Few people realize what it takes to keep a lawn green. In many parts of the country, lawn grasses cannot survive the summer without frequent watering. The lawn sprinkler shown here is able to water large sections of the lawn. Over a summer, it can use hundreds or thousands of liters of water. In Chapter 8, you will learn about Earth’s limited freshwater resources. You will learn about the ways they are used by people, farms, and industry. You will also learn about different sources of water pollution. Finally, you will find out how you can help conserve this important resource.

**Organize Your Thoughts**

**Global water resources**

**Resource use**
- Household
- Agriculture
- Industry

**Pollution and problems**
- Aquifer depletion
- Point-source pollution
- Nonpoint-source pollution

**Goals for Learning**
- To describe Earth’s water resources and why they are important
- To identify the main ways water is used and how it is managed
- To define three major sources of water pollution
- To explain how people can conserve and protect water resources
Objectives
After reading this lesson, you should be able to
- describe how people and wildlife use water
- explain how water is distributed on Earth
- explain how pollution affects people living in a watershed
- describe how groundwater is stored, used, and recharged

When you turn on the water faucet, freshwater usually comes pouring out. Many people do not think about where the water comes from. There seems to be an unlimited supply. However, the world’s freshwater supplies are actually very limited. In many parts of the world, freshwater is in short supply. The supplies can also be polluted. That makes it very important to know where freshwater comes from. Knowing this will help you learn how to better protect it.

As you learned in Chapter 5, only 3 percent of the earth’s water is freshwater. Most of the freshwater on Earth is frozen or difficult to reach. That leaves about 1 percent that is in a form that humans can use. This small amount of water is found in lakes, rivers, and streams. It is also stored in special layers of rock underneath the ground.

Worldwide Water Supplies
Freshwater is divided into two types: surface water and groundwater. Surface water is water above the ground. It flows in rivers, streams, and creeks, and fills up lakes, ponds, and swamps. Oceans are also examples of surface water, although they contain salt water instead of freshwater. Unlike surface water, groundwater is hidden from view. It is water that fills the spaces between soil particles and rocks underground. Both surface water and groundwater are important to people and other living things. About half of the people in the United States rely on groundwater for their drinking water. The rest rely on surface water.

Surface Water
Throughout history, people have settled near rivers, streams, and other sources of surface water. These bodies of water provide humans with drinking water, food, electricity, transportation, and recreation. Recreation includes activities such as swimming, boating, and fishing. Some of the world’s oldest cities have been built on major rivers. One well-known example is Cairo on the Nile River in Egypt.
Where does surface water come from? As you learned in Chapter 2, water cycles through the lithosphere, hydrosphere, and atmosphere. As it cycles, it changes from liquid water to a gas. During condensation it returns to a liquid form. Surface water forms as precipitation falls on the earth’s surface. This water flows down mountains, hills, and other land areas, forming fast-flowing streams. These streams combine with other streams, eventually emptying into rivers. Eventually, larger rivers empty into oceans or lakes.

**Watersheds**

No matter where you live in the world, you live within a **watershed**. In a watershed, all the rainwater and melting snow drains into the same stream or river. Watersheds can be small areas of land that drain water into small streams. They can also be huge areas of land that drain water into large rivers. Within every large watershed there are many smaller watersheds.

Watersheds are often named for the river that the water in the area drains into. For example, you might live in the Ohio River watershed or the Potomac River watershed. The Rio Grande watershed and several others are illustrated in Figure 8.1.1. Every person and organism living in a watershed has an impact on its future. Your watershed also has an impact on you.

As rain and melting snow flow into streams and rivers, they wash over the land. That means they wash through farmland, lawns, forests, roads, and industrial sites. As water flows over these places, it picks up different materials. In some cases, the water washes trash, dirt, chemicals, oil, and other waste into waterways. Pollution anywhere in a watershed can end up in a stream or river. It is then taken farther downstream.

*Figure 8.1.1  Surface water from the Rio Grande River area is included in the Rio Grande watershed.*
Groundwater

A large percentage of the earth’s freshwater is stored as groundwater. Groundwater starts with rain or snow that seeps, or soaks, into the ground. The amount of water that seeps into the ground varies from place to place. In some areas, more than half of the rain or snow soaks in. In other areas, most of the water runs off into other bodies of water. It may also evaporate into the air instead of soaking into the soil.

As water soaks into the ground, some of it stays in the soil. The rest keeps moving down until it reaches the place where the ground is saturated. Saturated means that it cannot hold any more water. The top of this saturated zone is called the water table. You can think of the water table as the top boundary of the groundwater. Above the water table, water can still soak into the soil. Below the water table, all the cracks and spaces are filled with water.

Aquifers

The area underground that contains groundwater is called an aquifer, as seen in Figure 8.1.2. Aquifer is another name for the water-saturated area of the earth. It contains underground formations that can store water and also transport it. Aquifers are usually layers of rock, sand, or gravel where water builds up over time. Aquifers are found in most parts of the world.

Figure 8.1.2 An aquifer is an area that contains groundwater.

