DOCUMENT RESUME

ED 371 991 SO 024 011

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TITLE Water Matters: Every Day, Everywhere, Every Way. Teacher's Handbook.
INSTITUTION National Geographic Society, Washington, DC.
PUB DATE 93
NOTE 31p.; This document was published as part of the observance of National Geography Awareness Week, November 14-20, 1993.
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Economic Development; Elementary Secondary Education; *Environmental Education; *Geography Instruction; *Resource Allocation; Social Studies; *Water Resources

ABSTRACT

This booklet examines the subject of fresh water and the ways in which it affects every aspect of human life. The document includes an introduction and seven sections: (1) "Agriculture"; (2) "Transportation"; (3) "Culture"; (4) "Engineering"; (5) "Health and Domestic Use"; (6) "Politics and Economics"; and (7) "Industry." Inside each section is an introduction, "Aquativities" (student activities relating to fresh water), "H2...Ohs!" (featuring amazing facts about water), case studies, and "Seeking Clear Solutions" (which calls upon students to devise answers to problems involving water). A resource list concludes the document. (SG)

TEACHER'S HANDBOOK

NATIONAL
GEOGRAPHY
AWARENESS
WEEK
NOVEMBER 14–20, 1993

This booklet, prepared by the National Geographic Society, was made possible through the generous contributions of Citibank.

WHAT'S IN THIS BOOKLET?

SEE INTRODUCTORY AQUATIVITY ON HANDOUT

The topic: Fresh water—how it matters in every aspect of our lives!

Using the booklet: Use as much or as little of it as you see fit. The booklet will help you explore issues about fresh water with your class during Geography Awareness Week—issues that merit close attention in the days, and decades, to come.

What's inside the sections?

Background: General topic information for teachers (see topics in box, below)

Aquativities: Student activities related to fresh water

H_2...Ohs! Amazing facts about water

Case studies: Examples of water usage in North America and other continents

And at the end: A chance for students to contribute clear solutions to water problems

What about grade levels? Check the water meter on each Aquativity. There's something here for everyone in K–12. (The meters are approximations. Activities may be adapted.)

INTRODUCTION: WATER IN OUR LIVES

Water Every Day

Everywhere we look, we see water. It cleans our sidewalks, overflows in our fountains, glints in our swimming pools. Water gushes from our taps and shower heads. With this abundance of clean, fresh water all around us, it seems reasonable to suppose that water is the most plentiful and least valuable commodity around.

The reality is that water is a limited and precious resource. Yet we in North America use more of it per person than anyone else in the world.

The water we use for our many needs—and for nonessential purposes—comes from rivers, lakes, streams, and underground reserves.

Water Everywhere

Despite broad regional shortages, the U. S. has a lot of cheap and clean fresh water. That's not the case for much of the world. In countries where clean, fresh water is scarce, it is highly valued and used sparingly. There are those who walk hours every day just to get a few gallons for basic necessities.

With global water needs growing and reserves shrinking, conservation of fresh water is one of the most important challenges we face going into the next century.

Everyone everywhere must have fresh water to live. Many of the world's cities were founded near freshwater rivers and lakes. Proximity to fresh water, however, doesn't guarantee access to a clean supply of it. Many rivers and lakes cross state or national boundaries, and rights to these waters are often in dispute. In many parts of the world, including parts of North America, access to water has the potential for creating major strife. Issues of controlling

AT A GLANCE

H_2...Oh!

In the United States, the average person uses about 100 gallons of water a day domestically.

SOURCE: U. S. GEOLOGICAL SURVEY

supply and quality of water are significant in shaping local, state, national, and international politics.

Water Every Way

Through natural processes, water sculpts the land, carries soil and nutrients from one place to another, periodically floods the landscape, and replenishes itself—on the surface and underground—through stages of the water cycle.

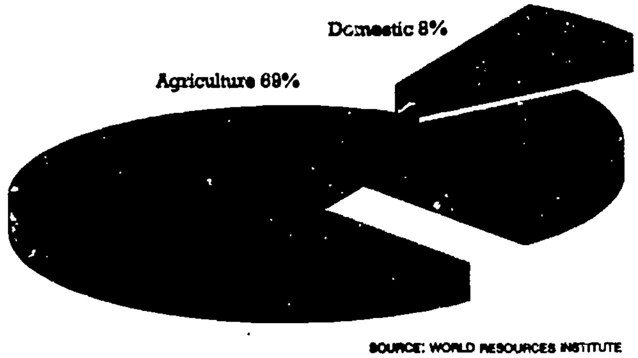
Despite the extent to which natural forces control water, humans exert a strong influence over it in many ways. We divert, transport, and store water to meet our needs. Technologies include dikes, levees, dams, seawalls, reservoirs, canals, and aqueducts. These provide water for personal use, irrigation of crops, industry, transportation, and much more.

Our challenge today is to use water wisely. We need to sustain an adequate supply of clean, fresh water. We need to use it efficiently, to apportion it fairly, and, at the same time, to preserve wetlands and other crucial components of the ecosystem.

AQUATIVITY

How Do We Use Water?

Percentages
Of Total Water Withdrawal
Worldwide:



- What are the implications of this information in planning conservation strategies? (For example, in which sphere of our lives would a 30 percent savings make the biggest difference?)
- Ask students to graph the data in other ways—a bar graph, or a pictograph using corn, factory chimneys, and other symbols, to show these percentages.

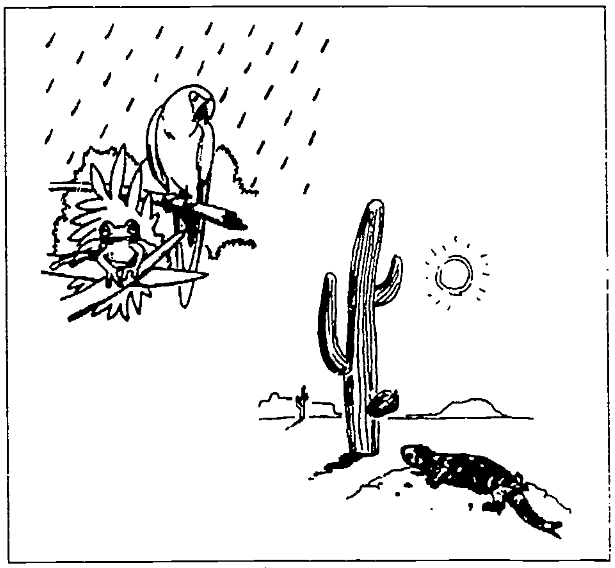
AQUATIVITY

Where *Is* the World's Water?

Where is fresh water abundant and where is it scarce?

Distribute a copy of the map on page 4 to each student. It shows annual precipitation, minus evaporation, worldwide. Ask students to consult an atlas in conjunction with the map to do the following:

- Identify and label the world's largest deserts.
- Compare areas of maximum water supply on this map with a biome map of the world. What correlations are evident?
- Which continent receives the least water relative to its size?
- Compare this map with a topographical map. In northwestern North America, what accounts for the heavy rainfall along the coast and the lighter precipitation a short distance inland?
- Water rights are more of an issue in the Middle East than in the Sahara. Why?
- What accounts for the difference in rainfall between East and West Africa? It might help in answering this question to consult a topographical map.
- What factors might explain the pattern of water supply in Australia?



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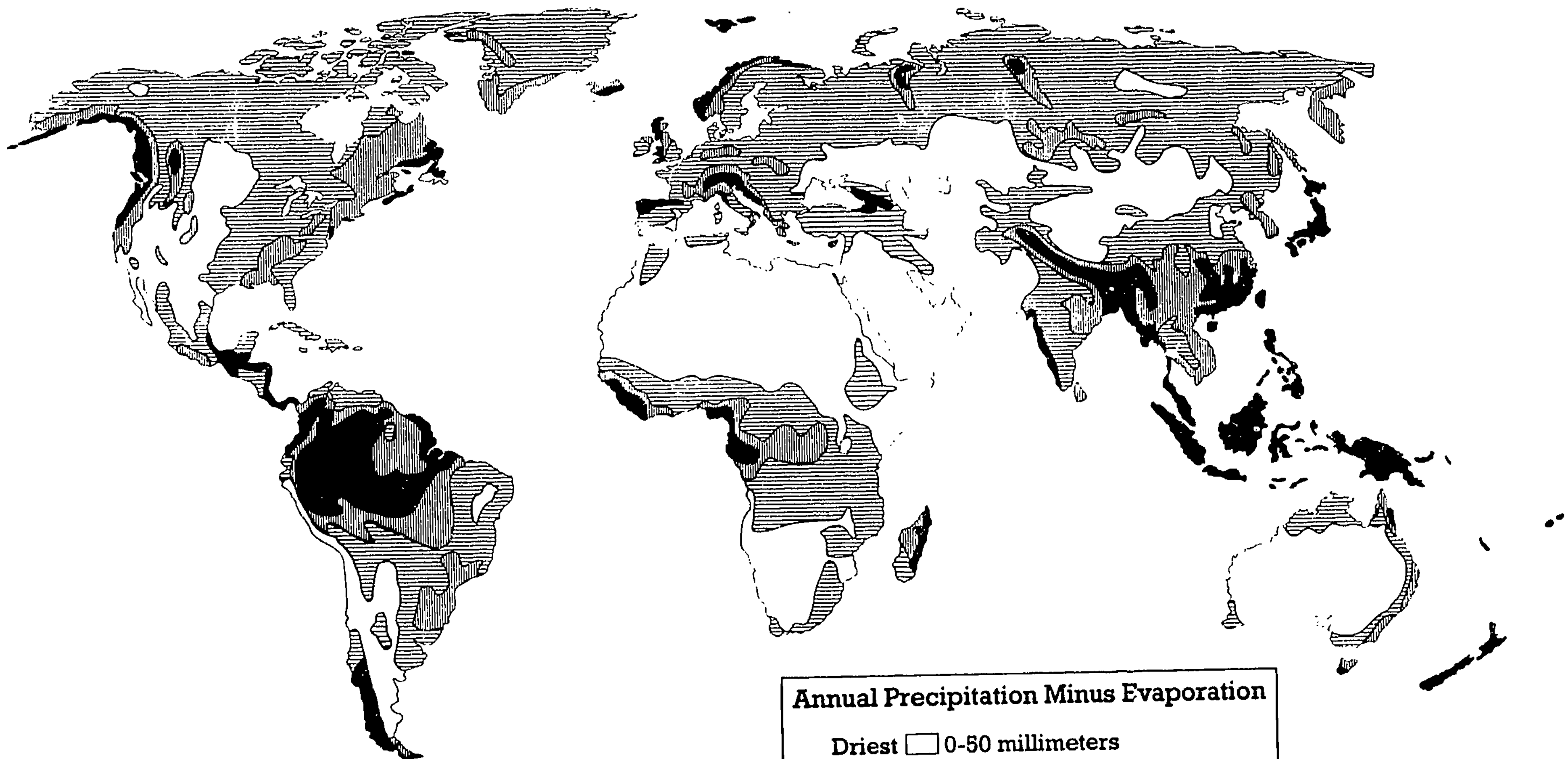
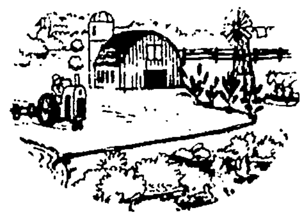
The World's Renewable Water Supply



BY MARTIN WALZ, ADAPTED WITH THE PERMISSION OF THE WORLDWATCH INSTITUTE FROM SANDRA POSTEL, *LAST OASIS: FACING WATER SCARCITY*

PART I: AGRICULTURE



Of all the fresh water that people use in the world, about two-thirds goes to agriculture.

