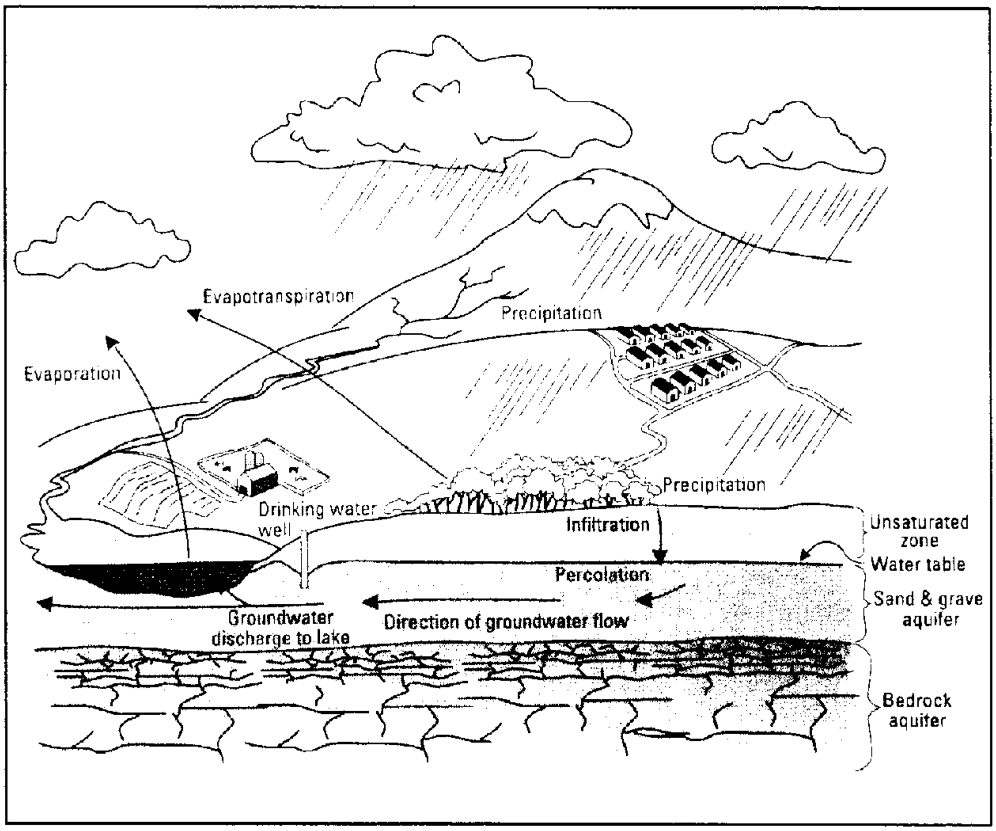
October

What is a watershed?

During the month of October, ***The Salmon Times*** explores where water comes from and where it goes. Understanding the **hydrologic (water) cycle** and the **watershed** concept are critical to this exploration.



It is the water cycle at work that gives us, here in New England, the seemingly endless supply of water we enjoy (except when we've planned a day at the beach or ball game!). Although three-quarters of the earth is covered by water, the percentage of freshwater that is available for everyday human use is very small. Clean freshwater is even more scarce. The following table lists where the Earth's water is located.

oceans	97.0%
icecaps and glaciers	2.24%
groundwater	0.61%
lakes and ponds	0.009%
the atmosphere	0.001%
streams and rivers	0.0001%

While both salt water and freshwater are essential to supply water for the water cycle, the freshwater that most of us use in our daily lives makes up less than 1% of the water on the planet. That is all there is. Because the "same" water is recycled year after year, contamination or overuse of this valuable resource can create both short- and long-term problems. Protection and conservation, on the other hand, may help maintain a supply suitable for plants, wildlife, and human uses. Understanding how water evaporates, collects, flows, and circulates is the first step in this protection effort.

When precipitation in the form of rain, snow, sleet, or hail reaches the earth, it can take any of a number of pathways. Refer to

Water is often called a universal solvent. When surface waters evaporate they leave solutes behind. Once in the atmosphere, however, water vapor will combine with gases such as carbon dioxide, nitrogen oxides, and sulfur dioxides forming carbonic acid, nitrous acid, and sulfuric acid respectively. Nitrogen oxides and sulfur dioxide are released into the atmosphere during the burning of fossil fuels. High concentrations of these compounds in combination with water vapor result in acid formation producing acid precipitation. Acid precipitation falls to the earth, flows into surface and groundwater, and with continuous supply and strong acid concentrations may create inhospitable environments for plants and animals. It also corrodes steel, limestone, iron, and other structural materials.

