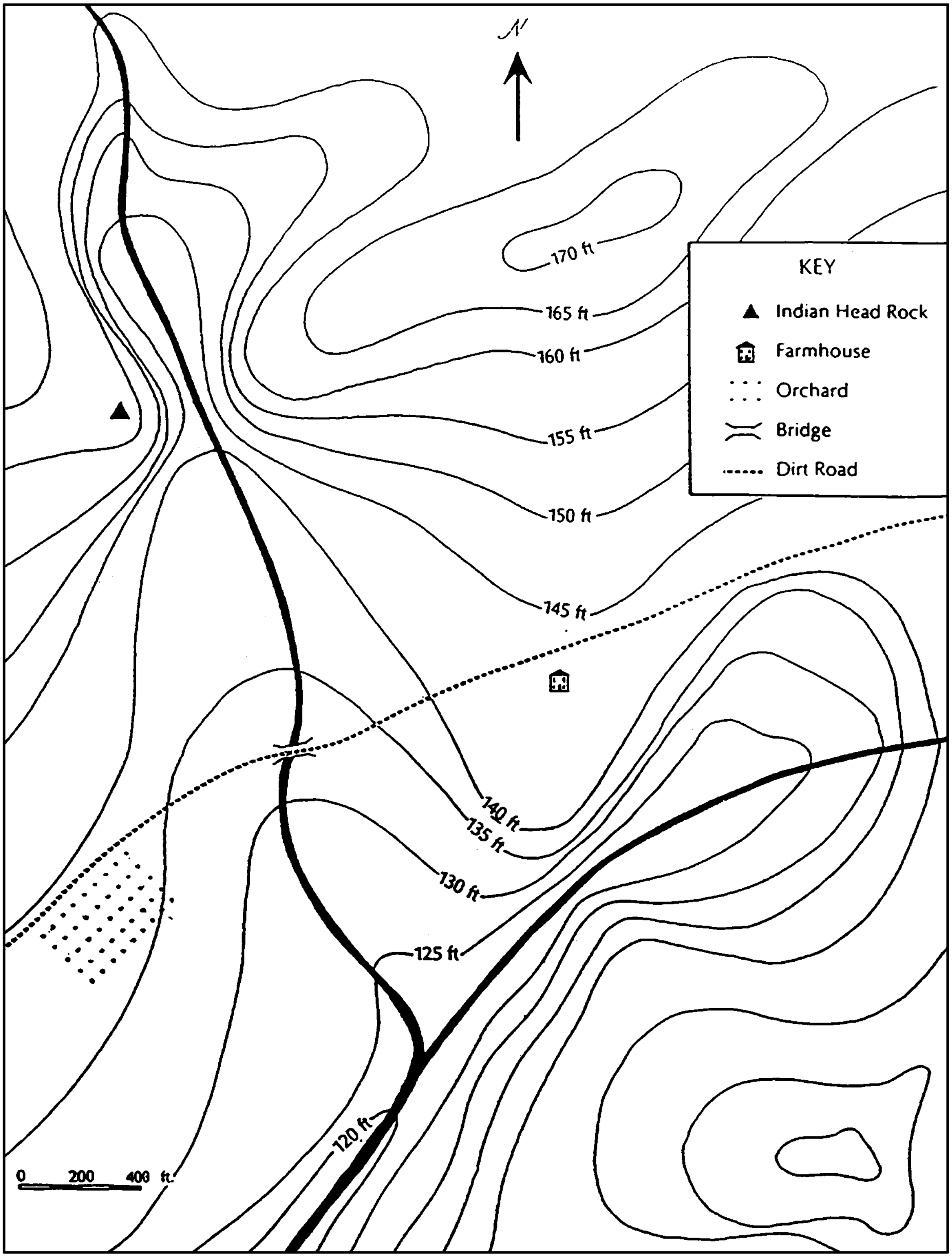
Students can get an idea of how much power this is if they consider the fact that a typical auto engine runs at roughly 100 to 150 horsepower. A car generates about 100,000 times as much power as their little waterfall!

