SECTION 2

Water Use and Management

Objectives

- Identify patterns of global water use.
- Explain how water is treated so that it can be used for drinking.
- Identify how water is used in homes, in industry, and in agriculture.
- Describe how dams and water diversion projects are used to manage freshwater resources.
- Identify five ways that water can be conserved.

Key Terms

potable
pathogen
irrigation
dam
reservoir
desalination

You may have heard the expression "We all live downstream." When a water supply is polluted or overused, everyone living downstream can be affected. The number of people who rely on the Earth's limited freshwater reserves is increasing every day. In fact, a shortage of clean, fresh water is one of the world's most pressing environmental problems. According to the World Health Organization, more than 1 billion people lack access to a clean, reliable source of fresh water.

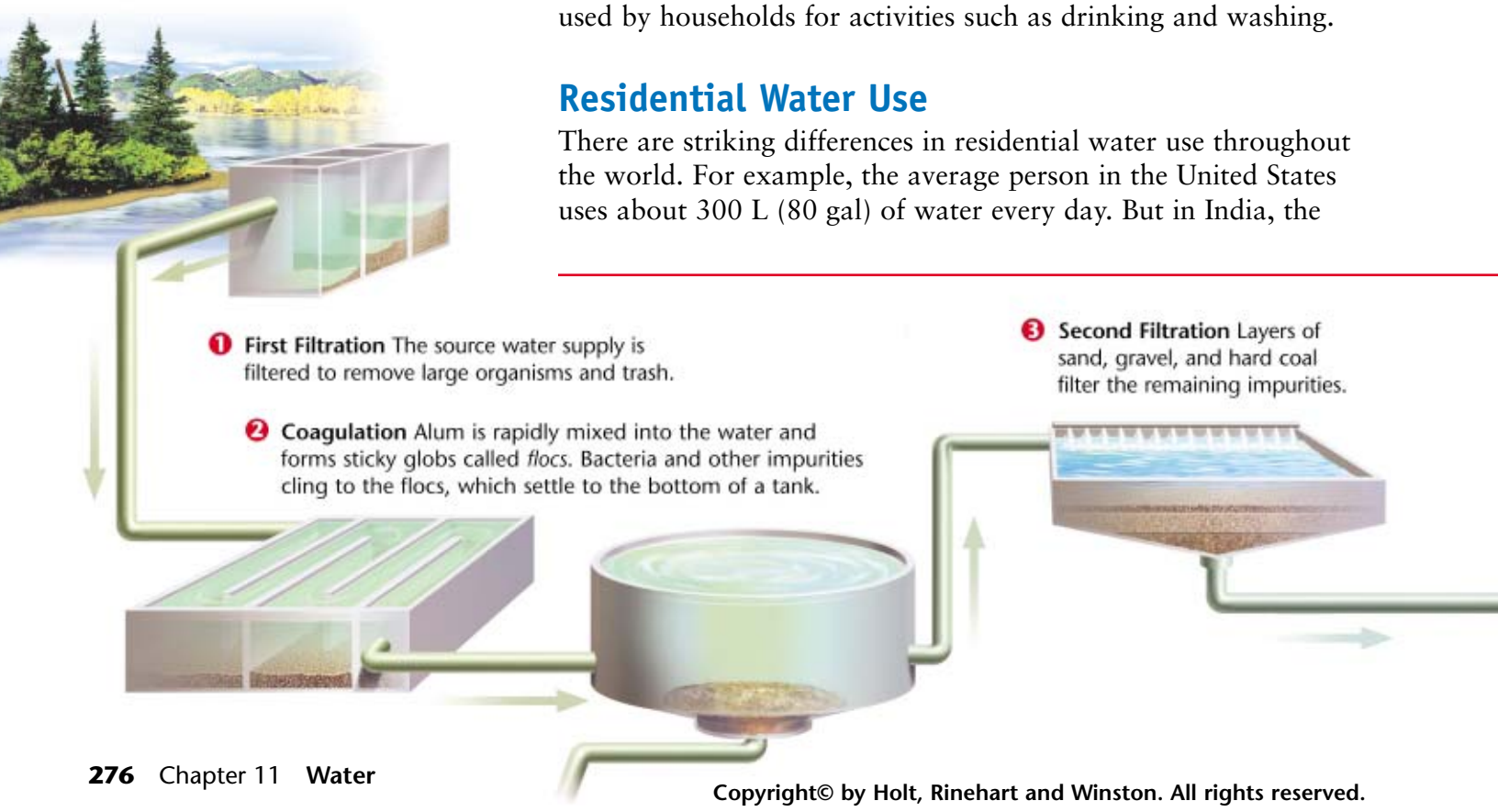
Global Water Use

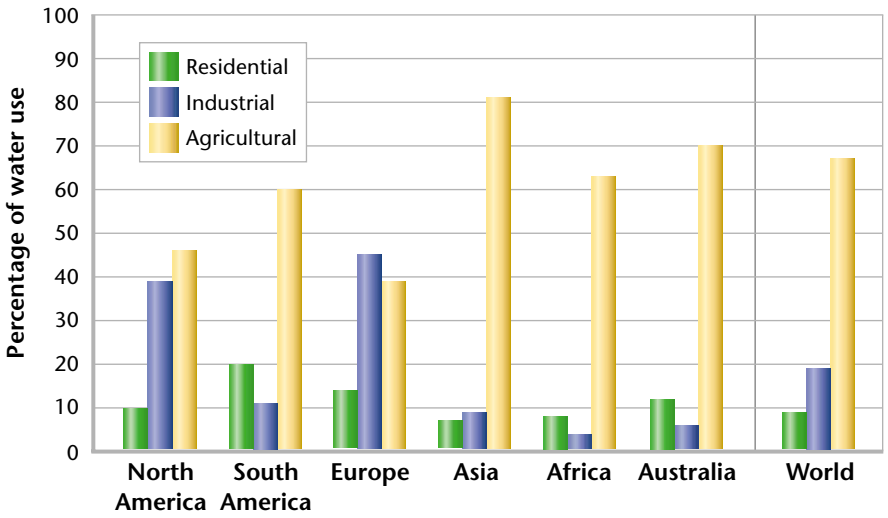
To understand the factors that affect the world's supply of fresh water, we must first explore how people use water. **Figure 5** shows the three major uses for water—residential use, agricultural use, and industrial use.

Most of the fresh water used worldwide is used to irrigate crops. Patterns of water use are not the same everywhere, however. The availability of fresh water, population sizes, and economic conditions affect how people use water. In Asia, agriculture accounts for more than 80 percent of water use, whereas it accounts for only 38 percent of water use in Europe. Industry accounts for about 19 percent of the water used in the world. The highest percentage of industrial water use occurs in Europe and North America. Globally, about 8 percent of water is used by households for activities such as drinking and washing.

Residential Water Use

There are striking differences in residential water use throughout the world. For example, the average person in the United States uses about 300 L (80 gal) of water every day. But in India, the





Source: World Resources Institute.

Figure 5 ▶ Europe is the only continent that uses more water for industry than for agriculture.

average person uses only 41 L of water every day. In the United States, only about half of residential water use is for activities inside the home, such as drinking, cooking, washing, and toilet flushing. The remainder of the water used residentially is used outside the home for activities such as watering lawns and washing cars. **Table 1** shows how the average person in the United States uses water.

Water Treatment Most water must be treated to make it **potable,** or safe to drink. Water treatment removes elements such as mercury, arsenic, and lead, which are poisonous to humans even in low concentrations. These elements are found in polluted water, but they can also occur naturally in groundwater. Water treatment also removes **pathogens,** which are organisms that cause illness or disease. Bacteria, viruses, protozoa, and parasitic worms are common pathogens. Pathogens are found in water contaminated by sewage or animal feces. There are several methods of treating water to make it potable. **Figure 6** shows a common drinking water treatment method that includes both physical and chemical treatment.