Seep

To soak into something

Water table

The top of the groundwater layer

Aquifer

Underground layers of rock, sand, or gravel that trap, store, and transport water

Earth Science

Limestone caves form when rain mixes with carbon dioxide to form carbonic acid. This acid enters the groundwater and seeps into the layers of limestone. Carbonic acid dissolves the mineral calcite, which makes up limestone. As this happens, small holes in the limestone become bigger and bigger, forming caves.
Most of the groundwater people use comes from aquifers. They are important sources of water for wells and springs. In many areas, more than 50 percent of the population relies on groundwater for their drinking water. In rural areas, outside of cities, more than 80 percent of the people rely on groundwater.

In many parts of the world, people are pumping too much water from aquifers. Some are becoming depleted, or used up. The Ogallala Aquifer is under parts of eight states in the western United States. It contains water left from the time of the last glaciers. Many people are concerned that this water is being depleted faster than it can recover. The same thing is happening in many other parts of the world. As more water is pumped out of the ground, the level of the aquifer may fall. As the water table drops, it becomes harder and harder to reach the water.

**Recharge Zones and Wells**

Water that seeps into an aquifer recharges it, or refills it. The water that recharges an aquifer comes from sources including rain, melting snow, and streams. It can also come from groundwater flowing from other areas. The recharge zone is an area where water travels downward to become part of an aquifer.

In some places, people have built too many roads and parking lots. This affects the recharge area. Less water soaks into the ground. That means that an aquifer cannot recharge as quickly. Materials that allow water to flow through them are called permeable materials. Gravel, sand, and certain kinds of rock are permeable. They have holes or cracks that allow water in and out. Materials such as clay and concrete are impermeable. They stop the flow of water.

In some places the water table is deep below the surface of the earth. In other places, it is nearer to the surface. A well is a deep hole in the ground that allows people to reach the groundwater. In many parts of the world, people depend on wells for their water supplies. When digging a well, people search for the water table. People often dig below the water table. This means they will still have water if the height of the water table drops.
Using Too Much Water

In many parts of the world, too much water is taken out of rivers and streams. Groundwater is also being used too quickly. Much of the water is used for businesses and farming, as well as drinking water. When too much water is used too quickly, aquatic life can suffer. Over time, groundwater sources can become threatened. Wells can dry up as the water table drops below the bottom of the well. In some places water is redirected upstream. People and wildlife living farther downstream are left with very limited amounts of water. This increasing water *scarcity* in many parts of the world is a huge problem.

Pollution of surface water and groundwater supplies is also a very serious problem. This can affect water supplies for entire regions. It takes years for groundwater to recharge. It can also take tens or hundreds of years for polluted groundwater to be recycled.

**Express Lab 8**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>◆ safety goggles</td>
<td>1. Put on safety goggles.</td>
</tr>
<tr>
<td>◆ large glass container (aquarium or baking dish)</td>
<td>2. Spread rocks, 5–10 cm thick, on the bottom of the container.</td>
</tr>
<tr>
<td>◆ rocks, 3–5 cm in diameter</td>
<td>3. Make a layer of sand, 1–2 cm thick, on top of the rocks.</td>
</tr>
<tr>
<td>◆ sand</td>
<td>4. Make an uneven layer of gravel, 1–15 cm thick, on top of the sand.</td>
</tr>
<tr>
<td>◆ pea gravel</td>
<td>5. Slowly pour about a liter of water onto different parts of the top layer.</td>
</tr>
<tr>
<td>◆ water</td>
<td><strong>Analysis</strong></td>
</tr>
<tr>
<td>◆ ruler</td>
<td>1. Which part of the model is the water table?</td>
</tr>
</tbody>
</table>

2. How does the water recharge this aquifer?
Lesson 1  REVIEW

On a sheet of paper, write the word from the Word Bank that completes each sentence correctly.

1. Groundwater can be _____ because of pumping of water from wells.
2. A lack of freshwater resources is an example of _____.
3. The process of water going into an aquifer is called _____.

On a sheet of paper, write the letter of the answer that completes each sentence correctly.

4. Layers of rock that water can move through are said to be _____.
   A saturated  B rural  C permeable  D gravel

5. A(n) ____ is an area of land that drains into the same surface water.
   A aquifer  B watershed  C well  D drain

6. Most of Earth's freshwater is found in _____.
   A ice  B aquifers  C oceans  D lakes

Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

7. How do surface water and groundwater compare as water resources in the United States?

8. What would keep the amount of water in an aquifer about the same over a period of time?

9. Why does a well need to be deeper than the water table?

10. How does development in cities affect water resources?
Think about the ways you used water today. Did you brush your teeth or wash your face? Did you water your lawn, wash a car, or flush a toilet? Maybe you used water to cook or give your pet a bath. On average, American households use more than 760 liters of water each day. Still, individuals use a small amount of the total water society uses. Agriculture uses the most water around the world. More than 67 percent of the global water supply is used for agriculture. **Industry** is the making and selling of a particular kind of good or service. It is the second largest use of water around the world.