Infiltration potential of various soil types as a percentage of precipitation

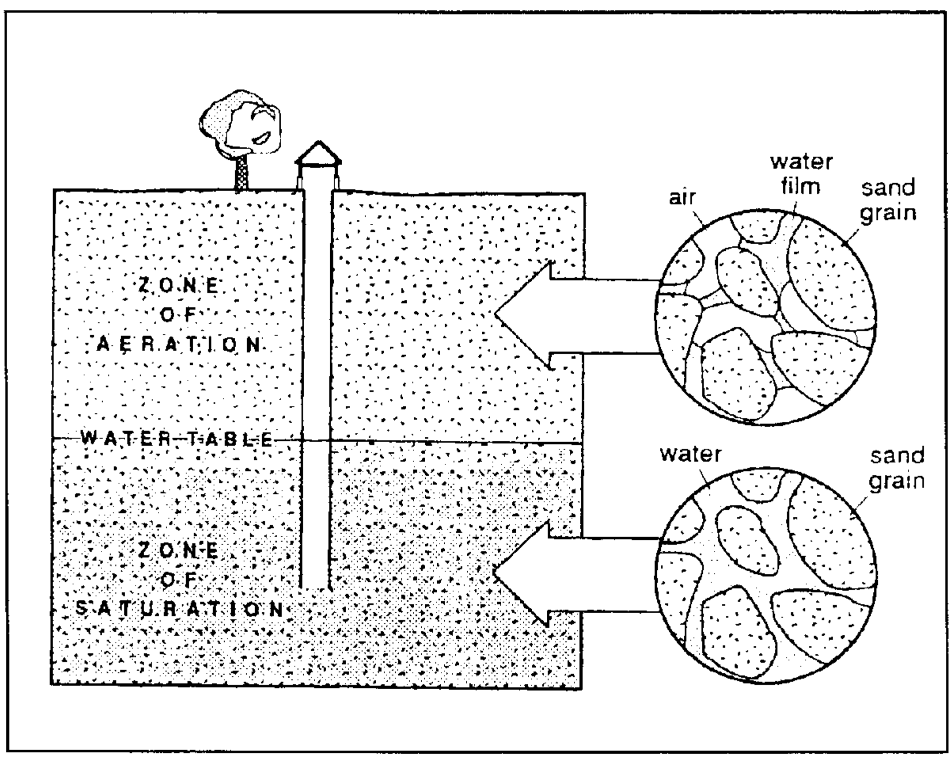
40% - 60%	**Sand and gravel soils**
15% - 25%	**Glacial till derived soils**
5% - 15%	**Clay and silty soils**

the hydrologic cycle diagram to see some of the following terms illustrated.

Water **evaporates** from the earth's surface into the atmosphere. The sun's energy creates both heat and wind, which cause **evaporation**. During evaporation, water vapor rises into the atmosphere on warm air currents. Once this water vapor hits the cool upper layers of the atmosphere, it condenses around tiny particles, such as dust and pollen, and forms clouds. As more moisture is added to the atmosphere, the droplets continue to grow until they are too heavy to circulate and they fall to the earth as precipitation.

Transpiration describes what happens when water that has been taken up by plants through their roots from the ground escapes during gaseous exchange through the surfaces of leaves. The escaping water enters the atmosphere as vapor. Plants influence many aspects of the hydrologic cycle. For example, they produce shade, which decreases the rate of evaporation. (Can your students think of other examples?)

Depending on local conditions, some water will **infiltrate** soil and **percolate** into the ground to become **groundwater**. Groundwater is found in the tiny spaces between bits of sand and gravel, within **till**, or in fractures in bedrock. The **unsaturated** zone or **zone of aeration** is the upper zone where both water and air fill