What about the power in a real waterfall?

The Merrimack River drops 32 feet at Pawtucket Falls in Lowell. Its average flow is about 3600 cfs. How many horsepower is this?

32 ft x 3600 cfs x 0.113 = 13,018hp

No wonder the early mill owners looked with favor upon Pawtucket Falls as a source of power for their mills!


N
170 ft
165 ft
160 ft
155 ft
150 ft
145 ft
140 ft
135 ft
130 ft
125 ft
120 ft
0 200 400 ft.
KEY
Indian Head Rock
Farmhouse
Orchard
Bridge
Dirt Road

2. Getting to Know Your River

One popular definition of geography states that it is the study of the whole world and everything on it. In this activity students will use the five basic themes of geography: location, place, human/environment interactions, movement and region, to begin an investigation, not of the whole world, but of their corner of it. They will be studying their town and the river nearest to its location, learning about its history, its physical and cultural characteristics and its connection with the rest of the watershed region.

Activity
The questions below can be used as focus questions to open discussion on local history and as starting points for student research. The list is not exhaustive; in fact, it is meant to stimulate students to formulate further questions based on their own curiosity and areas of interest.

Location: Obtain a map of your state. Locate your river and town on it. If possible, find your town's latitude and longitude. What is the name of your river? Where is its source? What body of water does it empty into? Is it a major river or the tributary of another river? How long is your river? How far are you from its source? From its mouth? How far does your river drop along its entire course? Using the scale on your map, see if you can estimate the size of your watershed (the area drained by your river).

Place: What is the population of your town? How far away is the nearest town upstream from you? Downstream from you? What are the populations of these towns? How much average rain and snowfall does your area receive? What kind of terrain predominates in your area? Does your town's section of the river contain a waterfall? What can you find out about your area's geologic history? Are there signs of glacial, volcanic or tectonic activity?

Human/Environment Interactions: Where do the names of your river and town come from? If Native American, what are their meanings? What is the history of human settlement along your river? How has the river been used by different populations that have occupied your area? How have those uses changed over the years? Are there any structures on your section of the river? What is (or was) their purpose? Are they still being used for that purpose? What changes in the river ecosystem have been brought about by human activity along the river?

Movement: When was your town incorporated? Trace changes in your town's population level, as far back as you can find records for. Try the town library, Town Hall, or the local historical society for archived information and old records. Can you correlate changes in population with changes in river use? What kinds of business and industry have come and gone since your town was settled? Can you trace changes in these activities to specific causes? What kind of trade existed historically between your town and neighboring towns along the river? What about now? Where do most of your stores' goods come from? What role does the river play in trade, industry and recreation in your town?

Region: What physical region is your town/river system located in (for example, a mountainous area, flood plain, coastal region, etc.)? What are the physical characteristics of this region? Obtain a topographic map(s) (available from the United States Geological Survey, or any big outdoor camping, hiking store) of this region. What kinds of features and variations in landscape can you find? Does your river cut through more that one region? Does it connect several regions together? How is the river used in other regions it passes through?

3. Who owns the water?

Title to a parcel of land recorded at a registry of deeds and can always be verified by surveying the bounds. Land can be fenced off or marked in such a way that everyone can recognize its ownership. However, water is usually regarded as a common resource, and because of its dynamic nature, it is a lot more difficult to "fence" or control. For the Boston Associates who created the great Lowell industrial experiment, water was money. Controlling the use of water meant buying the land on either side of the river and determining how the water that ran through it would be routed and used. You thereby owned the "riparian rights." With the onset of the Industrial Revolution came the buying and selling of a natural resource on a large scale. What was thought to have no ownership by the Native Americans became private property. The people who owned the land through which the river ran were the ones who determined the use of it.