All of these uses are affecting worldwide supplies of freshwater. In some areas, water is already scarce. Natural disasters, such as **droughts** and earthquakes, can increase water shortages. During a drought, there is very little rainfall, which puts more pressure on water supplies. Because of these issues, it is important to learn how to use and manage water.

**Household Water Use**

About 8 percent of the global water supply is used by households. The amount varies, depending on the country and community. On average, individuals in the United States use about 379 liters of water daily. In developing nations, water consumption averages as little as 15 liters per day. The world average is 60 liters per day.

**Science Myth**

**Myth:** Bottled water is safer than tap water.

**Fact:** The Environmental Protection Agency (EPA) regulates the quality of tap water in the United States. The Food and Drug Administration (FDA) regulates the quality of bottled water. Both agencies use similar standards, but neither requires drinking water to be 100 percent pure.
Household water is used for drinking, cooking, cleaning, watering gardens, and other activities. People need to drink about 1.9 liters of water a day to stay healthy. That is less than 1 percent of household water use. The rest goes to flushing toilets, taking showers, and washing clothes and dishes. People also use huge amounts of water to keep their lawns green. They also use water to fill up their swimming pools and water their gardens.

**Water Treatment**

Most water is treated to make it safe for drinking. Water **treatment** removes harmful chemicals, which can make people sick. Water treatment also removes bacteria, parasites, and other living things that can cause diseases. Living things that can cause diseases are known as **pathogens**. Harmful chemicals and pathogens are found in polluted rivers, streams, lakes, and ponds. They can also be found in groundwater.

**Agricultural Use**

The single biggest water user around the world is agriculture. It takes more than 181,700 liters of water to make an average Thanksgiving dinner for eight people. Just making a hamburger consumes a large amount of freshwater. Each hamburger takes more than 2,270 liters of water to create. That includes water needed to grow the grain that feeds the cow. It also includes the water the cow needs to survive. The water needed to process the hamburger is also added in. Americans eat more than 72 billion hamburgers a year. That can add up to a lot of water.

**Cultures**

Humans began to use water from nearby rivers to irrigate crops about 7,000 years ago. The Egyptians were the first culture known to use irrigation. They dug short channels to direct yearly floodwaters from the Nile River to their fields. By B.C. 2000, cultures in Mesopotamia, Peru, China, and North America were irrigating crops.
To grow more crops, many farmers **irrigate** their farmland. To irrigate means to artificially supply land with water for farming or **landscaping**. Irrigation uses the largest amount of water of any process in the world. In some cases, water is brought from other areas to farmland through ditches or pipes. Sometimes rivers are **diverted**, or turned from one course to another. Figure 8.2.1 shows how the Yangtze River in China has been diverted to supply water for industry and irrigation. Fields are often flooded with water. Many areas also use **sprinkler systems**, which spray water from above the ground. Sometimes, the water used to irrigate farms evaporates and never reaches the crops. Scientists are looking at how to grow crops by using water more efficiently.

**Industrial Use**

The second-biggest use of water is industry. More than 20 percent of water in the world is used for industrial purposes. Almost every product manufactured, or built, uses water during part of the production process. Water is used to cool substances as they are produced. It is also used for transportation, boiling or cooking, and preparing raw materials. For example, it takes about 147,600 liters of water to produce a car, including the tires. Water is also used to make many parts of products people use every day. This includes computers, semiconductors, clothing, paper, and soft drinks. More than half of the water industries use goes toward cooling power plants and other industrial areas.

**Figure 8.2.1** Water is diverted from the Yangtze River in China for use in industry and irrigation.
Ecosystem Use

Ecosystems use water to support living things. They also provide ecosystem services that manage water, such as flood control and water purification. As human water demands increase, however, many ecosystems are being changed or destroyed. In some cases, freshwater wetlands and swamps have been filled in. Dams have been built across streams and rivers. Instead of soaking into the ground to recharge aquifers, more water is being directed elsewhere. In many areas, water that used to support ecosystems has been drained or polluted.

This loss of ecosystems has many effects. Wild species decline, and ecosystem services are affected. Wetlands, for example, help prevent floods and filter water. In some places, people have built water treatment plants to replace these natural ecosystems. Some experts estimate that the services that wetlands provide are worth billions of dollars.

Science at Work

Irrigation Engineer

Irrigation engineers design and install irrigation systems. Some irrigation engineers specialize in large systems for agricultural crops. Others specialize in sprinkler irrigation systems for home or business landscapes.

Many irrigation engineers work in developing countries, where farming methods are being improved. Irrigation engineers spend a lot of time working outdoors. They survey areas, large or small, that need an irrigation system. They must understand the climate of the area and the needs of the plants. They must also understand how water behaves as it flows and moves through the soil. An irrigation engineer then uses all this information to design a system for the area.

