TEACHER'S GUIDE
Unit 1, Lesson 1

SURFACE WATER AND GROUNDWATER

This lesson and its corresponding activities are targeted to grades 5-9 and subject areas English language arts, mathematics, science, social science and physical development and health. Most of the activities and the following background information may be adapted to other grade levels.

Hydrology is the study of movement and distribution of waters on earth. Water may be found in the ground (aquifers), on the surface (lakes, rivers, ponds, streams, wetlands) and in the atmosphere (precipitation, clouds and airborne toxics). Water is also found in all organisms and is essential to life. Water is a renewable natural resource and changes forms through the water cycle.

About 97 percent of the earth's water is saltwater, with most of it in the oceans. The remaining three percent is found in freshwater rivers, ponds, lakes, icecaps, water vapor, groundwater and in organisms. The two most available sources of fresh water are surface water and groundwater. The other main source of fresh water is the ice in the polar regions.

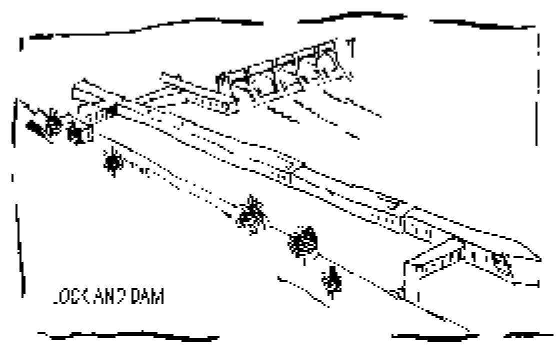
Illinois is a very water-rich state. Water practically surrounds Illinois, as it is bordered by three major rivers and one Great Lake. Illinois receives 35 to 42 inches of rainfall each year and has vast groundwater supplies. The citizens of Illinois use much water each year with a 1985 study ranking Illinois fourth in the United States for the amount of average freshwater withdrawals per day (U.S.G.S. 1987).

Surface Water

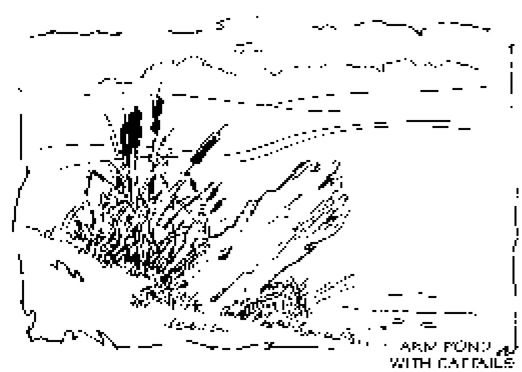
Surface water includes permanent, open bodies of water 0.1 acre or larger. They are separated from wetlands by their permanence and by their general lack of emergent woody vegetation. There are four subclasses of surface water in Illinois: Lake Michigan; flowing waters; impoundments; and reservoirs. Combined these four categories total more than 1.6 million acres of surface water.

Only about seven percent (976,640 acres) of Lake Michigan is within the state of Illinois' jurisdiction and only that portion will be referred to here. This amount accounts for about 61 percent of the surface water of Illinois. Lake Michigan borders Cook and Lake counties.

The flowing water classification includes streams, canals, creeks (small streams) and rivers. Streams make up about 20 percent (325,000 acres) of Illinois surface water with the majority of the streams found in southern and western Illinois. Henderson (21,388 acres), Calhoun (20,838 acres), Rock Island (14,359 acres), Hancock (12,899 acres) and Carroll (12,514 acres) are the five counties with the highest stream acreage (IDNR 1996).



Impoundments are standing bodies of water constructed by artificial means or formed by nature, excluding Lake Michigan and the three reservoirs to be mentioned in the next paragraph. About 16 percent (259,400 acres) of Illinois surface water is contained in impoundments. The majority of the impoundments are found in the southern and western regions of the state. Forty-three percent of the impoundments are privately owned, followed by 32 percent



that are publicly owned, 15 percent state owned, 9 percent organization owned and 1 percent commercially owned. The top five counties in regard to impoundment acreage are Lake (14,739 acres), Mason (14,246 acres), Williamson (12,615 acres), Fulton (12,052 acres) and Cook (7,858 acres).

