

11.0

Monitoring water systems is critical for maintaining water supply and quality.



The sedimentation tanks are part of the the wastewater treatment plant in Canadian cities and towns.



What You Will Learn

In this chapter, you will:

- explain how natural events and human activities can change the water table and affect our water supply
- explain the stages involved in processing drinking water and treating waste water
- design and build a water filter and test its efficiency
- analyze a local water issue and develop a plan of action

Skills You Will Use

In this chapter, you will:

- follow established safety procedures when using apparatus
- design, build, and test a water filtration device
- test water samples for a variety of chemical characteristics

Why This Is Important

Regularly monitoring our water systems enables us to ensure that our water is clean and safe to drink now and in the future.

Before Reading

Thinking Literacy

Asking Questions

Science inspires readers to be curious. Think about the title for Chapter 11. Then, use the 5Ws and “How” to turn parts of the title into questions. For each question, indicate whether the answer would require the reader to (1) have a fact or knowledge or (2) form an opinion or make an evaluation.

Key Terms

- chlorine
- recharge
- discharge
- contaminants
- septic tank

11.0 Getting Started



Figure 11.1 This kind of *Escherichia coli* bacterium can make us very ill if it is in our food or our water (magnification of 50 000×).

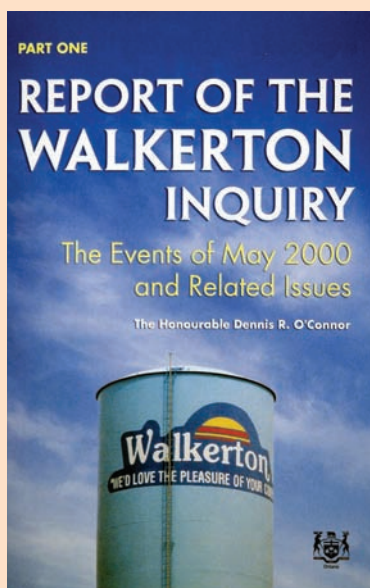


Figure 11.2 The tragedy in Walkerton, Ontario, reminded everyone about the serious consequences of unsafe drinking water.

You read in Chapter 10 that whatever happens in one part of a watershed can influence its other parts, affecting the health of forests, wildlife, and people. In May 2000, the people of Walkerton, Ontario, learned this first-hand (Figure 11.2).

Walkerton is a rural community of about 5000 people near the city of Owen Sound. Three large wells supply drinking water to the people living there. In the spring of 2000, the drinking water in one of the wells became contaminated because three things happened at the same time.

- A normal farming activity (spreading cow manure on a field as fertilizer) resulted in bacteria seeping into the ground and washing into the well water.
- The amount of chlorine usually added to treat the water in the well was not being monitored. **Chlorine** is a chemical used to disinfect (meaning kill organisms in) water. If enough chlorine had been added to the well water, the bacteria would have been killed.
- Testing and reporting of the well's water quality was not being done properly.

As a result of these three things, the residents of the area who drank this contaminated, improperly chlorinated water became ill. Seven people died and more than 2000 others became ill.

As you may recall from previous studies, bacteria exist all around us. Some can harm humans. The bacterium that contaminated the Walkerton well water is called *Escherichia coli* O157:H7 (Figure 11.1). This is the same bacterium that can be found in uncooked ground beef. There are many, many other kinds of *Escherichia coli* (*E. coli* for short), but not all are harmful. *E. coli* bacteria are found in the intestines of mammals. A lot of them are present in your intestines right now, helping to keep them functioning normally. The O157:H7 kind, however, can make us very ill or even kill us. Cows, on the other hand, are not affected by it. *E. coli* O157:H7 can live in a cow's intestines and a farmer would not know it.

The sad story of Walkerton's contaminated water supply reminds us of the importance of checking to see that our drinking water is safe. Even water that looks clear and clean may contain harmful bacteria and other microorganisms that are invisible except under a microscope. For this reason and many others, it is critical that our water systems be monitored.

WORDS MATTER

A bacterium is a type of micro-organism. The plural of bacterium is bacteria.

D20 Quick Lab

Dissecting a Water Filtering Device – Teacher Demonstration

Many people use small purchased water filtering devices in their homes. These are designed to filter out some heavy metals that might get into tap water from old pipes. Your teacher will cut a filter apart so that you can see what is inside.

Materials & Equipment

- 1 water filter
- hacksaw

CAUTION: The hacksaw blade is very sharp. Use the saw with care.

Procedure

1. Watch as your teacher opens up the side of the water filter.

Questions

2. Draw a diagram of the cross-section of the opened water filter.
3. What is the filter capable of removing from the water?

Natural and Human Factors Affecting Our Water Supply

Here is a summary of what you will learn in this section:

- Natural occurrences such as flooding, droughts, and earthquakes can cause changes in the height of the water table.
- Overuse of wells has the potential to alter groundwater supplies permanently.
- How much water we take from our environment and how we alter it before disposing of it can affect both the supply and the quality of water.

Imagine that you have a large rain barrel filled with water. Every time you need to use water outside, it must come from the barrel. That includes watering plants and washing the car. The barrel can only recharge after a rainfall. **Recharge** means refill. Therefore, if you were to use water faster than the supply in the barrel could recharge, you would soon run out.

Like the rain barrel, a watershed receives only a certain amount of water each year. That water recharges above-ground reservoirs, such as rivers and lakes, and underground reservoirs, such as aquifers. Because most of the fresh water in Canada lies below the surface, we need to pay attention to natural and human factors that can affect our groundwater supply.

D21 Starting Point

Skills **P** **C**



Nature and the Water Table

Draw a three-column K-W-L chart.

- In the first column, write down three statements that you know about nature's water table. At the top of the column, put K ("What I know").
- In the second column, write down three questions that you would like to have answered about the water table. At the top of the column, put W ("What I want to learn").
- As you are studying this section, fill in the third column with statements describing what you learned about the water table. At the top of the column, put L ("What I learned").

The Rising and Falling Water Table

The rain barrel described earlier is a lot like a watershed. If more water leaves a watershed than enters it, a shortage will result. The usual water levels in lakes and rivers will start to drop. Below ground, the level of the water table will drop as the amount of ground water decreases (Figure 11.3).

On the other hand, if more water fills a watershed than can leave it, a different problem occurs. When it rains, water soaks into the ground, filling up the layers of soil and aquifers. If the rain continues, the top of the water table will rise closer to the ground's surface. In low-lying areas, this means that the water table might reach the surface and lead to flooding (Figure 11.4). Flooding may not only damage property but also cause drinking water to become contaminated. For example, when flooding occurs in saltwater areas, the water table may become contaminated with salt, making it unsuitable for drinking.

Both natural factors and human activities can affect our water supply by changing the water table. The result can be a scarcity of water for consumption or too much water, which can lead to flooding and possibly contamination.