Irrigation engineers work for government agencies as well as for private companies. Any kind of engineering career requires the study of math. Irrigation engineers also take courses in plant sciences, geology, and soil science. Most irrigation engineers have a bachelor's degree in civil or agricultural engineering or landscape design.
**Water Management Systems**

For thousands of years, people have tried to change natural water systems. In some cases, these projects have been designed to bring more water to dry areas. In other cases, water storage areas called **reservoirs** have been built. Reservoirs store water to meet the needs of growing communities. Many rivers have been diverted into canals that carry water to new areas. For example, water from the Colorado River has been diverted to supply water to seven western states. This diverts a lot of water from the Colorado River. As a result, there is often not enough water for communities downstream. Communities in Texas and Mexico must find other sources of water.

Dams have also changed natural water systems. They have diverted rivers to help generate power. They have also been built to help control the flow of water and prevent floods. The power generated by dams is an important source of energy. However, there are some environmental and social problems with dams.

Dams often change environmental conditions downstream. This affects both wildlife and human communities. Sometimes human communities are forced to relocate because of changes dams have brought about, both upstream and downstream.

The number of dams being built has grown steadily since the 1950s. There are more than 45,000 large dams in the world. China alone has more than 22,000 large dams and more than 80,000 dams in total. More than 60 percent of the world’s 227 largest rivers have been broken up by dams.

To help prevent problems with dams, many states and countries are looking at alternatives to dams. Some countries have decided that big dams are not environmentally sound investments. Instead, engineers are looking at ways to build smaller dams that have smaller environmental impacts.
Lesson 2  REVIEW

Word Bank
agriculture
industry
reservoir

On a sheet of paper, write the word from the Word Bank that completes each sentence correctly.

1. The practice of _____ uses most of Earth’s freshwater resources.

2. A(n) _____ is a place where water is stored.

3. The second-biggest user of water around the world is _____.

On a sheet of paper, write the letter of the answer that completes each sentence correctly.

4. A(n) _____ is a long period of little rainfall.
   A landscape  B irrigation  C pathogen  D drought

5. People irrigate in order to provide water for crops and _____.
   A industry  C reservoirs  B landscaping  D pathogens

6. Much of the water used to manufacture goods is used for _____.
   A cooling  C sprinkler systems  B water treatment  D ecosystems

Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

7. How is most household water used in the United States?

8. Explain the many different ways water is used to make a hamburger.

9. How are wetlands valuable ecosystems?

10. How is the water that is diverted from rivers and streams used?
INVESTIGATION 8

Materials
- safety goggles
- lab coat or apron
- gloves
- tap water
- outdoor water
- wax pencil
- 4 small test tubes and stoppers
- test tube rack
- pH test solution
- pH color card
- nitrate test solutions #1 and #2
- nitrate color card

Water Quality Testing

How do you know your drinking water is safe to drink? Experts test the water for many contaminants. In this lab, you will test water samples for two different contaminants.

Procedure

1. Copy the data table below onto a sheet of paper.

<table>
<thead>
<tr>
<th>Water source</th>
<th>Kind of test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
</tr>
<tr>
<td>Tap water</td>
<td></td>
</tr>
<tr>
<td>Outdoor water</td>
<td></td>
</tr>
</tbody>
</table>

2. Put on safety goggles, a lab coat or apron, and gloves.

3. Place 5 mL of tap water in two test tubes. Label the test tubes A and B using a wax pencil. Safety Alert: Do not taste any of the water samples.

4. Add three to five drops of the pH test solution to Test Tube A. Safety Alert: Be careful when handling glassware and chemicals. Close the test tube with a stopper and gently shake the tube several times.

5. Find the pH of the water by matching the color of the solution to the same color on the pH color card. Record the pH.

6. Add 10 drops of nitrate test solution #1 to Test Tube B. Close the test tube and gently shake it several times.
7. Shake the bottle of nitrate test solution #2 forcefully for 30 seconds. Then add 10 drops of this solution to Test Tube B. Close the test tube again, and shake it forcefully for 1 minute. Let the test tube stand in the test tube rack for 5 minutes.

8. Find the amount of nitrate in the water in parts per million (ppm) by matching the color of the solution to the same color on the nitrate color card. Record the amount of nitrate.

9. Repeat Steps 3–8 for the outdoor water sample.

Analysis
1. Summarize the results of your tests.
2. How do the two water samples compare?

Conclusions
1. Which water sample would be safest for aquatic life?
2. Can the water you tested be considered safe to drink? Explain.

Explore Further
Test more water samples from different sources such as a creek, a lake, rainwater, and different brands of bottled water.

Cleanup/Disposal
Before you leave the lab, be sure your work area is clean. Wash your hands thoroughly.
Many types of water pollution are easy to spot. Bottles, cans, tires, and other debris can wash up along the beach. Dead fish might be floating in a lake. Other types are invisible but are still serious threats to aquatic ecosystems. All types of aquatic ecosystems, from oceans to rivers, are affected by water pollution.

Water pollution is not new to human societies. For centuries, people threw their waste into the ocean and other large bodies of water. Today there are two important reasons why water pollution is more of a threat. The first is the rise in industry. More industry has caused massive amounts of waste. The second is the rapid increase in human population. More people create much more waste. Unfortunately, this waste often ends up in water systems.