Because rain may be insufficient for growing crops, farmers rely on a variety of techniques to bring water to their fields. Called irrigation, these methods include flooding entire fields, channeling water between rows of crops, spraying water through sprinklers, and letting water drip onto crops through small holes in hoses or pipes.

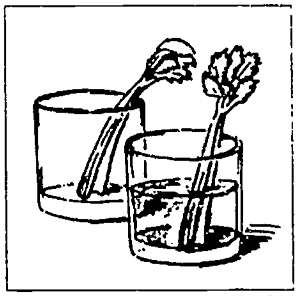
Agronomists are finding out how to make the most of the available water by learning more about soil and erosion, about plants and their needs, and about conserving groundwater.

In many parts of the world, careful selection of crops, as well as new techniques for irrigation, are increasing the amount of food available.

AQUATIVITY
Drought in a Glass!

When drought strikes, crops often wilt and die before they're sufficiently mature to be harvested. You can easily simulate the effects of drought on a crop.

Place a stalk of cut celery in a glass with no water. Let it stand overnight. What happens to the celery? Now, cut the celery stalk about half an inch from the base and place it back in the glass—this time filled with water. Let it stand overnight. What happens to the celery? How is the celery like crops?



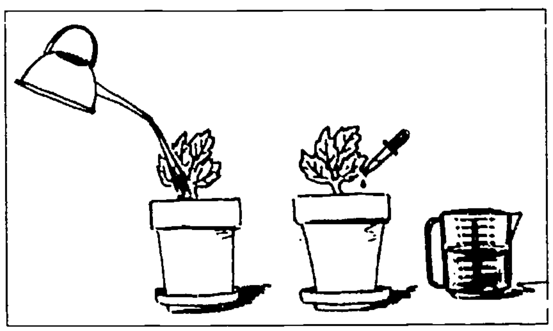
AQUATIVITY: Making Every Drop Count

Plant two small, leafy plants of the same size in moist soil. Use equal-size, small flower pots with drains in the bottom. Over the course of two weeks, water both plants at about the same time, keeping a careful record of exactly how much water you are providing each. The two plants should be watered by distinctly *different* methods:

1. Water one plant with a pitcher or watering can. Moisten the entire pot of soil. Remember, measure and keep a record of exactly how much water you are using.

2. Water the other plant with an eyedropper. Drip the water so that it soaks down directly to the roots, near the stem. Water only as much as you think the plant needs. Keep a precise record of how much water you use.

After the two weeks, compare how much water you used on each plant. Did the two methods use significantly different amounts?



H_2...Oh!

- *It takes more than 60 gallons of fresh water to make one egg.*
- *Production of a steak takes nearly 1,000 gallons.*
- *A glass of milk takes almost 50 gallons of water to produce.*

SOURCE: "REFLECTIONS ON WATER," A NATIONAL GEOGRAPHIC SOCIETY VIDEO

It takes 115 gallons of fresh water to grow enough wheat to make one loaf of bread.

SOURCE: *EXPLORING YOUR WORLD*, NATIONAL GEOGRAPHIC SOCIETY

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CASE STUDY: OGALLALA AQUIFER

Despite low rainfall, the land of the High Plains is a rich agricultural region—thanks in large part to millions of gallons of water pumped to the fields from the Ogallala aquifer. This huge natural reservoir of groundwater under the High Plains holds a quadrillion gallons. The aquifer lies only a foot or two under the surface in some places, and as deep as 1,300 feet in others. Every day, farmers pump the Ogallala for the water that helps to keep America's supermarkets stocked and its livestock amply fed.

In the 1950s, when heavy pumping began, the Ogallala seemed like an endless source of fresh water. But it is now being emptied in places much faster than it is being naturally replenished.

Many farmers use flooding and sprinkler systems to irrigate their crops. But flooding wastes water and increases runoff that can be polluted by fertilizer. And much sprinkler water, aimed high, evaporates before reaching the ground.

To conserve the Ogallala, some farmers are using innovative measures that save water. They are using treated wastewater to irrigate their crops. New, lower pressure sprinkler systems increase efficiency, and other systems deliver water closer to crops, reducing evaporation. Techniques for measuring the moisture in the ground are helping farmers regulate the amount of water they use. All of these innovative techniques save farmers both money and water.

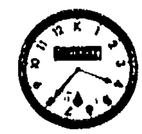
> **H_2...Oh!**
>
> *The Ogallala aquifer holds enough water underground to fill Lake Huron.*
>
> SOURCE: MARCH 1993 *NATIONAL GEOGRAPHIC*

AQUATIVITIES

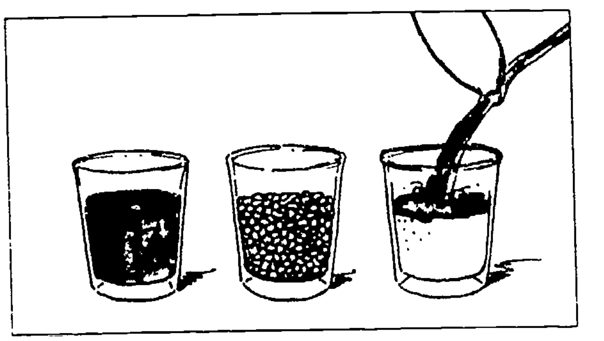
Make A Mini-Aquifer

In a clear glass or plastic container, arrange (in the following order) stones, bits of sponge, gravel, soil, and vegetation. Slowly add water until it collects up to the gravel. How is the water distributed in your aquifer? How would changing the size of the rocks change the volume of water the aquifer holds? (See activity, right.)

The Water-holding Capacity Of an Aquifer



Fill three identical glasses: one with gravel, another with coarse sand, and a third with soil. The sample materials must be dry. Add red food dye to a supply of water, then add an *equal* volume of the water to each glass. Observe what occurs. Does the water soak into the various materials at the same rate? Does the "water table" come to the same level in all three glasses? If not, what determines which water table is the lowest? What does this indicate about the water-holding capacity of the materials? (The lower the resulting water table, the greater the water-holding capacity of that material.)



CASE STUDY: ISRAEL

Israel is dry, most of it desert. It receives little rainfall, and much of its water supply has a fairly high level of salt. Nevertheless Israel maintains rich agricultural production, even exporting quantities of citrus fruits and other produce. One of the keys to Israel's agricultural success is water management.

The most important technique used by Israeli farmers to manage water is drip irrigation. Drip irrigation uses perforated pipes or plastic tubes and computerized systems to bring exactly the necessary amount of water to the roots of each plant. It avoids the unnecessary irrigation of soil between plants. About half of Israel's irrigated fields are now watered by drip irrigation.

Besides facing scarcity of supply, Israelis have had to deal with salinity in their water. They have worked to find and develop crops that can thrive on brackish water—water that con-[illegible]s some salt.

For all the peoples of Israel and neighboring Syria and Jordan, rights to surface water and groundwater are highly charged, crucial issues in need of long-term resolution.

Making every drop count, drip irrigation rations water to individual plants from holes in pipes or plastic tubes.

NGS PHOTOGRAPHER JAMES L. STANFIELD

AQUATIVITY

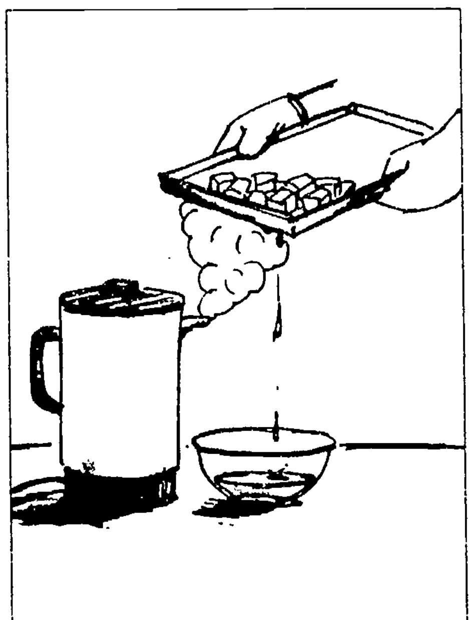
Cucumbers + Salt = ?

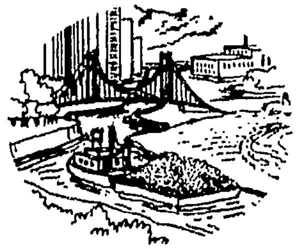
Plant equal numbers of cucumber seeds in two small cups of soil. Place them in the sun. Water each daily with equal amounts—one with fresh tap water, the other with salt water (made by adding 1 part salt to 25 parts water). Observe and record the results over the course of a week. What can you conclude? Try this experiment with other seeds.

AQUATIVITY

Desalination: Making Salt Water Fresh

Mix a solution of salt water by adding 1 part salt to 25 parts water. Taste the water. Is it salty? In an electric tea kettle, heat the salt water to boiling. As steam pours out of the kettle, hold a cookie sheet (use kitchen mitts!) full of ice cubes over the spout so that the steam condenses on the underside of the pan. Collect the condensed drops in a bowl. Taste the collected water. Is it salty? The collected water is distilled—a process used commercially to desalinate water in many countries with inadequate freshwater supplies.





PART II: TRANSPORTATION

The North American continent is rich in lakes and rivers—liquid highways that connect people and goods. Most of our largest cities grew up along waterways. The history of our land and people is largely tied to the systems that facilitate transportation by water.

Among the most important inland water systems are the Mississippi River system, the Great Lakes–St. Lawrence Seaway system, and the Atlantic Intracoastal Waterway. They provide inland access for enormous amounts of freight carried by tug-guided barges and steaming freighters.

Transportation by river and lake is as important overseas as it is in North America. Major rivers of the world are really international superhighways, connecting whole economies.

To avoid unnavigable hazards on rivers and to open new shipping routes, many nations have constructed navigation canals—thousands of miles of them. The Chinese began building the Grand Canal, the world's longest canal system—some thousand miles long—more than 2,400 years ago. Canal locks, which enabled canal builders to negotiate hills and waterfalls, were probably invented some 700 years ago in Europe.