The reservoir classification includes only the three reservoirs constructed by the U.S. Army Corps of Engineers. The three reservoirs total 54,580 acres or three percent of the surface water in Illinois. Lake Carlyle covers 24,580 acres in Fayette, Bond and Clinton counties. Rend Lake occupies 18,900 acres in Jefferson and Franklin counties. Lake Shelbyville covers 11,100 acres in Shelby and Moultrie counties.

Groundwater

Groundwater results from precipitation. This precipitation percolates under the surface of the earth and fills the cracks, crevices and tiny pores between soil and rock particles much like water saturates a sponge. It may remain undisturbed for years, even centuries, or it may flow into wells drilled into the ground or flow out of the ground as springs. Groundwater does move--an average of three inches per day depending on the porosity of the rock. Groundwater is affected by the type of soil in the area. Permeability ranges from 0.06 inches per hour in some clay soils to more than 20 inches per hour in some sandy soils.

WATER FACTS (IDNR 1992)

- Major users of groundwater in Illinois are public water supply (47 percent), industry (21 percent), agriculture (21 percent) and private water supply (11 percent).
- About 50 percent of Illinois' population uses groundwater from wells for drinking.
- Almost all of the people (98 percent) who live in rural areas draw their drinking water from wells.
- About 75 percent of Illinois' community water systems use groundwater.
- More than 410,000 wells are used to tap the groundwater in Illinois.
- Almost all Illinois groundwater is recharged, or replenished, locally.
- Only about 15 percent of the potential groundwater supply is presently being used.
- Water wells range in depth from 20 feet to more than 2,800 feet.
- A large-scale year-round community water system may cost up to one million dollars.

Although less than eight percent of the tested Illinois community water wells show measurable levels of contamination, groundwater may be contaminated. In some areas of Illinois, the groundwater is contaminated with naturally occurring minerals like calcium and magnesium which makes the water "hard." In parts of northern and western Illinois, radium in deep, bedrock aquifers exceeds the drinking water standard.

Groundwater may be contaminated by other sources, too. Gasoline and other harmful liquids have leaked from underground storage tanks into groundwater. Pollutants can seep into groundwater from poorly constructed landfills or septic systems. Groundwater may also be polluted by runoff from fertilized fields, livestock areas, abandoned mines, salted roads and industrial areas. Homeowners can contribute to contamination by dumping household chemicals down the drain or pouring them on the ground. Also, because groundwater moves so slowly, the contamination is likely to remain concentrated and close to the point where the pollution occurred.

Groundwater contaminated with bacteria, chemicals, pesticides, gas or oil can result in serious health problems. Overuse of farm chemicals can pollute groundwater with nitrates, and people and/or animals who drink the water can be poisoned. Contaminated groundwater can be cleaned up, but it is very expensive and time-consuming to do so.

As an example, in December 1981, the Rockford Water Utility permanently closed two of its wells due to contamination. These wells, with a capacity of 7.5 million gallons of water per day, met one-fourth of Rockford's water needs. To replace them, the city drilled five new wells into deeper, less productive aquifers. The new wells cost approximately $1.5 million each. In addition, the city replaced several hundred private wells just south of Rockford with piped water connections at a cost of $4 million. Some of the costs were covered by the U.S. Environmental Protection Agency's Superfund. Southeast Rockford is an industrial area with many factories. The contamination was probably caused collectively by the legal dumping of small amounts of waste into the ground. Eventually, these materials seeped into the aquifer.

Legislation

Illinois has tried to reduce the threat to its groundwater by expanding and unifying the state's groundwater protection programs. In 1987, the General Assembly passed the Illinois Groundwater Protection Act. The Groundwater Protection Act is a comprehensive law that deals with three types of potentially contaminating land uses. Potential primary sources of contamination include disposal and storage sites that handle large amounts of hazardous materials and any amount of hazardous waste. Potential secondary sources of contamination include facilities that store smaller amounts of hazardous materials, for example, agricultural chemical facilities, storage sites for de-icing salt, wastewater treatment plants and above- and below-ground petroleum storage tanks. Potential routes of contamination are possible pathways for contaminants and include abandoned wells, drainage wells and sand and gravel mining operations. Several agencies assist in making sure that the provisions of the act are being carried out. Those agencies include the Illinois Environmental Protection Agency, Illinois Department of Natural Resources, Illinois Department of Public Health, Illinois Pollution Control Board and the Office of the State Fire Marshal.