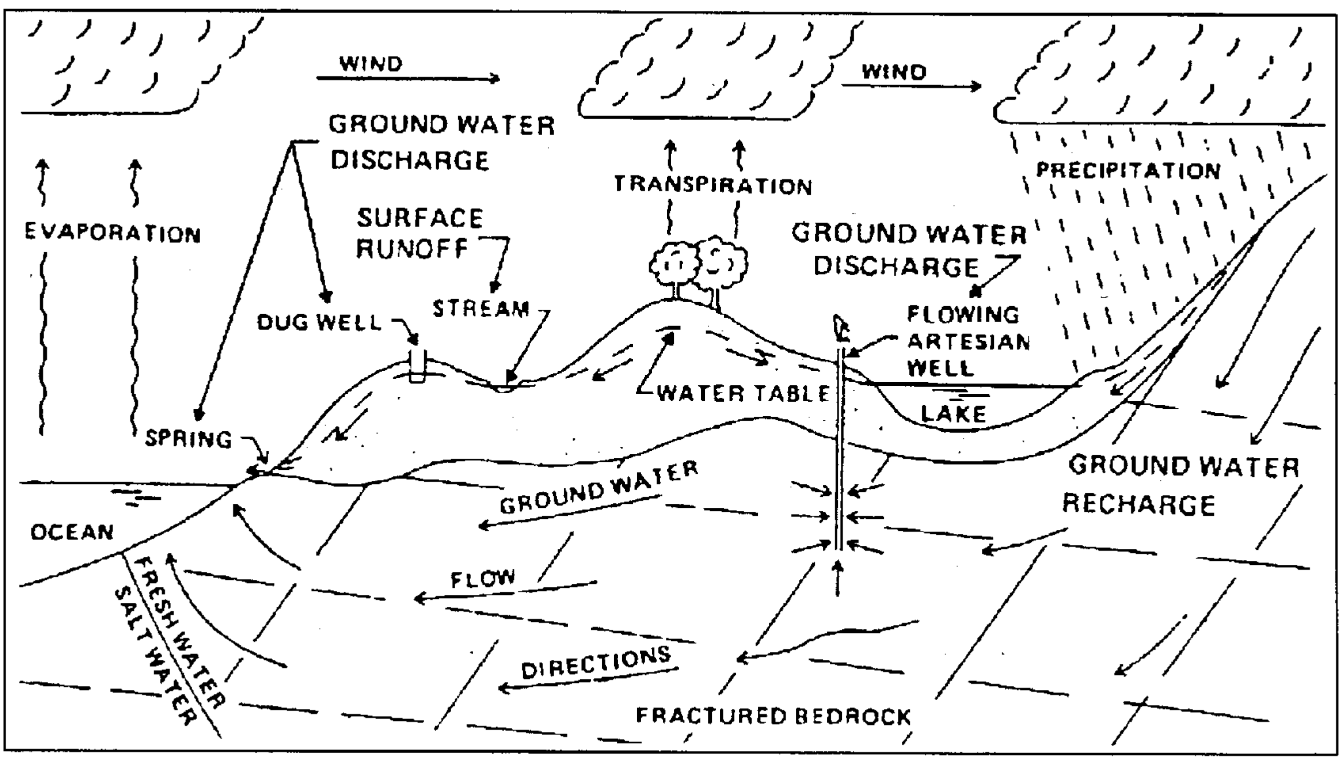
Contaminated groundwater is a very serious problem. Attempts to clean contaminated goundwater are extremely expensive and often ineffective. There are many threats to groundwater, household wells, and community water supplies, including

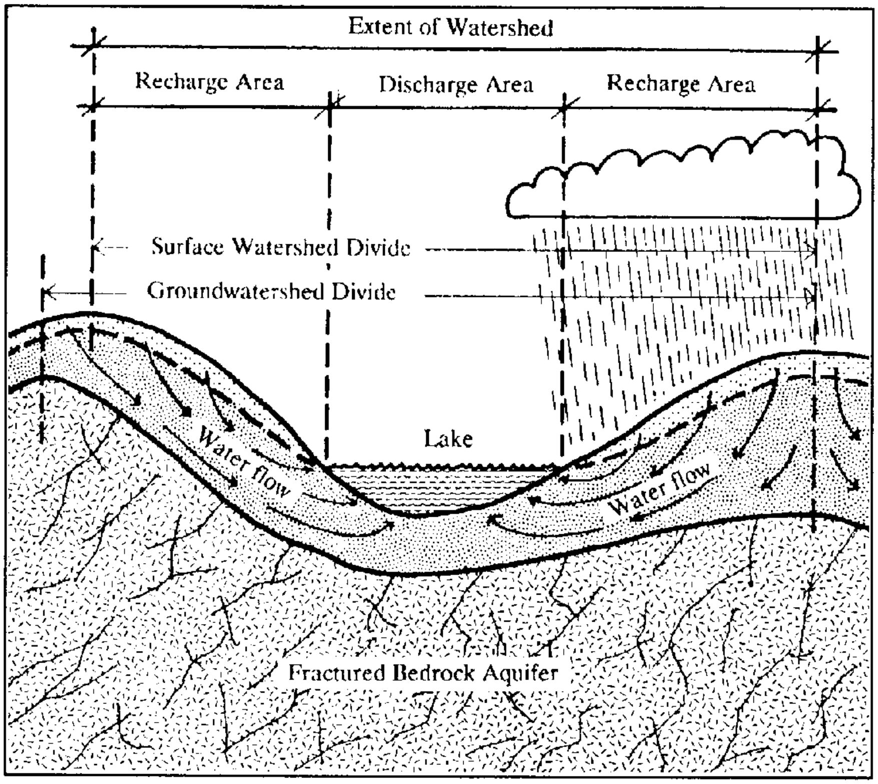
- **Leaky underground storage tanks containing petroleum products;**
- **Mismanaged agricultural chemicals and manure;**
- **Landfills;**
- **Faulty septic systems;**
- **Sand/salt storage and spreading;**
- **Improper storage and disposal of hazardous waste from households, industries, and farms.**

the pores between soil particles. The zone below the water table is **saturated**. Here, the spaces between soil particles contain only water. The **water table** is the uppermost edge of the saturated zone. **Aquifers** refer to places within the saturated zone where water, between soil particles or in fractures in bedrock, is available and can be readily obtained by drilled wells.