Table 1 ▼

Daily Water Use in the United States (per Person)

Use	Water (L)
Lawn watering and pools	95
Toilet flushing	90
Bathing	70
Brushing teeth*	10
Cleaning (inside and outside)	20
Cooking and drinking	10
Other	5

*with water running
Source: U.S. Environmental Protection Agency.

Figure 6 ▶ Drinking-Water Treatment

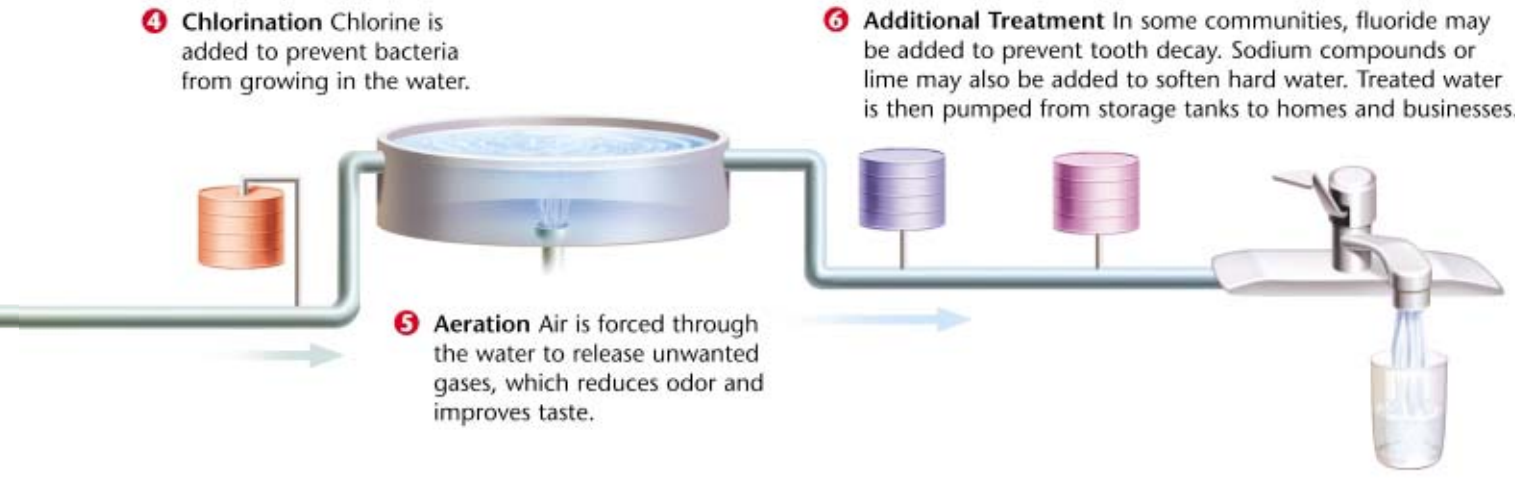


Figure 7 ▶ Water is a very important industrial resource. These nuclear power plant cooling towers release the steam produced from water used to cool a nuclear reactor.

Industrial Water Use

Industry accounts for 19 percent of water used in the world. Water is used to manufacture goods, to dispose of waste, and to generate power. The amount of water needed to manufacture everyday items can be astounding. For instance, nearly 1,000 L of water are needed to produce 1 kg of aluminum, and almost 500,000 L of water are needed to manufacture a car. Vast amounts of water are required to produce computer chips and semiconductors.

Most of the water that is used in industry is used to cool power plants. **Figure 7** shows water being released as steam from nuclear power plant cooling towers. Power-plant cooling systems usually pump water from a surface water source such as a river or lake, carry the water through pipes in a cooling tower, and then pump the water back into the source. The water that is returned is usually warmer than the source, but it is generally clean and can be used again.

Agricultural Water Use

Did you know that it can take nearly 300 L (80 gal) of water to produce one ear of corn? That's as much water as an average person in the United States uses in a day! Agriculture accounts for 67 percent of the water used in the world. Plants require a lot of water to grow, and as much as 80 percent of the water used in agriculture evaporates and never reaches plant roots.