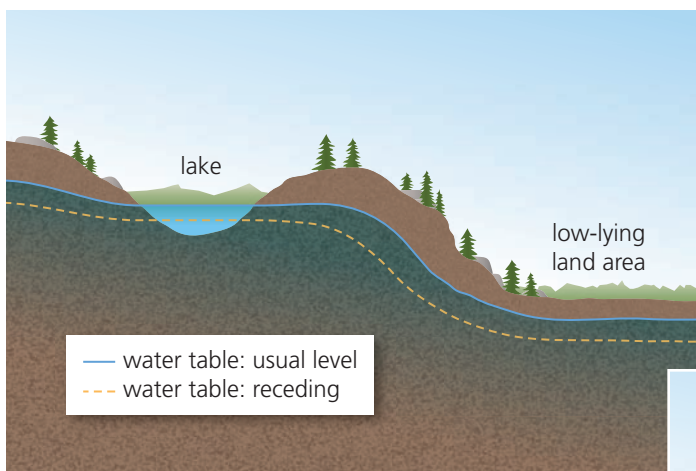


Figure 11.3 The results of a falling water table

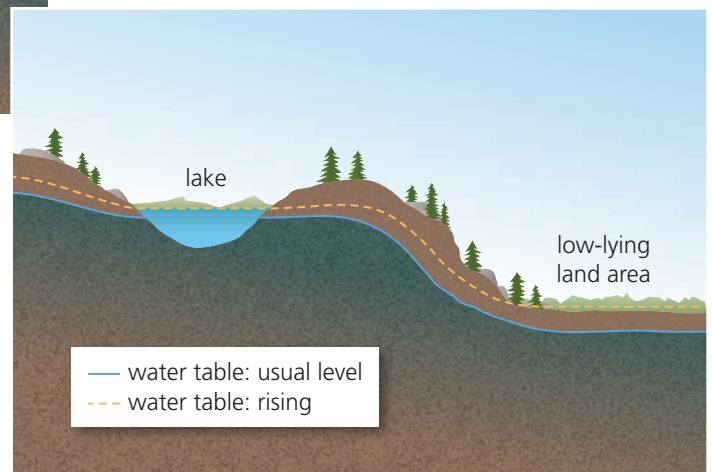


Figure 11.4 The results of a rising water table



Figure 11.5 Many streets and basements filled with water during the 2004 flood in Peterborough, Ontario

Natural Water Table Changes

On July 15, 2004, Peterborough, Ontario, received 200 mm of rain (Figure 11.5).

Basements flooded and waste water backed up in pipes. People with drilled wells were told to boil their drinking water. Floods are natural occurrences within a watershed.

As water cycles from water bodies to the atmosphere and back again, water levels naturally rise and fall. Droughts and earthquakes are other natural occurrences that affect water supply.

Flooding

Flooding can be brought on by heavy rainfall, ice-jams, sudden spring thaws, and storms. Flash floods are floods that come without much warning. They are caused by heavy, concentrated rainfall such as the kind you would see during a thunderstorm. The rain flows rapidly across bare ground and paved surfaces, causing the water level in storm drains to rise, overflow, and back up. Surface flooding then occurs.

Drought

Canada's Prairies have been experiencing drought conditions in recent years. Droughts are long periods of little or no precipitation. The result is that a watershed gradually starts to lose water. Lakes and rivers may experience falling water levels. As less ground water collects, the upper surface of the water table gradually drops. Communities must restrict water use during these drought periods.

Earthquakes

Although earthquakes are not that common in central Canada, they can affect the water table directly. In earthquake-prone areas of the world, scientists have noticed a drop in the water table by as much as 1 m after a quake. This affects the ability of wells to draw water. Such a disruption in the water table can also cause ground water to become cloudy, affecting its potability.

Suggested Activity • • • • •

D23 Problem-Solving Activity
on page 315



Your Water Table K-W-L Chart

Referring to the reading that you have just completed on natural water table changes, add two sentences about what you learned to the third column (column L) in your K-W-L chart.

Human Causes of Water Table Changes

Human activities can also affect the water supply. For example, flooding may occur if a dam or other human-made water reservoir collapses. Most often, however, it is our overuse or misuse of water that hurts the supply.

Overuse of Wells

More than 25 percent of Canadians rely on ground water for their water needs. Most of these users live in rural areas. As you read in Chapter 10, wells are drilled into aquifers to obtain the water (Figure 11.6).

The water cycle naturally recharges our groundwater supply. An unusually dry summer or a winter with little snow results in less water sinking into the ground and collecting in aquifers. Because we cannot do anything about a dry cycle in nature, it is important that users of wells be aware of the reduced precipitation and draw less water from the ground. Overuse of wells can deplete underground aquifers, often for long periods.

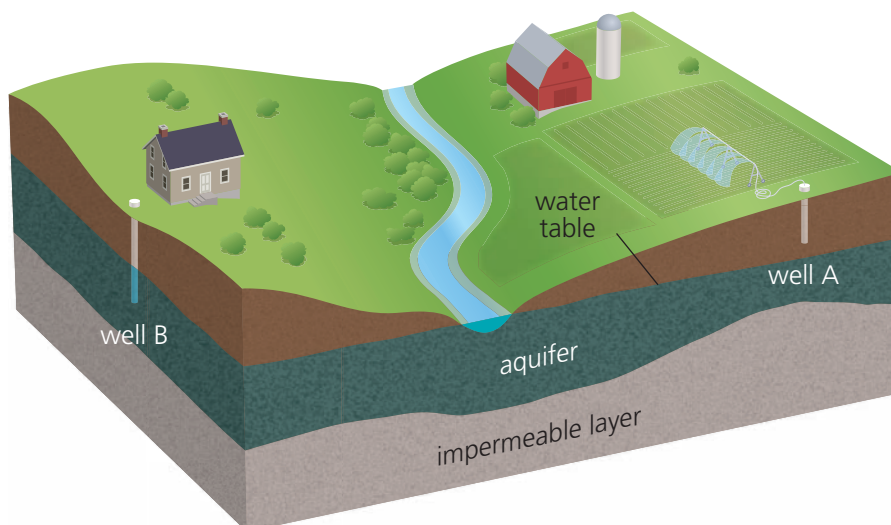


Figure 11.6 This cross-section of ground shows two wells. Well A has run dry because the depth of the water table has fallen below it. Well B is continuing to produce water because the well still reaches the aquifer.

Farming and Industry Practices

Many large-scale farms and industries need immense quantities of water in their operations. That is one reason why many

industrial plants are located beside a river or lake. After the water is used, it is discharged back into the environment. **Discharge** means to release or pour out. The used water may be discharged directly into a water body, the atmosphere, a wastewater drainage system, or a ground filtration system. Often, the water that is put back is not as clean as it was when it was taken out of the environment. Also, sometimes less water is put back into the natural system than was removed.

Examples of large-scale water use include crop irrigation, power generation other than hydroelectric (Figure 11.7), and industries such as pulp and paper production and mining. The oil sands development in northern Alberta's Athabasca River basin is of particular concern because of the enormous effect it is having on the supply and quality of fresh water in the region (Figure 11.8).



Figure 11.7 Producing electricity in nuclear power plants, such as this one at Pickering, Ontario, uses a great deal of water.



Figure 11.8 The mining and petroleum industries use large volumes of water. In Alberta's Athabasca River basin, hot water is used to separate the oil from the oil sands deposits.