Some of the precipitation that falls becomes **surface water**. The **geology** and **topography** of the land determine how surface water flows. Compact soils and steep terrain diminish infiltration and will accelerate surface water **runoff**. Sandy soils and flat terrain increase infiltration and decrease the rate of surface water runoff. Surface waters are familiar to us as streams, rivers, lakes, ponds, oceans, and wetlands.

Groundwater plays an important role in supporting plant and animal (including human) life. Roughly 22% of the earth's freshwater is groundwater. However only about one-half of that is actively exchanged through the water cycle. Water table levels fluctuate depending on how much water enters the system at **recharge areas** and how much is withdrawn. Recharge areas are surface areas where precipitation or surface water infiltrates the soil to enter the groundwater system. Often they are **upland** areas. **Discharge areas** occur where the surface of the Earth dips below the water table, causing





tap into groundwater under these conditions.

A **perched water table** occurs in very permeable material when infiltrating water is prevented from moving downward by a low permeability layer, such as clay or silt, and is thus held above and separated from the regional groundwater system. Perched water tables may result in wetland or pond formations.

In coastal areas, fresh groundwater or surface water flows into salt water. When this happens, the freshwater tends to "float" because it is less dense than salt water. However, there are many factors, such as the amount of suspended material and temperature differences, that influence the nature of fresh/salt water interactions.

groundwater to become surface water. Groundwater can discharge as a spring or into other waterbodies such as streams, wetlands, estuaries, or marshes.

In North America, recharge levels are usually highest during winter and spring because of snowmelt, rainfall, and low rates of evaporation and transpiration. Water table levels may rise during this time because there is less uptake of water by plants. In contrast, water table levels usually decline during summer and early fall due to evaporation, uptake by plants, withdrawals for public water supplies, and irrigation of agricultural crops and lawns. Water tables are affected year-round by withdrawals for commercial, industrial, and residential water use.

In addition to topography and geology, **confining layers** will influence the location of groundwater. Confining layers are impermeable layers of bedrock or clay that prevent water from flowing into or out of a particular area. In practical terms, confining layers serve as barriers that limit the amount of water available to a well, separate one aquifer from another, or act as partial barriers to contamination in an aquifer. Groundwater sandwiched between two confining layers may be under pressure. **Artesian wells** are wells that

Watershed refers to the land over and through which water flows to reach a common waterbody. It has two components — surface drainage and groundwater drainage. An underground drainage area is sometimes called a **groundwatershed**. Just as surface

Layers of clay are sometimes injected into the earth by environmental engineers and scientists to serve as confining layers where there is contaminated groundwater.

Drilled wells near the coast run the risk of saltwater intrusion. A saltwater intrusion into a freshwater aquifer occurs when excessive groundwater pumping draws adjacent sea water into freshwater wells. The salty well water must then be purified or the well must be abandoned.

Water flowing over land surfaces constitutes runoff. Runoff is a major contributor of nonpoint source pollution when it contains toxics, excess nutrients, sediments, and bacteria. Nonpoint source pollution refers to contaminants that enter our water resources with water washing across the surface of the land or infiltrating into the ground.

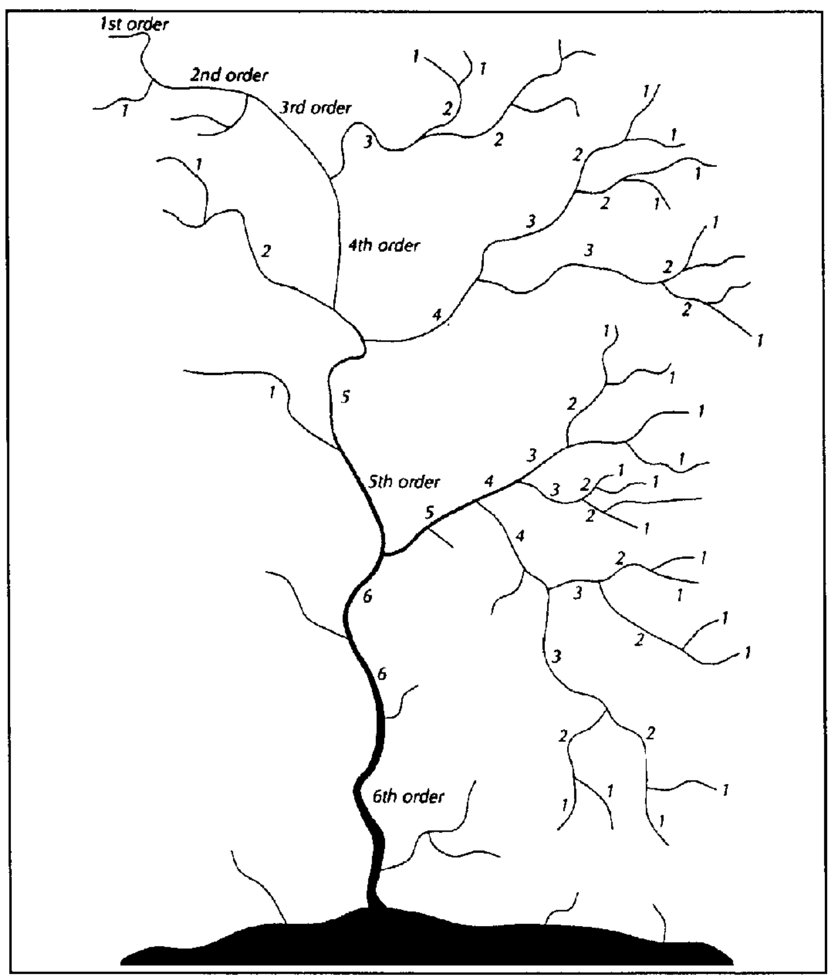
water flows over the surface of the land in response to gravity, groundwater flows through permeable soils and fractures in bedrock in response to gravity. Groundwater, however, flows much more slowly.