**Types of Water Pollution**

There are many types of water pollution. Some pollution is caused by chemicals that get into water supplies. Some pollution is caused by human or animal waste that is dumped into the water. Water pollution can even be caused by heat. In fact, almost all the ways humans use water can create water pollution. There are two main categories of water pollution.

**Point-source pollution** is water pollution that comes from a single source. An example of point-source pollution is a pipe pouring waste directly into a river. This waste might come from a factory. Another example would be a tanker ship that spills oil into the ocean. Point-source pollution is easier to trace back to a source and to control.

**Research and Write**

Oil spills have had a huge effect on some ocean and coastal ecosystems. Research the cause and effects of a major oil spill. Find out what measures were taken to clean up the oil spill. Write a report and present it to the class.
Nonpoint-source pollution is much more difficult to control. Nonpoint-source pollution comes from many sources. It is caused by a variety of human land uses. For example, farming, logging, construction, and other activities can all cause nonpoint-source pollution. What usually happens is that falling rain washes over farms and urban areas. As the water flows over the land, it picks up pesticides and other pollutants. Eventually, this water carries the pollutants into rivers, lakes, and other bodies of water. This water is called runoff. Runoff brings material that washes off roads, fields, lawns, and other surfaces with it.

It is difficult to find the origin of nonpoint-source pollution. This is because the pollutants are picked up from across a large area. Different areas of land contribute different types and amounts of certain pollutants. What matters is how the land is used. Three different types of land use are agricultural, urban and other development, and forest land.

The map shows the sources of phosphorous pollution emptying into Lake Champlain. This is also called phosphorous loading. The area is divided up into different lake segments. Each lake segment has different percentages of its phosphorous output coming from different sources.

These percentages depend on the watershed's land use. Use the map and its legend to answer the following questions.

1. Does the same land use cause the most phosphorous loading in each watershed? If not, give examples showing this is not the case.

2. What do you think causes the differences in the percentages between watersheds?
Major Water Pollutants

Many different chemicals and other types of pollutants get into surface water and groundwater supplies. Below are some of the major water pollutants and the problems that they cause.

**Sewage.** In many parts of the world, bacteria and *viruses* get into water supplies. When that happens, these pathogens can cause diseases, including *hepatitis*, *cholera*, and *dysentery*. The source of many of these organisms is untreated human waste from homes and factories. Water that carries waste from people and industries is called *sewage* or wastewater. Sewage comes from toilets, sinks, dishwashers, washing machines, and factories. It can carry everything from food scraps to soap to chemicals. It is the second-largest source of water pollution.

Sewage is usually cleaned at *sewage treatment plants* before being released into surface water. These facilities are designed to kill pathogens and get rid of other types of pollution. You can see a picture of a sewage treatment plant in Figure 8.3.2. Wastewater is carried to sewage treatment plants by an underground system of drains, pipes, and sewers. Unfortunately, sewage treatment plants can get overloaded during storms. When they back up, untreated waste can wash directly into surface water. There are also not enough sewage treatment plants to treat all the sewage in the world. In many places, the sewage is dumped into the ocean and other bodies of water.

![Figure 8.3.2](image)

*Figure 8.3.2* At sewage treatment plants, sewage is cleaned before it is released into surface water.
Untreated human waste can do more than cause diseases. It can also decrease the amount of oxygen in the water. As bacteria break down organic waste, they use up the oxygen in the water. Organic waste is waste from living organisms. The more waste there is to break down, the less oxygen is left in the water. As a result, fish and other aquatic creatures do not have enough oxygen.

Organic waste can come from overflowing sewage treatment plants. It can also come from farms, ranches, and other sources of food and animal waste.

Fertilizers. The biggest source of water pollution is runoff from farms and ranches. One reason is that they produce so much animal waste. Another is that many pollutants are used to grow food and crops and raise livestock. These pollutants include pesticides and herbicides, chemicals that kill weeds. They also include fertilizers, which are nutrients to help plants grow.

Animal wastes and fertilizers both contain nutrients for plants. In small amounts, they can help crops and other plants grow. In the water, they can cause algae and other aquatic plants to grow too much. Over time, these plants start to die. As explained earlier, bacteria that break them down use up oxygen. Without enough oxygen in the water, whole communities of life can die. This process is called eutrophication. Eutrophication is actually a natural process. It becomes a problem when pollution speeds up the process.

Making water safe to drink requires several processes at a water treatment plant. Flocculation involves adding chemicals that cause substances in the water to form clumps. These clumps settle out during sedimentation. Filtration removes the remaining particles, such as soil and organic materials. Ion exchange and absorption are then used to remove metals, minerals, and other unwanted elements. Finally, disinfection with chlorine compounds or ozone kills harmful microbes.
Bioaccumulation
The process by which toxic chemical compounds accumulate through the food chain

Thermal pollution
Heat added to water by humans that causes ecological changes

Radioactive waste
Waste that contains or is contaminated by radioactive materials

Toxic Chemicals. Many water pollutants are toxic chemicals. Some are organic chemicals that come from living things. Although not all organic chemicals are toxic, many are poisonous to living things.