Irrigation Fertile soil is sometimes found in areas of the world that do not have abundant rainfall. In regions where rainfall is inadequate, extra water can be supplied by irrigation. **Irrigation** is a method of providing plants with water from sources other than direct precipitation. The earliest form of irrigation probably involved flooding fields with water from a nearby river.

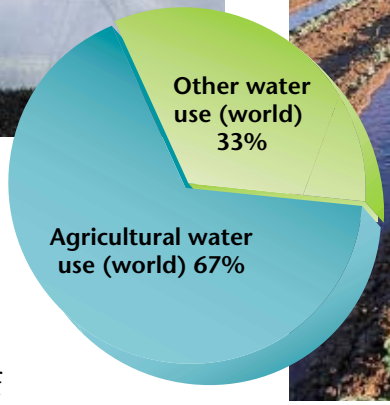


Figure 8 ▶ High-pressure overhead sprinklers (left) are inefficient because a lot of water is lost to evaporation. Water-filled ditches (above) irrigate cotton seedlings.

Many different irrigation techniques are used today. For example, some crops, such as cotton, are irrigated by shallow, water-filled ditches, as shown in **Figure 8.** In the United States, high-pressure overhead sprinklers are the most common form of irrigation. This method of irrigation is inefficient because nearly half the water evaporates and never reaches the plant roots. Irrigation systems that use water more efficiently are becoming more common.

Water Management Projects

For thousands of years, humans have altered streams and rivers to make them more useful. Nearly two thousand years ago, the Romans built aqueducts, huge canals that brought water from the mountains to the dry areas of France and Spain. One such aqueduct is shown in **Figure 9.** Some of these aqueducts are still used today. Engineering skills have improved since the time of the Romans, and water projects have become more complex.

Figure 9 ▶ This Spanish aqueduct was built almost two thousand years ago by the Romans.

People often prefer to live in areas where the natural distribution of surface water is inadequate. Water management projects, such as dams and water diversion canals, are designed to meet these needs. Water management projects can have various goals, such as bringing in water to make a dry area habitable, creating a reservoir for recreation or drinking water, or generating electric power. Water management projects have changed the American Southwest and have proved that if water can be piped in, people can live and grow crops in desert areas.

Water Diversion Projects To supply dry regions with water, all or part of a river can be diverted into canals that carry water across great distances. **Figure 10** shows a canal that diverts the Owens River in California to provide drinking water for Los Angeles. Another river, the Colorado River, is diverted to provide water for several states. The Colorado River begins as a glacial stream in the Rocky Mountains and quickly grows larger as other streams feed into it. As the river flows south, however, it is divided to meet the needs of seven western states. So much of the Colorado River's water is diverted for irrigation and drinking water in states such as Arizona, Utah, and California that the river often runs dry before it reaches Mexico and flows into the Gulf of California. In fact, the Colorado River reaches the Gulf only in the wettest years.

Dams and Reservoirs A **dam** is a structure built across a river to control the river's flow. When a river is dammed, an artificial lake, or **reservoir,** is formed behind the dam. Water from a reservoir can be used for flood control, drinking water, irrigation, recreation, and industry. Dams are also used to generate electrical energy. Hydroelectric dams use the power of flowing water to turn a turbine that generates electrical energy. About 20 percent of the world's electrical energy is generated by hydroelectric dams, such as the one shown in **Figure 11.**

Although dams provide many benefits, interrupting a river's flow can also have far-reaching consequences. When the land behind a dam is flooded, people are often displaced and entire ecosystems can be destroyed. It is estimated that 50 million people around the world have been displaced by dam projects. Dams also affect

Figure 10 ▶ This canal carries water more than 300 km across mountains and deserts to supply drinking water to Los Angeles, California.