A **surface watershed divide** is the set of points separating one watershed from another. Surface watershed divides are usually mountains and high points of land. **Groundwatershed divides** separate groundwatersheds from each other. Surface watershed divides may be in different places than groundwatershed divides.

In every watershed, small streams flow into larger streams, which flow into rivers, lakes, and bays. The smallest streams at the outer limits of a watershed are called **headwaters**. In New England, headwaters are often located in the mountains. All streams are **tributaries** of other waterbodies. Streams with no tributaries are called **first order streams**. **Second order streams** form when first order streams meet. **Third order streams** form when second order streams meet and so on.

In regions like New England that have varied terrain, we often describe water as flowing ***from the mountains to the sea***. Water in an open system follows gravity and the contours of the landscape. A watershed is identified by the name of the waterbody that serves as the collecting basin for that drainage area. ***All land is part of a watershed!*** The Gulf of Maine watershed incorporates all of the land east of mountains in the states of Massachusetts, New Hampshire, and Maine as well as the land south of mountains in the provinces of Quebec, New Brunswick, and Nova Scotia. Precipitation that falls to the Earth within this region of land flows into the Gulf of Maine. Most watersheds are made up of smaller watersheds. Two sub-watersheds of the Gulf of Maine are the Merrimack River watershed and the Penobscot River watershed. In other words, water that flows into small streams that flow into larger streams that flow into either the Merrimack River or the Penobscot River will eventually flow into the Gulf of Maine. It is this characteristic of watersheds that makes stewardship of freshwater streams, especially streams that are healthy, particularly important. It is all connected!

Not only do streams and rivers flow to the sea, but so do the impacts that humans have



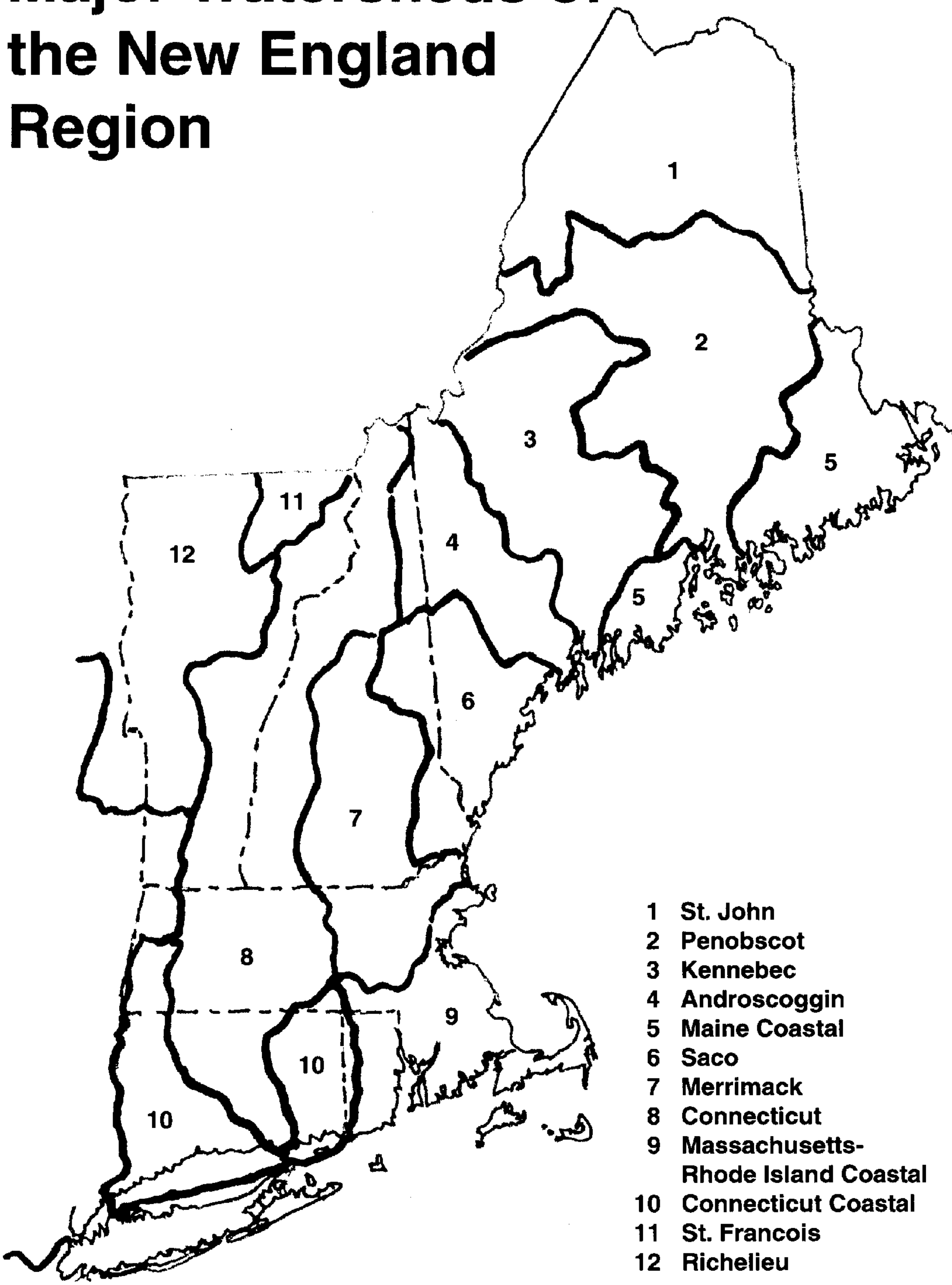
upon those waterbodies. Human activities that impact the water quality of water flowing to the sea collectively impact the ocean environment itself. The plants and animals of the ocean provide humans with oxygen and food. The oceans influence our weather, support our livelihoods, and supply us with mystery, beauty, and opportunities for recreation. There are many ways that oceans support life for humans.