The most common and dangerous organic pollutant is petroleum. Oil often spills or leaks while being transported. It can enter water supplies when it is drilled out of the ocean floor. Accidents can happen along oil pipelines and at oil refineries. All of these accidental spills add up to enormous amounts of water pollution.

Other types of toxic chemicals are inorganic. Lead, mercury, sulfur, nickel, and arsenic are all inorganic chemicals. Even small amounts of these chemicals can cause brain, liver, and kidney diseases. This damage can be caused by bioaccumulation.

Bioaccumulation happens when these chemicals work their way up the food chain. For example, when mercury washes into a lake, the fish are exposed. When people eat the fish, they take the mercury into their bodies. The more contaminated fish people eat, the more chemicals they are exposed to. These chemicals can build up in their bodies and cause serious health problems.

Other Types of Water Pollution. There are many other types of water pollution that can affect living things. For example, heat can be a pollutant. Thermal pollution is heat added to a body of water. This heat often comes from factories or power plants as they release hot water. This heat can kill living things. It can also harm entire ecosystems by decreasing the amount of oxygen in the water.

Another serious water pollutant is radioactive waste. Radioactive waste comes from nuclear reactors, research institutions, or hospitals. In some cases, this waste is dumped illegally into the water, creating serious health risks.

The many types and sources of water pollution often make it difficult to protect water resources. In Lesson 4, you will learn about the efforts being made to control water pollution.
Lesson 3  REVIEW

On a sheet of paper, write the word or words from the Word Bank that complete each sentence correctly.

1. A leaking gasoline pipeline is an example of _____.
2. Rain or melted snow that flows over land into bodies of water is called _____.
3. Farming and driving contribute to _____.

On a sheet of paper, write the letter of the answer that completes each sentence correctly.

4. Sewage is wastewater that comes from the activities of _____.
   A plants   B humans   C bacteria   D animals

5. Chemicals that are used to kill unwanted plants are _____.
   A radioactive wastes   C fertilizers
   B organic wastes   D herbicides

6. Excessive plant growth happens in lakes that are undergoing _____.
   A bioaccumulation   C eutrophication
   B decomposition   D pollution

Critical Thinking

On a sheet of paper, write the answers to the following questions. Use complete sentences.

7. How are leaking sewer pipes a threat to groundwater quality?

8. How is untreated human waste a threat to fish and other aquatic life?

9. Explain why oil pollution is so common.

10. Which do you think is more dangerous, oil pollution or radioactive waste? Explain your answer.
Materials
- safety goggles
- lab coat or apron
- gloves
- outdoor water
- 2 small test tubes and stoppers
- test tube rack
- nitrate test solutions #1 and #2
- nitrate color card
- soil
- sand
- gravel
- filter paper
- funnel
- jars

Testing Groundwater
Surface water soaks through one or more layers of soil and rock as it becomes groundwater. As water moves through the ground, soil and rock filter out some pollutants. How well do these materials remove nitrates? Find out by designing and conducting an experiment.

Procedure
1. In your lab group, discuss the kinds of pollutants that are found in water. Also discuss the kind of soil that is found in your area.
2. Write a hypothesis about how well different soil materials filter out pollutants. This hypothesis should be able to be tested with an experiment that uses the materials listed here.


4. Have your hypothesis, procedure, and Safety Alerts approved by your teacher. Then carry out your experiment. Record your results.

**Cleanup/Disposal**
Before you leave the lab, be sure your work area is clean. Wash your hands thoroughly.

**Analysis**
1. Which kind of material was easiest for water to filter through?

2. What other differences do you notice in the water that has filtered through soil?

**Conclusions**
1. Which kind of material best filtered nitrates out of the water?

2. Think about the soil types in your area. How well would they filter nitrates out of water?

**Explore Further**
Repeat your experiment using another type of material such as potting soil, aquarium gravel, or crumbled modeling clay.
How can people preserve water resources for the future? In this lesson, you will learn more about how people are preserving water resources. You will also learn what you can do at home to make a difference.

**Controlling Water Pollution**

In 1969, the Cuyahoga River in Cleveland, Ohio, caught on fire. It burned for several hours until the oil and other garbage had burned off. When many people saw the photograph of the burning river, they were shocked. It was not the first time this had happened, however. The river had caught fire several times before. These fires caused damage to the docks, ships, and factories along the river.

The fire on the Cuyahoga did bring about one good thing. It was one of the events that led to important water pollution laws. In 1972, Congress passed the Clean Water Act. This act has helped clean up many waterways around the country, including the Cuyahoga River. Its goal was to make all surface waters clean enough for fishing and swimming by 1983. Although that goal has not been achieved, the results have still been encouraging. Many rivers, lakes, and streams have been cleaned up. Many toxic chemicals are now removed as part of wastewater treatment.

The Clean Water Act led to other laws designed to improve water quality. These included laws that banned ocean dumping. Others required oil tankers to have stronger hulls to help prevent oil spills. Congress also passed the Safe Drinking Water Act in 1974. This helped to protect community drinking water supplies.