Those who are downstream have no say in what happens upstream. If an upstream owner with riparian rights diverts water for use and interferes with that water getting downstream for non-riparian users, the non-riparian users are just out of luck. If an upstream riparian owner interferes with the activity of a downstream riparian owner then it is off to court to see who has a greater claim to the water.

Activity
Here are two cases to discuss:

Amoskeag Cotton Mills in Manchester employs 3,000 people. It builds a dam that diverts water. Farmer Amos Barney owns 200 acres along the riverbank between Manchester and Nashua. He depends on a regular flow of water to irrigate his hay crops which he markets in Manchester as bedding and food for livestock. Who has greater right to the water? Farmer Ethan Perkins of Methuen has an inland farm on which he raises several hundred head of sheep. He sells his wool to the mills in Lawrence. He crosses his neighbor's farm to wash his sheep in the river in preparation for shearing. The Boott Mill in Lowell has discharged red dyes as a result of its calico operation. Perkins' sheep come out of their dip with pink coats? Does he have a claim against the Boott Mill?

4. Sum of the Parts

Background
During the course of this activity, students will discover:

- the interconnectedness and the interdependence of a watershed area

- the uses of the river and the land surrounding it

- the concept that everyone in a watershed area shares the responsibility for the health of that watershed. Students should know that individual actions, both positive and negative, have a cumulative impact upon the watershed.

Activity
For this activity, you will need the following materials:

- "Pieces of the river" pattern at the end of this activity
- Six sheets of 22" x 28" white posterboard
- Markers (dry-erase, if you wish to laminate and re-use the river segments)
- A large map of the Merrimack River watershed or your own watershed area

Take the six sheets of posterboard and lay them out in a large work area, lined up with their 28" sides together. Using the "pieces of the river" pattern as a guide, draw a continuous river through all six sheets. Color the river portion of each segment blue and leave the rest white. Number the segments in order.

Collect groups of common items from the classroom, such as paper clips, crayons, and pencils, and establish a "pollutant tray". Students will be using these items later on in the activity to show the build-up of pollution in the river.

Divide the class into six groups and give each group a segment of the river and a set of markers.

Explain to all groups that they have just inherited this particular section of land along the riverbank, along with the right to use the water, AND . . . several million dollars in cash.

Tell them that, to date, the land has been undeveloped. They are now free to use their money to develop the land in any way they choose: they can build on it, farm it, plant it with trees, establish businesses, undertake commerce, leave it as unspoiled wilderness or establish a wildlife refuge--anything they want to do that they can afford.

Give them some time to discuss their options as a group. Then have them use the markers to draw in elements of the development they have decided upon. For example, if they have decided to build a town, they could draw in houses and shops, streets, parking lots, perhaps even a bridge over the river.

When their drawing is done, have the groups bring their segments together and reassemble the river.

Have each group of students describe how they have used the river and the land beside it. Have them identify any of their development activities on their individual parcels that could result in addition of pollutants (or other changes) to the river. Draw out some more subtle effects that they might not be aware of, such as the paving over of land, the cutting of timber, the building of a bridge, etc.

When each group has listed several sources of pollution or change, have them select one item from the "pollutant tray" to represent each source they have thought of. Have them line up along their river segment, and have segment number one pass their items downstream to segment number two. Have segment number two then speculate upon the possible effects of the new incoming pollutant on their planned activities for their property. Then have segment number two pass ALL of the pollutant items down to segment number three. Have segment number three try and determine what the effects of all of this incoming stuff will be on their planned activities. Continue this until all pollutants have reached the final segment. Have that group describe the total effect that all of the upstream activities and additions to the river will have on their plans.