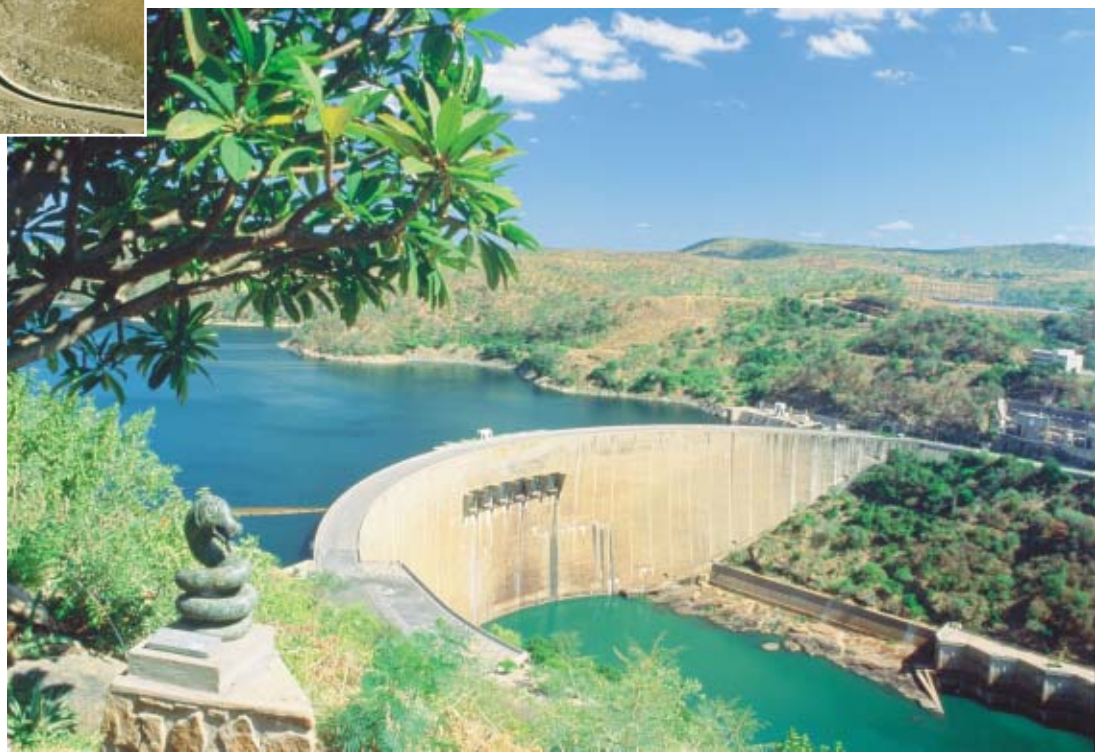


Figure 11 ▶ Dams, such as this one in Zimbabwe, are built to manage freshwater resources.

the land below them. As a river enters a reservoir, it slows down and deposits some of the sediment it carries. This fertile sediment builds up behind a dam instead of enriching the land farther down the river. As a result, the farmland below a dam may become less productive. Dam failure can be another problem—if a dam bursts, people living along the river below the dam can be killed. In the United States, the era of large dam construction is probably over. But in developing countries, such as Brazil, India, and China, the construction of large dams continues.

Water Conservation

As water sources become depleted, water becomes more expensive. This is because wells must be dug deeper, water must be piped greater distances, and polluted water must be cleaned up before it can be used. Water conservation is one way that we can help ensure that everyone will have enough water at a reasonable price.

Water Conservation in Agriculture Most of the water loss in agriculture comes from evaporation, seepage, and runoff, so technologies that reduce these problems go a long way toward conserving water. *Drip irrigation systems* offer a promising step toward conservation. Shown in **Figure 12,** drip irrigation systems deliver small amounts of water directly to plant roots by using perforated tubing. Water is released to plants as needed and at a controlled rate. These systems are sometimes managed by computer programs that coordinate watering times by using satellite data. Using precise information, a well-designed drip irrigation system loses very little water to evaporation, seepage, or runoff.