REFERENCES

Illinois Department of Natural Resources. 1992. *Groundwater: Illinois' buried treasure education activity guide*. Illinois Department of Natural Resources, Springfield, Illinois. 161 pp.

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See related CD-ROM components: Unit 1, Lesson 2; Unit 2, Lesson 1; Unit 2, Lesson 2; Unit 3; *Aquatic Illinois* video; *Illinois Rivers and Lakes Fact Sheets*.

UNIT 1, LESSON 1
ACTIVITY 3

LEACH OUT AND TOUCH SOMEONE

SUGGESTED GRADE LEVELS: 5-9
SUBJECTS: English language arts, science, social science, physical development and health
SKILLS: observation, inference, prediction, model formulation
CORRELATION TO ILLINOIS LEARNING STANDARDS: English language arts 3C, 4B, 5C; science 12E, 13B; social science 17B, 17C; physical development and health 22C

OBJECTIVES
Students will demonstrate how surface and groundwater may become contaminated from point and nonpoint pollution sources.

METHOD
Students construct models of groundwater pollution sources.

BACKGROUND
What could a farm in the Midwest have in common with a remote wilderness area like Isle Royale National Park in Lake Superior? What could a landfill several miles away from your home have to do with your drinking water? Because of the interconnections between the land, air and water in the hydrologic cycle (circulation of a water molecule in different phases and places), they could be contaminated by the same chemicals.

There are several ways surface and groundwater can be contaminated. For example, when hazardous chemicals are stored underground in tanks or barrels, the containers may corrode and allow the waste to leach into local surface and groundwater sources. Since this leaching occurs from a single, relatively easily identified source, it is called a "point pollution" source. Another example would be a pipe traced back to an identified source such as a water treatment plant or an industry.

Other pollution sources are not as easily traced. Fertilizers, pesticides and soil may be washed into waterways by rainfall and snow melt. Oils, metals and other chemicals may be washed from city streets, parking lots and driveways. These "nonpoint pollution" sources may affect many square miles of surface water or land and eventually could be absorbed into the groundwater. Current scientific studies show that farm chemicals routinely applied to crops have been found in such remote areas as Isle Royale. DDT, a chemical now banned in the United States (but still exported by the U.S.) has been found all over the world, including the Arctic Circle.

MATERIALS
per group: one clear plastic container about the size of a shoe box; washed, fine, white sand; tube from an eyedropper with the rubber bulb removed; an eyedropper with a rubber bulb; food coloring and unsweetened powdered drink mix (red of one and blue of the other work well); a spray bottle; water; one copy of the "Leach Out and Touch Someone" activity sheet for each student; a beaker or cup to pour water from; collecting buckets; pencils

PROCEDURE
NOTE: This activity may be done as a demonstration. If done in demonstration format, you may wish to start it at the beginning of class and look at it periodically until a significant amount of movement and leaching has taken place. If you wish students to conduct the experiment in groups, be warned that it can be messy.

Per group:
1. Distribute materials and "Leach Out and Touch Someone" activity sheets.
2. Fill container one-half full of sand, dampen so that it holds its form and try to create some topographic features, such as hills, valleys, rivers and lakes. Add water carefully to minimize erosion and observe what happens as more water is added.
3. Create a hill of sand and a low area of water that represents a lake, pond or river. Insert the dropper tube on the hill, well above the subsurface water level. Place it against the side of the container so that the dropper tip beneath the