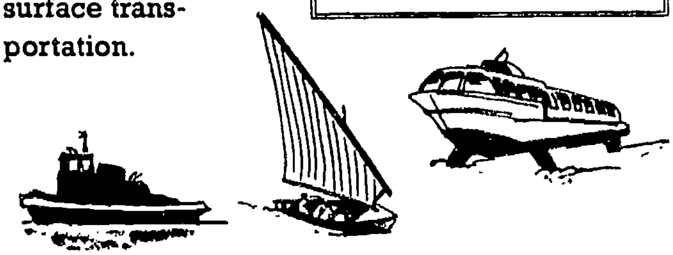
Although not the first or the longest, the Panama and Suez Canals are perhaps the most important in the world. The Panama Canal, opened in 1914, cuts across the Isthmus of Panama, linking the Atlantic and Pacific Oceans. The Suez Canal, opened in 1869, connects the Mediterranean and Red Seas. The 51 miles of the Panama Canal and the 101 miles of the Suez Canal radically changed the face of surface transportation.

AQUATIVITY
Getting Around On Water

How many ways do you and other people get around on water? Work with your class to list as many as you can, then illustrate them in a bulletin board display. Examples: ferry, barge, rowboat. Then there are water skis, ice skates, snowmobiles, hydrofoils!

AQUATIVITY
Who Lives Near Water?

Identify in an almanac the 15 largest cities by population in North America. Find the cities in an atlas, then label them on a copy of the map on the next page. How many of these cities have access to major bodies of water? Check in an encyclopedia to see how the cities make use of these bodies of water.

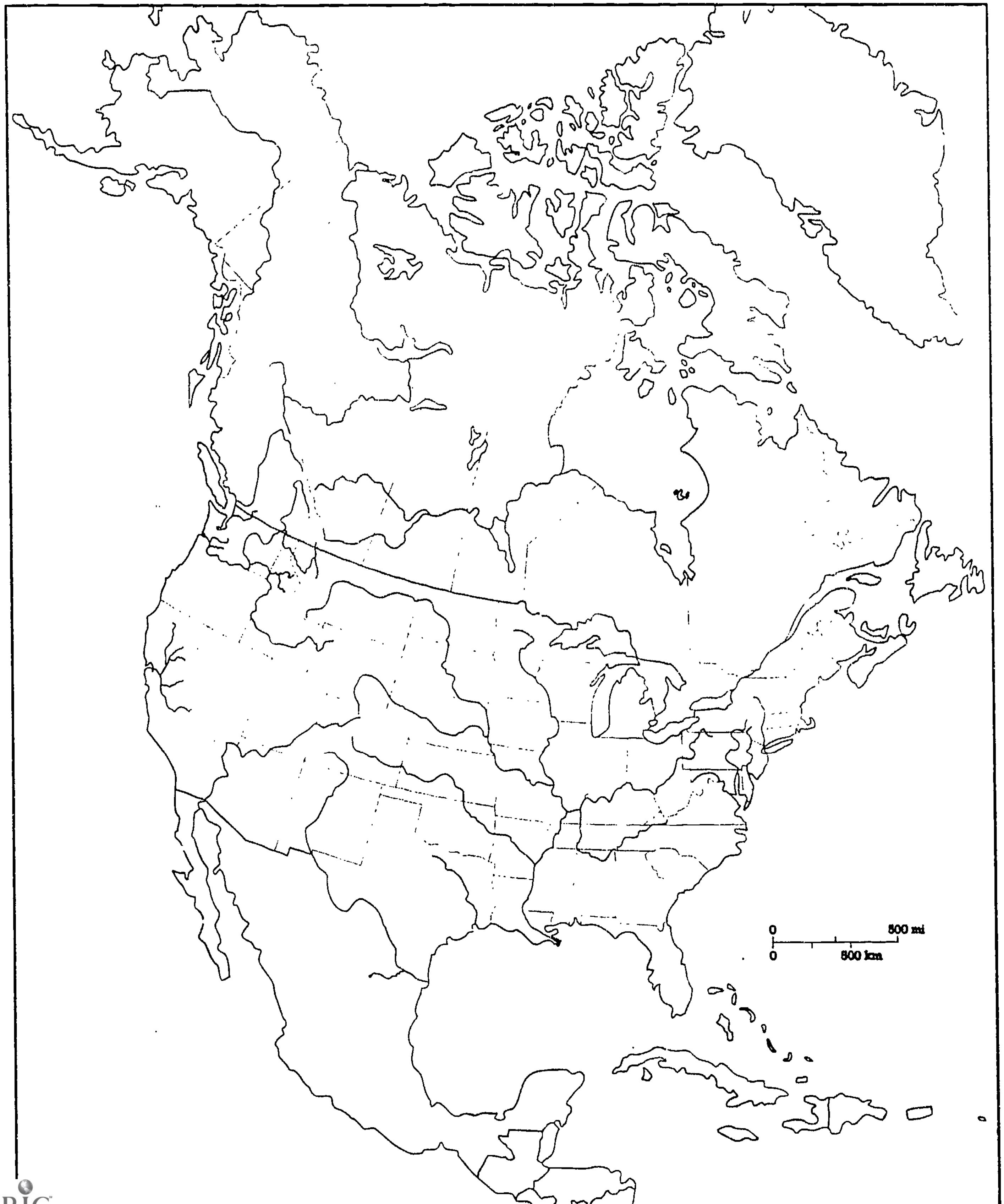


AQUATIVITY
Water Shortcuts

On a map of the Western Hemisphere, calculate the distance a ship must sail from Boston to San Francisco without using the Panama Canal. Then figure out the distance via the canal. What is the savings in miles? How many days would a ship save, using the canal, if it traveled an average of 20 miles an hour, 24 hours a day? Perform similar calculations for a ship sailing between London, England, and Bombay, India, without—then with—the Suez Canal. What do ships save besides time?

North American Rivers

Photocopy this map for activities on pages 8, 13, and 16.



MARTIN WALZ

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CASE STUDY: ERIE CANAL

In 1817, construction started on a canal that would link Lake Erie with the Hudson River—and the Atlantic Ocean. The project provided a vital tie that gave westward bound immigrants and manufactured goods a cheap and easy route to the Great Lakes. In turn, it provided passage for agricultural products and timber to the East.

The project, including numerous locks and aqueducts, took eight years to build. The locks lifted or lowered canal boats 564 feet between Lake Erie and the Hudson.

The Erie Canal handled medium-size barges. These were towed by horses and mules that walked on a towpath along the bank. In its earliest days, the canal carried heavy traffic. Railroads, however, outpaced the horses and mules and eventually eclipsed the canal as the favored route for both passengers and freight.

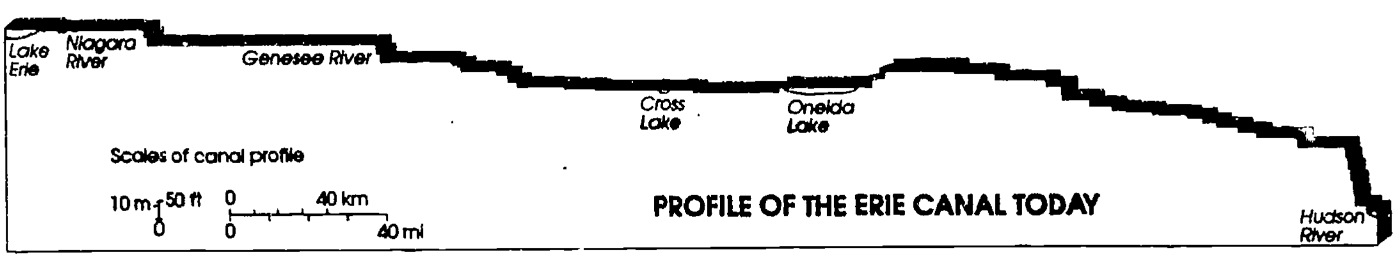
AQUATIVITY: Why Canals?
(Questions for Discussion)

- What do canals provide that a river often doesn't? *(Flat water. No rapids. No shoals. Shortcuts.)*
- Why are locks necessary on some canals? *(They allow boats to change elevation while keeping the water level.)*
- What is the advantage of flat water? *(No current; no rapids.)*
- What was the advantage of no current? *(It made possible towing by mules and horses as a means of locomotion.)*

Projects:

- Build a diorama showing a canal and locks.
- Learn the song "The Erie Canal."* Act out the lines. Perform them for another class.

A horse-drawn passenger boat enters a lock on the Erie Canal (right). Canal builders faced more than digging a 363-mile, 40-foot-wide, 4-foot-deep ditch. The canal had to climb 169 feet from the Hudson River and traverse the irregular breadth of New York State through 83 locks.



CANAL PROFILE BY DALE GLASGOW "ENTERING THE LOCK" BY E. L. HENRY. COLLECTION OF THE ALBANY INSTITUTE OF HISTORY AND ART

*YOUNG STUDENTS WILL ENJOY THE INFORMATIVE AND WELL-ILLUSTRATED BOOK *THE ERIE CANAL* BY PETER SPIER

CASE STUDIES: AMSTERDAM AND VENICE

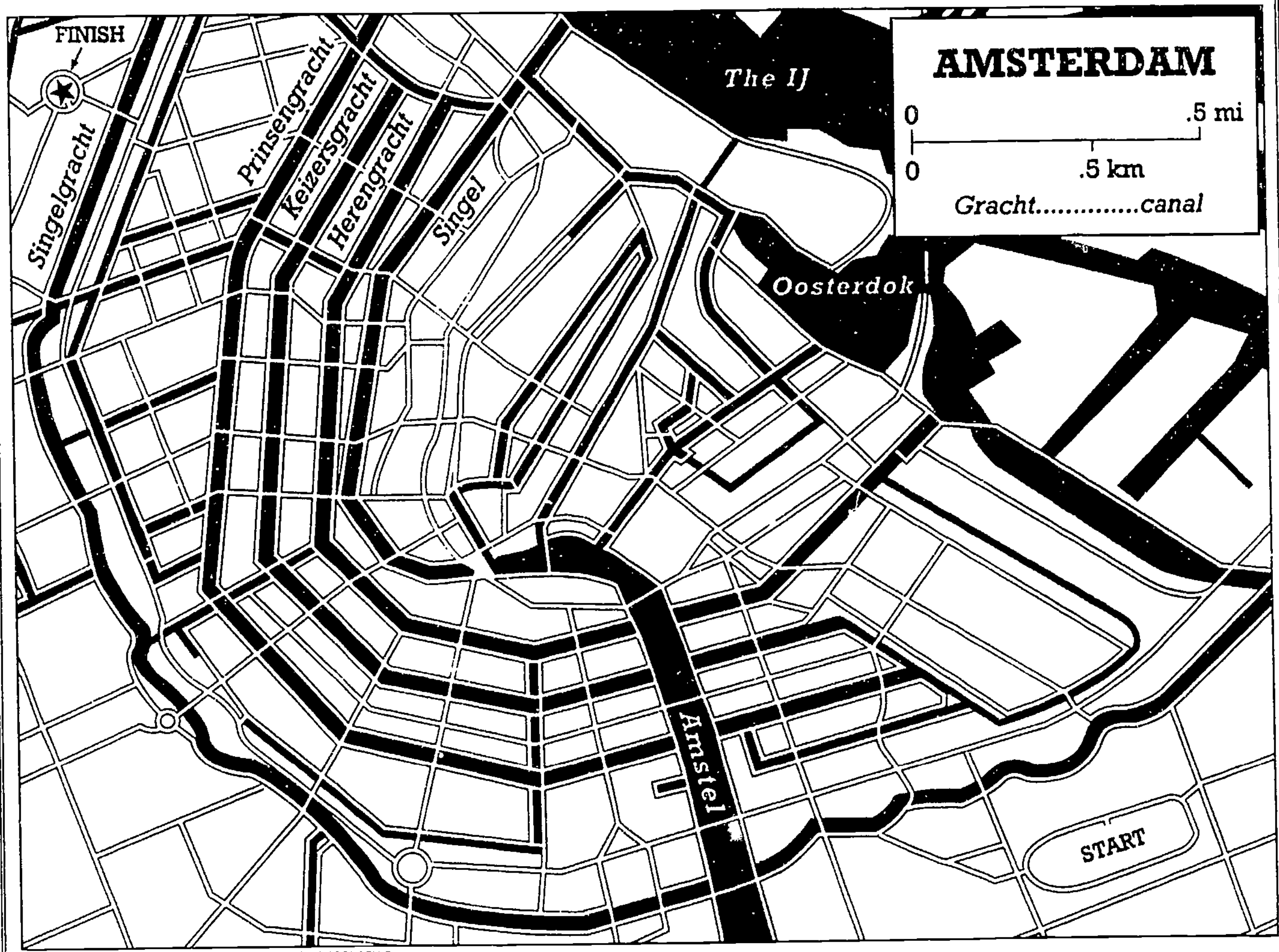
European canals were built largely to carry goods from one city to another. Canals were crucial to the growth of industry and agriculture, providing safe, rapid routes for getting goods and produce to major markets. Although some canals in Europe were outmoded by railroads, many still see heavy use.