Water Conservation in Industry As water resources have become more expensive, many industries have developed water conservation plans. In industry today, the most widely used water conservation practices involve the recycling of cooling water and wastewater. Instead of discharging used water into a nearby river, businesses often recycle water and use it again. Thus, the production of 1 kg of paper now consumes less than 30 percent of the water it required 50 years ago. Small businesses are also helping conserve water. Denver, Colorado, was one of the first cities to realize the value of conserving water in business. In an innovative program, the city pays small businesses to introduce water conservation measures. The program not only saves money for the city and for businesses but also makes more water available for agricultural and residential use.

MATH PRACTICE

Israeli Agriculture

From 1950 to 1980, Israel reduced the amount of water loss in agriculture from 83 percent to 5 percent, mainly by switching from overhead sprinklers to water-saving methods such as drip irrigation. If a small farm uses 10,000 L of water a day for overhead sprinkler irrigation, how much water would be saved in one year by using a drip irrigation system that consumes 75 percent less water?

Figure 12 ▶ Drip irrigation systems use perforated tubing to deliver water directly to plant roots.

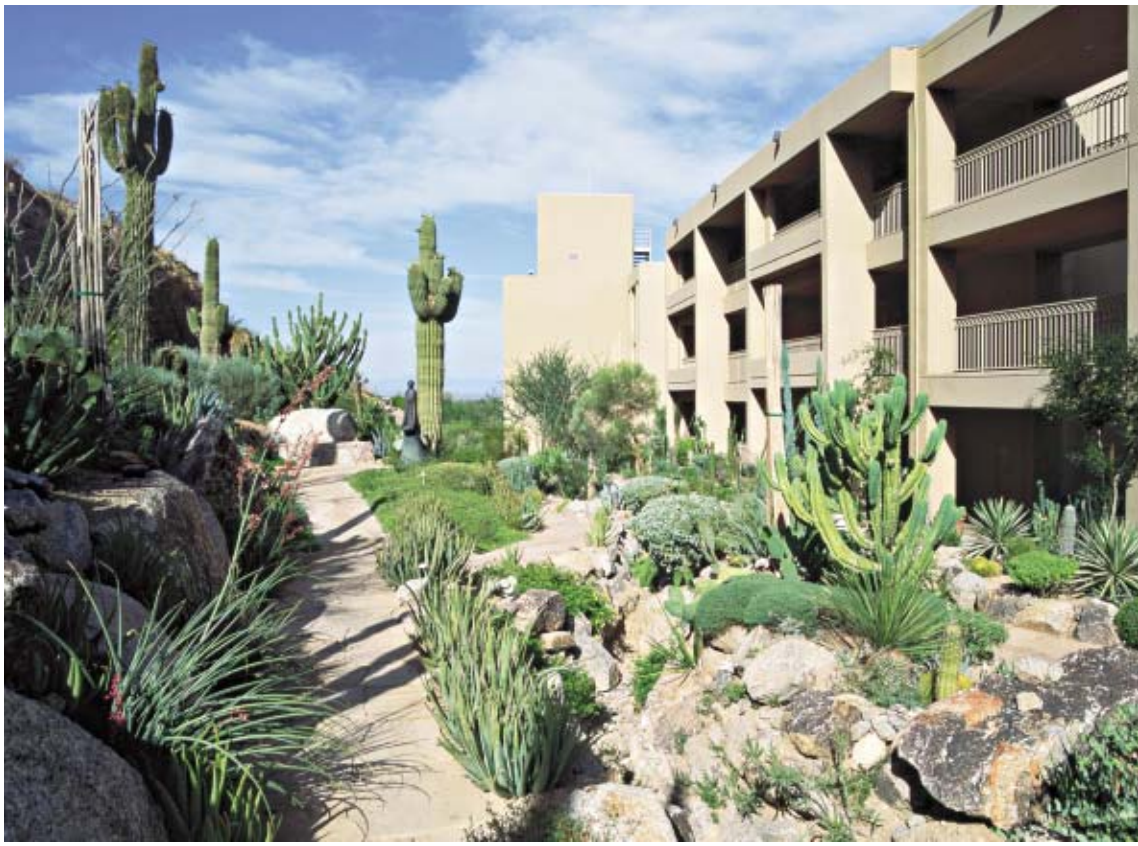


Figure 13 ▶ This xeriscaped yard in Arizona features plants that are native to the state. What kinds of plants are native to your region?