The Atlantic salmon is a species of fish whose life cycle depends on the connections between mountain headwaters and open ocean. Like the American shad and alewife, the Atlantic salmon is an **anadromous** fish because it spends part of its life in freshwater streams and rivers and part in the ocean. We will learn more about this facsinating fish and its watershed homes in the upcoming months.

Word Power

*anadromous
*aquatic
*aquifer
*contour lines
*elevation
*endangered species
*evaporate/evaporation
*federal
*habitat
*hen
*landforms
*legend
*life cycle
*migrate
*mouth
*pollutants
*precipitation
*reproduce
*saddle
*sediment
*topographic map
*transpiration/evapotranspiration
*tributary
*water cycle
*watershed
confining layer
discharge area
first, second, third order streams
geology
groundwater
groundwatershed
groundwatershed divide
headwaters
hydrologic cycle
infiltrate/infiltration
perched water table
percolate
recharge area
rivulet
runoff
saturated
surface water
surface watershed divide
topography
unsaturated
upland
water table
zone of aeration

Major Watersheds of the New England Region



1 St. John
2 Penobscot
3 Kennebec
4 Androscoggin
5 Maine Coastal
6 Saco
7 Merrimack
8 Connecticut
9 Massachusetts-
Rhode Island Coastal
10 Connecticut Coastal
11 St. Francois
12 Richelieu

Evaporation Demonstration

Concepts:

The sun's energy causes water to evaporate.
Water vapor collects and drops.
Dissolved materials do not evaporate with water.

Objectives:

1. Students will construct and observe device.
2. Students will form hypotheses, write down observations regularly and respond to their original hypotheses.
3. Students will draw connections between what is happening in their devices and the water cycle.

Materials:

- a large clear glass jar with cover
- a plastic ounce cup
- colored water
- a sunny window ledge

Subjects:

Science

Preparation and Procedure:

While many students are familiar with diagrams of the water cycle, experiences and activities strengthen the concepts of evaporation and condensation for them. This demonstration takes a small amount of time to set up, but provides interesting opportunities for students to observe evaporation and condensation over time.

Put a small amount of colored water into the ounce cup. Gently place the ounce cup upright with water inside the glass jar. Cover the glass jar and put it on the window sill. Encourage students to form hypotheses, make diagrams and record their observations of any changes that occur inside the jar over time.

What changes do you observe about the amount of water in the cup? in the jar?
What do you think is causing those changes?
How are your observations similar to the hydrologic cycle?
How are they different?
How could you speed up the condensation? Hint: ice.

Extensions:

Observe transpiration and infiltration (as well as evaporation and condensation) within a closed system. Make terrariums using wide mouth jars with covers or large soda/seltzer bottles cut and inverted into their bases. Place about an inch each of pebbles, peat moss, and potting soil into each container. Add small plants that students have grown or collected to the jar. If you are collecting plants from the field, please be judicious in selecting and gathering! Gently water the system, seal it, and place it on a sunny window ledge. Observe over time.