Several major cities in Europe even today boast vibrant networks of functioning canals. Perhaps most notably, Amsterdam and Venice are criss-crossed by canals that carry cargo boats, water taxis, houseboats, gondolas, and tour boats.

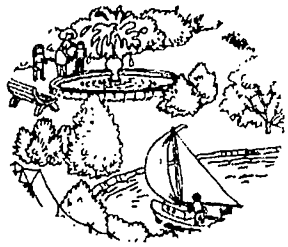
Amsterdam's more than one hundred canals, which help drain the land, virtually lace the city (see map below) with water access to the homes of 17th-century merchants. And no city in the West is more famous for canals than Venice—built on islands—where the only vehicles in town are boats.

AQUATIVITY: A Web of Canal Life in Amsterdam

This map shows central Amsterdam, in the Netherlands. The city is *full* of canals (shown dark) off the Amstel River. Almost all of them connect, under bridges. On an enlarged copy of the map, make a maze through the city from "START" to "FINISH" by blocking roads (shown in white) with pencil marks. Use the roads as pathways. Can friends figure out your maze?



AP BY MARTIN WALZ, ADAPTED FROM NATIONAL GEOGRAPHIC



PART III: CULTURE

Water is a part of the cultural environment of peoples throughout the world. It plays a major role in religious and cultural beliefs and ceremonies in many nations. It features in stories, myths, and art. In some cultures water is thought to have special powers: It grants wishes, harbors ancient monsters, bestows blessings, and cleanses body and soul.

In North America, water is a central focus of recreation. We are a nation of swimming holes and swimming pools. We focus much of our attention on water sports such as fishing, boating, canoeing, sailboarding, water-skiing, and jet-skiing.

Water also surfaces—metaphorically—in our everyday language, as when we "wash our hands of situations," and even in superstitions, as when we toss a penny into a fountain for good luck.

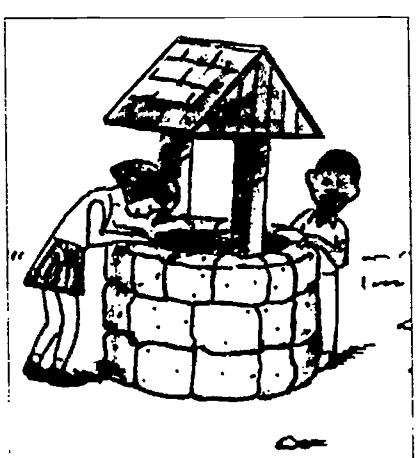
AQUATIVITY
Having Fun With Water

Look through sports, travel, and other magazines. Cut out pictures of people involved in recreational activities related to water in North America. Then make a large classroom collage with the pictures. Do other cultures depend as heavily on water for recreation?

H_2...Oh! *Around the world, different cultures use different means of storing and carrying fresh water for personal use. The San (Bushmen) in the Kalahari Desert, in southern Africa, store water in empty ostrich eggshells. Bedouin nomads in Saudi Arabia transport water in goatskin bags. What do you use to carry water with you?*

AQUATIVITY
Wishing Well

Work together as a class to make a wishing well out of cardboard. Decorate it with paint or wrapping paper. Place a large metal salad bowl or other wide-mouthed container in the well and fill it with water. Now each student should make a wish and toss in a penny. Why do you think this custom arose? Why do we like to think water has the power to grant wishes?

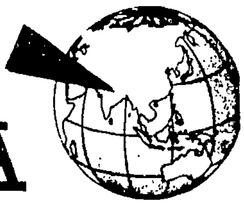


CASE STUDY: THE HOPI

The Hopi, of Arizona, use elaborate rituals to perform a rain dance. Priests of the Antelope and Snake Societies in the tribe collect and wash live rattlesnakes for the ceremony. Then priests perform a sacred dance with the snakes. They circle four times around the village plaza, holding the snakes in their teeth. Then they throw the snakes aside. At the end of the dance, runners pick up the snakes and dash away with them into the desert, where the snakes are released.

The Hopi believe that the snakes carry their prayers under the earth to the rain gods, who provide rain for crops, for grass that game eat, and for the Hopi themselves.

CASE STUDY: INDIA



The Ganges River flows from its source high in the Himalaya to the Bay of Bengal. It is considered by Hindus to be the personification of the goddess Ganga—and the holiest river in the world.

Every year in April, thousands of Hindus come to the river to celebrate the new year by attending festivals and bathing in the river. About every 12 years, Hindus come by the millions to the Ganges to commemorate a mythical struggle between gods and demons. According to the story, each wanted a share of nectar that would bestow immortality. In the struggle, drops of the nectar fell to earth. The most holy of the drops fell at the confluence of the Ganges and Yamuna Rivers. Hindus bathe in the Ganges to wash away their sins and escape the cycle of reincarnation.

© RAGHUBIR SINGH

The Ganges provides the opportunity for purification of body and soul to a father and his son in Varanasi, India.

CASE STUDY: THAILAND

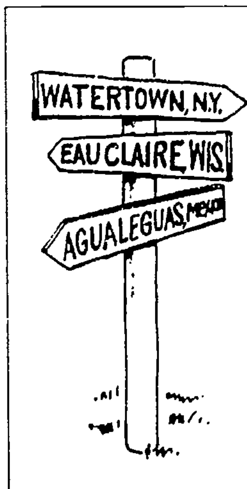
Every year on the 13th of April, the people of Thailand celebrate Songkran, the new year. At Songkran, Thailand comes alive with parades, beauty contests, parties—and splashing water. In Thai tradition, water is an agent for spiritual cleansing. And during Songkran, everyone is thoroughly cleansed. A traditional custom during Songkran involves pouring a small bowl of "lustral," or blessed water, over the hands of a respected person. But in many places, the blessings escalate to entire buckets of water, garden hoses, and even squirt guns. Water is important to many other Thai traditions, including weddings and farewells to the dead.

AQUATIVITY

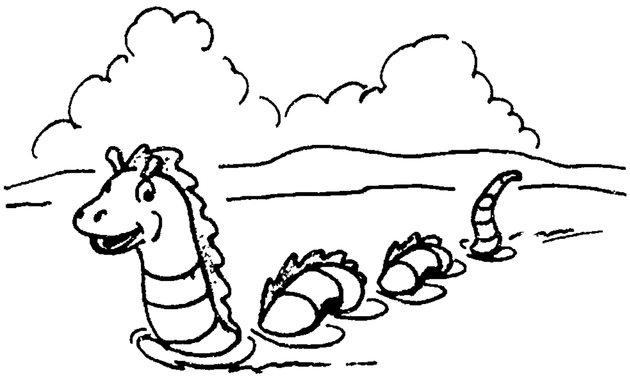
What's in a Name? (Water!)

Use the index and maps of an atlas to find and locate all the towns, cities, and other place-names in the United States, Canada, and Mexico that contain the word "water." Then locate and label each of these places on a copy of the map on page 9. Also label place-names that contain the word "water" in French ("eau") and Spanish ("agua").

Why is "water" used so commonly for place-names? What do some of the names mean? (What, for example, does "Waterford" or "Waterton" mean?) Are most of the towns you found situated along water? Are they in places where water is plentiful?



CASE STUDIES: LAKE CHAMPLAIN AND LOCH NESS



It's a Real Champ . . . Maybe

It looks like a serpent, it's about the thickness of a barrel, and it may be as long as 30 feet—that is, if it really exists.

In 1609, French explorer Samuel de Champlain was the first to report seeing an elusive monster in a lake on what is now the border between New York State and Vermont—a lake that now bears his name.

Since Champlain's time, hundreds of people have reported sighting the monster. Is it a zeuglodon—a snakelike ancestor of whales? Or is it three giant sturgeons swimming in a row? Or . . . could it be just floating logs?

Not even high-tech sonar searches have revealed the mystery of "Champ" of Lake Champlain.

Nessie of Loch Ness, In Scotland

Visitors to scenic Loch Ness, in Scotland, also have long reported sighting a huge creature in the lake.

Nessie, as the monster was nicknamed, is usually described as about 20 feet long, with a long neck, small head, humps, and flippers.

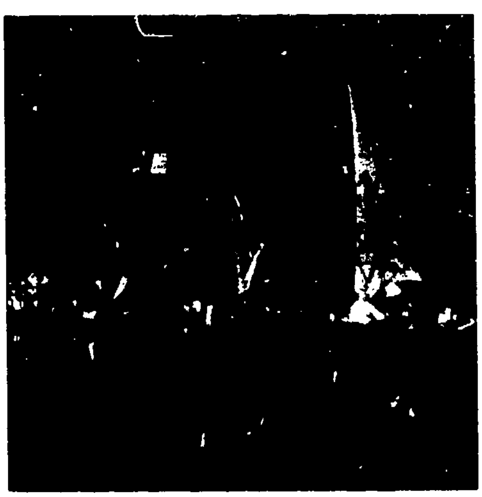
Many expeditions to Loch Ness have sought to find, identify, and photograph the creature, but none has been successful. Scientists who take the idea of Nessie seriously suggest that there may be a plesiosaur, a huge animal otherwise believed to be extinct for 65 million years, "ecologically trapped" in the landlocked lake. Others surmise it may be a deer or an otter. So far, Nessie's secret is still loched up tight.

AQUATIVITY: Myth-terious Creatures

Make a presentation to classmates of a story or myth related to fresh water, such as the two described at left. Other sources include collections of myths, folktales, tall tales, and fables from different parts of the world. Tell the stories using your own or other illustrations, models, videos, or multimedia presentations. If your story subject, such as Nessie, could *possibly* be real, try to provide a logical or scientific explanation. If your story is a fable or a folktale, discuss with classmates what lesson the story might be intended to teach.