sand's surface can be seen. This tube represents a point source of pollution that can be traced to a water treatment plant or an industry.
4. Add a dropper of undiluted food coloring into the tube.
5. Produce a gentle spray of water above the point source to represent rain soaking into the ground. Watch closely at the bottom opening of the dropper tube, beneath the sand's surface. (Water generally flows very slowly through soil and rock beneath the earth's surface.) What happens to the surface water?
NOTE: This apparatus may be left up overnight and observed again. Initially the leaching should occur rapidly but may take as long as 24 hours for the "pollution" to reach the surface water.
6. To demonstrate nonpoint sources of pollution, sprinkle unsweetened powdered drink mix on the surface of the sand to represent fertilizers, pesticides and oils. Use a different color than you used in Step 4. Spray the water over the land surface in the model. What happens? Spray more clean water to represent rain and observe. Eventually the nonpoint source also contaminates the groundwater and surface water. How can you tell if the two types of pollution have mixed? (If red was used for the point source and blue for the nonpoint source, the polluted water should appear purple.)
7. The final step is to clean the coloring out of the sand. Rinse it out in the sink or collecting bucket by adding water, stirring the sand, allowing it to settle and pouring off the excess water. Be careful not to dump sand down the drain, or the drain may become clogged. Water in collecting buckets may be dumped outdoors or down the drain, if the sand is completely excluded. Is the sand easy to clean? How many rinses does it take until the water is clear?
8. Discuss with students if they think the "soil" in this model is easier or harder to clean than real soil and rock at a landfill or other possible point source of pollution. Is there any truly practical way to clean groundwater once it has become contaminated? How does your model actually resemble real life situations? How is it different? What could you do to make it more realistic?

EXTENSIONS

1. Use topographic maps* to locate various uses of land around the area in which students live. List as many land uses as possible. Which of these may be possible sources of groundwater or surface water pollution? What precautions are taken by your community to reduce and prevent water pollution? What could be done to reduce current pollution sources on an individual basis? What can a community do to prevent larger point and nonpoint sources of water pollution? How about closer to home? Can you find possible nonpoint source pollution in your yard or school grounds? What can be done to prevent the nonpoint source pollution?
2. Challenge students to develop a clay liner that will block the leachate (moving groundwater with dissolved material) as described in this activity. Is this a practical solution to the problem? Where might clay be useful?
3. Have students graph the spread of pollutants in the demonstration activity over time. A wax pencil could be used to trace the spread on the side of the container in lieu of the graph.

EVALUATIONS

1. Students should complete and turn in the "Leach Out and Touch Someone" activity sheet.
2. Have students work in groups to create songs, raps, posters, commercials, videos or other creative demonstrations to illustrate the concepts of point and nonpoint water pollution, its problems and possible solutions. Have each student or group present the work to the class.

*Topographic maps may be obtained from the Illinois Department of Natural Resources' Illinois State Geological Survey, 615 E. Peabody Dr., Champaign, IL 61820; phone 217/333-4747. You may write or call for a free topographic index map and topographic index key. A guide to the use of topographic maps is available for a small fee.

Adapted with permission from: Illinois Department of Natural Resources. 1992. *Groundwater: Illinois' buried treasure education activity guide*. Illinois Department of Natural Resources, Springfield, Illinois. 161 pp.

LEACH OUT AND TOUCH SOMEONE
ACTIVITY SHEET

STUDENT NAME____

TEAM MEMBERS____

SETTING UP

1. Collect all materials needed: a clear container; sand; an eyedropper without a rubber bulb; an eyedropper with a rubber bulb; food coloring; unsweetened powdered drink mix; a spray bottle; water; a beaker or cup.

2. Fill container one-half full with sand, dampen it and create a hill and a low spot.

PROCEDURE

1. Slowly (so as not to wash the sand away) add enough water so there is some in the low spot you created and observe what happens. What is the relationship between groundwater and surface water?

2. Insert the eyedropper without a rubber bulb in the hill next to the side of the container. Add a dropper of food coloring into the tube. What type of pollution does this dropper of food coloring represent?

3. Spray water over the tube. What does this represent? Observe the bottom of the tube under the sand and describe what happens. What does this tell you about groundwater movement? Do you think it flows rapidly beneath the earth?

Describe what happens to the surface water.

4. Sprinkle some unsweetened powdered drink mix over the sand. Spray water over the land surface in the model. What type of pollution does this represent?

Spray more clean water to represent rain and describe what happens.