Water Diversion and Export

The bottled water industry also removes large quantities of water from our water supply. The majority of Canada's bottled water industries are in Ontario, Quebec, and British Columbia. Millions of litres of water are removed from a variety of sources, including springs, municipal water treatment systems, aquifers, and glaciers. If more water is removed than replaced, the height of the water table will be affected. Also, water may be pumped out of one location and shipped to another province or country. When this happens, the water is not returned to the watershed from where it was extracted.

- Identifying possible solutions
- Designing, building, and testing

Clearing Muddy Waters

Recognize a Need

Events such as flooding can cause soil to dirty well water. The first step in bringing this water back to a usable condition is to filter out the soil. In this activity, you will design, build, and test a device for filtering soil sediment out of water.

Problem

What is the best way to filter muddy water?

Materials & Equipment

- one 2-L plastic pop bottle
- scissors
- 1 L muddied water (from your teacher)
- coarse, dry sand
- cotton balls
- 2 sheets of paper towel
- approximately 250 mL of pebble-sized gravel

Criteria for Success

Your water filter must:

- allow at least 250 mL of the muddy water to pass through it without clogging up.
- remove enough of the soil particles so that the water that has passed through the filter is noticeably clearer.

Brainstorm Ideas

With a partner, discuss how you might use the materials provided to create a filter. In a design brief, write down all your ideas.

Make a Drawing and Build a Prototype

1. Decide on the best idea for your filter. Make a drawing first of the outside of your filter structure and then of the inside of the filter, showing the layers.
2. Build your water filter.

Test and Evaluate

3. Obtain the sample of muddy water from your teacher. Test your filter by *slowly* pouring the muddy water into the filter.
4. Observe what happens to the water as it passes through the filter layers. Record your observations on your design brief.
5. Suggest one improvement that you could make to the water filter you designed.

Communicate

6. Present your results to the class, including how they met the two design criteria set out.
7. How did the construction of your filter compare with that of other groups in your class? Which group's filter removed more of the soil particles than other filters did? Why?
8. As water moves through the ground layers on Earth, it is naturally filtered. How does your water filter compare with Earth's natural water filter in cleaning our ground water?
9. Think back to what you learned about the Walkerton tragedy at the start of this chapter. Even though you have removed soil from the muddy water, is it safe to drink? Explain your answer.



Figure 11.9 The design materials

Key Concept Review

1. Why does heavy rainfall sometimes result in flooding?
2. (a) Name two large user groups of our freshwater supplies.
(b) Explain how each group's actions can affect our water supply.
3. Describe two ways in which humans have negatively affected ground water.

Connect Your Understanding

4. A bottled water company wants to set up a plant in your community. What are two concerns that your community might have?
5. Flood water can be contaminated with chemicals, salt, and unsafe levels of microorganisms. Explain why this should be a concern to the people in the community.

Practise Your Skills

The table below contains data on some historical floods in Canada. Use the information to answer question 6.

Date	Location	Cause	Estimated Property Damage (year 2000 dollars)
Sept. 1999	Maritime provinces	Heavy rainfall (Tropical Storm Harvey and Hurricane Gert)	\$12.0 million
April 1999	Melita, MB	Flooding of Souris River	\$103.0 million
May 1997	Manitoba	Flooding of Red River and Assiniboine River valleys	\$815.0 million
July 1996	Québec	Flooding of Saguenay River valley	\$1.5 billion
May & June 1974	Québec	Excessive snow melt and higher-than-normal rainfall	\$359.0 million
Oct. 1954	Toronto area, ON	Heavy rainfall (Hurricane Hazel)	\$1.0 billion

6. Create a graph to display the property damage figures for the flood events shown in the table.

For more questions, go to ScienceSource.



D24 Thinking about Science, Society, and the Environment



Competing for Water Use

Most golf courses require large amounts of water to keep their fairways green. In communities where the supply of fresh water is already at low levels, some groups have argued that using a limited natural resource for a recreational activity should not be allowed. What do you think about this? Should recreational businesses have the same access to water resources as industries, farm operations, and public facilities such as hospitals do?

What to Do

1. Discuss the issue as a class. Make a list of the social, economic, and environmental consequences of both sides of the argument.
2. Think of what actions could be taken to help resolve the concerns on both sides.

11.2

Obtaining Water Quality

Here is a summary of what you will learn in this section:

- Water quality can be affected by physical, biological, or chemical contaminants.
- We obtain the water we need from underground and aboveground sources.
- Water that is removed from our water systems must be treated and tested before it is safe to drink.

You have learned how important having a steady supply of water is to us and to our environment. Just as important is the quality of our water systems, because they provide us with drinking water. Our drinking water must be clean and free from harmful organisms and chemical substances (Figure 11.10). To ensure that it is, we treat it.

We have a responsibility not to take our treated water for granted. More than one billion people in the world do not have access to clean drinking water. Many developing countries cannot afford to build facilities to treat or test drinking water. People wash and drink directly from the same river water where human and animal wastes have been discharged. Illnesses caused by contaminated water kill thousands of people in these countries every year.



Figure 11.10 The water we drink and even the water we play in needs to be clean and free from harmful chemicals and from organisms that can cause disease.

D25 *Starting Point*

Skills **A** **C**



How Much Do You Know about Your Drinking Water?

Answer the following questions orally with a partner to determine how much you know about the water you drink.

1. What is the source of the drinking water (for example, the name of a lake or river) in your home?
2. Is your drinking water chlorinated?
3. What water storage facilities (for example, water tower) exist in your community, and where are they located?



(a) *Cryptosporidium parvum*
(greatly magnified)



(b) Chemical pesticides



(c) Visible sediment (on the left)

Figure 11.11 Examples of water contaminants: (a) biological, (b) chemical, and (c) physical

Factors Affecting Water Quality

The water that flows into your sink or bathtub has flowed through your local watershed. Therefore, whatever human activities or natural events affect the water systems in your watershed will affect the water that reaches your home.

You might think that a factory 50 km away that discharges harmful chemicals into a nearby river has nothing to do with you or with your community's health. Yet, the factory's actions do affect you because that river is likely part of your watershed. The same is true if home gardeners and golf course operators near you are using harmful chemicals that can seep into the water system. All of these actions are connected to you because they all have the potential to contaminate your community's water supply. **Contaminants** are contents that are harmful to humans, other animals, and the environment.

The contents of water are typically categorized into three types:

- biological: both visible (such as zebra mussels) and microscopic organisms (such as bacteria and viruses)
- chemical: dissolved substances that come from natural processes (such as dissolving limestone) or human activity (such as dissolved road salt)
- physical: all materials that do not dissolve in water (such as animal waste and plant debris)

Not everything that water contains is harmful. Figure 11.11, however, shows examples of contents that are. When water is removed from the environment for drinking, it must be treated and then tested to ensure that contaminants do not harm our health.

Treating Groundwater Sources

For the many Canadians who get their water from a well, the water is usually filtered before drinking to remove contaminants. The water must also be tested regularly to ensure that it is safe to drink. Samples of the water can be sent to laboratories for testing.

Canada has some very large aquifers that supply ground water to industry and municipalities. One such aquifer in the Kitchener-Waterloo area of Ontario provides much of that region's water.