CASE STUDY: AUSTRALIA

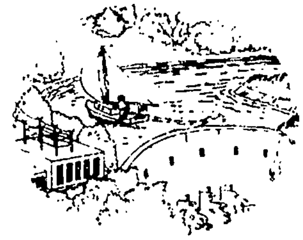
Most of Australia receives little rain (see map, page 4), yet the country's cattle and sheep industries thrive. To sustain herds in a land so often arid, herders depend on a whole culture of rugged, outback truck drivers who move the herds from place to place in multiple-trailer "road trains" to wherever rain supports sufficient grass.



The fact that the bed of the Todd River is bone-dry much of the year does not stop central Australians near Alice Springs from enjoying a mock boat race. A dry sense of humor notwithstanding, Australians take water issues very seriously.

JEFF CARTER

PART IV: ENGINEERING



Water is a potential source of food, health, wealth, political power, and energy. Establishing a reliable supply of it is vital to any viable community. Great amounts of time, money, and effort have been invested over millennia in controlling water—tapping, collecting, piping, and pumping it.

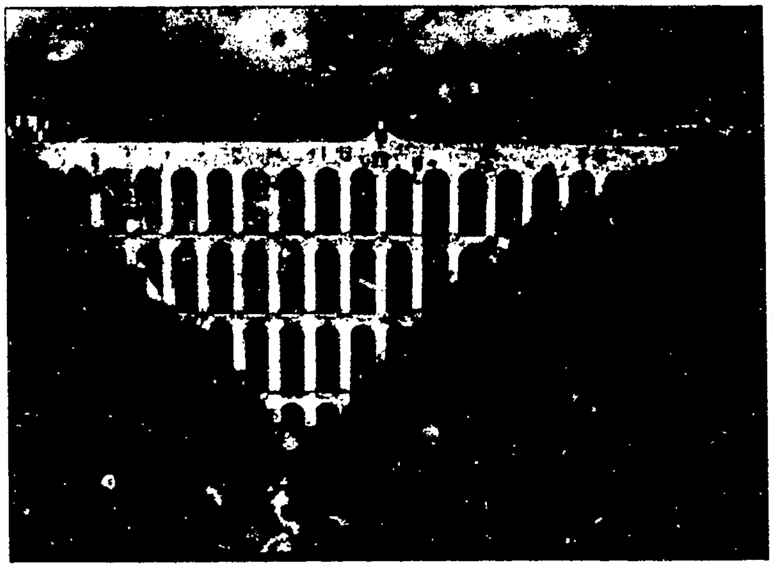
Two critical devices for controlling water are aqueducts and dams. Both have been built for thousands of years.

Aqueducts are used to transport water. The Romans were so skilled at building them that some of their structures are still being used today.

Dams, which block the flow of water and form reservoirs, serve several purposes. Besides providing recreational uses, reservoirs store water to help ensure that sufficient water is available for a specific population to use when they need it.

Water collected behind a dam can provide energy to power electrical generators. Dams are also used to control flooding.

Though useful in many ways, dams and aqueducts are often controversial. Aqueducts may affect whole ecosystems—draining a lake, drying up wetlands, or reducing the flow of a river. Dams not only affect the area upstream, flooding valleys and dislocating humans and wildlife; they also control the flow of streams and rivers below them. Reducing the flow of water to populations downstream can have dire effects on industry, agriculture, and people's very existence.



SEFTON PHOTO LIBRARY, MANCHESTER

Modeled after the peerless design of Roman aqueducts, a 19th-century aqueduct bridge spans a gorge near Malaga, Spain.

H_2...Oh!

More than 36,500 dams over 15 m (49 ft) high have been built worldwide.

SOURCE: WORLD RESOURCES 1992-93

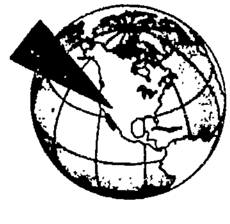
AQUATIVITY: Controlling Water—Every Day, Everywhere, Every Way

We dam, divert, and transport water to provide a public water supply, as well as for industry and agriculture. But have you ever thought about the many ways we dam, divert, and transport water in our everyday, personal lives? We're always manipulating water in one way or another.

Write three headings on the chalkboard: Damming, Diverting, Transporting. Discuss as a class the ways we dam, divert, and transport water in our daily lives, and jot them down as classmates think of them. Examples: *Damming:* a drain plug and bathtub caulking serve as "dams," blocking water. *Diverting:* roof gutter, street gutter, shower curtain, dehumidifier—even the crown of a road. *Transporting:* drinking glass, bottle, pipe, and hose.

What happens when we fail to control water? (Floods! Leaks! Mold!)

CASE STUDY: COLORADO RIVER



The Colorado River runs 1,450 miles from the Rocky Mountains to the Gulf of California. It has carved—and is still carving—the Grand Canyon and other natural wonders, and has brought much of the southwestern desert to life.

By building a complex of dams, aqueducts, and canals along the Colorado, engineers have brought water to areas once considered unlivable. But by changing a desert into farmland and making large cities far from the river dependent upon its water, we have created a thirst that is overtaxing the supply.

The Colorado River system serves people in Colorado, New Mexico, Utah, Arizona, Nevada, Wyoming, California, and northern Mexico.

Near the river's source, the Grand Ditch cuts into the Rocky Mountains and diverts water to Fort Collins for crop irrigation. Downriver, the Glen Canyon Dam blocks the Colorado, creating Lake Powell, a 186-mile-long recreational lake at the Utah-Arizona border. At the Nevada-Arizona border, the Colorado meets the enormous Hoover Dam, a structure that collects water that is sent to Las Vegas. At the Arizona-California border, the Parker Dam holds back water that is diverted to San Diego and other cities in southern California and to Phoenix and other Arizona cities.

The last major diversion carries water to Tijuana via the Canal Central. By the time the river reaches its end, in Mexico, what was a major waterway is a thin trickle. When drought strikes, the Colorado dries up before it even reaches the Gulf of California.

AQUATIVITY
Diverting the Colorado Until There's Hardly Any Left

On a copy of the map of the Colorado River (opposite), locate the major blockages and diversions—the dams, canals, and aqueducts. Can you find the Grand Ditch, Glen Canyon Dam, Hoover Dam, the All-American Canal, the Canal Central, the Central Arizona Project, and the Colorado River Aqueduct? Also locate and identify the major lakes created by the dams: Powell, Mead, Havasu, Mohave. Check in an atlas to see where sites of the National Park System lie along waterways and add them to this map.

Now, on a fresh copy of the map on page 9 (North American Rivers), draw in the outline of the Colorado River Basin. Use the Colorado River map for the information you need. (The Colorado River Basin is the river's watershed—the total land area drained by the river.) In a different, bright color, draw in large arrows to show all the places where water is taken from the river, and where the water goes.

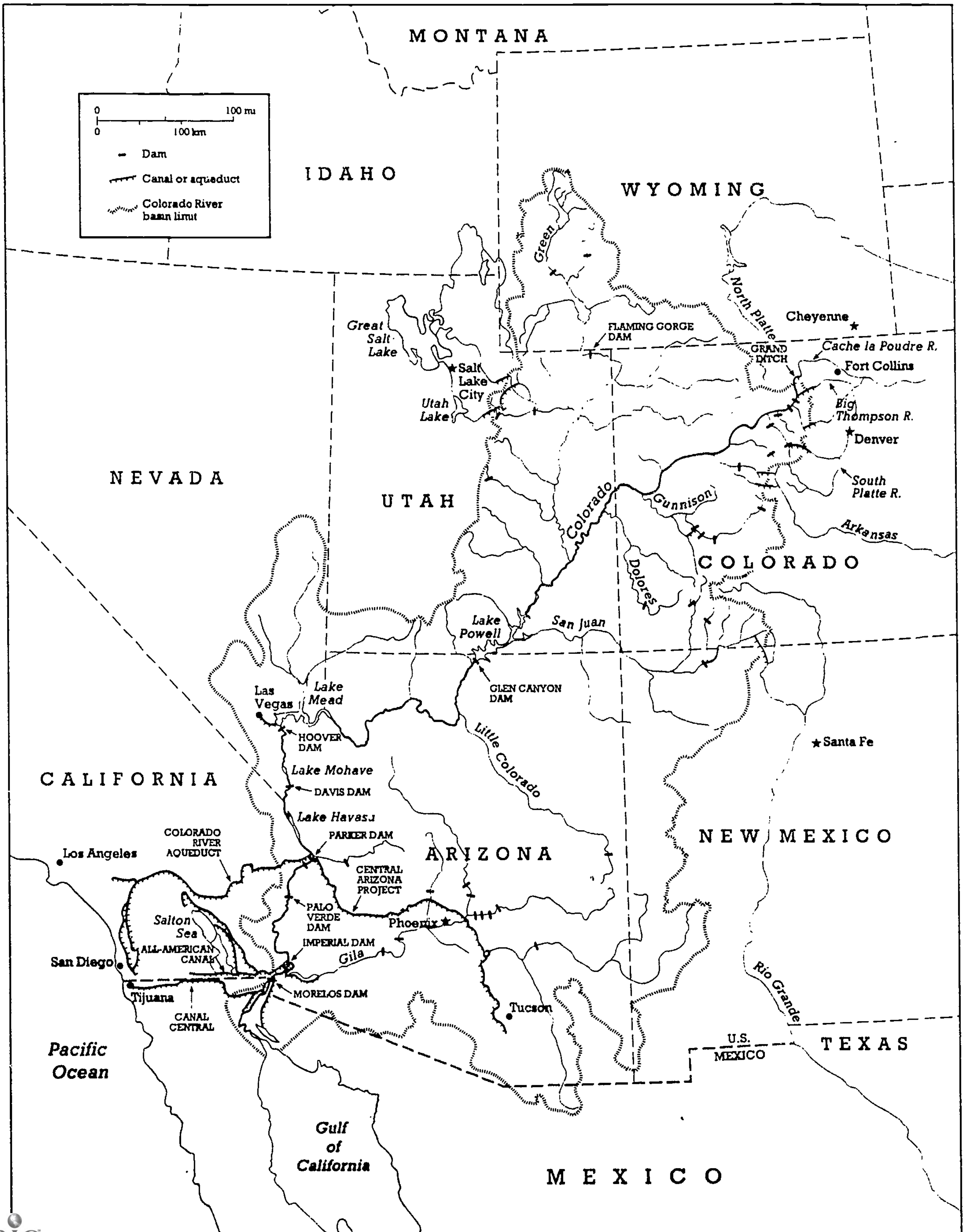
In a watershed, water naturally flows from the edges of the watershed toward a central draining channel. What does your new map tell you about the Colorado River? Does it give you a clue as to why the Colorado sometimes dries up before it reaches its outlet?

AQUATIVITY
Big Dams

Look up in an almanac the 12 highest dams in the U. S. Locate them in an atlas, then plot them on a copy of the map on page 9 of this booklet. Label all the rivers, as well.