In addition to laws, new technologies help protect water resources. For example, in many areas, irrigation water contains salt. When the water evaporates, salt is left behind. This can harm crops and ruin the land. Farmers are exploring ways to reduce the salt and protect groundwater supplies and topsoil.
Many countries have also built water treatment plants that remove salt from water. This is especially important in countries that do not have enough freshwater. Scientists are experimenting with ways to turn salt water from the ocean into drinking water.

Many countries are also banning toxic chemicals that can seep into water supplies. Recently, many countries have signed a treaty banning some of the most deadly pesticides.

**Conserving Water**

Conserving water is important for preserving water supplies for the future. This is especially true in areas that have limited supplies of freshwater. Water conservation can take place in homes, communities, farms, and industries.

**Reducing Water Use in Farming.** Since the 1960s, the amount of land that is farmed has increased by 12 percent. This increase in farmland has greatly increased worldwide water use. There are many new technologies that farmers are using to help conserve water. For example, some farmers are using drip irrigation. In drip irrigation, water tubing lets water drip directly over the roots of plants. It helps prevent evaporation, which can cause huge losses of water in fields. This system is still expensive, but it holds great potential for the future. An example of a drip irrigation system can be seen in Figure 8.4.1. Many farmers are also looking at the types of crops they grow. Many grow nonnative crops that require huge amounts of water. Now they are looking at more native and water-efficient options.

![Drip irrigation systems help reduce water use by preventing loss through evaporation.](image)
Reducing Water Use in Industry. As water supplies decrease, many industries are looking at ways to conserve. One of the most effective is recycling wastewater and reusing it. For example, many beverage industries use water to cool bottles or equipment. This water can be reused, which reduces the need for more water. In many plants, water that is used to clean equipment can be recycled. It can be used for many other things, including landscaping and washing vehicles.

Reducing Water Use at Home. Homes and communities can also do a lot to reduce water use. Many communities are exploring new ways to recycle water. For example, systems can be built that collect gray water. Gray water is water that has been used in sinks, showers, and washing machines. It can be recycled and used for things like flushing toilets and watering the lawn. There are also many new technologies that can help cut water use. Low-flow showerheads and low-flow toilets are both designed to use less water.

Individuals can take other steps to reduce water use, too. Turning off the faucet while brushing your teeth is one example. Watering the lawn at night can prevent evaporation and water loss. Another way to save water is to not use plants that need too much water. Many communities in very dry climates have banned nonnative plants that require more water. People are not allowed to plant vegetation such as grass and leafy shrubs. Instead, these communities encourage xeriscaping. Xeriscaping is designing a landscape that uses the least water possible. When one action is multiplied by all the people conserving, it saves a lot of water.
Protecting Aquatic Ecosystems

Many countries are exploring new technologies that will provide more water for more people. Providing clean water for people living throughout the world is an important goal. At the same time, it is important to protect the ecosystems that help support all life.

There are a number of things being done to restore damaged habitats. In some cases, rivers are being returned to their original courses. Dams are being taken apart to create normal water flows. Vegetation is being planted along streams to prevent erosion. These efforts also help to restore damaged habitats and the ecosystem services they provide.

Science in Your Life

Technology: Water Conservation

Conserving freshwater is one way to help all people get enough water. Conserving water is something everyone can do. There are many products that reduce the amount of water used in households. Low-flow toilets, low-flow showerheads, and other fixtures are designed to cut water use. Xeriscaping and drip irrigation techniques also help households reduce their water use outdoors.

When it comes to conserving, personal responsibility is the key. This means realizing that you make a difference and doing what you think is right. You can decide to use the water-saving technologies that are available. Then you can take an active role in deciding how you and your household use water.

1. What are some ways that you can conserve water?
2. What are some ways that you can encourage others to conserve water?
Lesson 4 REVIEW

On a sheet of paper, write the word from the Word Bank that completes each sentence correctly.

1. The Clean Water Act led to laws that ban ocean _____.
2. Scientists are looking to new _____ to provide more water to a growing population.
3. Industry can conserve water by _____ wastewater.

Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

4. What was an important result of the 1972 Clean Water Act?
5. What are some of the benefits of protecting watersheds and restoring aquatic ecosystems?

Achievements in Science

Xeriscaping

Neatly trimmed green lawns were once the model for home landscaping. Lawn grasses are easy to grow and maintain, but they require huge amounts of water. Green lawns are not always practical because of water shortages. Xeriscapes are replacing many grassy lawns. The prefix xeri- is from the Greek word xeros, meaning "dry." The word xeriscaping was first used in Denver, Colorado, in 1981. At first, it referred to the use of drought-tolerant plants in landscaping. Since that time, xeriscaping has taken on a wider meaning.