Table 2 ▼

What You Can Do to Conserve Water
• Take shorter showers, and avoid taking baths unless you keep the water level low.
• Install a low-flow shower head in your shower.
• Install inexpensive, low-flow aerators in your water faucets at home.
• Purchase a modern, low-flow toilet, install a water-saving device in your toilet, or simply place a water-filled bottle inside your toilet tank to reduce the water used for each flush.
• Do not let the water run while you are brushing your teeth.
• Fill up the sink basin rather than letting the water run when you are shaving, washing your hands or face, or washing dishes.
• Wash only full loads in your dishwasher and washing machine.
• Water your lawn sparingly.

Water Conservation at Home Although households use much less water than agriculture or industry, a few changes to residential water use will make a significant contribution to water conservation. People can conserve water by changing a few everyday habits and by using only the water that they need. Some of these conservation methods are shown in **Table 2.**

Water-saving technology, such as low-flow toilets and shower heads, can also help reduce household water use. These devices are required in some new buildings. Many cities will also pay residents to install water-saving equipment in older buildings.

About one-third of the water used by the average household in the United States is used for landscaping. To conserve water, many people water their lawns at night to reduce the amount of water lost to evaporation. Another way people save water used outside their home is a technique called *xeriscaping* (ZIR i SKAY ping). Xeriscaping involves designing a landscape that requires minimal water use. **Figure 13** shows one example of xeriscaping in Arizona.

Can one person make a difference? When you multiply one by the millions of people who are trying to conserve water—in industry, on farms, and at home—you can make a big difference.

Solutions for the Future

In some places, conservation alone is not enough to prevent water shortages, and as populations grow, other sources of fresh water need to be developed. Two possible solutions are desalination and transporting fresh water.

Desalination Some coastal communities rely on the oceans to provide fresh water. **Desalination** (DEE SAL uh NAY shuhn) is the process of removing salt from salt water. Some countries in drier parts of the world, such as the Middle East, have built desalination plants to provide fresh water. Most desalination plants heat salt water and collect the fresh water that evaporates. **Figure 14** shows one such plant in Kuwait. Because desalination consumes a lot of energy, the process is too expensive for many nations to consider.

Transporting Water In some areas of the world where freshwater resources are not adequate, water can be transported from other regions. For example, the increasing number of tourists visiting some Greek islands in the Mediterranean Sea have taxed the islands' freshwater supply. As a result, ships travel regularly from the mainland towing enormous plastic bags full of fresh water. The ships anchor in port, and fresh water is then pumped onto the islands. This solution is also being considered in the United States, where almost half of the available fresh water is in Alaska. Scientists are exploring the possibility of filling huge bags with water from Alaskan rivers and then towing the bags down the coast to California, where fresh water is often in short supply.

Because 76 percent of the Earth's fresh water is frozen in icecaps, icebergs are another potential freshwater source. For years, people have considered towing icebergs to communities that lack fresh water. But an efficient way to tow icebergs is yet to be discovered.

Figure 14 ▶ Most desalination plants, such as this one in Kuwait, use evaporation to separate ocean water from the salt it contains.

SECTION 2 Review

1. **Describe** the patterns of global water use for each continent shown in the bar graph in Figure 5.
2. **Describe** the drinking water treatment process in your own words.
3. **Describe** the benefits and costs of dams and water diversion projects.
4. **List** some things you can do to help conserve the world's water supply. Give at least three examples.

CRITICAL THINKING

5. **Making Comparisons** Write a description of the evaporative method of desalination using terms from the water cycle. WRITING SKILLS
6. **Identifying Alternatives** Describe three ways that communities can increase their freshwater resources.