Can you make general observations about the location of the largest dams in the U. S.? What purposes do these dams serve?

The Colorado River and Watershed



MARTIN WALZ, ADAPTED FROM THE JUNE 1991 *NATIONAL GEOGRAPHIC*

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CASE STUDY: ITAIPU DAM

Paraguay and Brazil, South American neighbor nations, joined forces in 1974 to build the nearly five mile long Itaipú Dam, among the largest in the world. Spanning the Paraná River, it produces enough electricity from its 18 mammoth generators for a city of three million people.

Paraguay uses only five percent of the power—all that it needs—and sells the rest of its share to Brazil. Through this arrangement, Paraguay is able to support its national budget, and Brazil is able to power a third of its factories and cities.

To build the dam, workers dug a 1.3-mile diversion channel along the river on the Brazilian side. Then they constructed a portion of the new dam in this dry canal. In 1978, the river was diverted to the new channel, and the original riverbed was left dry for the construction of the main dam. Three concrete-mixing plants were built on the site to accommodate the need for all 28 million tons of concrete. By the time of its completion in 1984, the dam reached 643 feet in height and contained five times as much concrete as Hoover Dam.

LOREN MCINTYRE

The giant Itaipú Dam, along the Brazil-Paraguay border, is among the largest in the world. The 18 generators in the hydroelectric plant each tower 13 stories and measure 52 feet across—the largest of their kind.

AQUATIVITY

A River Runs to It (How a Dam Works)

Make a model riverbed in a large, low-sided aluminum baking pan by molding aluminum foil over crumpled newsprint and painting on the landscape. Form a channel for the river from high ground ending in a pool. Place a green Monopoly® house near the source and a red hotel near the mouth of the river.

Gather around the pan. Discuss what is always true about the direction rivers flow. Which building will get river water first? Pour water from a pitcher onto the river's source to demonstrate the river's flow.

With the model dry again, dam the riverbed below the green house with a slab of Plasticine. What will occur when the river flows now? Pour water slowly so that it collects in the area above the dam. What happens to a river when it is blocked by a dam? Notice that a pool or lake forms where there was no lake, and that no water passes through the dam at first. What happens to land animals living in and around the upstream part of the river? What good effects will the dam have for animals and people above the dam?

How would you feel about the dam if you lived in the green house? How would you feel about the dam if you lived in the red hotel?

PART V: HEALTH AND DOMESTIC USE

Like all other living things, human beings are made up largely of water. Every day, we must take in about half a gallon of water simply to stay alive and healthy. For most people in the United States, access to clean, fresh water is no problem. We turn on the tap in our homes, and out pours a seemingly unlimited supply. In fact, the average person in the United States uses about 100 gallons a day for drinking, bathing, cooking, washing, swimming, watering gardens, and such. And the water each of us uses directly is only a start, because water is essential in producing the food we eat and the products we use, and in the transportation we ride.

While many of the industrialized nations of the world are rich in fresh water, much of the developing world is water-poor. Many women and children in the devel-

(cont'd on next page)

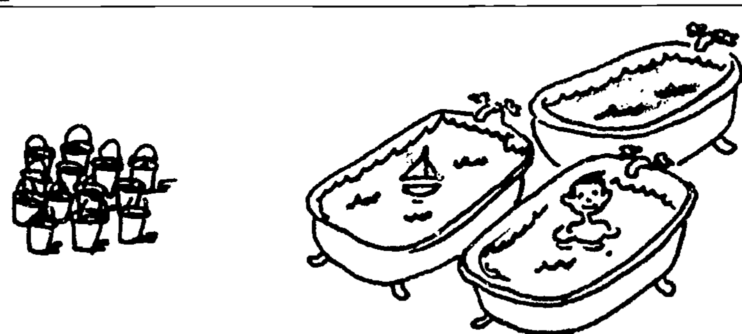
AQUATIVITY (Directed to Teachers)

How Much Water—Here and There?

Two-thirds of the people in the world use less than 13 gallons of water a day. To illustrate this quantity, fill 13 one-gallon jugs with water and display them in class. Ask students how many gallon jugs they would have to fill to supply their *own* needs for a day. Record all of their estimates. Then distribute a tally sheet to each student, titled "How I Use Water," and tell the students that over the course of the next 24 hours they should make a record of each water use—from brushing teeth to washing hands to flushing a toilet to watering the lawn to washing dishes, and so on. When they return to school, ask the students to use the table below to compute how many gallons they each used during the course of the 24 hours. How do the quantities compare with 13 gallons? Ask students to explain the discrepancies.

Amount of water used (Quantities given are estimates *for each use,* except where noted):

Washing hands.......................¼ gal
Flushing toilet.........................5 gal
Showering.............................30 gal
Taking a bath.........................40 gal
Brushing teeth.........................1 gal
Washing car...........................20 gal
Washing dishes.....................10 gal (by hand, with water running)
Washing dishes.....................15 gal (by machine)
Laundry................................30 gal (per load)
Watering lawn.....................240 gal (30 minutes)
(Add ½ gal water taken in through food and drink for the day.)



(Cont'd from page 19) oping world must walk miles to the nearest water source; some spend the better part of their lives fetching and carrying water to their homes. Water may be considered too important to use on things such as flower gardens and fountains—or even washing hands.

Having a sufficient quantity of water for domestic use is vitally important. But the quality of that water is just as important. In the U. S., much of our drinking and cleaning water comes from treatment plants and is safe to drink. Most homes are connected to sewer or septic systems, which carry away waste to be treated or safely returned to the soil.

In much of the world, however, there are few sewer or septic systems. Human waste is not carried away from people's homes, and may be dumped into streets or water sources. Drinking water may be taken directly from the same water where raw sewage is dumped. More than a billion people in the world do not have a safe and reliable supply of drinking water. Unclean water causes many serious medical problems, such as schistosomiasis, cholera, diarrhea, and dysentery. Every day, some 25,000 people in the world die from waterborne diseases.

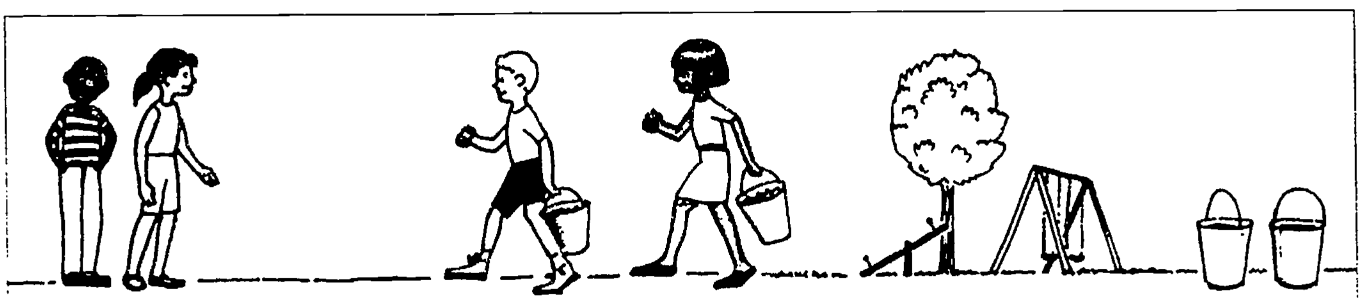
NGS PHOTOGRAPHER GEORGE F. MOBLEY

Well water in Pushkar, India, provides women with their household supply—to be carried home in ceramic containers on their heads.

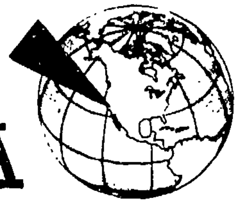
AQUATIVITY: It's Not Like Turning On the Tap

Place several full one-gallon buckets of water far from the classroom—ideally at the far end of a playing field or playground. Now set the scene for your class: "One of your parents has told you that the family needs three gallons of water today. You have no running water in your home, and it's your job to bring the water from the well."

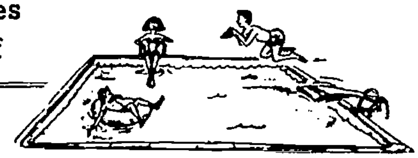
Have several students fetch their family's water and carry the buckets back to the group Discuss how it felt to carry water from so far away. How would it feel to do this every day for all the water used in their homes? Would the students use water any differently than they do now?



CASE STUDY: CALIFORNIA



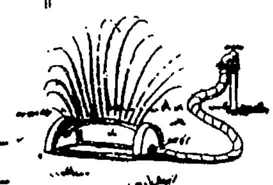
Swimming pools are a hot topic in California. As of 1990, there were 647,000 pools across the state—more than 75 percent in the south. Much of the water used to fill those pools comes from the water-rich northern end of the state. Northern Californians are concerned about the water-use habits of Southern Californians, arguing that northern water is being siphoned away for nonessential uses. To help resolve the issue, the Los Angeles Department of Water and Power cut back on water allowances for Southern Californians, and enforced fines for overuse of water.



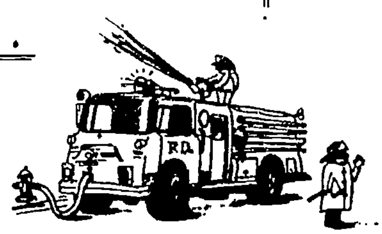
AQUATIVITY
Cutting Back on Water: *How?*

Imagine that because of an earthquake, your community must suddenly cut back its total water consumption to a small fraction of normal use. List on the board which uses will be affected. Examples: fire fighting, residential use, commercial use, hospitals, farms, bathing, plumbing, car washing, hair washing, swimming pools, lawn watering, industry, fountains. Discuss as a group which uses should have priority. Which ones would be easy to give up? Would you cut out some uses altogether or scale back each use? Who in town should decide how the water is distributed?

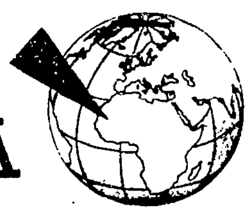
What could *you* do in school to make sure you have enough water? Some examples: Carry water to school in jugs. Store excess water not used. Reduce your physical activity. Bring lunches naturally high in water content, such as fruit. Share with those who forgot or who didn't bring their supply for the day.



ADAPTED WITH PERMISSION FROM *WATER WISDOM*, MASSACHUSETTS WATER RESOURCES AUTHORITY, AND *MY WORLD, MY WATER AND ME!*, THE ASSOCIATION OF ENVIRONMENTAL AUTHORITIES (NJ)



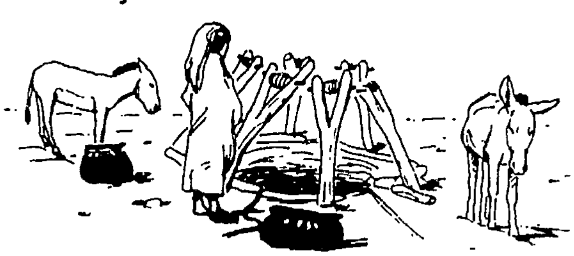
CASE STUDY: MAURITANIA



The Gorgol region of Mauritania is a semidesert. There, it is up to 18-year-old Khajettu to fetch the water her family needs.