Xeriscaping is the use of plants that are best adapted to local conditions for landscaping. In dry regions, this may mean using desert plants in the landscape. Scientists look in areas with similar climates for new landscape plants to use. Xeriscaping also involves using mulch as ground cover to hold in moisture. With xeriscaping, people can reduce water use and still have a pleasing landscape.
Illnesses Caused by Water Pollution

Waterborne diseases are caused by bacteria, viruses, and other pathogens in water. These diseases cause serious problems wherever there is water pollution or poor sanitation. In developing nations, waterborne diseases make up as much as 80 percent of illnesses. Most deaths of infants and young children in these countries are caused by waterborne diseases. Industrialized nations, such as the United States, sometimes experience waterborne diseases due to flooding.

Diarrhea is a symptom of waterborne bacterial diseases such as cholera, typhoid, and dysentery. The bacteria grow in the intestines. Waste material from infected individuals contains the bacteria. When people drink water or eat food that is contaminated with infected feces, the diseases spread. Diseases also spread when people use contaminated water for recreation. The resulting diarrhea can lead to dehydration and other physical problems that can cause death.

Hepatitis A is an example of a waterborne disease that is caused by a virus. The disease is most common in areas without safe drinking water. Much of the world’s population does not have access to safe drinking water. Giardiasis is an example of a waterborne disease caused by a protozoan. It, too, causes diarrhea but is usually not a life-threatening disease.

Industrialized nations face other health problems that are caused by water pollution. Toxic chemicals and radioactive substances have been linked to cancers. Pollution in heavily industrialized areas has also been linked to birth defects and many other health problems.

Some developed nations have worked together to set safety standards. One goal is to have toxic waste treated and disposed of as close to its source as possible.

1. Why should world travelers be careful about what they eat and drink?
2. What could help reduce the incidence of waterborne diseases in the world?
3. How do you think treating toxic waste close to the source will help prevent water pollution?
All living things need water, and many kinds of wildlife live in water.

People use water for drinking, bathing, cooking, landscaping, farming, industry, transportation, and recreation.

Oceans hold 97 percent of Earth's water. The remaining 3 percent is freshwater on the surface, underground, and in ice caps.

Creeks, rivers, ponds, lakes, swamps, and oceans hold Earth's surface water. Aquifers store groundwater, which enters from the surface through a recharge zone.

Pollution in a watershed causes contaminants to enter bodies of water. All water resources downstream from the pollution will have contaminants.

Wetlands and other aquatic ecosystems purify water and control floods.

People manage water resources by building dams, reservoirs, and water treatment plants.

Point-source pollution comes from a single source, such as a sewer pipe. Nonpoint-source pollution is collected from broad areas by runoff.

Inorganic pollutants, such as lead, mercury, and arsenic, are poisonous to living things. Organic pollutants, such as animal wastes, contain disease-causing agents.

Drip irrigation in agriculture and xeriscaping around homes and businesses help conserve water.

Legislation passed in the 1970s led to many laws that protect water resources.

Protecting watersheds and wetlands from pollution and development can help protect water resources.

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Vocabulary Review
On a sheet of paper, write the word or words from the Word Bank that complete each sentence correctly.

1. Surface water drains into rivers and lakes from their _____.
2. A type of irrigation that helps conserve water is _____.
3. A ____ is an area of land where water enters an aquifer.
4. Hot water from power plant cooling towers causes _____.
5. A method of gardening that is designed to conserve water is _____.
6. The process of ____ makes drinking water safe.
7. Waterborne diseases include _____, dysentery, and hepatitis.
8. A ____ releases cleaned wastewater into surface water.
9. To conserve freshwater, some communities are using _____ to water lawns.
10. Aquifers are found in ____ layers of rock.
11. People use many bodies of water for boating and other forms of _____.
12. A well must be dug below the _____, or it will go dry if the water level drops.
13. Farmers must often _____ crops to help them grow.
14. Nonpoint-source pollution is carried into freshwater sources by _____.
15. Layers of rock that water cannot flow through are said to be _____.
16. Much of the material in sewage is _____, or waste from living organisms.

Continued on next page
Chapter 8  Review - continued

Concept Review
On a sheet of paper, write the letter of the answer that completes each sentence correctly.

17. The Clean Water Act was passed after a _____ caught fire.
   A building  C river
   B farm field  D chemical plant

18. Much of the water in the Ogallala Aquifer came from _____.
   A the Colorado River  C heavy rainfall
   B the Red River  D melting glaciers

19. Some toxins accumulate in living things. These toxins are most concentrated in the _____ levels of food chains.
   A highest  C middle
   B lowest  D second

20. People in the United States use an average of _____ liters of water daily.
   A 16  C 100
   B 40  D 379

21. Most large cities of the world developed in areas with nearby sources of _____.
   A groundwater  C recreation
   B surface water  D water treatment
Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

22. Caves and sinkholes serve as points of recharge for many major aquifers. Evaluate the practice of using caves and sinkholes as trash dumps.

23. Many desert cities, such as Las Vegas, are growing very quickly. What effects could this have on local and regional water resources?

24. How do organic wastes both benefit and hurt the environment?

25. Water quality has improved in many ways over the years. What still needs to be done to protect the quality of water?

Test-Taking Tip
Do not wait until the night before a test to study. Plan your study time so that you can get a good night’s sleep before a test.