What parts of the water cycle are occurring within the terrarium?
What is causing each of these events?

Adapted from an article by Sally Aberth of Fieldston Lower School in Riverdale, NY as printed in CONNECT, Jan/Feb 1994, VOL. 7 NO. 3.

What is a Watershed?

Concept: **Watershed** describes the area of land over which water flows to a common place such as a stream, river, pond, lake, wetland, or ocean.

Objectives: To provide students with an opportunity to ...

1. build a watershed model
2. make predictions about where water will flow and collect within this watershed model
3. point out high points in terrain which delineate a watershed
4. participate in spraying water, making predictions, making observations, and making future predictions based on experience.

Materials:

- child's small plastic pool or outdoor space
- newspaper
- large sheet of plastic or shower curtain
- spray bottles
- waterproof marker
- or common pins with colored heads
- water
- food coloring
- towels

Subjects: Geography, cooperation, science

Preparation and Procedure:

Students can be involved in every aspect of this preparation. This demonstration illustrates surface water movement within a watershed. Keep the materials handy and in good condition for further investigations in the upcoming months. During March, sprinkle powdered drink mix on the model to simulate pollution on land.

Crumple the newspaper and place it in the pool to create a landscape of hills and valleys. Drape the shower curtain over the crumpled newspapers and adjust it to fit the landscape. Shape a variety of elevations and depths. The spray bottles will be used to produce moisture (representing rain and snow) over the landscape in the pool. Before producing the precipitation, ask students where they predict water will collect within the pool.

Where will the largest amount of water collect within the pool?

Name that basin.

What parts of the shower curtain shed water into that big basin? The area of the shower curtain that sheds water into the basin you named represent the watershed of that basin.

What bodies of water represent the largest basins which collect water on our planet?

Have students take turns spraying the precipitation into the air above the plastic sheet.

Can you find smaller collecting basins?

Which areas of the shower curtain shed water into those basins? Point out each small basin's watershed.

What do you think a subwatershed is?

What bodies of water represent smaller collecting basins and waterways on our planet?

Look again at the largest basin within your pool. With a magic marker, draw an X on each of the peaks which contribute water to the largest basin. Connecting all those Xs will show the boundary of that watershed. Alternatively, use sewing pins with colored heads to mark the ridges that surround that watershed.

Where does the water go that falls on the other side of that boundary?

Find the next largest basin. With a different color marker, make an X on all of the peaks that contribute water to that basin. Continue finding smaller and smaller basins. Use different colored Xs to identify the peaks that contribute to those smaller water bodies. When you are not sure which basin a peak will drain into, test it by spraying with the spray bottle. Connecting each set of colored Xs will delineate each watershed. Smaller watersheds are always subsets of larger watersheds.

All land is within a watershed.

5). **Conclusion:** The different size and shape of the particles creates different size pore spaces. The ease with which the water seeps through (permeability) is determined by the smallest of the gaps, as this is where water would start to back up. In solid rock, water's ability to pass through depends on how well the pores are connected.

Which material was the most permeable?
Which was the least permeable material?
Was there a difference between mixtures and single substance cups? Explain.

Extensions:

Contact UNH Cooperative Extension if you are interested in using a groundwater model. The model is an excellent tool for helping students visualize how groundwater travels. It illustrates how various components including wells, ponds, and contamination sites affect and are affected by groundwater. The models are available for demonstrations through UNH Cooperative Extension.

Have students collect and measure the water that comes through the soil. If you start with dry soil some moisture will be left behind reinforcing the unsaturated zone soil moisture concept.

Adapted from experiment in 4-H Water Quality Resource Notebook and taken from *Sandcastle Moats and Petunia Bed Holes*, A Book about Groundwater, Instructor's Guide to *Sandcastle Moats and Petunia Bed Holes* by Pat Nickerson

Rock in a Box

Concepts: Contour lines on a map indicate changes in elevation.
Changes in elevation influence where surface waters flow.

Objectives: 1. Students will participate in exercise and create a contour map of a small rock.
2. Students will recognize that a contour line on a topo map signifies a change in elevation.

Materials:

- masking tape
- waterproof marker
- ruler
- clear plastic box
- a rock that can fit in the clear plastic box
- plastic wrap
- rubber band
- funnel
- water
- paper

Subjects: Math, Geography, Mapping

Preparation and Procedures:

Take an 8 to 10 centimeter piece of masking tape and mark it off in 1 cm increments with a waterproof marker. Place the tape vertically on one side of a clear plastic box (a plastic shoe box works well) with the zero end of the tape lined up with the bottom of the box. Find a rock of suitable size that has a sloping side and place it in the box.