Each day she rises before the sun and walks about three miles to the well with her donkeys and water cans. At the well, she must wait—sometimes hours—for the local cows, sheep, camels, and donkeys to drink. Finally, when her turn comes, she must ask for help to bring the heavy containers of water up from the bottom of the well.

Khajettu's water goes to her family's poultry and goats; it is used for cooking and drinking; and everyone uses it for ritual washing. She will probably continue to be the water-bearer for her family and her husband's family until she is an old woman.



PART VI: POLITICS AND ECONOMICS

Many rivers flow from one state to another, from one nation to another. As they make their way from source to mouth, a great many are dammed, diverted, or polluted.

Because people in the same watershed depend upon the same source of water, the question "Who owns the water?" is critical. The answer ultimately can mean the difference between war and peace, poverty and prosperity.

When a river is dammed or diverted or pumped onto fields, its quality and quantity are altered. Dams may diminish, or at least regulate, the amount of water available to people downriver. Aqueducts may also lessen the flow downriver.

River water is withdrawn for industrial or agricultural use, and then often polluted by industrial waste or fertilizer, or it may be heated—causing problems for plants and animals in and along the water and for people downriver.

The intensity of debates over the ethical, political, and economic issues related to water use—in the United States, Israel, Turkey and Syria, North and South Korea, just to name a few—attest to the crucial position water commands in our lives, and to the need for equitable answers.

AQUATIVITY

Watershed Blues Put Countries in the News

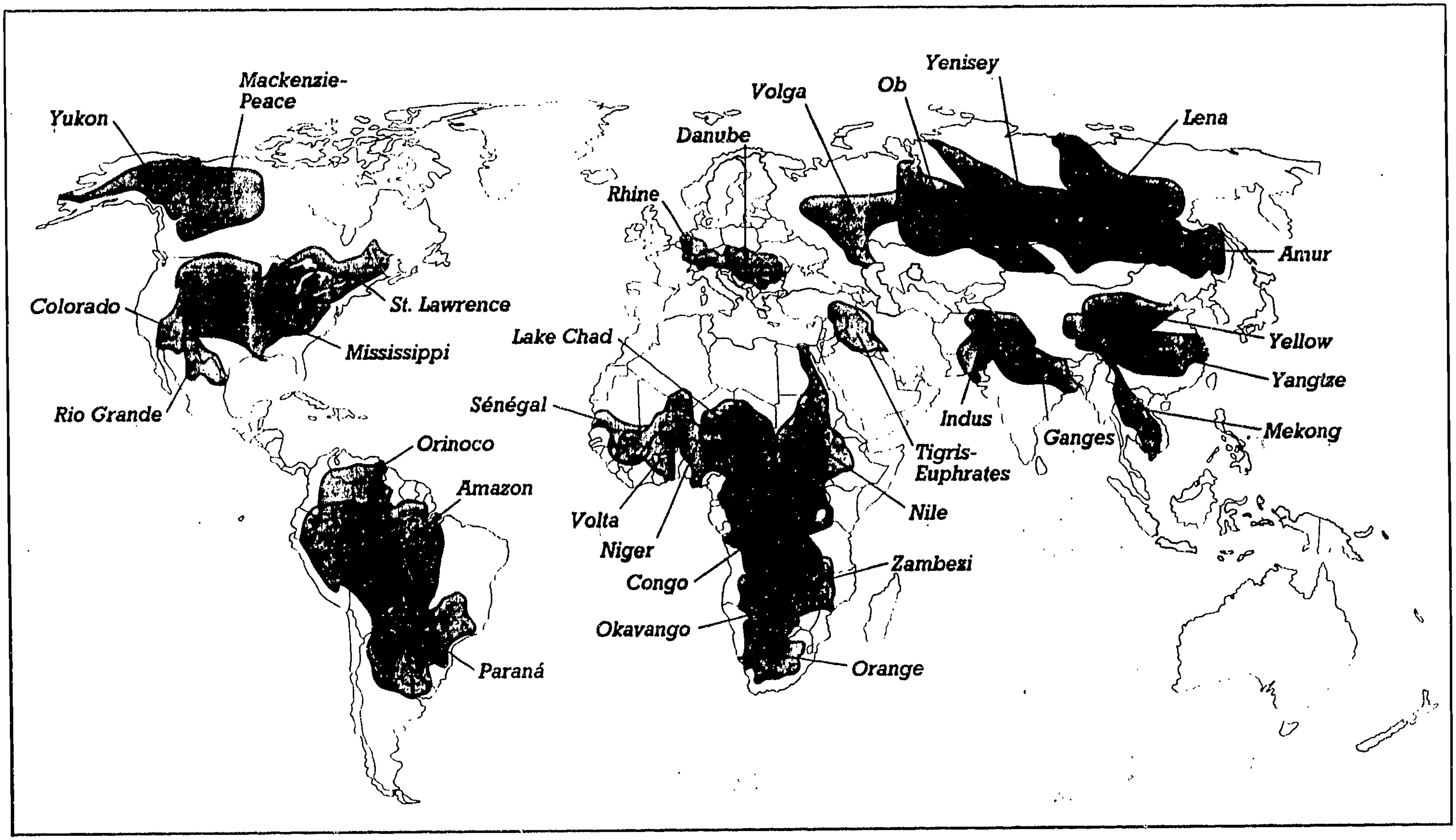
Assign teams of students to research water issues in various parts of the world, as outlined on the chart at right. News magazines, NATIONAL GEOGRAPHIC, *Smithsonian*, and other periodicals will be good current sources, along with resources listed on page 28. Use the map on the next page to locate the watersheds of the rivers in the chart and identify the countries that share them. Have students report their findings to the class. Reports should include pictures or graphics. The cumulative effect of the reports will make clear the breadth of issues related to water rights and conservation worldwide.

International Water Disputes

River	Countries in Dispute	Issues
Nile	Egypt, Ethiopia, Sudan	Siltation, flooding, water flow/diversion
Euphrates, Tigris	Iraq, Syria, Turkey	Reduced water flow, salinization
Mekong	Cambodia, Laos, Thailand, Vietnam	Water flow, flooding
Paraná	Argentina, Brazil	Dam, land inundation
Rio Grande, Colorado	Mexico, United States	Salinization, water flow, agrochemical pollution
Rhine	France, Netherlands, Switzerland, Germany	Industrial pollution

TABLE ADAPTED WITH PERMISSION OF THE WORLD RESOURCES INSTITUTE AND THE WORLDWATCH INSTITUTE, WASHINGTON, D. C.

Major Watersheds of the World



MAP BY MARTIN WALZ. SOURCE OF WATERSHED DATA: WORLD RESOURCES INSTITUTE, WASHINGTON, D. C. WATERSHED BOUNDARIES ARE APPROXIMATE.

CASE STUDY: JAMES BAY, QUEBEC

In 1971, Hydro-Quebec, a Canadian utility company, began work on a massive, long-term hydroelectric project in northern Quebec. Just the first phase of the project has dammed three river drainages, flooding 4,000 square miles and affecting an area the size of New England—with an output of 15,719 megawatts of electricity. The largest of the dams creates one of North America's biggest reservoirs. The project has been promoted as vital to the economy and industry of the province.

The James Bay project has stirred up controversy among the Cree and Inuit peoples whose homeland is being altered, and among environmentalists concerned about the displacement, poisoning, or killing of plants and animals.

The second of the three phases of the project has been held up in court. For the part of the project already completed, the Cree are receiving compensation for environmental damage to their land.

AQUATIVITY
To Dam or Not To Dam

Assign two debate teams to prepare arguments for and against the James Bay project. The teams should research and argue issues in favor of a network of dams and hydroelectric plants, and issues in favor of preserving the environment and protecting the conditions of Native Americans living in the wilderness. Hold the debate in class.

CASE STUDY: TIGRIS AND EUPHRATES RIVERS

Inside Turkey lie the sources of two great rivers, the Euphrates and Tigris, which provide much of the water used in southeastern Turkey, Syria, and Iraq.

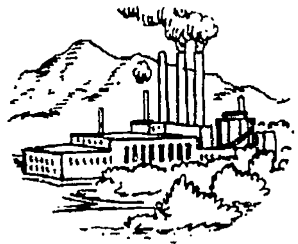
Turkey has undertaken the mammoth Southeastern Anatolia Project on the two rivers, a system that will include 22 dams and 19 hydroelectric plants. The biggest of the dams, the Atatürk, already completed on the Euphrates, will hold back ten times the volume of the Sea of Galilee. Two 25-foot-diameter irrigation tunnels will carry water 40 miles to the Harran Plain for agriculture. Syria and Iraq have raised strong objections: The project may deplete the Euphrates by as much as 60 percent—water on which Syrian and Iraqi agriculture depends. Iraq has filed suit to halt part of the project.

AQUATIVITY
Debating Water Rights

Ask students to imagine that they live in a country cabin and depend for water on a small creek on the property. How will they deal with neighbors upstream who dam the stream for a cattle pond and for irrigating crops—on fields that drain back into the stream? What *rights* does each landowner have to the water? Do people upstream have *obligations* to those downstream?

Assign students to research, and then debate, water-rights issues on the Colorado, Pecos, or Red River in the U. S., or on the Tigris and Euphrates Rivers.

PART VII: INDUSTRY



Nearly one-quarter of all the fresh water used by humans goes to industry. Water in industry is used for cooling power stations and machinery, cleaning food and other raw materials, air-conditioning, and factory cleanup, among other things. Only about six percent of the water used for industry is actually consumed—for example, in canned foods and soft drinks.

When water is used in industry, it usually undergoes a change in quality or characteristics. Water used for cooling is heated, and water used for cleaning is polluted. Since cooling and treatment are expensive, and many countries have few laws governing water use, water from factories is often returned to rivers and lakes untreated or overheated.

In the U. S., stringent laws require industries to clean and cool water before returning it to rivers and lakes. In an effort to economize—and conserve water—many factories have begun to recycle the same water over and over again instead of disposing of it immediately after first use.

Other industries are devising innovative ways to reuse water in other capacities, or treating it by natural methods before returning it to its source. Water reclamation and natural treatment systems can be not only economical but also beneficial to the land and to wildlife.

SERGIO A. BALLIVIAN

Cooling water from a Potomac Electric Power Company plant returns to the Potomac River, in Dickerson, Maryland, past man-made obstacles constructed in the sluiceway so expert ...kers can practice their sport in the rapids—year-round.

AQUATIVITY
Putting Water to Use . . . A Second Time Around

Partly treated wastewater is reclaimed and reused for a variety of industrial and other purposes. Among these are fountains in Las Vegas, snow-making machines in Colorado, and golf courses in Arizona. Think of as many uses as you can for ways in which partly treated wastewater might be safely reused in your area. Remember that this water cannot be used for drinking. Make a list of your ideas. If appropriate, send your class's ideas to local industries. In the letter, ask for a response.