Treating Aboveground Water Sources

We generally cannot drink the water as it exists in our freshwater systems. As you have learned, water in our streams, rivers, and lakes can contain harmful organisms and substances that can be hazardous to our health. The water from aboveground water sources needs to be treated before it becomes drinking water. Boiling water before drinking it will kill harmful organisms, but it will not remove chemical or physical contaminants.

Most Canadians obtain their drinking water from a lake, river, or reservoir. The water is treated and distributed by the town or city where they live so that it is safe to drink. The type and amount of treatment the water receives depends on the condition of the water at its source. Polluted sources require more treatment than cleaner sources. Water treatment is very expensive, however. This is another reason to keep our water supply clean.

The Water Treatment Plant

Imagine standing on a steel floor grid with water churning and bubbling beneath your feet. Behind you is the lake where the water came from. In that lake, at least 0.5 km from shore, is the opening of the intake pipe that brings the water to this building, a water treatment plant (Figure 11.12).

A first stage in the treatment process is to pass the raw water through extremely fine membrane filters to remove contaminants. The filters are so fine that they can remove an organism called *Giardia*, which causes an illness called “beaver fever.” *Giardia* is a microscopic parasite often found in the feces of beavers and other animals. If it gets into drinking water, it can make people very ill.



Figure 11.12 Inside a water treatment plant, you would see a complicated system of pipes and controls such as the ones shown here.

Most of us in Canada rely on a water treatment facility such as this to purify our water so that it is safe to drink. Not all cities use the same treatment method. Figure 11.13 shows the basic treatment stages that are typically followed.

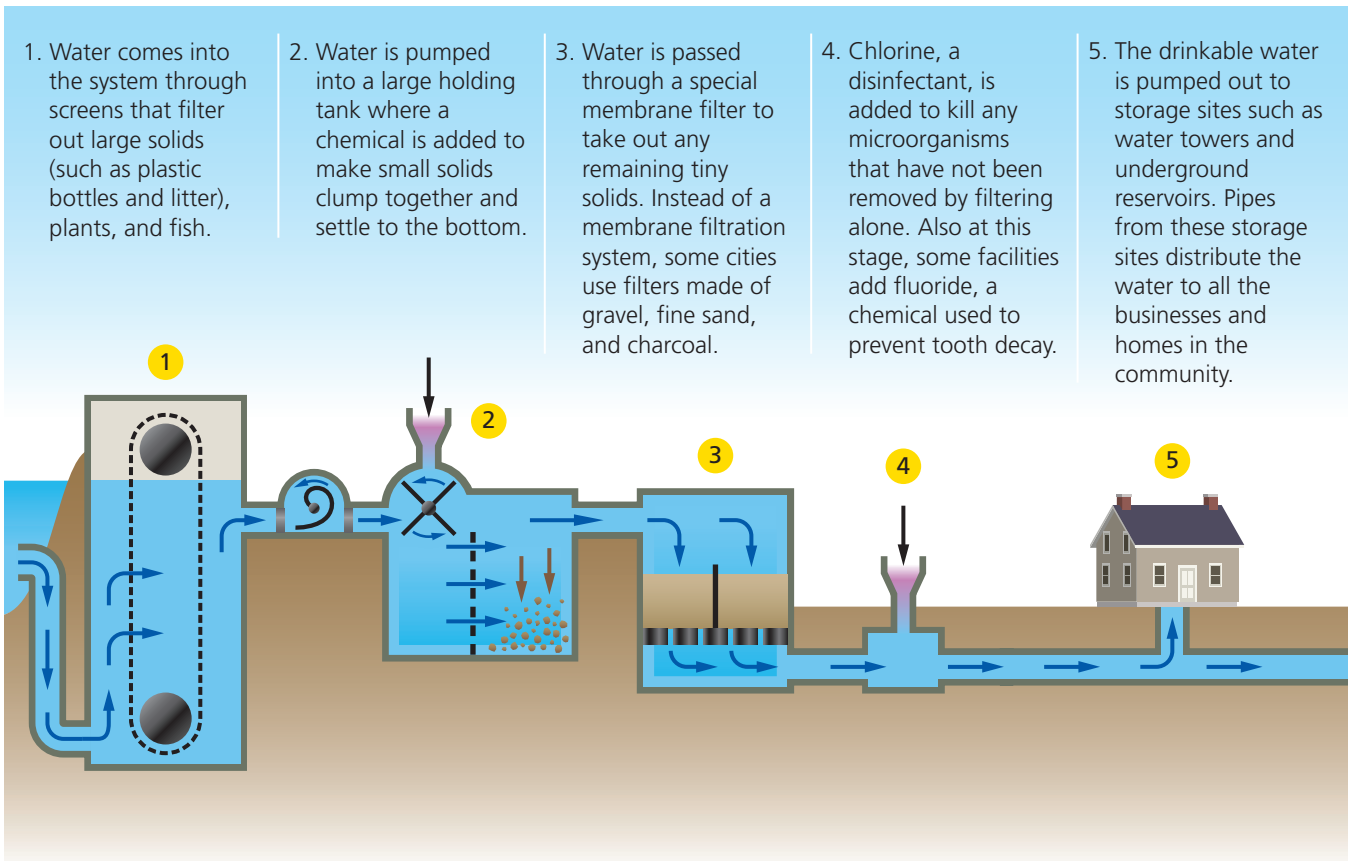


Figure 11.13 The basic stages in the water treatment process

Water treatment plants are very sophisticated and expensive facilities. They use a computerized system of checks, rechecks, monitors, and alarms to ensure that no step in the treatment process fails. Samples are tested often to show that everything is working properly and that the finished water does not have harmful concentrations of such things as bacteria and a broad range of chemicals. The people who monitor the system are highly trained to recognize problems immediately.



The Water You Drink

1. Give one reason why it is important to keep our supply of drinking water clean.
2. What causes “beaver fever,” and how is water treated to prevent this illness?
3. Why is chlorine sometimes added in the water treatment process?

Testing Water Quality

In past centuries, before technology such as the microscope was invented, no one knew why people could sometimes become ill or die from drinking water. Today, we have the knowledge and the equipment to detect microscopic contaminants even after the water is treated so that we can be sure it is truly safe to use.

Water samples from treatment plants are sent to scientists in laboratories to test. In larger communities, the tests might be done inside the water treatment plant itself. Biological, chemical, and physical tests are performed (Figure 11.14).

Drinking water samples are also taken from sites that receive the processed water, such as hospitals and schools. If an abnormal test result is obtained, the cause is investigated. Sometimes the pipes that transport the water may have caused the problem. Action is always taken immediately to repair any problems found.

In addition to biological testing for the presence of harmful bacteria, our drinking water is tested for harmful chemical substances (such as lead and nitrates) and radioactive matter. Test results are compared with government standards for safe limits. Contamination that is above the acceptable standards means that the water must not be consumed.

Suggested Activity •••••

D27 Inquiry Activity on page 322



Figure 11.14 This microbiologist is analyzing a drinking water sample.

D27 Inquiry Activity**Toolkit 2****SKILLS YOU WILL USE**

- Measuring
- Drawing conclusions


Be a Water Quality Inspector

In this activity, you will measure the pH and salt and chlorine content of four sources of water.