How can you tell if the two types of pollution have mixed?

5. Try to rinse the coloring out of the sand. Using the designated area, add water, stir the sand and allow it to settle, pouring off the excess water. Is the sand easy to clean? How many rinses does it take until the water is clear?

RESULTS

How does pollution affect groundwater?

UNIT 1, LESSON 1
ACTIVITY 4

NATURE'S WATER WHEEL

SUGGESTED GRADE LEVELS: 5-6
SUBJECTS: mathematics, science, social science
SKILLS: analysis, description, discussion, observation
CORRELATION TO ILLINOIS LEARNING STANDARDS: mathematics 10B; science 11A, 12E; social science 17B

OBJECTIVE
Students will measure rates of evaporation.

METHOD
Teacher conducts a demonstration then involves students in activities and experiments on evaporation and condensation.

BACKGROUND
Hydrology is the study of the movement and distribution of the waters of the earth. In nature, water circulates through a system called the water cycle or the hydrologic cycle. Heat from the sun causes water to evaporate and become water vapor. The atmosphere holds the water vapor in the form of an invisible gas. When the temperature of the air cools, the water vapor condenses to form droplets that are visible as clouds, steam or fog. When there is enough cooling, the droplets become large enough to fall back to the earth as rain, hail, sleet or snow. Rain that falls directly on the oceans completes the cycle and returns to its source, but rain that falls on the land may soak through the soil and become part of the groundwater.

The two most available sources of fresh water to humans are surface water and groundwater. The majority of fresh water is as ice in the polar regions.

Surface water includes all the lakes, rivers and streams that flow over the land. Streams flow into rivers which join larger rivers that eventually return the surface water to the oceans from which it may have originally evaporated.

Groundwater is beneath the surface of the earth and fills the cracks, crevices and tiny pores between soil or rock particles. This water flows into wells drilled into the ground, or flows out of the ground in springs. About half of all people in the United States obtain their drinking water from groundwater. In Illinois, almost all people (98 percent) who live in rural areas draw their drinking water from wells. The wells are drilled into the soil and rock to collect groundwater.

MATERIALS
Demonstration: a hot plate; a pan to heat water; a flat pan made cold with ice cubes; a set of four clear plastic glasses; a marking pen; a ruler; a "Nature's Water Wheel" activity sheet for each student

Experiment One: per group–four clear plastic containers; marking pen; ruler; and copy of "Where Does That Water Go?" activity sheet

Experiment Two: per group--grocery store plastic vegetable bag; bag tie; string; tape; round plastic lid; clear plastic container; copy of "It's in the Bag" activity sheet; food coloring (optional)

PROCEDURE
Demonstration:
1. Prepare the materials for the demonstration. Put water in a pan on a hot plate to boil. Instruct students not to touch the water. While waiting for the water to boil, prepare the flat pan by filling it with ice.

2. Have students carefully gather around the boiling water. Observe the steam coming off the water.

a. Explain that boiling causes the evaporation process to speed up. Steam can be seen here, but water that evaporates from lakes, streams and oceans cannot.

b. Ask students to observe how the steam seems to disappear farther away from the hot water.

c. Now bring the cold pan over the steam source. Observe what forms on the bottom of the pan. When the steam (water vapor) hits the cold pan, it condenses to form water drops.

d. The cold pan is equivalent to the cold air in the atmosphere. When enough water cools on the pan, it drips. When enough water cools and accumulates in the sky as clouds, it rains.

e. What is being observed is a model of the water cycle or hydrologic cycle.

3. Give students a copy of the "Nature's Water Wheel" activity sheet to complete. Repeat the demonstration if necessary to clarify the water cycle.

Experiment I: WHERE DOES THAT WATER GO?

Per group:

1. Distribute the materials and discuss the activity sheet. Assign each group, or let students choose, a name or number.

2. Decide where (such as the window sill or on the heat vent) to place the four containers.

3. Fill each container half full with water and mark the level before placing the containers around the room. Use the ruler to measure the water level in inches. Use equal amounts of water in each container.

4. Observe the containers and record the water level daily. It is more scientifically accurate to select a time and make the observations at the same time each day.