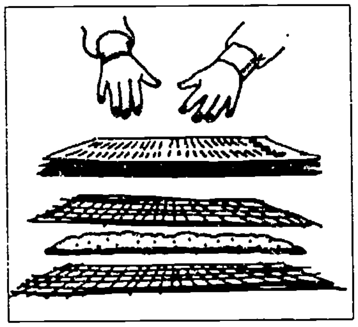
AQUATIVITY
Reusing Water Wisely at Home

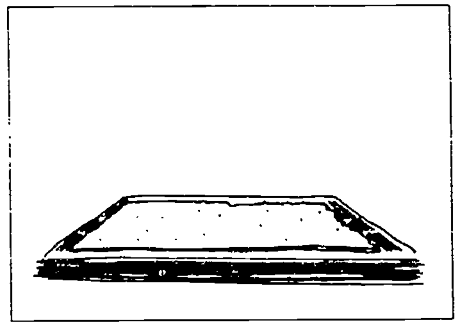
What are some ways in which water can be reused in your home or classroom? For example, water used for washing a potato can be reused to water a plant. Water that runs while you're waiting for it to get hot can be saved for washing cars or washing a dog. Can dishwater be reused? How about rinse water? List all ideas on the board. Discuss with students which ideas are feasible, which would make the most difference, and under what circumstances each approach might be employed (e.g., only during times of drought).

AQUATIVITY:
Using Water to Make Paper

The papermaking industry uses a tremendous amount of water. To make one copy of a Sunday paper, it takes some 80 gallons.

To experience how water is used in this common industry, make paper in your classroom. First rip up uncoated scrap paper into tiny pieces. Soak it in warm water, then mix it to a smooth pulp in a blender. Pour the mixture over a horizontal piece of window screen. Put another piece of screening on top of the paper pulp, and then some sheets of newspaper on top of the second piece of screening. Press down to remove excess water, then remove the top screen. Turn over the bottom screen, leaving the new paper lying on fresh, dry newspaper. Allow your newly made paper to dry, and use it later for arts and crafts or other activities.





CASE STUDY: UNITED STATES

A new system for water treatment is actually age-old: cleansing water through wetlands.

Wetlands are lands that are covered or saturated by water most of the year. They act as a natural filter for water by straining out impurities.

Today, American factories such as the Logan Aluminum plant in Russellville, Kentucky, and the American Crystal Sugar Company plant in Hillsboro, North Dakota, are filtering wastewater through artificial wetlands.

For a long time, people didn't understand the value of wetlands. A great many wetlands were filled in or paved over. Many wetlands are still being drained, but we understand today that wetlands are not only vitally important to wildlife, but also are inexpensive and efficient systems for cleaning our water.

H_2...Oh!

- *It takes 100,000 gallons of water to make one car.*
- *To make a pound of rubber, it takes 300 gallons of water.*
- *A pound of aluminum (that's 29 cans) takes 1,000 gallons.*

SOURCE: WET AND WILD WATER, INDIANA DEPARTMENT OF EDUCATION

AQUATIVITY
The Value Of Wetlands

Invite a speaker from a local wildlife refuge or agency to speak to your class about the importance of wetlands and ways to protect local wetlands—or other water resources.

Seeking Clear Solutions

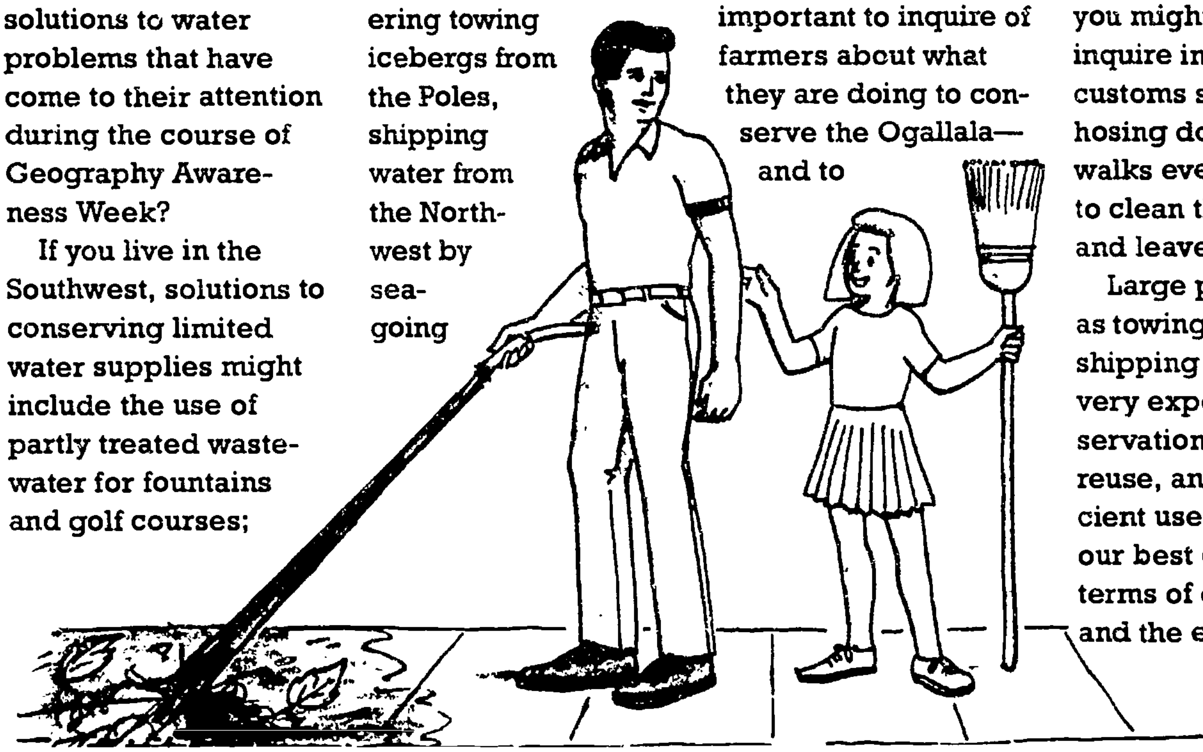
What can your students do to help offer clear solutions to water problems that have come to their attention during the course of Geography Awareness Week?

If you live in the Southwest, solutions to conserving limited water supplies might include the use of partly treated wastewater for fountains and golf courses; xeriscaping (gardening with water-conserving plants); and conservation at home. Scientists are considering towing icebergs from the Poles, shipping water from the Northwest by seagoing tankers, and piping fresh water south from the Columbia River.

If you live in the High Plains, it may be important to inquire of farmers about what they are doing to conserve the Ogallala—and to find out if they are using any new, water-saving irrigation techniques.

If you live in a city, you might want to inquire into cleaning customs such as the hosing down of sidewalks every morning to clean them of trash and leaves.

Large projects such as towing icebergs or shipping water are very expensive. Conservation, recycling, reuse, and more efficient use of water are our best options in terms of economics and the environment.



AQUATIVITY
Making a Splash in Your Community

• First, ask students to determine which water issue or problem is most important in their community.

• Second, decide on the best way for your class or school to address the problem. For example, you might visit a local factory to learn more about its water recycling policy, organize a public information campaign, initiate a water conservation program at your school, or raise money toward an improved local sanitation system. Try to be positive. Pursue constructive solutions to problems you are working on.

• Third . . .

—Let local media know what projects your students are undertaking, so that your efforts will have the greatest possible exposure and impact. Use the news-release form included with this handbook for assistance in preparing your news release.

—Have students write letters of inquiry or suggestion to the editor of your local newspaper about the issues that concern them most.

ACKNOWLEDGMENTS

Grateful acknowledgment to Citibank MasterCard and Visa for underwriting the preparation and mailing of the 1993 Geography Awareness Week packet.

The staff thanks the following individuals and organizations for permission to use or adapt activities and illustrations: Albany Institute of History and Art; Association of Environmental Authorities, Mercerville, N.J.; Neil Clark, Massachusetts Water Resources Authority, Boston; *Science Weekly*, Silver Spring, Md.; Water Environment Federation, Alexandria, Va.; World Resources Institute, Washington, D. C.; Worldwatch Institute, Washington, D. C.

For outline review, the staff is grateful to Michael Libbee, Central Michigan University, and Joe Harkins, University of Kansas. For consultation, the staff wishes to thank Ron Marlow, U. S. Department of Agriculture, and Sandra Postel, Worldwatch Institute, Washington, D. C.

Published by the
National Geographic Society
Gilbert M. Grosvenor,
President and Chairman

Geography Education Program
Robert E. Dulli,
Assistant Vice President, Director
Kim Hulse, *Manager,*
Geography Awareness Week

Geography Awareness Week Materials
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RESOURCES

Publications and Materials

All About Water, Metropolitan Water District of Southern California. Available from Education Programs, Metropolitan Water District, Public Affairs Division, Box 54153, Los Angeles, CA 90054. Tel. 213-250-6739. (Water activities for K–3, related to water conservation, the water cycle, and the water we use.)

Andrews, Elaine, ***Educating Young People About Water, A Guide to Goals and Resources,*** the United States Department of Agriculture, 1992. Available from the author at University of Wisconsin–Madison, Environmental Resources Center, 216 Agriculture Hall, 1450 Linden Dr., Madison, WI 53706. (Lists curricula for all grades that cover science of water, water-related ecosystems, drinking water supply [quantity and quality], water use, sources of water pollution and contamination, management and protection strategies, government/citizenship issues, water-related careers.)

Postel, Sandra, ***Last Oasis: Facing Water Scarcity,*** W.W. Norton & Co., New York; © 1992 Worldwatch Institute.

Vesilind, Priit J., **"Middle East Water—Critical Resource,"** NATIONAL GEOGRAPHIC, vol. 183, #5, May 1993.

Waterstone, Marvin, ***Water in the Global Environment,*** National Council for Geographic Education, 1992. Available from NCGE, 16A Leonard Hall, Indiana University of Pennsylvania, Indiana, PA 15705. For 7–university; comprehensive 57-page manual for teachers with information on water quality, water resources management, and current global water-related problems. $5, plus postage and handling.

Water Wizards [3–4], ***Water Watchers*** [6–8], ***Water Wisdom*** [9–12], Massachusetts Water Resources Authority School Programs, Charlestown Navy Yard, 100 First Ave., Boston, MA 02129. Tel. 617-241-4643. (Illustrated manuals with activities and worksheets to help students understand water supply and water conservation. *Water Wizards* and *Water Watchers* are free. *Water Wisdom* is free within the Authority's service area, and $10 elsewhere.)

World Resources 1992–93, A Guide to the Global Environment, World Resources Institute. Available from WRI Publications, P.O. Box 4852, Hampden Station, Baltimore, MD 21211. (This 385-page, large-format paperback includes figures and statistics for nearly every country, on economic condition, population, natural resources, and environmental status and trends; $19.95. Also available: a companion loose-leaf 160-page teacher's guide; $5.95.)

Zwingle, Erla, **"Ogallala Aquifer, Wellspring of the High Plains,"** NATIONAL GEOGRAPHIC, vol. 183, #3, Mar. 1993.

U. S. Geological Survey, National Water Information Clearinghouse, 423 National Center, Reston, VA 22092. Tel. 800-H_2O-9000 (800-426-9000).