Question

Which water sample will have the highest and which will have the lowest values for each test?

Materials & Equipment

- a chart for recording test results
- water-soluble marking pen
- 4 water samples to test, collected in clean 250-mL containers: tap water, rain water, bottled water, and water from a river, stream, or pond
- pH test strips
- clock or watch that reads seconds
- 4 microscope slides
- four 1-mL dropper pipettes
- light source
- 4 test tubes
- silver nitrate (1 percent weight per volume solution) in a dropper bottle 

CAUTION: Do not taste any of the water samples. Follow your teacher's instructions for handling and disposing of chemicals.

Hypothesis

Write a separate hypothesis for each of the three tests you will perform. Refer to all four water samples.

Procedure**Part 1 — Measuring pH**

1. Put a separate pH test strip into each sample of water for about 10 s. Remove the test strip and wait 1 min.
2. Note the colour change (the pH value) and compare it with the values shown on the test kit. Write the pH value in your chart.

Part 2 — Measuring Salt Content

3. Put a clean pipette into each water sample and leave it there for the remainder of the tests.
4. With the marking pen, label each microscope slide with one of the four water sources. With the pipette, drop 1 mL of each water sample onto its labelled slide. Place the slides under the light until they dry.
5. Examine each slide for salt residue and record your observations.

Part 3 — Measuring Chlorine Content

6. Label each test tube with one of the four water sources. With the pipette, drop 5 mL of each water sample into its labelled test tube.
7. Add four drops of silver nitrate solution to each tube.
8. Examine each tube for a change and record your observations.

Analyzing and Interpreting

9. Compare your test results with your hypotheses. Did any result surprise you? If so, which one?
10. For each water sample, explain the results that you observed for pH, salt, and chlorine.

Skill Builder

11. Why must you add the same amount of silver nitrate to the same amount of each water sample tested?

Forming Conclusions

12. (a) Would you ever expect to find salt in rainwater? Explain your answer.
(b) What could be a source of salt in a pond water sample?

Key Concept Review

1. Name four sources of drinking water for Canadians.
2. Explain what is meant by the term “water treatment.”
3. (a) How are the contents of water categorized?
(b) When are those contents of concern to scientists who test our drinking water?

Connect Your Understanding

4. You have learned from previous studies of water that it is an excellent solvent. Explain how this property of water contributes to drinking-water contamination.

Practise Your Skills

5. For each item in the list below, indicate whether it should be classified as a biological, chemical, or physical contaminant of a freshwater system. Explain your decision.
 - (a) dissolved fertilizer from a riverfront golf course
 - (b) spill of gasoline while refuelling a motorboat
 - (c) lawn clippings from storm drain run-off
 - (d) dog waste washed into the lake from a nearby campsite
 - (e) smoke from a smokestack in an industrial plant
 - (f) chlorine bleach used in household laundry

For more questions, go to ScienceSource.



D28 Thinking about Science, Society, and the Environment



Down the Drain

Many people are unaware of what gets poured down the drains in their home or school. When cleaning products, laundry detergents, medicines, hair dye, and many other products are disposed of in this way, it is easy to think they have just disappeared. This is not the case, of course. The products flow into septic tanks or wastewater pipes. Regardless of treatment, the risk of our water supply becoming contaminated is always a concern.

What to Do

1. For the next week, keep a small notebook in the kitchen of your home. Every day,

record all the things that you and other family members wash down the drains in your house. (You do not need to record food items or human waste.)

2. At the end of the week, analyze your results. If you have questions about the contents of certain products, do some research to find answers. Begin at ScienceSource.
3. Propose a plan of action that would enable your family to improve the quality of the water disposed of down the drains in your home.



Here is a summary of what you will learn in this section:

- How we dispose of our waste water affects the quality of our water systems.
- Protecting our water systems is important to maintaining safe drinking water sources.



Figure 11.15 All of the waste water in your home goes into an underground collection system of pipes.

When we turn on a tap to get water, we usually give little thought to where the water is coming from. The same holds true when we flush a toilet. We are fortunate to be able to do this. Most of us in Canada obtain water from a municipal water supply like the one you just read about in section 11.2.

Municipalities also manage the removal of waste water. The sink drains and toilets in urban homes and businesses are connected to a pipe. The pipe joins a large system of underground pipes (Figure 11.15). Pumping stations send all that waste water to a treatment plant, where chemical contaminants and harmful microorganisms are removed. After that, the water is discharged to a nearby stream, river, lake, or ocean.

Treating our waste water is part of an overall plan to manage our water systems and keep them healthy.

D29 Starting Point

Skills **A** **C**



How Much Do You Know about Waste Water?

Answer the following questions orally with a partner to determine how much you know about the waste water that leaves your home.

1. Where does the waste water in your home go? If it goes to a treatment plant, where is the plant located?
2. What body of water receives the treated waste water that leaves the plant?

Treating Waste Water

Every day, we get rid of water that we have finished using or that we no longer need. Water is emptied down the drains in our homes and businesses and flushed down the toilet. With it go substances such as soap, food residue, human waste material, rags, and anything else that can accidentally or intentionally get flushed into the system.

If we were to put this waste water directly back into our rivers and lakes, we would be contaminating our drinking water supply and the water used by other animals. We therefore treat our waste water before letting it re-enter the natural environment. Several treatment methods exist. They are described below.

Septic Systems

The rural home that gets its drinking water from a well probably disposes of its waste water in a **septic system**. A septic system is a self-contained wastewater treatment facility. Waste water from all indoor sources such as toilets, sinks, and bathtubs enters the **septic tank**. Immediately, bacteria in the tank begin to break down the waste (Figure 11.16). Solid material settles to the bottom. Lighter materials such as kitchen grease float to the surface. The liquid layer in between flows into pipes that lead out from the tank. This waste water contains organic matter and nutrients such as nitrogen.

The pipes leading from the septic tank are perforated on the bottom. This means they have small holes that allow the water to seep into the soil. Once the water is in the soil, more bacteria digest and break down the organic waste. Eventually the liquid returns to the groundwater supply.

WORDS MATTER

The word septic comes from a Greek word meaning to putrefy (decay).

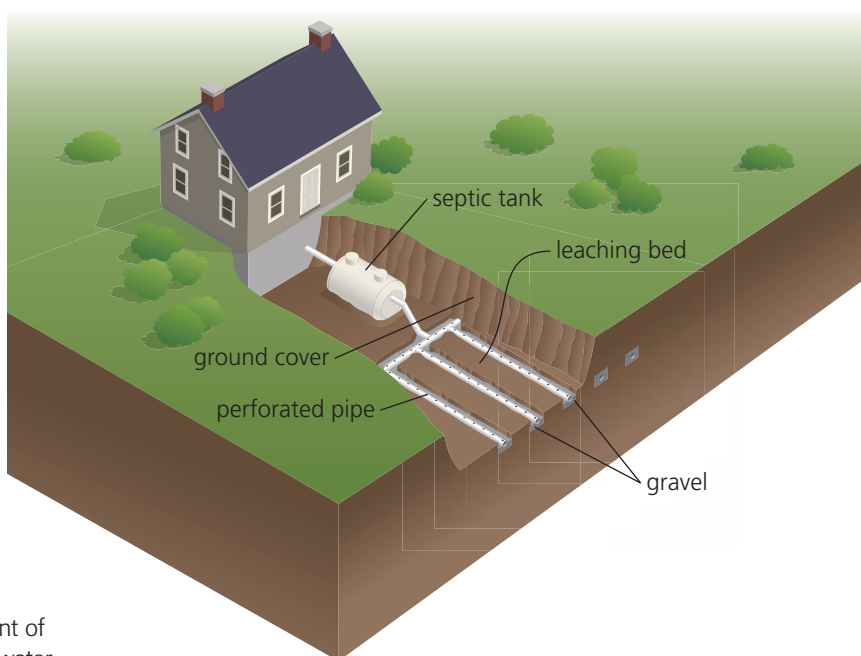


Figure 11.16 A septic system. About 25 percent of Canadians use this method to treat their waste water.