Discussion
For wrap-up, summarize what the students have learned. Why is it important for people along the river to be careful how they use the land and water? Display the large map of the Merrimack River Watershed or your own watershed area. Explain that the river segments they designed earlier could represent locations along the Merrimack or along their own river. They should consider the locations of the large cities on the river; what would happen at Manchester if something was done to the river at Concord? What would happen at Lawrence if something was done to the river at Lowell? Consider also the upstream effects; what happens at Nashua because of the mill pond created by the Pawtucket dam at Lowell? Analogous questions can be posed using your own river system.

These are the kinds of issues that all users of the watershed must face--they are all dependent upon each other for cooperation in using and preserving this critical natural resource.

Terms

anadromous - a migratory species, such as the Atlantic salmon, capable of living in the ocean but breeding in the freshwater streams

aquifer - When it rains, some of the water flows down into the ground into regions called aquifers, which are porous rock structures that hold water (sometimes for thousands of years).

Dissolved oxygen (DO) - the amount of oxygen gas molecules dissolved in water. Fish and other life forms depend of DO for respiration.

ecosystem - the interdependence of all the life forms and their physical surroundings

effluent - a liquid flowing out, such as the outflow of a sewer or septic system.

erosion - the process by which soil and rock particles are carried away by wind and water.

macro invertebrate - macro means large, invertebrate means without a backbone; usually large enough to be seen without magnification

permeability - the measure of how easily water can flow through a material like rocks, soil, clay, or and aquifer.

pollutants - anything that creates as undesirable change in the properties of the environment that can have harmful effects on humans or bother organisms. Two types: 1) degradable - can be reduced, decomposed, or removed through natural processes that assist nature, e.g., sewage treatment plants and 2) non-degradable - is not decomposed or removed through natural processes.

riparian rights - those who own the riverbank property have the right to use and control the water that runs along it.

river - a natural flow of water which results from springs, streams and creeks joining together to produce a larger volume of water which empties into another river, a lake, or an ocean.

sedimentation - the deposition or accumulation of soil particles in water

sewage - liquid and solid waste mixed with water

stewardship - the act of taking responsibility to maintain and protect a clean and healthy environment

turbidity - the amount of sedimentation in the water

Wastewater treatment plant - a facility where household, business, and industrial sewage is treated to remove harmful bacteria and chemicals.

watershed - the total land area that drains into a particular stream, river, or lake.

water quality index (WQI) - the overall health of a body of water measured by such tests as dissolved oxygen (DO), pH (acidity), temperature, and turbidity.

water treatment plant - a facility that treats water with chemicals and filtration then distributed to homes, businesses and industries for drinking and other clean water uses.

Electronic Resources

One World Online
Address: http://www.oneworld.org
A meeting place for the international community containing global news, teaching resources and projects, ways to get involved with social and environmental issues, and "guided tours" of key issues.

U.S. Environmental Protection Agency
Address: http://www.epa.gov
Excellent library resources and good response

United States Geological Survey (USGS)
Address: http://www.usgs.gov
Government scientific fact-finding and research organization providing regional USGS fact sheets, general information, and topographical maps of varying scales. Also contains information about water quality and quantity issues, along with potential health hazards. The Learning Web provides teaching information aimed at younger students, along with general earth sciences topics for all ages. Includes access to other educational sites.

The Rivers Project
Address: http://www.siue.edu/OSME/river
The study of rivers from historical, social, and economic perspectives.

Environmental Education Organizations and Projects
Address: http://www.nceet.snre.umich.edu
Lists electronic brochures for many organizations and projects related to environmental education, including projects, contacts and general environmental education.

Global Rivers Environmental Education Network (GREEN)
Address: http://www.earthforce.org/green
Contact: Green@green.org
Presents information about GREEN, which deals with maintaining the quality of watersheds in the United States, Canada, and Mexico.

Northeast Business Environmental Network (NBEN)
http://www.nben.org

American Water Works Association (AWWA)
http://www.awwa.org

New Hampshire Department of Environmental Services
http://www.des.statenh.us/640index.html

NEIWPCC - New England Interstate Water Pollution Control Commission
http://www.neiwpcc.org

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