5. Record the results on the "Where Does That Water Go?" activity sheet until containers are dry or until enough time has expired to observe a marked drop in the water level (five days is usually sufficient). The drier the conditions, the quicker the lesson will be completed.

6. Discuss factors influencing evaporation rates, such as: temperature in the locations around the room, furnace or air conditioning operation, drafts from open windows or direct sunlight.

7. Discuss the activity sheets and place each group's results on the chalkboard. Compare the results of each group.

8. Develop a class hypothesis on the evaporation conditions for your room.

Experiment II: IT'S IN THE BAG

Per group:

1. Distribute materials and discuss the activity sheet.

2. Review the water cycle and the previous experiment. Stress evaporation, condensation, precipitation and surface water.

3. Tell the students that they will be creating a miniature water cycle in a bag. Their model will have all the characteristics of the real water cycle, that is, it will be a closed environment fueled with energy from the sun.

4. To set up the experimental water cycle: fill a container 3/4 full with water, set it on a plastic lid to stabilize it and place it inside a plastic bag. Fill the bag **completely** with air; use bag tie to close it off. NOTE: Food coloring may be added to water for easier observation and self-sealing bags could be used in place of bag and tie. Use tape to secure one corner of bag upright.

5. The bag must be placed in a warm, sunny place, because the sun starts and moves the process. NOTE: One of the bags may be placed in a position out of the sun for comparison.

6. If this experiment is started on Monday, it should be ready to be taken down and discussed on Friday (four days are enough for the cycle to be completed). Compare and relate the results of the bag experiment to the water cycle as seen in the "Nature's Water Wheel" activity sheet.

EXTENSION

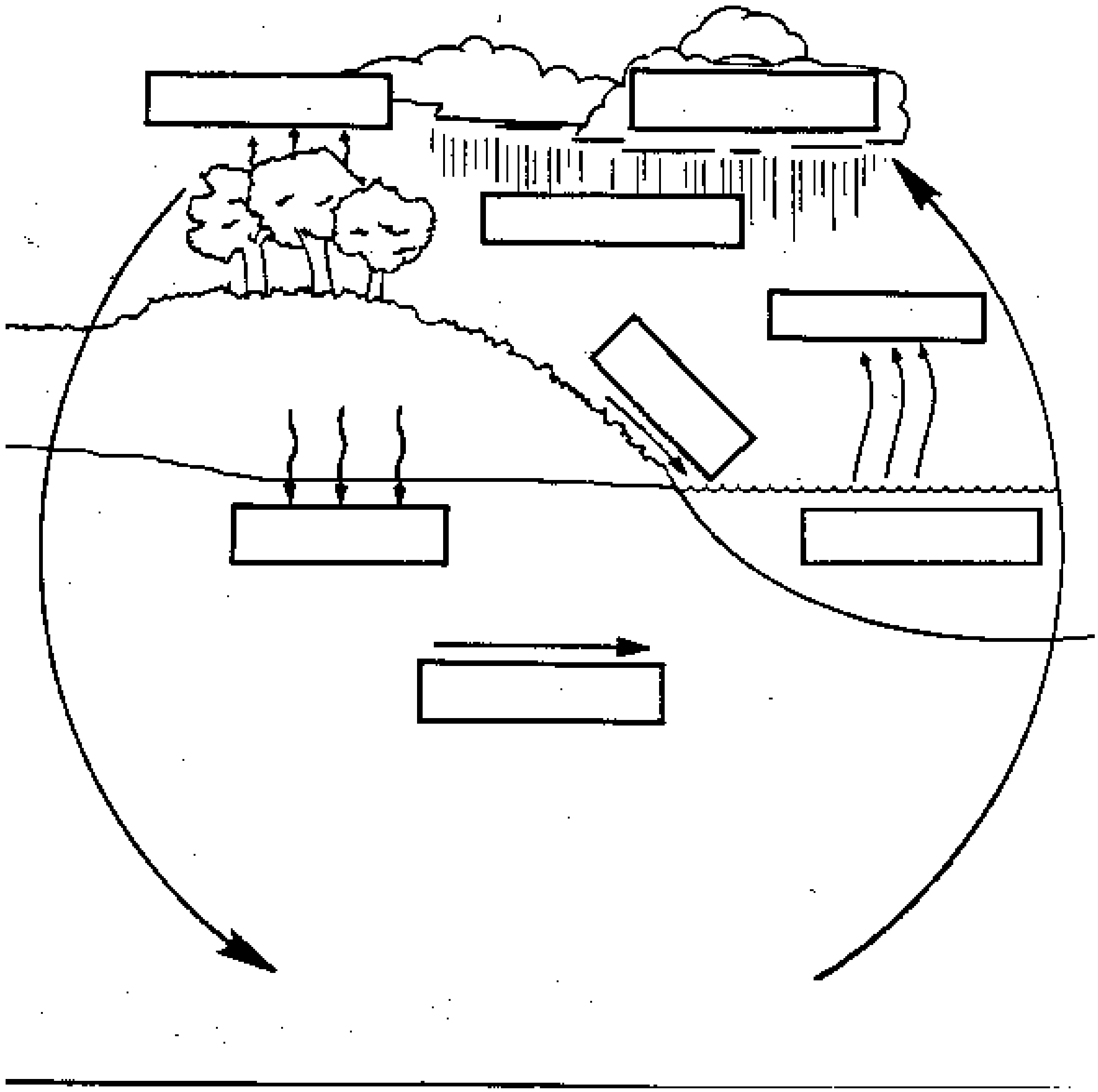
1. Have students list examples of ways they have seen the water cycle at work. Encourage them to think of many examples. For instance, water drops forming on a cold glass of liquid or a mirror that has water drops after you exhale on it would be good examples.