Figure 11.17 Instead of making expensive renovations to enlarge its existing treatment system, the Kortright Conservation Centre in Kleinburg, Ontario, constructed a wetland to treat its waste water.

Wetland Technology

A wetland, such as a marsh or swamp, is land that is saturated with water for long periods of time. Water-loving plants that grow in wetlands can filter and purify water. Scientists have combined knowledge of the filtering ability of natural wetlands with human technology to construct wetlands for wastewater treatment. Many smaller communities and businesses use this enhanced natural method. Some of these human-made wetlands even look like natural marshes (Figure 11.17). Just as they do in a natural setting, the plants and microorganisms in a human-designed wetland remove and recycle nutrients. Roots and soil filter out contaminants.

The Wastewater Treatment Plant

If someone asked you to name the most expensive facility in your community, you might answer that it is the new sports complex and ice arena, or the performing arts centre with the up-to-date acoustics. It is unlikely that either of those answers is correct. The most expensive facility in any community is usually the wastewater treatment plant. It costs millions of dollars to construct. For example, for a city with a population of about 50 000, a wastewater treatment facility may cost over \$40 million to build and maintain.

The treatment of our waste water involves the physical plant and the network of underground pipes that gets the waste to the plant. Figure 11.18 shows the route waste water takes from your home before being released back into the natural environment.

D30 Learning Checkpoint



Treating Waste Water

1. What is waste water?
2. Why is it not a good idea to put waste water directly back into the environment?
3. Name three methods of wastewater treatment that Canadians use.

1. Waste water leaves your home through an underground system of pipes. It is pumped to the treatment plant.
2. Waste water passes through screens to remove large particles such as garbage.
3. Waste water enters the grit chamber. Small particles such as sand and coffee grounds settle to the bottom.
4. Waste water passes into a primary treatment tank. Heavy solids settle to the bottom, forming sludge. Material that floats gets skimmed off the top.
5. The grey effluent enters the aeration tank. It contains microorganisms such as bacteria and protozoa that digest the organic wastes. Oxygen is added to supply the microorganisms with the environment they need.
6. The waste water passes into another settling tank. This time, the microorganisms settle to the bottom as sludge. Some of this sludge is returned to the aeration tank for reuse.
7. Harmful microorganisms can still be in the waste water, so the final treatment is usually disinfection with chlorine. Most of the chlorine is allowed to get used up before Stage 8.
8. Cleaned and treated water is discharged back into the environment.

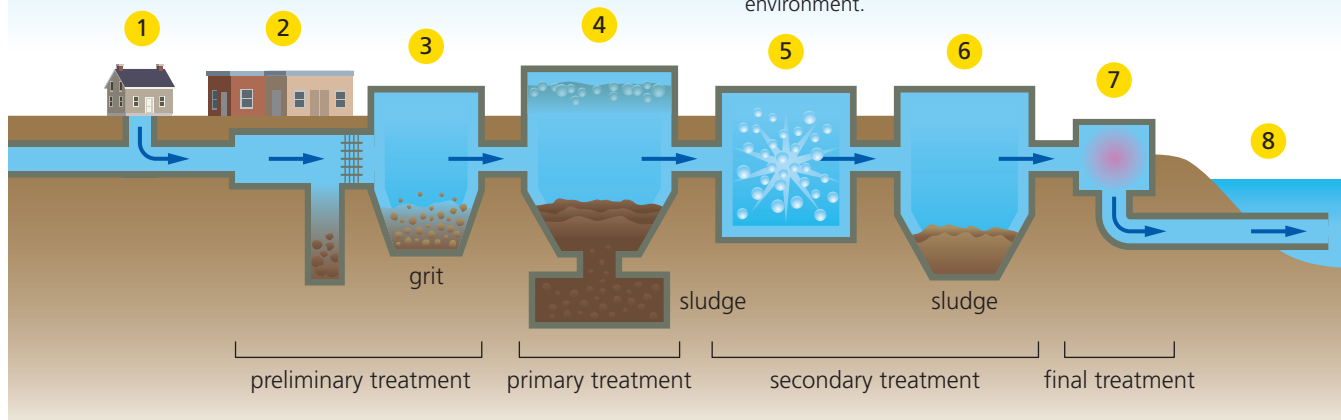


Figure 11.18 The basic stages in the wastewater treatment process

Protecting Drinking Water Sources

It costs a lot of money to treat our water so that it is safe to drink and use for other purposes. Therefore, it makes sense to prevent our rivers and lakes from becoming contaminated in the first place. The less contaminated they are, the less they need to be treated to become drinking water. Also, because not all chemical contaminants can be removed from water, it makes sense to avoid putting them there to begin with (Figure 11.19).

Protecting our drinking water sources is not only better for us, but healthier for other animals and the plants that also depend on them.

All human activities that affect our water systems affect the sources that supply our drinking water (Figure 11.20). The combined effects of these actions can make a body of water so polluted that it is unsuitable for human use.



Figure 11.19 Read product labels to find out whether special disposal is needed. Many cleaning products should not simply be poured down the drain.