Take a piece of plastic wrap and place it over the top of the box. Secure the plastic wrap to the box with a rubber band. Using a funnel, poke a hole in the plastic wrap at one corner of the box. Leave the funnel in place. Pour water into the funnel until the water level has reached the 1 cm mark on the tape. Take a waterproof marker and, while looking down on the top of the box, draw a line on the plastic wrap where the water touches the rock. This is the first contour line. Repeat the procedure at 1 cm increments until no more contour lines can be made.

After all the lines are drawn, take the plastic wrap off the box. For ease in determining the height of the rock, darken every third line and label it with the corresponding height (3cm, 6cm, and so on). To calculate the height of the rock, count the number of contour lines, then multiply that number times the contour interval (1 cm). If the rock was not entirely covered by water when the last contour was drawn, measure the height of the rock sticking out of the water and add the measurement to the height computed from the contour lines.

Next, take a piece of paper, lay it over the plastic wrap, and trace the contour map. Label the darkened lines with their elevations. To complete the map, include the contour interval of the map and give the map a title.

Taken from Teaching Topography by Barbara S. Fife in *The Science Teacher*, May 1995

Extension:

Use a topographic map to determine the boundaries of local watersheds. Cover the topo map with clear contact paper, pinpoint the water body whose watershed you want to delineate. Using a fine point dry erase marker, draw Xs on the highest points within the area, then, draw arrows along any streams indicating down-stream flow. Use contour lines to confirm downstream direction. Continue drawing arrows on all water bodies in the area. The region between arrows pointing in opposite directions is the watershed divide. Find where you live within the watershed.

References

Caduto, Michael J. *Pond and Brook: A Guide to Nature in Freshwater Environments.* Hanover, NH: University Press of New England, 1990 reprinted.

DuBois, Marianne. *Groundwater - Facts for Municipal Officials.* Augusta, ME: Maine Department of Environmental Protection.

Horsley and Witten, Inc. for US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. *Coastal Protection Program Workbook for Workshops in Innovative Management Techniques for Estuaries, Wetlands, and Near Coastal Waters.* Washington, D.C.

New Hampshire Fish and Game Department and the University of New Hampshire's Cooperative Extension. *Stream Study and Water Quality Assessment Curriculum.* Concord, NH: 1991

Slattery, Britt Eckhardt. *WOW!: The Wonders of Wetlands, an Educator's Guide.* St. Michael's, MD: Environmental Concern Inc., 1991

Additional Resources

Groundwater Model and Soil Erosion Demonstration Boxes are available for loan at each county Cooperative Extension Office . Call your local Cooperative Extension Office for more information.

New Hampshire's Water, A Youth Water Quality Awareness Program developed by the Water Quality Team of the University of New Hampshire Cooperative Extension, 4-H and Youth Development, Moiles House, University of New Hampshire, Durham, NH (603) 862-2180

The Stream Scene, Watersheds, Wildlife and People, An Aquatic Education Program Publication, Distributed by Oregon Department of Fish and Wildlife, P.O. Box 59, Portland, OR 97207

Contact NH Department of Environmental Services for information about groundwater and well-head protection.

Contact UNH Cooperative Extension for information about fact sheets on wells and water treatments.

Sources of Information for Maps

US Geological Survey topographic maps
    Bookstores, sporting stores, libraries, town offices, National Survey, Chester, VT (802)-875-2121 or 1-800-USAMAPS

Aerial photographs
    County USDA Agricultural Stabilization and Conservation Service Office, County UNH Cooperative Extension Office

Sand and gravel aquifer maps and environmental groundwater availability maps
    NH Dept. of Environmental Services, Water Resources Division, 64 North Maine Street, PO Box 2008, Concord, NH 03302-2008 (603)271-3503
    or from USGS (see above)

Information of water wells or watersheds - Town or city offices

Illustration Credits

Page 1
Hydrologic cycle
As appears in *The Volunteer Monitor,* Volume 6, No. 2, Fall '94. Adapted from *Groundwater Protection and Management in Pennsylvania: An Introductory Guide for Cititzens and Local Officials.* Pennsylvania Groundwater Eduction Project, 1993.

Page 2
Zones of Saturation and Aeration
Strahler, 1972 in *Coastal Protection Program Workbook for Workshops in Innovative Management Techniques for Estuaries, Wetlands, and Near Coastal Waters,* Horsley and Witten, Inc. for US EPA, Office of Wetlands, Oceans, and Watersheds, Washington, DC.

Page 3
Groundwater/water cycle
Groundwater Handbook for the State of Maine - Bulletin 39

Page 4
Watersheds and Groundwatersheds
DuBois, Marianne, *Groundwater - Facts for Municipal Officials.* Augusta, ME: Maine Department of Environmental Protection.

Page 5
Stream ordering in a watershed
As appears in *Testing the Waters: Chemical and Physical Vital Signs of a River* by Sharon Behar. River Watch Network, 1996.

Page 7
Map
Adapted from USGS watershed map.