EVALUATIONS

1. Students will complete the data table and interpret the results.
2. Students will name the phases of the water cycle and explain how water can move from one to another.

Adapted from Illinois Department of Natural Resources, *Groundwater: Illinois' buried treasure education activity guide*. Illinois Department of Natural Resources, Springfield, Illinois. 1992.

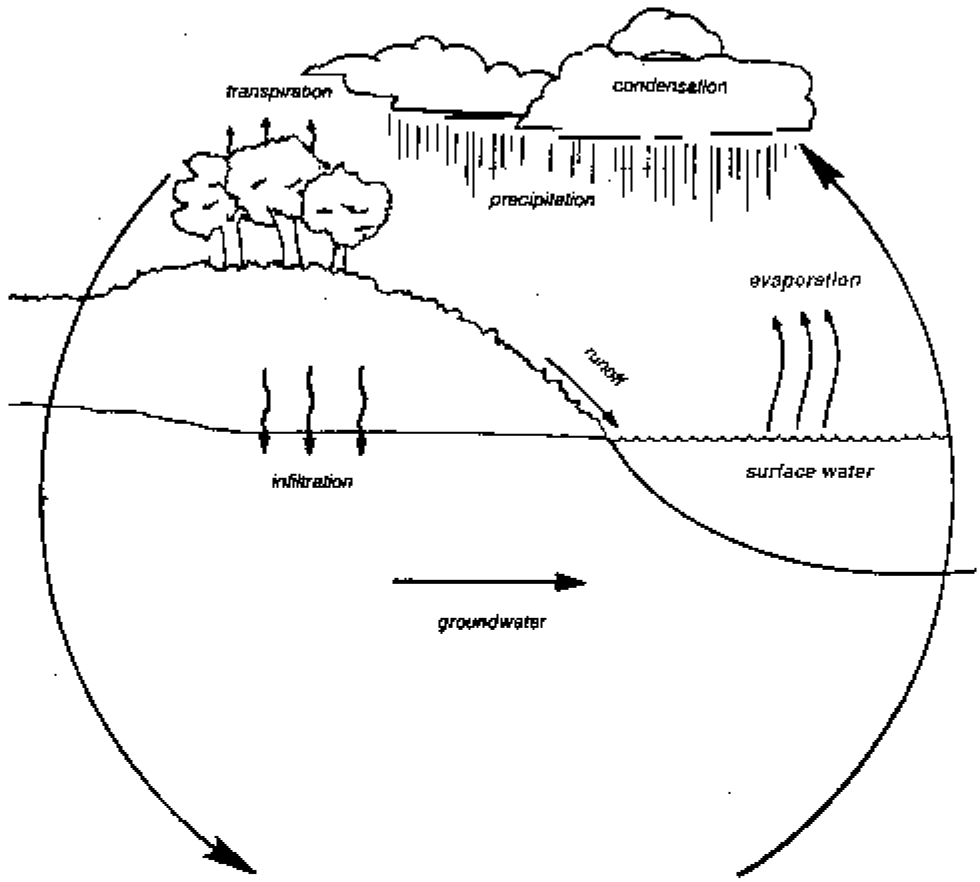
NATURE'S WATER WHEEL



Hydrologic Cycle

condensation - The changing of water vapor to liquid.
evaporation - The changing of water into water vapor.
groundwater - Water found below the surface of the earth.
hydrologic cycle - Process involving the circulation and distribution of water on the earth.
infiltration - The process by which water seeps into the soil.
precipitation - Forms of condensed water vapor that are heavy enough to fall to the earth's surface such as rain, snow, sleet, hail and fog.
runoff - Water that drains or flows off the surface of the land.
surface water - All the water on the surface of the earth.
transpiration - The process in which water vapor is released into the atmosphere through plants.

NATURE'S WATER WHEEL--ANSWER SHEET



Hydrologic Cycle

Think about the water on the ground. The water on the ground evaporates when the ground gets warm. Think about the warm air rising. The air and water vapor expand and rise high. The air is cooled when it rises. When the air is cooled, the water vapor condenses. The water vapor condenses to make clouds. Cloud and fog drops come together to make bigger water drops. The bigger drops are rain, snow or hail which fall on the ground. The water evaporates again. The whole cycle starts again.

WHERE DOES THAT WATER GO?
EXPERIMENT I

Group member names____

PROCEDURE
1. Collect the materials needed: four clear-plastic containers; marking pen; ruler.

2. Use the marking pen to put your group's name/number on the side of your four plastic containers. Label them A, B, C and D.

3. Fill each container half full with water and mark the level. Use the ruler to measure the water level in inches and record under Day 1 on the "Evaporation Table." Use an equal level of water in all containers.

4. For each container:
   a. choose a location in the classroom to place the container and record this information on the chart below.
   b. predict how many days it will take one inch of water to evaporate at this location.
   c. list the conditions that led you to make this prediction.

Cup	Location	Evaporation Prediction (days)	Conditions of Location
A			
B			
C			
D			

5. For quick reference, record your prediction times again on the "Evaporation Table."

6. Observe the cups daily and record water levels on the "Evaporation Table."

RESULTS
Evaporation Table

Cup	Evaporation Prediction (days)	Water Level in Inches Day 1 2 3 4 5
A		
B		
C		
D		

1. Which cup of water evaporated fastest?____

2. How did these results compare with your predictions?____

____

3. What conditions do you think caused this cup to evaporate the fastest?__________________________

____

4. Think of a place in the room to place a cup of water so it will evaporate faster than the water did in your set. What conditions exist at this site that would cause faster evaporation?

____

____

5. In the space below, create a graph of your results.

IT'S IN THE BAG!

EXPERIMENT II

Group member names____

PROCEDURE

1. Collect the materials needed for this experiment; a plastic bag and twist tie; a 3/4-full cup of water; a plastic lid.

2. Place the cup of water inside the bag on the plastic lid, fill the bag completely with air, close it tightly with the twist tie and place it in a sunny spot.

3. Describe the environmental conditions of the bag's location that may affect water evaporation.

____

____

4. Make the following predictions.

We predict that water condensation will appear in ______________ days.

We think that it will take this long because____.

5. Observe your miniature water cycle and draw pictures to show what happens to the water in your cup. Describe what is happening.

____

____

____

Beginning of experiment

Day 2 of experiment

Day 3 of experiment

Day 4 of experiment

Day 5 of experiment

RESULTS

1. Describe what the bag looked like when you first observed condensation occurring.

____

____

2. Were your predictions about when condensation would happen correct or incorrect? Why?

____

____

3. What conditions caused your prediction to be correct or incorrect?

____

____