Protecting Our Drinking Water Starts at the Source

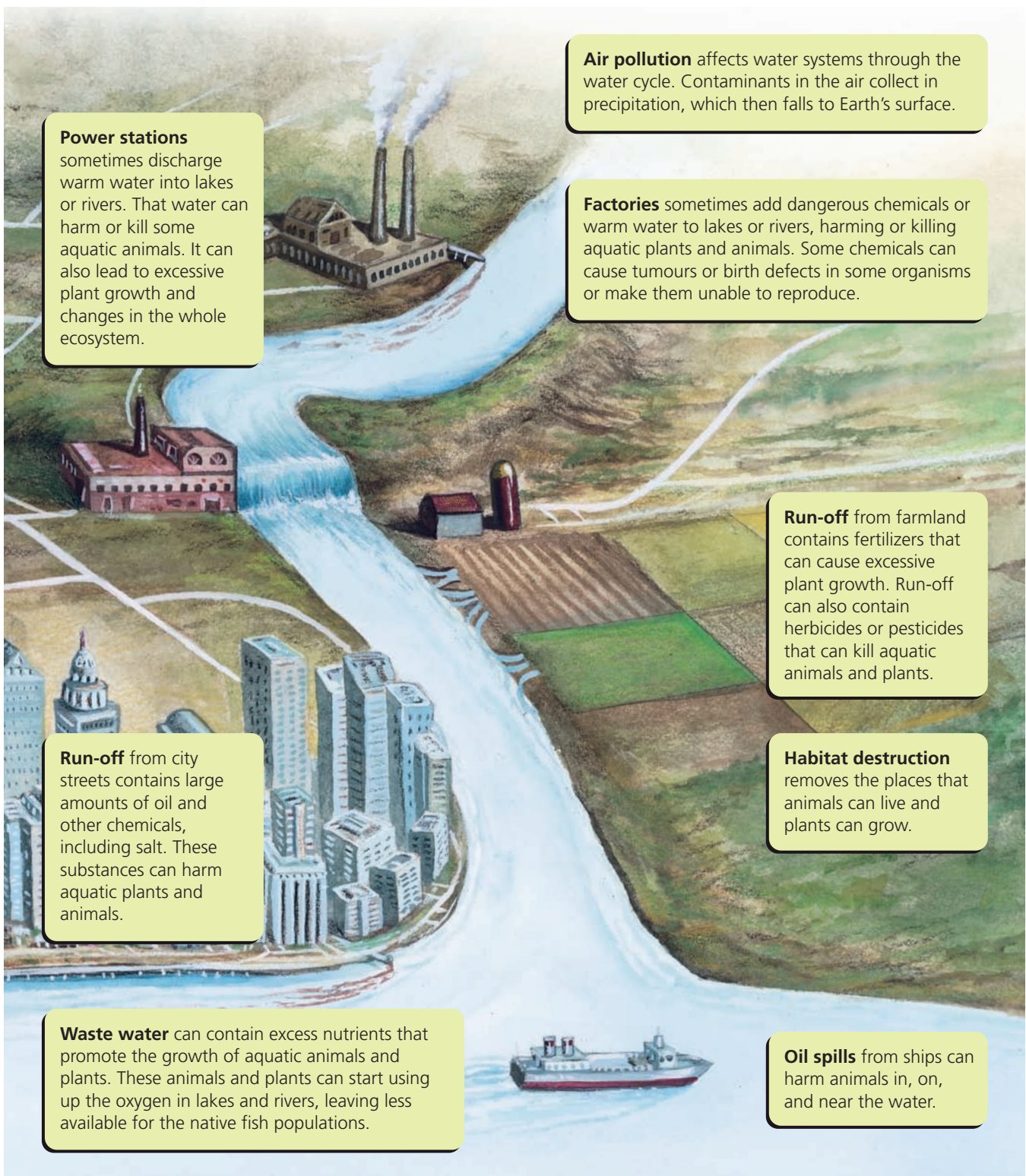


Figure 11.20 Human activities and their effects on water systems

The Yellow Fish Road Program™

If you see storm drains near your home or school marked with yellow fish symbols, you will know that the Yellow Fish Road Program™ has been to your neighbourhood. The program reminds people of the connection between our storm drains and our water systems (Figure 11.21).

As Figure 11.20 notes, city run-off may pick up many contaminants. People have even intentionally disposed of chemical products by pouring them down storm drains.

Since the Yellow Fish Road Program™ began, thousands of students have helped paint yellow fish symbols next to storm drains. Volunteers also distribute brochures to homes, educating people about the dangers that aquatic animals, plants, and our drinking water face when materials are dumped down our storm drains.



Figure 11.21 A storm drain with the Yellow Fish Road symbol

Who Manages Our Water?

All levels of government — federal, provincial, territorial, and municipal — help to manage Canada's water systems (Figure 11.22). Responsibility for a water body depends on many factors, such as where the water flows. Managing our water systems is a shared responsibility.

Your community has bylaws that manage the local water supply. An example of this is restricting lawn watering in the summer. The Ontario Water Resources Act sets out rules that apply to many water-related activities, such as the transfer of water from the Great Lakes, the construction of wells, and the operation of wastewater treatment plants.

Ontario also has laws to protect our province's drinking water specifically. These laws, made under the Clean Water Act, require communities to identify how the quality of their drinking water might be threatened and to make an action plan to reduce or remove those threats.

Figure 11.22 The Canadian Coast Guard has an oil spill clean-up program that can be put into action even in remote parts of Canada's offshore areas.



Suggested Activity •••••

D33 Decision-Making Analysis on page 331

The Question-Answer Relationship

The Question-Answer Relationship strategy helps a reader identify four types of questions to ask about a text and to identify where the answers might be found. The first two types of questions are “Right There Questions” and “Here and There Questions.” Answers to these are likely to be in one or more places in the text. The other two types of questions are “Author and Me Questions” and “Just Me Questions.” Answers to these require the reader to use prior

knowledge and to look at other details in the text. Not all answers to a reader’s questions will be found in the text.

Think of questions based on the title of the Quick Lab below. Identify the type of question you have created and where you expect to find the answer. Confirm this Question-Answer Relationship by reading the lab. What kinds of questions are included at the end of the lab? Where will you find these answers?

D32 *Quick Lab*

How Phosphates Affect Our Water Supply

You might have seen the words “phosphate free” on detergent boxes. Detergents and soaps that contain phosphates upset the natural balance of our lakes and rivers. Removing phosphates from these products protects our water supply.

Purpose

To investigate why phosphates contribute to pollution

Materials & Equipment

- 1 L pond water
- 2 transparent 500-mL containers
- small beaker
- tap water
- 2 measuring spoons, 5 mL and 15 mL
- 1-mL dropper pipette
- 5 mL detergent containing phosphates
- stirring spoon

Procedure

1. Fill each of the 500-mL containers two-thirds full with pond water.
2. Fill the beaker with 45 mL of tap water and add 5 mL of detergent. Stir.
3. With the pipette, add 1 mL of the detergent solution to one of the pond water samples.
4. Set both containers of pond water on a windowsill.
5. In your notebook, record what you observe about the two samples every day for five days.

Questions

6. Why did you add the detergent solution to only one pond water sample?
7. Describe the difference you observed between the two samples.
8. By preventing phosphate contamination of our water supply, how could we benefit the environment?

- Gathering information
- Summarizing information

Managing Small Sound's Water Supply

Issue

The town of Small Sound, where you live, is proposing to install a very expensive storm sewer pipe to handle an increase in storm water run-off from its streets. In addition to being very costly, the pipe will extend into the bay that is the source of the town's drinking water. You have gathered a group of friends to propose an alternative plan because you know that storm waters contain many contaminants. You do not want more of this entering your drinking water supply and the waters where you swim and kayak.

Background Information

Your community has noticed an increase in the number of extreme weather events in the past five years. Two major storms produced above-average rainfall, and in one of those storms, flooding occurred because the storm drains could not handle the run-off from the streets. They backed up and overflowed. This cost more than \$1 million in property damage.




Figure 11.23 Think of Small Sound as looking something like this.

Analyze and Evaluate

Your task is to come up with a plan that will reduce the amount of run-off on Small Sound's streets. You will present your plan to town council. Part of your plan involves educating residents about the contaminants present in surface run-off.

Begin developing your plan, using the following information to guide you.

1. Go to ScienceSource to search for information on using native plants instead of paved boulevards to reduce surface run-off. 
2. Look in print materials such as newspapers and books for information on how plants can protect water supplies.
3. Investigate ways in which individual homeowners can reduce surface run-off from their roofs and driveways.
4. Summarize the information you find in a short report for presentation to town council. Include only information that supports your viewpoint or refutes the proposed pipe plan.
5. Prepare a flyer for local residents that includes:
 - (a) information on the kind of contaminants that can be present in surface run-off that enters a drinking water supply
 - (b) an explanation of ways to reduce surface run-off on their own property

Key Concept Review

1. What methods are used for the treatment of waste water?
2. What is added to waste water during the aeration part of its treatment?
3. Give two reasons why it is necessary to protect our drinking water sources.

Connect Your Understanding

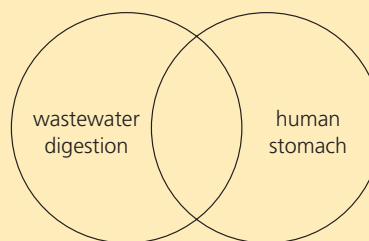
4. Why is the chlorine that is added to final, treated waste water allowed to get used up before it is discharged into a river or lake?

Practise Your Skills

5. Several of the main stages in how our bodies digest food are listed in the next column. Copy the diagram shown here into your notebook. Using the diagram, compare the stages in food digestion with the stages in wastewater treatment.

Stages in Food Digestion

- The stomach provides a site for temporary food storage.
- The stomach mechanically breaks down food.
- The stomach chemically breaks down some foods, such as protein.
- Stomach contents are transferred into the small intestine, which is the main site for food digestion.
- The intestines contain bacteria that work to break down food further.



Use this Venn diagram to show how the human digestive system is like a wastewater treatment plant.

For more questions, go to ScienceSource.



D34 Thinking about Science, Society, and the Environment



Educating the Community

You read about the Yellow Fish Road Program™ in this section. This is one way to raise awareness about the risk of run-off contaminating local lakes, rivers, and streams.

What to Do

1. As a class, think of a project you could do together to educate your community about the harmful effects that run-off can have on local water systems. Participating in the Yellow Fish Road Program™ is one option, but there are many others as well.

2. Develop a plan and schedule to carry out your project and then take action.

Consider This

3. Think of ways to evaluate how effective your project has been. How could you find out, for example, how many people heard or read your message? How could you learn whether your project influenced them to change their behaviour?

Career: Public Health Inspector



Figure 11.24 Becky Hester taking a water sample for testing

When you turn on your taps to fill a glass with drinking water, you can thank people such as Becky Hester for their role in keeping it safe. Hester is a senior public health inspector (Figure 11.24). Her job is to prevent water-borne illnesses in our community. Her work is guided by the provincial standards.

On the wall in Hester's office is her framed certificate indicating that she is well qualified to help manage our water. After studying environmental health at university, Hester passed oral and written exams and a 12-week practical session to become a certified public health inspector.

"My job has a lot of variety," says Hester. "I am never bored. I deal with numerous aspects of public health, including monitoring drinking water test results, promoting well water safety, sampling beach water, and investigating the effects of a water main break."

Hester is also an educator and promoter of public health programs. "I enjoy presenting at community events," she explains. "I have spoken on such topics as how to maintain, disinfect, and treat wells, and even on how our beaches get polluted. I have also had the opportunity to work on a lot of exciting projects, such as the York Children's Water Festival" (Figure 11.25).

Questions

1. How is a public health inspector involved with people who obtain their drinking water from underground sources?
2. Why would regular tests be taken on beach water in the summer?
3. Describe three ways in which you can show respect for our water and the people like Becky Hester who help manage it.



Figure 11.25 These children are at a water festival. Learning about water systems helps children make wise choices about using them.

Key Concept Review

1. Explain the statement, “The water that flows into your sink or bathtub has flowed through your local watershed.” *k*
2. (a) Explain the importance of the chlorination step in drinking water treatment. *k*
(b) Why is chlorination usually also a final treatment step in the treatment of waste water? *k*
3. Give an example of each type of drinking water contaminant: biological, chemical, or physical. *t*
4. The waste water that enters a treatment plant is 98 percent water. The other 2 percent is removed during preliminary treatment. What might the other 2 percent contain? *t*
5. Describe four threats to our drinking water sources. *k*

Connect Your Understanding

6. A company wanting to extract ground water for use in a bottled water plant must first obtain a licence from the province. Explain why this licence helps to manage our freshwater supplies. *t*
7. In desert areas, such as the Los Angeles region of California, hot, dry summers have led to a lot of water being pumped from underground aquifers for use by the large population.
(a) If annual rainfall is not enough to recharge these aquifers, how would the water table be affected? *t*
(b) Describe two ways in which the government of California could manage the drinking water supply. *k*
8. When water is withdrawn from natural water systems to irrigate crops, much of it is returned to the environment in a more contaminated state.
(a) Explain what this statement means. *t*
(b) What kind of contaminants might be of concern? *k*

After Reading

Thinking
Literacy

Reflect and Evaluate

Science is about inquiry and asking questions. Have all your original questions from the beginning of the chapter been answered? Use the following organizer to summarize what you have learned about the value of asking questions as you read:

3-2-1 Review

3 things I learned about the strategy of “asking questions.”
2 ways this strategy helps me as a reader.

1 question I still have.

ACHIEVEMENT CHART CATEGORIES



Knowledge and understanding



Thinking and investigation



Communication



Application

Practise Your Skills

9. Each circle below represents a step in the treatment of drinking water in a typical water treatment plant. Copy the diagram into your notebook.

(a) Label each step in the correct order, choosing from the list provided. **k**

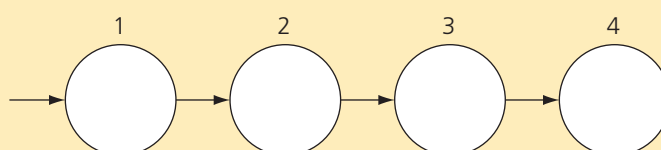
(b) Describe what happens after step 4. **k**

filtration through a membrane or sand and gravel

addition of chlorine to kill microorganisms

screening out of large solids

addition of chemical so solids clump and settle out



Unit Task Link

If you lived in the African country of Sierra Leone, your supply of water would be limited. What personal behaviours would you need to change immediately?

D35 Thinking about Science, Society, and the Environment



Lessons Learned

At the beginning of this chapter, you read about how, even in a country such as Canada, we cannot take having clean, safe water for granted. Maintaining water quality is a responsibility we all share.

What to Do

Working with a small group, reread the Walkerton story at the beginning of the unit. Then discuss the following points.

1. What three things happened at the same time that led to the tragic outcome?
2. Identify two ways in which the outcome could have been prevented.

Consider This

The events at Walkerton, Ontario, led to a public inquiry. An inquiry is a formal and detailed examination by government of what went wrong in a situation and why. At the Walkerton inquiry, many scientists were asked to give their expert opinion about water contamination and water treatment methods.

3. Can knowledge of science alone prevent a similar event like Walkerton from happening in another town or city? Discuss your answer to this question with your group.